NIFA
Annual Report
2019-2020

Nuclear Institute for Food and Agriculture (NIFA), Peshawar

NIFA

Annual Report

2019-20

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NIFA ANNUAL REPORT 2019-20

PRELUDE

Climate change is a serious threat to agriculture and food security. Extreme weather conditions like erratic rainfalls, windstorms, hail storms, droughts, flash floods and landslides along with unusual outbreaks of diseases and pests result in the decline of crops productivity by influencing their growing periods. The adverse effects of climate change can be mitigated by developing climate resilient cultivars and modifying current production technologies of field and horticultural crops. Nuclear Institute for Food and Agriculture (NIFA) is striving for the development of climate resilient production technologies and climate smart high yielding crop varieties through the use of innovative research and development (R&D). NIFA aims at promoting sustainable food production systems to meet rather to exceed the expectations of end-users through human resource development and use of nuclear and other contemporary advanced technologies. 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 162076 showed excellent performance in National Uniform Wheat Yield Trial (Normal) and ranked 1st throughout the country. Similarly NIFA rainfed line NRL 1664 ranked 2nd on Khyber Pakhtunkhwa basis and 3rd on country basis in NUWYT-Rainfed. NRL 1664 exhibited more or less similar results in national trials conducted under normal conditions and ranked 2nd on Khyber Pakhtunkhwa and Punjab basis and 3rd on Baluchistan and Pakistan basis. Two advanced lines CTHN-162009 and CTHN-162056 secured 1st and 2nd position in Khyber Pakhtunkhwa Wheat Yield Trials (Normal) respectively. NIFA rainfed line NRL 1643 also performed exceptionally well and ranked 2nd in KPWYT-Rainfed by producing mean grain yield of 3420 kg ha^{-1}. Based on high yield and disease resistance 195 wheat genotypes were selected from preliminary, advanced and international wheat nurseries/trials.

A new candidate variety NIFA Sarson-T20 has been recommended by Variety Evaluation Committee for Khyber Pakhtunkhwa and Punjab. The candidate variety has a yield potential of more than 3000 kg ha^{-1} and is resistant to Alternaria blight and tolerant to Aphid. Two rapeseed candidate lines RR-8-1 and RR-8-2 ranked 1^{st} and 4^{th} respectively by producing 9% and 4% more seed yield over Super Canola in National Uniform Rapeseed Yield Trial. Mustard mutant MM-31-5 out yielded the national check by 13% in seed yield and ranked 5^{th} in National Uniform Mustard Yield Trial. In Zonal adaptability trials RRM $F_1M_4$106-1 achieved highest genotypic mean (2342 kg ha^{-1}) followed by RM M_2/014-1-2 (2329 kg ha^{-1}) against Faisal Canola (2085 kg ha^{-1}). In replicated seed yield trials at NIFA, 33 out of 91 genotypes of rapeseed / mustard in various trails performed better than checks and achieved seed yield of 1889-3452 kg ha^{-1}. Depending on the objectives of breeding program selections were made in F_2 - F_4 generations.

Two years mandatory Distinctness, Uniformity and Stability (DUS) of two black-seeded mungbean candidate lines has been completed. Six (06) out of 48 black-seeded mungbean genotypes evaluated in 3 PYTs in spring 2020 produced significant higher seed yield of 1672-1794 kg ha^{-1} compared with parents Kuram black mung (average seed yield of 1230 kg ha^{-1}) and NIFA black mung (average seed yield of 1655 kg ha^{-1}). In common bean, 1^{st} year mandatory DUS of 4 common bean candidate lines NCB-1, NCB-2, NCB-3 and NCB-4 has been completed. In preliminary chickpea yield trials 30 out of 77 advanced recombinants produced statistically significant higher seed yield (400-2224 kg ha^{-1}) compared with 2 check varieties i.e. NIFA-2005 and Bittal-16.

Twelve healthy plants selected from exotic germplasm (PW & Z-4) of peach were transferred to orchard for further studies i.e., early blooming, fruit maturity, dwarfism and fruit quality. Local germplasm selected from farmers' fields and mutants of Early Grand and Florida King were transferred to orchard for further evaluation. Early flowering in three plants and fruit setting in two plants were noted as compared to check variety Early Grand. Plum variety Fazli Manani budwood irradiated with 20 Gy doses were shifted to the semi-permanent orchard for desirable characters evaluation. The data of plant height shows a decrease in plant of irradiated populations. Three varieties of plum i.e. Blasting Star, Santa Roza and Fazli Manani were budded on Mariana rootstock in the nursery. The highest bud sprout was recorded in Blasting Star followed by Fazli Manani and Santa Roza. Santa Roza was inferior in all varieties for percent sprouting but was earlier in sprouting and took lowest number of days to sprouting.

FOOD AND NUTRITION DIVISION

In Food and Nutrition Division (FND) the R & D efforts focus on value addition and shelf life extension of food/agricultural commodities through gamma radiation and other contemporary techniques to enhance food safety and achieve food 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 income of Rs. 4.72M was generated from sale of mentioned products and services which is around 37% less than previous year due to Covid-19 pandemic lockdown. Under ALP research project, R&D work on Zero Energy Cooling Chamber (ZECC) was carried out and optimization of construction and operational parameters were studied. In the designed cooling chambers experiment, an overall decrease of 10-11 ^{o}C in temperature and 50-60% increase in relative humidity was observed. Retention of high humidity and low temperature proved very important in restricting the weight loss of horticultural produce.

Mushroom cultivation technology as cottage industry is being popularized through training workshops. Mushroom spawn (Button, Oyster and Milky) was produced at NIFA and sold-out on subsidized rates to the growers. R&D work on Ganoderma (*Ganoderma lucidum*) or reishi medicinal mushroom is being initiated for the first time and resulted in its successful cultivation at pilot scale. Plant extracts/botanicals (*Melia azedarach* and *Azadirachta indica*) efficacy testing trial for the management of yellow rust disease in wheat was conducted. These botanicals showed encouraging results in term of yellow rust urediospore % germination inhibition and spray efficacy for managing yellow rust under natural field conditions. Food and Environmental Safety Group of FND, NIFA has recently developed indigenous bio-preservatives collectively known as bacteriocin. These bio-peptides were isolated from probiotic culture of lactic acid bacterial strains specifically from *Enterococcus faecium*- NIFA-N1 (AS.No:MN560018.1), *Enterococcus faecium*-NIFA-N2 (AS.No:MT043863.1) and *Enterococcus lactic*-NIFA-N3 (AS.No:MF369859.1). It is expected that these bio-peptides will serve as effective bio-preservatives in dairy food products.

The effect of Electron Beam (EB) and gamma irradiation was studied on disinfestation of dates and sprout inhibition in bulb food. The radiation doses of 1.5 kGy and 0.3 kGy were optimized for disinfestation of Dhaki and Gulistan dates, respectively. Sprout inhibition in Ginger was studied, 40 and 60 Gy irradiation doses were found more appropriate to maintain the samples with healthy physiochemical properties up to storage period of one month at ambient temperature.

SOIL AND ENVIRONMENTAL SCIENCES DIVISION

Research endeavors at Soil and Environmental Sciences Division address the issues of abrupt climatic changes and inherent poor fertility of Pakistani soils using conventional and nuclear techniques. The soil scientists in the division have devised environment friendly packages of production technology for various field and horticultural crops, perfected tunnel farming technology for off-season vegetables production, bio-geyser technology for warming water through the use of agro-wastes and developed organic fertilizer products (compost and compost tea) for particular use by vegetable growers. The developed technologies are disseminated to various stakeholders through awareness seminars, training workshops and field 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 of hydroponic study revealed that Zn efficiency of ten wheat genotypes varied between 35 to 76%, the genotype CTES-1804 was found to be the most efficient while C-1803 was the least. Similarly, under the field conditions *cv*. CT-161130 produced the maximum grain yield with application of 5 kg Zn ha^{-1} while Zincol depicted higher grain yield under Zn stress conditions.

Off-season vegetables farming in high tunnel has wide scope and creates economic opportunities particularly for small landholders. The critical timings, methods & economical levels of fertilizer and irrigation for tomato & cucumber were identified for growing in off season under high tunnels having furrow and drip irrigation systems. It was concluded that off-season tomatoes, bitter gourd and bell pepper grown in high tunnel gave ten to fifteen times higher income compared to conventional ones.

Development of fertilizer recommendations is mandatory for the approval of upcoming varieties as wanted by Provincial Seed Council. Findings revealed that wheat line CT-161130 performs better at 140-90-60 kg ha^{-1} NPK levels when applied in splits and at proper time. The nutritional requirement of three advance candidate lines of brassica was assessed and it was found that RR-41-4 produced the maximum grain yield @ 90-60-60 kg NPK ha^{-1}.

Findings from a study to improve yield of plum revealed that maximum plum fruit yield of 109 kg $tree^{-1}$ was obtained in the treatment receiving NPK @ 180 g N + 125 g P + 180 g K $tree^{-1}$ as fertigation. Increase in yield was 41% over the treatment to which NPK were broadcasted @ 360 g N + 250 g P + 360 g K $tree^{-1}$.

The effect of compost, compost tea and various levels of inorganic fertilizers on yield of potato was assessed under field conditions. The findings indicated that the treatment receiving 125-75-75 kg NPK ha^{-1} + compost @ 15 t/ha + compost tea @ 1:5 gave highest potato yield. In as similar study on spinach in pots, it was found that relatively higher chlorophyll content and plant yield were attained under combined application of fertilizers and compost tea.

PLANT PROTECTION DIVISION

Irradiation effects on *T. chilonis* pupae, adult emergence and adult longevity were established. Trichogramma (egg parasitoid) was standardized and established on host Sitotroga eggs. Lowest infestation of *H. armigera* and highest yield was recorded in both tomato and okra plots where 1500 pupae of bio-control agent *T. chilonis* were released. Anti-termite botanical with high toxicity was identified and prediction of fruit fly population dynamics using cumulative degree day (CDD) was established. Population and aphid resistance of wheat and oil-yielding brassica were characterized. Over season progress of airborne and vector borne diseases of wheat was established. Four wheat yellow rust races were detected. Fixed virulence's in local pathogen population were assessed and epidemiological consequences of using new *Puccinia striiformis* f. sp. *tritici* resistance genes were determined. Wheat ggenotypes were identified for rust management. Trials on the development of larval diet for Anopheles, Culex and Aedes species were conducted and NIFA diet was found better than IAEA diet. Water bug and Tilapia fish were found effective predators against mosquitoes.

PLANT BREEDING AND GENETICS DIVISION

Wheat Irrigated

Seed production and maintenance of NIFA released wheat varieties

NIFA since its establishment has released a number of improved varieties like Fakhr-e-Sarhad, NIFA Bathoor-08 and NIFA Aman for irrigated areas of the province. Continuous efforts are being made by the breeders for maintenance of seed purity and production of quality seed. Progeny rows / blocks of wheat varieties were planted at the institute, rows / blocks having off-type plants were discarded. Breeder nucleus seed was planted for the production of pre-basic seed. A total of 11.25 tons quality seed of NIFA Awaz, NIFA Insaf, NIFA Lalma and NIFA Aman was produced and certified with the assistance of FSC & RD officials. The seed will be distributed to agriculture extension, seed companies and farming communities of KP.

Performance of wheat genotypes in various yield trials under irrigated conditions

Based on higher grain yield and disease resistance, two candidate lines CTHN-162076 and CT-161130 were subjected to the 1st year mandatory evaluation in the national trials. NUWYT pooled analysis showed that CTHN-162076 secured 1st position and produced highest mean grain yield of 4816 kg ha^{-1} over all the candidate lines throughout Pakistan.

For assessment of grain yield stability, three promising genotypes CTHN-162056, CTHN-162009 and CTES-17133 along with checks NIFA Aman and local check were tested at 13 locations of KP. CTHN-162009 secured 1st position while CTHN-162056 secured 3rd position on Khyber Pakhtunkhwa basis by producing average grain yield of 3575 and 3337 kg ha^{-1}, respectively.

For the assessment of performance, sixteen genotypes in addition to four checks NIFA Aman, Bathoor, Fakhre Sarhad and Khaista were evaluated in micro plot trials. Out of sixteen, 4 high yielding and disease resistant genotypes CT-171010, CT-171058, CTHN-172114 and CTHN-172116 out yielded the check cultivars by producing grain yield in the range of 5333 to 6489 kg ha^{-1} in comparison to the checks (2897 to 3632 kg ha^{-1}).

A total of 4th genotypes were evaluated in two advanced selection yield trials under both normal and late planting conditions. In all, 14 genotypes out yielded both the check cultivars (NIFA Aman and Khaista). The selected genotypes produced grain yield in the range of 5511-7333 kg ha^{-1} under normal condition. Under late planting condition, the genotypes produced grain yield in the range of 4045-5244 kg ha^{-1}. Wheat cultivar Pasina along with NIFA Aman were used as check under late planting conditions.

One hundred and seventy six (176) genotypes were evaluated in 8 preliminary yield trials under both normal and late planting conditions. Based on higher grain yield and disease resistance, 23 genotypes out yielded the check cultivars NIFA Aman and Khaista. The selected genotypes produced grain yield in the range of 6000-7556 kg ha^{-1} as compared to the checks NIFA Aman (5167 kg ha^{-1}) and Khaista (5338 kg ha^{-1}). However, their yield under late planting condition was in the range of 3333-5251 kg ha^{-1}. Wheat cultivar Pasina (4000 kg ha^{-1}) and NIFA Aman (4089 kg ha^{-1}) were used as a check under late planting**.**

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 ideotype for wheat breeders. During 2019-20 a total of 414 exotic genotypes along with local checks NIFA Aman and Khaista were evaluated in International Bread Wheat Screening Nursery (52^{nd} IBWSN), High Rainfall Wheat Screening Nursery (30^{th} HRWSN) and Elite Spring Wheat Yield Trial (40^{th} ESWYT). Based on plant type, yield performance and disease reaction (*YR*, *LS* and *LR*), a total of 80 genotypes were selected for further evaluation. The selected genotypes produced grain yield in the range of 5333-9333 kg ha^{-1}.

NIFA Disease Screening Nursery (NDSN) consisting of 150 genotypes was evaluated for disease reaction against yellow rust (*YR*), leaf rust (*LR*) and loose smut (*LS*) using standard check (Morocco) as disease spreader.

Creation of new genetic variability and raising of segregating populations

Raising and maintenance of different segregating populations developed through hybridization and mutation is the most important breeding strategy. It is routinely carried out as a part of wheat improvement program at NIFA.

Genetic variability through hybridization

F_4 population resulted from 15 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, 13 desirable recombinants were selected for further evaluation in the observation nursery of the next cropping season. F_3 population resulted from 38 cross combinations were evaluated in the field and 8 desirable recombinants were retained for further evaluation during the next season. F_2 populations resulted from 5 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, 75 desirable recombinants were selected for confirmation of their desired traits during the next rabi season. F_1 generation resulted from 13 cross combinations was raised in the field. Seeds from all the crosses were successfully harvested on maturity. The material was space planted along with parents during the next rabi season for selection of desirable recombinants.

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, 3 fresh cross combinations (F. Sarhad/Yr-5, Tatara/Yr-5, Shahkar/Yr-5) were attempted. F_0 seeds were separately harvested from these cross combinations.

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 150 and 250 Gy doses of gamma rays was space planted in the field along with their respective control for comparison. Based on disease resistance, high tillering capacity and better ideotype, 57 desirable mutants were selected from M_2 population.

Wheat Rainfed

Performance of exotic germplasm

During 2019-20 three international wheat evaluation trials i.e. 18th High Temperature Wheat Yield Trial (18th HTWYT), 9th Stress Adaptive Trait Yield Nursery (9th SATYN) and 27th Semi-Arid Wheat Yield Trial (27th SAWYT) comprising of 50, 30 and 50 exotic genotypes respectively, were evaluated in field under moisture stress conditions at the Institute. Data regarding yield, agronomic traits and disease resistance were recorded for each genotype at different growth stages. Based on field performance 19 best genotypes were selected from HTWYT, 4 from SATYN and 27 from SAWYT.

Performance of wheat genotypes in various yield trials under rainfed conditions

Fourteen (14) promising wheat genotypes including Lalma as standard check were assessed for grain yield, yield components and disease resistance in advanced yield trial (AYT) at the institute. Based on grain yield and disease resistance 5 promising genotypes i.e. NRL 1804, NRL 1812, NRL 1816, NRL 1825 and NRL 1830 were selected. The overall grain yield in advanced yield trial was in the range of 3611 kg ha^{-1} to 4833 kg ha^{-1}. NRL 1812 ranked 1st by producing grain yield of 4833 kg ha^{-1} showing an increase of 26 % over the check cultivar Lalma. The lowest grain yield of 2322 kg ha^{-1} was produced by NRL 1803.

Thirty six (36) newly selected genotypes were tested for grain yield, disease resistance and other agronomic traits in 3 preliminary yield trials (PYT-I, PYT-II and PYT-III) under moisture stress conditions at the institute. Wheat variety Lalma was included as a standard check in each trial. On the basis of high yield and disease resistance a total of 22 genotypes were selected from these trials. The grain yield of different genotypes in these 3 preliminary yield trials ranged from 2667 kg ha^{-1} to 5556 kg ha^{-1}. These selected lines will be further tested in advanced yield trial during the coming growing season.

The relative effects of environment, genotypes and their interaction on grain yield and agronomic attributes were evaluated using 28 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 trails were conducted with standard cultural practices with no irrigation. NIFA three elite wheat lines (NRL 1643, NRL 1666 and NRL 1725) were among the contestant genotypes. NIFA elite line NRL 1643 secured 2nd position among the tested genotypes by producing grain yield of 3420 kg ha^{-1}. This line will be further evaluated in national trials during 2020-21. NIFA candidate varieties, NRL 1664 and NRL 1448 were subjected for 1st and 2nd year mandatory evaluation in National Uniform Wheat Yield Trials (NUWYT- Rainfed) at different sites in the country. NRL 1664 showed excellent results and ranked 2nd on KP basis (4601 kg ha^{-1}) and 3rd on country basis (4686 kg ha^{-1}). On provincial basis the candidate variety out yielded the check cultivars by 23% & on country basis it out yielded the checks by 19-22%.

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

Continued raising of different segregating populations achieved through gene pyramiding and single gene mutation is the most important breeding strategy that ultimately results in the availability of homozygous genotypes. A crossing block consisting of 46 genotypes was planted on three 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, fresh crosses among different wheat cultivars / genotypes were carried out. F_1 generation comprised of 9 cross combinations was raised. Each cross combination was planted in 2 rows with 2.5 m length and having 25 plants per row. Seed of this F_1 population was harvested, bulked and stored after proper labeling. In F_2 generation 11 cross combinations having about 1500-2000 plants per cross were space planted. Based on field performance 207 desirable plants were selected and threshed individually. F_3 generation of 18 cross combinations was raised in the field for isolating desirable plants. Ideal plants were selected in the best progenies. In F_4 generation (11 cross combinations) 28 progenies were selected. F_5 and F_6 populations comprised of 60 entries were raised in the form of observation nursery and 12 genotypes were finally selected.

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 by growing progeny blocks / rows of NIFA varieties on available land in the institute. In total 325 progeny blocks and 215 progeny rows were grown for these varieties. After regular observations 290 progeny blocks and 200 progeny rows were selected and the rest were discarded. A total of 450 kg breeder nucleus seed of NIFA rainfed wheat varieties i.e. 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

Variety Development

A new high seed and oil yielding variety NIFA Sarson-T20 (011-K-16-3) was recommended for Khyber Pakhtunkhwa and Punjab by Variety Evaluation Committee

(VEC) in a meeting held at PARC, Islamabad on 18.08.2020.

Evaluation of oilseed brassica mutants/ recombinants in various yield trials

Three rapeseed candidate lines viz; RR-8-1, RM-193-1 and RR-8-2 were evaluated in National Uniform Rapeseed Yield Trial (NURYT) 2019-20. RR-8-1 and RR-8-2 produced high genotypic means (2937 kg ha^{-1} & 2776 kg ha^{-1}) and ranked 1st and 4th, respectively among 21 candidate lines inclusive of check (2663 kg ha^{-1}) over eight locations while in National Uniform Mustard Yield Trial (NUMYT) 2019-20; MM-31-5 mustard mutant candidate line outclassed check in seed yield by recording 2525 kg ha^{-1} and ranked 5th among 35 test entries over 9 locations while MM-31-3 remained mediocre to check (2197 kg ha^{-1}).

Based on high seed and oil yields performance of 8 rapeseed recombinant/ mutants advanced lines were assessed in multi-location adaptation trial at selected sites in the KP & Punjab (NIFA, AZRC D.I. Khan, BARI Chakwal, BKU Charsadda, and BARS Kohat). The results of the three locations demonstrated that RRM $F_1M_4$106-1 achieved highest genotypic mean (2342 kg ha^{-1} followed by RM M_2/014-1-2 2329 kg ha^{-1}) while RM M_2-1-5 & RM M_2-1-9 exhibited numerically high seed yield against Faisal Canola (2085 kg ha^{-1}). NIFA, Peshawar was the most productive site with mean of 3000 kg ha^{-1} followed by AZRC, D.I. Khan (2460 kg ha^{-1}).

At station trials of brassicas genotypes developed at NIFA, fifteen rapeseed recombinants were evaluated for their agronomic performance against commercial check Super Canola in advanced yield trial. Six entries (RRF_3/016-49, RRF_3/016-101, RRF_3/016-20, RMF_3/016-28, RRF_3/016-30 & RRF_3/016-82) presented numerically high seed yield (2778 – 3000 kg ha^{-1}) compared to check (2666 kg ha^{-1}).

In PYT-I, MR-2-PT-I/19-20 produced 2666 kg ha^{-1} and significantly out yielded the check Super Raya (1833 kg ha^{-1}) while two MR-1-PT-I/19-20 and MR-3-PT-I/19-20 exhibited high seed yield (1994 – 2000 kg ha^{-1}). Regarding PYT-II, thirteen rapeseed mutants remained very mediocre to the check variety. In non-replicated trial, 24 rapeseed and 46 mustard entries were tested against respective checks replicated over blocks. The results indicated that 6 rapeseed entries achieved higher seed yield (3095 – 3333 kg ha^{-1}) compared to check (2857 kg ha^{-1}). In case of mustard, 16 entries showed better seed yield (2619 – 3452 kg ha^{-1}) against check (2119 kg ha^{-1}).

Field assessment/selection of mutants/ recombinants at early breeding generations

Seventy two (72) rapeseed and 33 mustard (F_3 / M_3) entries developed from different cross combinations and various doses (Gamma rays) were planted to stabilize desired characters. Nine single plant progenies of 33 entries of mustard and 61 of 72 inclusive of 18 rapeseed progenies developed from SIAE, China material were re-selected based on seed yield and other agronomic parameters against respective parental checks.

One hundred and ninety two (192) rapeseed single plants selection was made from M_2 & F_2 (SIAE, China material) based on the genetic potential for seed yield and other agronomic characters.

Two hundred fifty nine (259) fresh crosses in 7 cross combinations were attempted for creation and utilizing the variability through hybridization and mutation. The materials were species, cross and dose wise harvested / picked for the continuity in oilseed breeding to develop early maturing, short stature and high seed and oil yielding varieties characterized with better oil quality.

Oilseed Analysis

Near Infrared Reflectance Spectroscopy (NIRS) is a non-destructive, cost, time and labour effective technique for quality analysis of oilseeds. For on-going project at NIFA, about 800 samples of oilseed germplasm and breeding materials were analysed for fatty acid profile and glucosinolates contents. Regarding Quality Analysis Service of brassicas; approximately 512 samples of brassicas were analyzed at nominal cost for academician, researchers of different universities and R & D organizations both at provincial and federal levels.

Oilseed Brassica- varietal maintenance programme

To make sure timely and quality seed availability of oilseed brassica varieties; 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 214 kg and 268 kg Pre Basic Seed (PBS) of oilseed brassica varieties NIFA Gold and Durr-e-NIFA were produced respectively at NIFA and certified by FSC&RD.

Pulses

Mungbean

Evaluation of mungbean advanced lines in various yield trials

Thirty six genotypes along with three check varieties i.e. Ramzan, NIFA Mung-2017 and

Sona Mung were planted in advanced lines yield trials (ALYTs) in kharif 2019 for yield and yield related traits evaluation. In preliminary yield trials 92 recombinants were evaluated along with two check varieties i.e. Ramzan and NIFA Mung-2017 for yield and yield related traits. Due to abnormal rains and subsequent weeds infestation proper evaluation could not be done.

Evaluation of mungbean segregating material

Twenty one true breeding lines derived from 02 cross-combinations 'Sona mung x NM-2011 and ML-5 x Sona mung' were planted in F_5 generation in kharif 2019 at NIFA for selection of lines based on more pods and branches, better plant type, MYMV resistance and high grain yield. Similarly, F_6 generation derived from cross-combination 'Ramzan x Kuram green mung' comprising of 2 true lines was planted at NIFA in kharif 2019 to select best line(s) for further evaluation in replicated yield trials. Unfortunately, abnormal weather conditions in the season made proper evaluation impossible and no selections could therefore, be made.

In case of breeding black-seeded mungbean, 7 single recombinant plants derived from 2 cross-combinations 'Ramzan x Kuram black mung and Kuram black mung x NFM-5-36-27' were planted in F_3 generation in kharif 2019 at NIFA for further single plant selections based on more pods and branches, shiny black seed coat color, better plant type and MYMV resistance. Six (6) single recombinant plants derived from 2 cross-combinations i.e. NIFA black mung x Kuram black mung and Ramzan x Kuram black mung' were planted in kharif 2019 to select single plants based on above-mentioned desired criteria. F_4 and F_5 generations comprising of 4 single recombinant plants and 57 single recombinant lines, respectively derived from a cross-combination 'Kuram black mung x NIFA black mung' were planted in kharif 2019 for single line selections for evaluation in line-progeny-rows and replicated yield trials, respectively in kharif 2020. No proper evaluation could be done because of heavy rains and subsequent weeds problem.

In case of induced mutation for high grain yield and MYMV resistance, M_5 population from parent 'Kuram green large shiny (irradiated at 400 Gy of γ rays)' comprising of 2 single mutant lines was planted in kharif 2019 for further single line(s) selections for desired traits. The material was damaged by rains and weeds, and no proper evaluation could, therefore, be done. The entire breeding material will be re-evaluated in kharif 2020.

In spring 2020, 48 black-seeded mungbean recombinants were planted in 3 preliminary yield trials along with parents 'Kuram black mung (KBM), NIFA black mung (NBM)' and green-seeded check variety NIFA Mung-2019 at NIFA. Of these, 6 genotypes i.e. NBM-2-2-4-5, NBM-2-2-4-6, NBM-5-3-7, NBM-5-3-8, NBM-5-3-13 and NBM-8-2-3-5 produced statistically significant ($p \leq 0.05$) higher seed yield of 1672 to 1794 kg ha^{-1} compared with average yield of parents KBM (903 kg ha^{-1}) and NBM (1542 kg ha^{-1}), whereas their yields were lower than green-seeded check variety NIFA Mung-2019 (average seed yield of 1806 kg ha^{-1}).

In order to create new genetic variability for shiny black seed coat color, MYMV resistance and yield and yield components, 04 different cross-combinations i.e. NBM-2-14-4-6 x NIFA Mung-2019, NBM-2-14-4-6 x Ramzan, NBM-2-14-4-6 x V2817 and 2-14-4-20 x Ramzan were attempted in spring 2020. All crossed pods were picked and bagged cross-wise individually.

In case of quality seed production, 212, 20 and 86 kg of pre-basic/basic seed of NIFA mungbean varieties i.e. Ramzan, NIFA Mung-2017 and NIFA Mung-2019, respectively was produced in spring 2020.

Common bean

Evaluation of common bean genotypes in adaptation yield trials

1st year mandatory DUS of 4 common candidate lines NCB-1, NCB-2, NCB-3 and NCB-4 has been completed. Proposals for varieties will be submitted after carrying-out 2nd year DUS in spring 2021.

Six (6) genotypes namely Tajaki, Kenya, Charsadda watani, Kuram local, Afghani and China bean were planted in adaptation trials at NIFA, Peshawar, on farmers' fields at Kuram and Charsadda, ARS, Chitral and ARI, Swat in kharif 2020. At NIFA, farmers' field, Charsadda and ARS, Chitral, genotype 'Tajaki' produced statistically significant ($p \leq 0.05$) higher averaged seed yield of 1953 kg ha^{-1} followed by genotype Charsadda watani (1593 kg ha^{-1}), genotype Kuram local (1510 kg ha^{-1}) and genotype Kenya (1470 kg ha^{-1}). These genotypes possessed averaged seed weight of 21 – 44 g per 100 seeds across three locations. The trials at Kuram and ARI, Swat are being harvested / threshed and necessary data collection is in progress.

Evaluation of common bean segregating material

F_1 generation derived from 2 cross-combinations i.e. Charsadda watani x Kuram local and Kuram local x Charsadda watani was planted at ARI, Swat in kharif 2020.

Material is at maturity stage and all recombinant plants will be harvested, threshed and bagged individually. In order to create new genetic variability for grain yield and yield components, new cross-combinations between different parents have been attempted at ARI, Swat in kharif 2020. All crossed pods will be picked, threshed and bagged individually.

In case of induced mutation for yield and yield related traits, M_1 generation of 3 parents i.e. Charsadda watani (irradiated at 500 Gy of γ rays), Tajaki (irradiated at 500 Gy of γ rays) and Swat watani (irradiated at 500 Gy of γ rays) was planted at ARI, Swat in kharif 2020. The material is at maturity stage and harvesting will be carried-out soon.

Chickpea

Evaluation of chickpea advanced lines in various yield trials

Seventy seven recombinant lines along with two check varieties i.e. NIFA-2005 and Bittal-16 were evaluated in 7 preliminary yield trials during 2019-20. Of these, a total of 30 recombinant lines produced statistically significant ($p \leq 0.05$) higher seed yield (400 - 2224 kg ha^{-1}) as compared to NIFA-2005 and Bittal-16 (Average seed yield of 325 - 943 kg ha^{-1}).

A total of 25 true breeding mutants derived from two parents i.e. CM541/05 and Pb-2008 irradiated at 300 Gy of γ rays were planted in 2 non-replicated yield trials for evaluation for yield and yield components and subsequent seed increase for evaluation in replicated preliminary yield trials. The mutants produced seed yield ranging from 313 to 729 kg ha^{-1} against averaged seed yield of 532 kg ha^{-1} produced by NIFA-2005.

Evaluation of chickpea segregating material

F_1 generations were raised from a total of 161 crossed pods derived from 8 different cross combinations. All recombinant plants were harvested, threshed and bagged individually. F_2 generations comprising of 174 single plant recombinants of 13 different cross-combinations were planted during 2019-20. Of these, 172 single plants were selected on the basis of more pods and branches per plant and better plant type. F_3 populations comprising of 88 single plant recombinants derived from 8 cross-combinations were planted during 2019-20. From these populations, a total of 119 single plant recombinants were harvested. Sixty five (65) single plant recombinants in F_4 populations derived from 8 different cross-combinations were planted and a total of 30 single plants were selected based on above-mentioned criteria.

In case of induced mutation, M_3 population derived from parent CH40/09 irradiated at 400 Gy of γ rays comprising of 15 single plant mutants were raised during 2019-20. Of these, 30 single plants were selected on the basis of desired criteria i.e. more pods per plant and better plant type. M_4 population derived from D-075-09 (irradiated at 400 Gy of γ rays) comprising of 20 single plant mutants was raised during 2019-20. Based on yield and related components, 32 single mutant rows were selected.

Horticulture

Improvement of Peaches for yield/quality and Stevia popularization

Exotic/local germplasm collection and evaluation

Twelve healthy plants per each variety PW and Z-4 were selected and transferred to orchard in February, 2020 for evaluation of earliness, dwarfism and fruit quality etc. Plant height in cultivar PW ranged from 135-207 cm and in Z-4 ranged from 115-186 cm as compared to Early Grand (211 cm). Local germplasm from Charsadda (20 plants) was studied for desirable characters. Early flowering in three plants and fruit setting in two plants were observed as compared to check variety early grand.

Creation of genetic variability through induced mutation

Mutant plants of Early Grand & Florida King were transferred from nursery to orchard for further studies. Minimum plant height of 211 and 210 cm was recorded for Early Grand and Florida King mutants respectively as compared to the controls (251 cm and 236 cm).

Standardization of optimum budding time for peach nursery production

Three hundred and sixty (360) buds of varieties Early Grand and Florida King were budded at 10 days interval started from 20th May, 2020 to 10th July, 2020 on peach rootstock i.e., (20th May, 30th May, 10th June, 19th June, 30th June and 10th July). Maximum bud sprouting success in Early Grand and Florida King was 75.18 % and 76.58 % respectively when plants were budded on 10th June.

Stevia propagation and popularization

In order to popularize stevia 1000 plants were produced from seed and were shifted to polyethylene bags for interested farmers / stakeholders.

Improvement of plum for higher yield and better fruit quality

Effect of gamma rays on physiological characteristics of plum

The effect of gamma rays (20 and 30 Gy) on bud wood of plum cultivar Fazli Manani was studied. Maximum plant height of 198 cm was recorded in control plants as compared to 20 and 30 Gy doses where 157 and 165 cm plant height was recorded. Highest number of branches 43 was recorded in 20 Gy treatment followed by 42 in control. Internode length and seedling diameter were slightly affected by 20 and 30 Gy doses and were at par with control.

Response of plum varieties to budding on Mariana rootstock

Three varieties of plum i.e. Blasting Star, Santa Roza and Fazli Manani were budded on Peshawar local rootstock in the nursery. Highest bud sprout was recorded in Blasting Star (58.5 %) followed by Fazli Manani (39.5 %). The lowest bud sprout (33%) was recorded in Santa Roza, however, it was early in sprouting (17 days). Blasting Star took 18 days while Fazli Manani took 21 days to sprout. Santa Roza also took the highest budling length of 33 cm followed by Fazli Manani (29 cm) and Blasting Star (26 cm).

Raising of new plum cuttings

For raising new nursery plants Marianna plum cuttings (>3000) were planted in the nursery during December 2019. The plants were budded in October 2020 with different varieties with different budding dates for best budding date evaluation. For efficiency of cuttings to be rooted, different concentrations of IAA and IBA for promoting root formation and successful survival was studied. The cuttings were treated with 1000, 2000 and 3000 ppm IBA and IAA solutions for 24 hours. It was found that cutting treated with 2000 ppm IAA gave the highest plant height of 104 cm. Highest stem diameter of 7.0 mm was recorded in cuttings treated with 3000 ppm IAA.

NIFA Sarson-T20 (011-K-16-3)

Common bean adaptability trial planted at NIFA in spring 2020

Field view of mungbean variety 'NIFA Mung-2019'

Kharif pulses travelling seminar 2020 participants visiting NIFA mungbean material

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

Initially a model chamber with the dimensions of 165 cm x 107 cm x 79 cm (length x width x height) was constructed for preliminary study. The storage volume of model chamber was 1.39 m^3. Then three (3) low cost zero energy cooling chambers (ZECC) have been constructed at NIFA, Peshawar. The three constructed ZECC have different dimensions of length, width and height (depth) to study the effect of storage capacity on temperature and humidity. Chamber No. 1 (C1) is rectangle with dimensions 273 cm length, 121 cm width and 79 cm height/depth. Chamber No. 2 (C2) have dimensions of 152 cm x 152 cm x 70 cm and Chamber No 3 (C3) have dimensions of 198 cm x 198 cm x 89cm length, width and height respectively.

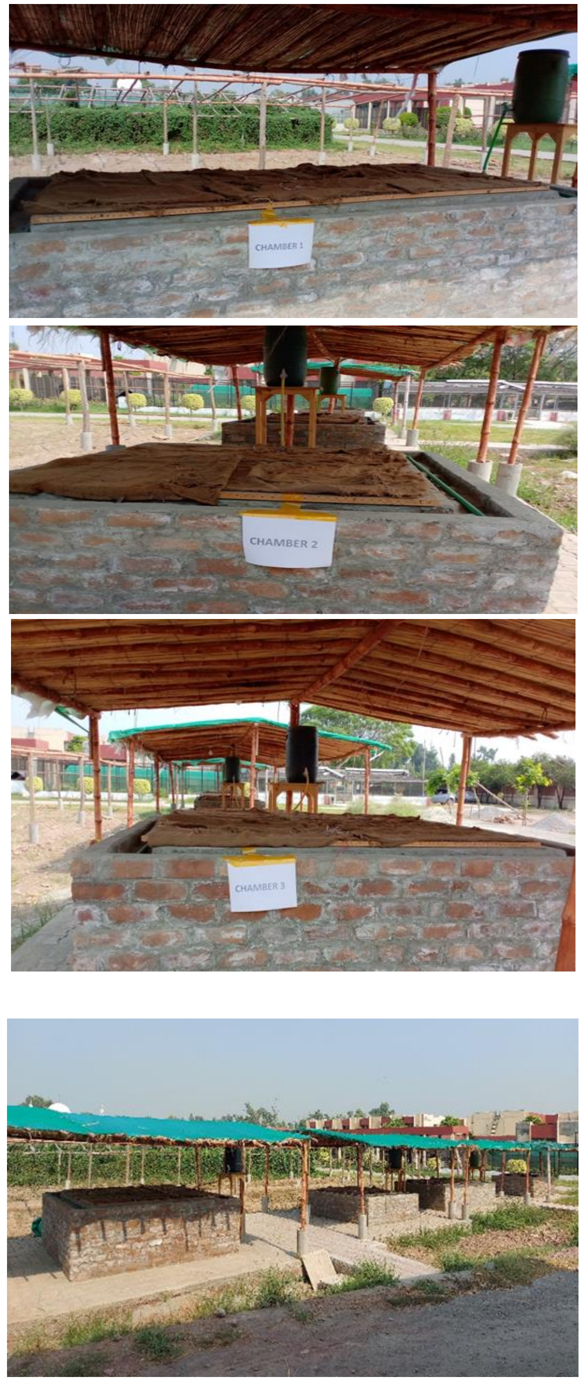
The 15 cm space between the outer and inner walls of all four chambers was filled with sand and achieved temperature by 10 to 11°C. Plastic drums were installed for each chamber for storage of water.

Spray pipes were connected to each drum for water supply from the drums to the space between outer and inner walls of the chambers filled with sand. Storage volumes of C1, C2 and C3 are 2.61 m^3, 1.62 m^3 and 4.9 m^3 respectively. The top cover (lids) made from wood, wire mesh and jute bags are used to cover chambers.

Solar radiations cause the storage temperature to increase significantly. Therefore, thatch sheds comprising of bamboo, straws, dry grass, plastic etc. were constructed in order to prevent solar radiations effect on storage temperature. Dimensions of thatch sheds for C1, C2 and C3 are 525 cm (L) × 370 cm (W) × 205 cm (H), 418 cm (L) × 414 cm (W) × 205 cm (H) and 467 cm (L) × 459 cm (W) × 205 cm (H) respectively.

Humidity and temperature data were recorded after every 2 hours. Data revealed an average decrease (difference) of 10.4, 9.8, 9.0 and 10.1°C in temperature in C1, C2, C3 and model chambers respectively as compared to atmospheric temperature. Similarly, an average increase (difference) of 58.6% in C1, 59.0% in C2, 56.8 in C3 and 56.7% in model chamber was observed in relative humidity as compared to atmospheric relative humidity.

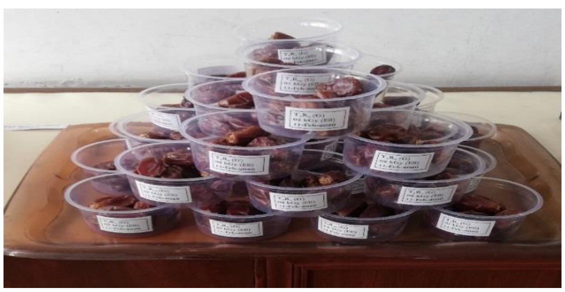
ZECC can maintain low temperature and high relative humidity as compared to the external atmospheric temperature and relative humidity. Reduction in the chamber temperature was mainly caused by the evaporative cooling of the porous chamber walls. Evaporative cooling system not only lowers the air temperature surrounding the produce, but also increases the relative humidity of the air. Due to this experimental design of cooling chambers, an overall decrease of 10-11°C in temperature and 50-60% increase in relative humidity were observed. Retention of high humidity proved very important in restricting the weight loss of horticultural produce. The higher relative humidity retains the water content of post harvested sample. Thatch shed also played a vital role in this process as it prevents the chambers and stored commodity from direct sunlight. Storage of fruit fly infested bitter gourd resulted in intensive spoilage due to conducive temperature and humidity conditions inside the chamber. Therefore, it was concluded that only fresh produce free from disease and insect infestation should be stored in ZECC.



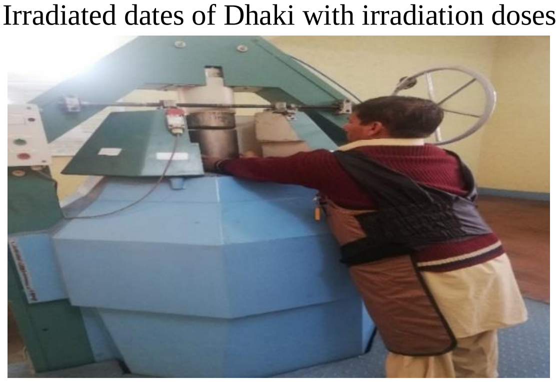
Zero Energy Cooling Chambers (ZECC) constructed at NIFA

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

The effect of Electron Beam (EB) and gamma irradiation was studied on disinfestation of dates and sprout inhabitation in bulb food. Both Dhaki and Gulistan dates were irradiated with irradiation doses of 0.3, 0.5, 1 and 1.5 kGy. The radiation doses of 1.5 kGy and 0.3 kGy were optimized for disinfestation of Dhaki and Gulistan dates respectively. Sprout inhibition in ginger was studied, 40 and 60 Gy irradiation doses were found more appropriate to maintain the samples with healthy physiochemical properties up to storage period of one month at ambient temperature.



Irradiated dates of Dhaki with irradiation doses



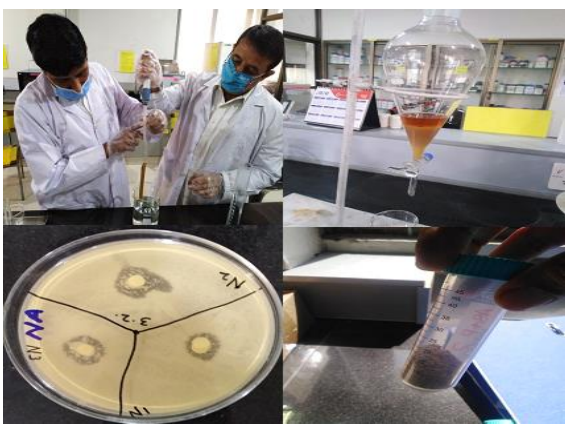
Gamma irradiation of Dhaki dates at NIFA of 0.3, 0.5, 1 and 1.5 kGy

Production of indigenous Food bio-preservatives from Dairy micro flora

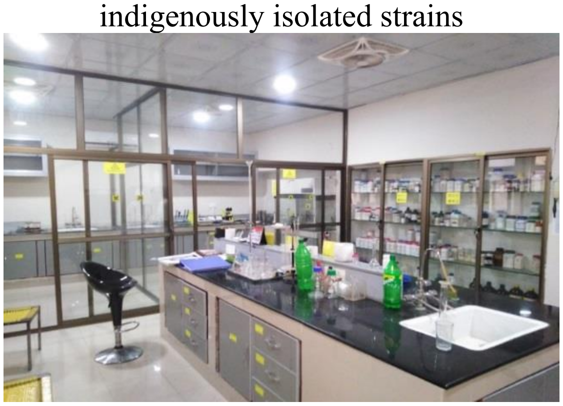
Under the ALP funded project (AS-221), Food and Environmental Safety Group of FND has been working on the production of indigenous bio-preservatives collectively known as bacteriocin. These bio-peptides were isolated from lactic acid bacterial strains predominately from *Enterococcus* species. These strains were registered in NCBI data bases with the nomenclature and Accession Nos. as *Enterococcus faecium*-NIFA-N1 (AS.No:MN560018.1),

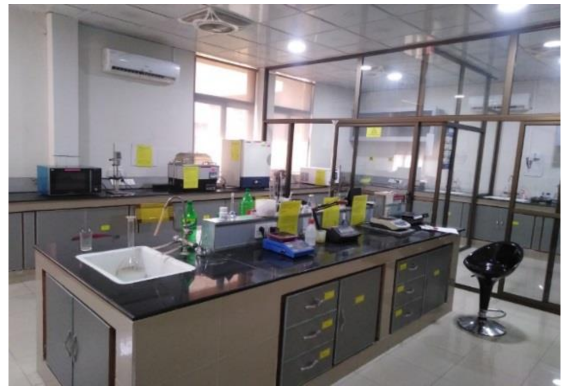
Enterococcus faecium- NIFA-N2 (AS.No:MT043863.1) and *Enterococcus lactic*-NIFA-N3 (AS.No:MF369859.1). These peptides were effective against common food pathogens including *Staphylococcus aureus, Listeria monocytogenes, Klebsiella pneumonia), E. coli, Salmonella and E. coli* ATTC. For the production, purification and application of bacteriocin as bio preservative, cell free supernatant was obtained and checked for antibacterial activities. Bacteriocin was precipitated by using 60% ammonium sulfate at 4^{o}C. The precipitate was purified by using 1000Da cutoff Dialysis Membranes and was freeze dried and re-assessed for antibacterial and protein concentration. Bacteriocin was characterized for tolerance against, acid, bile, salts, surfactant and enzymes. It is expected that these bio-peptides will serve as effective bio preservative in dairy food products.

Under Special Grant of Chairman PAEC, two state of the arts laboratories for Food Testing Services have been upgraded. Efforts are underway regarding Certification of these laboratories for ISO-17025:2017 from PNAC. In this regard Food Microbiology lab has satisfactorily clear Proficiency tests for selected tests. It is expected that by the end of year 2021 NIFA will have its first ISO-17025:2017 certified Lab.



Production of bio preservatives using indigenously isolated strains





Food Testing Labs

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

Mushroom cultivation technology as cottage industry is being popularized through training workshops at Academia (SBBW University Peshawar, University of Malakand) and Agriculture Extension Department at KP (Abbottabad) and upper Punjab (Gujjar Khan & Jhelum). Mushroom spawn (Button, Oyster and Milky) was produced at NIFA and sold-out on subsidized rates to the growers. R&D work on Ganoderma (*Ganoderma lucidum*) or reishi medicinal mushroom is being initiated for the first time and resulted in the successful cultivation at pilot scale. Previously developed NIFA-Bio pesticide (NIFA Horticultural Oil) was tested against scale insect on peaches, plum and apricot at Matta (Swat), Urmar Bala (Peshawar) and Dagbesud (Nowshera) respectively. NIFA Horticultural Oil (NIFA-HO) is organic in nature (paraffinic oil), equipped with pre added emulsification property. Fruit production of the treated orchards were high with less scale infestation (20-30%) as compared to untreated orchards in the area. NIFA-Hand sanitizer was formulated according to WHO guidelines and was distributed among NIFA employees for use.

R&D work was carried out on efficacy testing of plant extracts/botanicals (*Melia azedarach* and *Azadirachta indica*) on the management of yellow rust disease in wheat. These botanicals showed encouraging results i.e. yellow rust (*Puccinia striiformis*) urediospore % germination inhibition in laboratory (> 90%) and spray efficacy in natural field conditions (> 90%) regarding disease management.

Mushroom cultivation and popularization workshop

Bio-pesticide application

Study and optimization of drying behavior of banana through IR and forced air drying oven

Bananas from local market were purchased. Peeled Bananas were sliced to 4 mm thickness. Slices were divided into four portions each weighing 300 g. One portion of slices was kept as Control (Un-treated), the second one was treated with Sodium Benzoate (1% Sodium Benzoate solution), third waith with Potassium Meta bisulphate (200 ppm SO_2) while the remaining portion was treated with acetic acid (5% acetic acid solution Banana slices were dipped in preservative solutions separately for 15 minutes as preservation treatment. After 15 minutes solutions were drained and slices were placed on filter/blotting paper for removal of excess water. Slices were placed in trays over filter sheets and placed in forced air dryer.

Storage stability study of dried banana slices with different preservative treatments showed less browning in slices treated with 5% acetic acid solution. This treatment also showed promising results overall on the basis of acceptability like appearance, texture and taste.

A total of 5494 bottles of squashes and jams were produced. However a decrease of approximately 36% was observed in food products production due to covid-19 pandemic.

Organoleptic evaluation of dried Banana

Income Generation Activities of FND

S. No.	Name of Item	Amount (Million Rs.)
1	Rapid Test Kits (RTKs)	32.82
2	Gemstone Irradiation	0.73
3	Food Products	0.570
4	Analytical Services	0.09
5	Mushroom/mushroom spawn	0.047
	Total	**47.20**

SOIL & ENVIRONMENTAL SCIENCES DIVISION

Biofortification of zinc in wheat for balanced human nutrition

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. Now agriculture is undergoing a shift from producing more quantity of food crops to producing nutrient-rich food crops in sufficient quantities. This will help in fighting "hidden hunger" or "micronutrient malnutrition" especially in poor and developing countries, where diets are dominated by micronutrient-poor staple food crops.

A: 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°C until ready for transplanting. Three days after germination, 2 seedlings of each cultivar were transplanted into white thermo pore sheet placed in stainless steel container of 50L capacity filled with 40L 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. Zinc efficiency of these genotypes varied between 35 to 76%, the genotypes CTES-1804 being the most efficient one and C-1803 being the least. The genotype CTES-1849 accumulated Zn concentration of 17.4 µg/g at pM Zn2+ activity that was significantly higher than rest of the genotypes.

B: Evaluation of Zn efficiency under field conditions

The solution culture technique used in this study to grow the plants provides the similar conditions (Zn activity) as in zinc deficient soil for evaluation of Zn efficiency, however there are many other factors which are suppressed or affect the plant growth. On the basis of above hypothesis an experiment was executed under field conditions with 6 genotypes, (2 Zn-efficient, 1 medium, 2 Zn-inefficient and a reference genotype) and two levels of Zn (0, 5 kg ha^{-1}) to assess any change in their Zn efficiency. The experiment was laid out according to Split Plot Design with wheat genotypes in the main plot and Zn treatments in subplots. Prior to initiation of experiment, soil samples were collected from different fields and analyzed for available Zn so as to select Zn deficient site. The available Zn in experimental site was 0.26 µg g^{-1}. The soil also contained 0.76% O.M, 6.9 µg g^{-1} Olsen P having pH 7.3 and ECe 2.7 dSm^{-1}. The basal dose of P (90 kg ha^{-1}) and K (60 kg ha^{-1}) was applied to the entire experimental site at the time of sowing whereas N (120 kg ha^{-1}) was split into two portions. One half was applied at the time of sowing and the remaining portion was applied with first irrigation.

The variable response of each genotype for Zn was observed with the increasing level of applied Zn however, grain yield of all genotypes increased with Zn application. The wheat genotype *cv*. CT-161130 produced the highest grain yield of 4560 kg ha^{-1} with application of 5 kg Zn ha^{-1} which was significantly higher than rest of the genotypes. Under Zn stress conditions *cv*. Zincol depicted higher grain yield of 3600 kg ha^{-1} which was significantly higher than rest of the genotypes. It was also observed that *cv*. CTHN-162076 accumulated the maximum Zn from soil (21.7 ug g^{-1}) under Zn deficit conditions. The data depicted that Zn-efficient genotypes were less responsive to Zn application, however all the genotypes maintained the efficiency ranking assigned to them in hydroponic studies.

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

The purpose of tunnel farming is to grow vegetables inside the polythene tunnels so that proper atmosphere may be given to plants for their maximum growth and yield when these are impossible to be grown in open fields due to low temperature and high frost levels. The tunnel technology had paved the way for bringing revolutionary changes in agriculture sector not only enabling the growers to produce off-season vegetables but also for improving their economic condition. However, plant growth and produce of tunnel farming is correlated with environmental factors (light, relative humidity, temperature, carbon dioxide) and water/ nutrients management. Fluctuations in any of the environmental factors whether in low level or in excess results in reduction in plant vigor and poor quality produce. In addition, the major constraints in off-season vegetables production are pests and diseases and these limit the farmers in obtaining quality crop yield and in ensuring food security. Fertilizers, water and fungicides are the most costly inputs in tunnel farming system. The farmers in Khyber Pakhtunkhwa have small land holdings and normally grow traditional crops through traditional methods of irrigation. The food production from traditional farming has always been very low. Under this situation tunnel farming is the best option to get maximum production from such scarce sources. The adoption of tunnel farming with high efficiency irrigation system and by using high quality certified seed can fulfill the food demands of increasing population. Drip irrigation is a type of irrigation where water is supplied mixed with proper dose of plant nutrients under low pressure directly or near the plants root zone. The main advantage of drip irrigation is the efficient use of water and thus saving 50-80% water.

In high tunnel farming vegetables like tomatoes and cucumbers are grown in plastic tunnel and their production usually starts 6-8 weeks earlier than normal growing season. Khyber Pakhtunkhwa, 53% of the cultivated area is rain-fed and it needs proper attention. The farmers normally grow traditional crops using conventional methods of irrigation even though having water scarcity. Thus they have very low income from traditional farming. High tunnel farming including efficient irrigation system for growing off-season vegetables are particularly suitable for the farmers of rain-fed areas having scarce water and nutrients sources. The integrated nutrients and water management may be the environment friendly option to improve yield, fertilizer use efficiency and quality of produce.

Studies were conducted on off-season vegetables (tomato, bitter gourd and bell pepper) in three high tunnels with and without fitted micro-drip irrigation system.

Fertilizer nutrients such as nitrogen (N), phosphorus (P), potassium (K) and micronutrients (Zn & B) were applied in different concentrations at different intervals with irrigation as fertigation through drip irrigation and through placement in the crops. The nursery for tomato (F1: Sahel), bitter gourd (F1 Hybrid PALEE) and bell pepper (F1 Hybrid Orobelle) were raised during October. The nursery was transplanted to furrow and drip irrigated tunnels. After establishment of crop (30 days after transplanting), the fertilizer treatments were imposed on all crops. The data on the fruit yield of tomato, bitter gourd and bell peppers were recorded.

The results indicated that the timing of fertilizer application proved very crucial for growing tomato in high tunnels. The highest marketable yield (2.67 t/10 Marla tunnel), maximum N, P&K uptake (9.9, 2.1 and 12.7 kg/ 10 marla tunnel, respectively), SPAD Value (57.6) and improved shelf-life (10 days) in furrow irrigated tunnel were recorded in the treatment receiving recommended NPK level (75-75-90 kg ha^{-1}) as soil application at 30 day interval starting after establishment of crop till mid of June. Application of NPK at 30-day intervals was the most economical (value-cost ratio > 8.5 PKR) among all application intervals.

Likely another experiment was conducted on the nutritional requirements of bitter gourd in drip irrigated tunnel. Result revealed that the maximum bitter gourd yield (1.34 t/10 Marla tunnel), maximum mineral content of bitter fruit nitrogen (0.11 g $100g^{-1}$), protein (0.82 g $100g^{-1}$), phosphorus (38 mg $100g^{-1}$), potassium (324 mg $100g^{-1}$) and calcium (8 mg $100g^{-1}$) were obtained with 10-10-15 kg NPK ha^{-1} as fertigation at 7 days interval. Maximum total N, P&K uptake (4.8, 1.1 and 5.2 kg/ 10 Marla tunnel, respectively) was noted at 7 days interval.

In another study, bell pepper was grown in walk-in tunnel and different levels of N, P and K significantly affected the plant height, number of branches per plant, number of fruits per plant and fruit yield of pepper. The tallest plants (63.5 cm), the maximum branches per plant (16.8 branches/plant), & the highest number of fruits per plant (54.6) & fruit yield (0.56 t/10 Marla), maximum mineral content nitrogen (0.15g $100g^{-1}$), protein (0.89 $g100g^{-1}$), P (22 mg $100g^{-1}$), potassium (180mg $100g^{-1}$) & calcium (12mg $100g^{-1}$) were recorded in treatment receiving Urea, TSP & Potash @450 g each per marla at 15-day interval starting after establishment of crop till mid of May.

It was concluded that off-season tomatoes, bitter gourd and bell pepper grown in high tunnel gave ten to fifteen times higher income compared to conventional ones.

Effect of various level of NPK on yield of advance wheat lines evolved at NIFA

Plant growth and development depends on nutrients derived from the soil or air, or supplemented through fertilizer. There are eighteen essential elements for plant nutrition, each with their own functions in the plant, levels of requirement, and characteristics. Nutrient requirements generally increase with the growth of plants, and deficiencies or excesses of nutrients can damage plants by slowing or inhibiting growth and reducing yield. Two advance wheat lines of NIFA (CTHN 162076 and CT 161130**)** were treated with 14 levels of NPK fertilizer (0-0-0, 70-60-0, 70-60-30, 70-60-60,70-90-0,70-90-30, 70-90-60, 140-60-0, 140-60-30, 140-60-60, 140-90-0, 140-90-30, 140-90-60 and 120-90-60 NPK kg ha^{-1}). Split plot design was used where wheat lines were kept in main plots and fertilizer treatments in sub plots. The net plot size was 2.5 m × 2 m. Experiment was executed on 6^{th} November 2019 and harvested on physiological maturity in May 2020. The soil analysis showed that experimental field was silty loam in texture with pH of 7.9, organic matter 0.84%, 0.043% N and 7 ppm available phosphorus. Phosphorus and potash fertilizers were applied at the time of sowing along with 1/3 dose of nitrogen. The remaining nitrogen was applied in two equal splits with first irrigation and at booting stage. Result showed that there is no significant difference for different agronomic parameters among both wheat line and that yield increased with increasing level of nitrogen up to 140 kg ha^{-1}. The data showed that maximum grain yield (5 tons ha^{-1}) of wheat line CT 161130 was found with NPK applied at the rate of 140-90-60 kg ha^{-1}. In wheat line CTHN 162076 maximum grain yield of (4.6 tons ha^{-1}) was found in the treatment where NPK were applied at the rate of 140-60-30 kg ha^{-1}. Among these lines CT 161130 produce maximum grain yield than CTHN 162076. Value cost ratio of wheat line CT 161130 was found maximum than wheat line CTHN 162076. It is concluded from the study that wheat line CT 161130 performs better at 140-90-60 kg ha^{-1} NPK levels when applied at proper time and in splits.

Enhancing Plum orchard sustainability and fruit quality through fertigation

Application of solid or liquid mineral fertilizers in solution form through irrigation systems is called fertigation. It is precise method of slow application of water and fertilizer. Fertigation is one of the quickest ways to replenish the existing nutrient deficiency, particularly for macronutrients i.e. nitrogen, phosphorus and potassium, resulting in higher yields with improved quality of the crop produce. A field experiment at NIFA experimental farm is in progress. Plum bearing orchards of uniform size and age were selected. There are total eight treatments with three replications in RCB design and two trees per treatment. Treatments are as follows: T1 Control, T2: NPK (360 g N + 250 g P + 360 g K tree^{-1}) as broadcast, T3: NPK (360 g N +250 g P + 360 g K tree^{-1}) as fertigation, T4: NPK (270 g N + 187 g P + 270 g K tree^{-1}) as fertigation, T5: NPK (180 g N + 125 g P + 180 g K tree^{-1}) as fertigation, T6: NPK (360 g N + 250 g P + 360 g K tree^{-1}) as fertigation + foliar N (0.5%) + humic acid (0.05%), T7: NPK (270 g N + 187 g P + 270 g K tree^{-1}) as fertigation + foliar N (0.5%) + humic acid (0.05%) and T8: NPK (180 g N + 125 g P + 180 g K tree^{-1}) as fertigation + foliar N (0.5%) + humic acid (0.05%). All fertilizer was applied to the periphery of tree canopy. Leaves samples from the orchard were collected in mid of August for NPK analysis. Treatments in which nutrients were applied as fertigation significantly ($P \leq 0.05$) improved plum fruit yield and NPK contents in leaves than broadcasted fertilizer treatment. Leaves analysis showed that maximum NPK contents (2.31% N and 0.24% P) were recorded in the treatments of T7 and T6 where NPK were applied as fertigation. Maximum plum fruit yield of 109 kg tree^{-1} was obtained in the treatment T5 where NPK @ 180 g N + 125 g P + 180 g K tree^{-1} were applied as fertigation. Increase in yield was 41% over treatment where NPK were broadcasted @ 360 g N + 250 g P + 360 g K tree^{-1}.

Innovation in crop production technology to minimize/ mitigate the effect of climate change

Wheat (*Triticum aestivum* L.) is a main source of food for a majority of population in the world. In Pakistan it ranks first among the cereal crops. Realizing the importance of wheat crop, efforts for improving productivity are always under consideration throughout the country. Wheat yield can be increased by the adaptation of appropriate production technologies. An experiment was conducted for 2nd year at NIFA experimental farm. Two advance lines M-4, M-5 and a variety Aman (SRN-0911) developed at NIFA were tested for three different sowing dates, i.e. 2nd week of October (Oct. 16th, 1st sowing), 2nd week of November (Nov.16th, 2nd sowing) and 1st week of December (Dec. 6th, 3rd sowing) at the interval of 20-30 days (early, on time and late). Three fertilizers treatments@ T1: (80-40-20), T2: (120-80-40) and T3: (160-120-60) (N- P- K) kg ha^{-1} were applied to crop in three different dates of sowing placed in subplots. Three replicates of the experiment were made in each date of sowing. Phosphorus and K were applied as a basal dose at the time of sowing while urea was applied in two splits, half at the time of sowing and the second half with first irrigation. Plant height was recorded at early maturity stage before harvesting. The crop was harvested in the 1^{st} and 2^{nd} week of May at physical maturity and after drying, the biological yield, grain yield, spike length, and 100 grain weight were recorded. The average biological yield (19078, 12913 and 11020 kg ha^{-1}) and grain (6518, 5375 and 4757 kg ha^{-1}) on 1st, 2nd and 3rd sowings dates respectively shows that biological as well as grain yield decreases with delaying in sowing from early October to late December in all the three varieties/lines (Aman, M-4 & M-5). The maximum grain yield of 6518 kg ha^{-1} were obtained when crop were sown in October. Delaying in sowing of wheat crop from October to December reduces biological yield 42% and 27% grain yield of the wheat crop. Fertilizer has positive effect on yield and grain yield increased with the increase in fertilizer. All the varieties/lines have the potential to produce higher yield at early sowing however, cv. Aman produced 3622 kg ha^{-1} even at low NPK level under late sowing. It can perform better if sowing is delayed due to weather constraints or moisture stress.

Fertilizer requirement for newly developed candidate lines of oilseed brassica

Edible oil is one of the important commodities of everyday use. Pakistan produces 30% of edible oil and about 70% is imported at the cost of huge foreign exchange. Increasing domestic oil seed production can reduce this huge oil import bill. Brassica oilseeds have the potential to reduce the edible oil import bill if, brassica oilseed crops are properly managed. Big gaps exist between potential yield 3500 kg/ha and national average yield 922 kg ha^{-1}. There are many factors responsible for its low yield, one of them is the improper/imbalance use of plant nutrients/ fertilizer. Keeping in view an experiment was conducted to identify suitable NPK levels for new varieties/lines of oilseeds brassica developed at NIFA. Three advance candidate lines V1 (011K-16-3), V2 (RR-41-4) and V3 (RR-8-1) of *Brassica napus* were tested for high yield and optimum level of NPK fertilizer. The experiment was laid out in split-plot design with three replications, keeping varieties in main plot and NPK levels in sub plot. The fertilizer (NPK) treatments/levels included Control T_0: (0-0-0), T_1: (30 -20 -20), T_2: (60 -40 -40) and T_3: (90 -60 -60). 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 April and after drying in the field biological yield and grain yield were recorded. Fertilizer application enhanced yield of brassica over control. The maximum grain yield of 2177 kg ha^{-1} was recorded for RR-41-4 followed by 2158 kg ha^{-1} for RR-8-1 and 2022 kg ha^{-1} for 011K-16-3 where NPK were applied @ 90:60:60 kg ha^{-1}.

Monitoring the long term impact of conversion to organic farming systems.

Over the last few decades, there had been tremendous increase in wheat yield due to introduction of fertilizer responsive varieties. This boost in yield has been achieved at the expense of deterioration in soil health, loss of biodiversity and negative impact on environment. We have reached at a stage where wheat yields have become stagnant and farmers are losing interest in farming on account of marginal returns. The climate change is further exhilarating the situation as it poses serious threats to sustain production from soils. Sustainable soil fertility management has become a challenge under current conventional farming practices. Sustainable wheat production in the country requires to maintain soil fertility without compromising yields and ecosystem services. Situation demands to find suitable alternatives to deal with the twin menace of climate change and continually diminishing soil fertility. Organic farming systems offer one alternative to conventional farming systems (chemical fertilizer intensive farming).

A long term field experiment was established at the experimental farm of the institute during Rabi 2018-2019. Two distinct blocks of land (500 m^2 each) were planted under organic and conventional production systems. The experiment was laid out in randomized complete block design with three replicates. Prior to start of long term study, soil samples were collected for analysis of soil physico-chemical properties. This preliminary soil related data will serve as baseline information for comparative assessment of long term effect of conventional and organic farming treatments on soil fertility related parameters. Data on grain yield, water use efficiency, SPAD-chlorophyll content and protein content were recorded from wheat. Results revealed significant differences (*P≤0.05*) for grain yield and chlorophyll content between conventional and organic production systems. Grain yield of 5.05 t ha^{-1} and 4.9 t ha^{-1} was obtained under conventional and organic farming, respectively. Non-significant differences were recorded for water use efficiency and protein content between two different systems of production in the first year of study.

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.

During 2019-20, 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, compost @ 30 t/ha, half NPK (125-75-75 kg ha^{-1}) + compost tea (CT) @ 1:5, compost tea @ 1:5 alone, NPK @ 250-150-150 kg ha^{-1} + compost tea (CT) @ 1:5 and half NPK (125-75-75 kg ha^{-1}) + compost @ 15 t/ha + compost tea @ 1:5. The results revealed that maximum tubers yield (10.3 t ha^{-1}), chlorophyll content (51.9 %), plant height (51.8 cm) and grading (25 % A,30% B,44 % C) were recorded in treatment receiving half NPK (125-75-75 kg ha^{-1}) + compost @ 15 t/ha + compost tea @ 1:5. This yield was 20.6% more than that of NPK fertilizer treatment (250-150-150 kg ha^{-1}), and it was followed by treatment receiving, compost @ 15 t/ha which is 9.9 t/ha and 11.0

% increase over control. 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 3 replicates. The treatments were control, compost @ 30 t ha^{-1}, 100-100-40 NPK kg $ha^{-1,}$ compost @ 30 t ha^{-1} + 50-50-20 NPK kg ha^{-1}, Compost @ 15 t ha^{-1} + 50-50-20 NPK kg ha^{-1}, 100-100-40 NPK kg ha^{-1} + compost @ 30 t ha^{-1} + CT (1:5) @ 4000 l ha^{-1}, 50-50-20 NPK kg ha^{-1} + compost @ 15 t ha^{-1} + CT (1:5) @ 4000 l ha^{-1}, and CT (1:5) @ 4000 l ha^{-1}. Seventy days after sowing, data on fresh weight/pot and chlorophyll content were recorded. Relatively higher chlorophyll content and plant yield were attained under combined application of fertilizers and compost tea.

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

Higher costs of chemical fertilizers, environmental pollution risks associated with fertilizer applications, 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 main objective of the current study was to identify appropriate combination of bacteria and chemical fertilizers for increasing yield of mungbean.

A: Isolation and identification of N-fixing and P-solubilizing bacteria

N-fixing bacteria

Healthy unbroken pink nodules were obtained from the roots of mungbean plants grown in NIFA Experimental Farm. These nodules were washed under running water to remove adhesive soil particles and then were surface sterilized by dipping them for 4-5 minutes in $HgCl_2$ (0.1%). After that the nodules were washed with distilled water, 70% ethyl alcohol and again with distilled water to remove any traces of sterilizing agent stuck to them. 10-fold serial dilution of nodular extract was prepared by adding 1 g of nodular extract into 9 ml of sterile distilled water to get nodular extract suspension of 10^{-1} dilution. 1 ml of this suspension was again diluted with 9 ml of sterile distilled water making the dilution to 10^{-2}, similarly making the dilutions up to 10^{-8}.

Yeast Extract Mannitol Agar (YEMA) plates were prepared and sterilized in autoclave. 0.1 ml of nodular extract suspension from each of 10^{-3} to 10^{-8} dilutions was inoculated into these YEMA plates. The sample was spread throughout the YEMA plates and inoculated petri plates were incubated at 37°C for 7 days. After incubation, N-fixing bacteria were observed as large mucoid elevated colonies. These bacteria were stored for use in the inoculation of mungbean seeds for field experiment.

P-solubilizing bacteria

About 1 kg soil sample was collected from the rhizosphere soil of cultivated area of NIFA. The sample was air dried, powdered and mixed well to represent a composite sample. 10-fold serial dilution of soil sample was prepared by adding 1 g of composite soil into 9 ml of sterile distilled water to get soil solution of 10^{-1} dilution. 1 ml of this solution was again diluted with 9 ml of sterile distilled water making the dilution to 10^{-2}, similarly making the dilutions up to 10^{-8}.

Pikovskaya's agar medium (PVK) plates were prepared and sterilized in autoclave. 0.1 ml from each of 10^{-3} to 10^{-8} dilutions was spread on these PVK plates and was incubated at 28±2°C for 7 days. After incubation, P-solubilizing bacteria were identified as colonies showing clear zones. These bacteria 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 2020, a field experiment was conducted to study 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 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 @ 10-20 kg ha^{-1} + 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 dry weight (13.33 g) and 100-grain weight (5.2 g) as compared to all other treatments. The experiment will be repeated next year to develop reliable recommendations for end-users in Khyber Pakhtunkhwa.

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. Farmers always look for higher wheat yield and apply excessive inputs (particularly fertilizer and water) to get higher net returns. The intensive use of costly chemical fertilizers has introduced the problem of environmental pollution. Water scarcity issue is also becoming a limiting factor for sustaining irrigated agriculture. The current era focussing on sustainable use of natural resources compels us to improve productivity while ensuring their minimal wastage. Moreover, farmers in our system do not have scientific information on pros and cons of a given rotation and make decision on choice of crops without taking into consideration negative impacts of a given rotation on long term sustainability of the system. Therefore, it is critical to study water and nutrient dynamics under dominant wheat based rotations to provide technical evidence based guideline to farmers for making rational decisions on choice of crops over a year. Nutrient dynamics studies assume greater importance under legume based rotations as legumes are known to improve soil conditions and fertility for succeeding crop. The current study will not only be helpful in providing guidelines for sustainable use of scarce natural resources but also for the improvement of long term farm productivity of wheat based cropping system particularly in Khyber Pakhtunkhwa.

To identify wheat based cropping system that can make efficient use of fertilizer and available water, a wheat field experiment was executed at NIFA Research Farm in randomized complete block design with three replicates. During Rabi (2019-20), three wheat blocks were laid out one each for comparison with fallow, maize and mungbean with a permanent layout. After stand establishment, probes were installed up to 1 m depth for recording data on soil moisture. The experiment received usual agronomic management for the crop during the season. The biological yield of wheat in wheat-maize-wheat, wheat-fallow-wheat and wheat-mungbean-wheat blocks was recorded 11.47, 11.05 and 14.03 t ha^{-1}, respectively.

Similarly, the grain yield of wheat in these blocks was recorded 3.95, 3.35 and 4.93 t ha^{-1}, respectively. 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. Biological yield and 100-grain weight of mungbean were recorded 3.63 t ha^{-1} and 4.9 g, respectively. Similarly, plant height and biological yield of maize were recorded 205.33 cm and 31.08 t ha^{-1}, respectively. Data on soil moisture were recorded in both the seasons at fortnightly intervals using neutron scattering moisture probes. The experiment, with the same cropping scheme, will be repeated next year on the same experimental area to identify the most profitable rotation for the farmers in terms of water and nutrients dynamics and ultimately net profit.

PLANT PROTECTION DIVISION

A. AGRICULTURE ENTOMOLOGY

Bio-control using Trichogramma

The Hymenopterous wasp, *Trichogramma chilonis* (Ishii) is a wide spread polyphagous egg parasitoid having ability to breed in any environment and rapidly reproduce inside host eggs of numerous insect pests belonging to Lepidoptera, Coleoptera and Neuroptera. Angoumois grain moth, *Sitotroga cerealella* (Oliv.) is used as fictitious host for laboratory rearing of *T. chilonis.* An essential aspect of the mass production is to extend shelf-life of the host eggs and parasitoid to ensure their continuous rearing and supply during field releases.

Effect of Irradiation and low temperature on pupae of *T. chilonis* (Ishii).

Irradiation effects on *T. chilonis* pupae, adult emergence and adult longevity were studied using four radiation doses and an untreated control. Maximum adult emergence (95%) and adult longevity (8.3 days) were recorded in untreated control which was followed by 5 Gy (emergence: 83%, longevity: 7.33 days), 10 Gy (emergence: 67.3, longevity: 6.2), 15 Gy (emergence: 52.3, longevity: 5.2) and 20 Gy (emergence: 31.3, longevity: 4.2). Low temperature of 2^{o}C and three storage durations were investigated. Higher adult emergence (84.7%) was recorded after storage for 3 days which was followed by 5 days (63.0%) and 7 days (23.3%) emergence. Adult longevity of *T. chilonis* was significantly higher (7.3 days) after 3 days storage at 2^{o}C which was followed by 6.2 days for 5 days while minimum adult longevity was 5.3 days after 7 days storage.

Infestation of *Helicoverpa armigera* (Hub.) following release of *T. chilonis* in vegetables

Fruit worm, *H. armigera* (Hub.) is a cosmopolitan insect pest with a vast host range (150 hosts) including tomato and okra. Tomato variety Lariqa was raised in randomized complete block design with three replications and two factor arrangement. Four treatments were kept in which 500, 1000, 1500 *T. chilonis* pupae were released at appropriate time in a plot size of 48 m^2 while the fourth treatment was kept as untreated control. Lowest mean infestation was recorded in plots where 1500 pupae of *T. chilonis* were released. Eight observations record show that *H. armigera* infestation was statistically similar for six assessments. Highest tomato yield (32.9 kg/plot) was also recorded from plots where 1500 pupae of *T. chilonis* were released.

Okara variety Barat Kaveri was also raised in the same experimental arrangements and treatments as mentioned above under tomato experiment. Minimum mean infestation of *H. armigera* (Hub.) was recorded in plots where 1500 pupae of *T. chilonis* were released (i.e. 0.35 larvae/plant) followed by 1000 pupae (0.63 larvae/plant), 500 pupae (0.78 larvae/plant) while maximum infestation was recorded in untreated control (1.13 larvae/plant). Maximum mean yield of okra (24.25 Kg/plot) was recorded for 1500 *T. chilonis* pupae treated plot which was followed by 20.50 Kg /plot for 1000 *T. chilonis* pupae treatment and 17.88 kgs/plot for 500 *T. chilonis* pupae treatment while minimum okra yield was recorded in un-treated plot (13.29 Kg).

Monitoring *H. armigera* (Hub.) population using pheromones baited traps in vegetables

Monitoring of male *H. armigera* moth population was monitored using pheromones baited traps in tomato and okra. Maximum peak of male moths were recorded in April (20.50 moths/trap) followed by March (6.75), September (4.50), July (3.88), May (2.50), November (2.00), June (1.75), October (1.25), August (0.50) and no male moths was captured in the months of December, January and February in tomato and okra crops.

ii. Termites

Termites are notorious subterranean insect pest of agricultural crops and buildings in Pakistan and around the world and are causing billions of dollars losses. Due to cryptic in nature, it is very difficult to manage these pests. Huge amount of conventional insecticides are being used against termites, which are quite costly and environmentally hazardous. Therefore, search to develop cheaper and more effective alternate environment friendly termite control methods are being worked out.

Spices potential for management of subterranean termites.

Integrated management of termite through eco-friendly methods can be used as alternative to synthetic insecticides. Three different items of spices were explored including *Cinnamomum verum* (Cinnamon), *Piper nigrum* (Black pepper) and *Syzygium aromaticum* (Clove). Hot water based extracts of Cinnamon, Black pepper and Clove were tested for their insecticidal efficacy against common subterranean termite *Heterotermes indicola* and found that clove was the most effective against tested termite with high toxicity (Up to 100% in 24 h) and deterrent even at low concentrations (<5%). Cinnamon and Black pepper on the other hand were comparatively not that much toxic to termites but showed deterrent potential against termites. Research activities in the same line are under progress to search and select more plant origin material with insecticidal properties for screening to develop organic eco-friendly product for termite's management.

Termite control potential of entomopathogenic nematodes (EPN)

The subterranean termite specie *H. indicola* was exposed to foraging arena treated with entomopathogenic nematode (EPN), *Stenernema. carpocapsae* (Sc) in choice test. Three plastic cups (9 mm diameter) as different foraging arenas were connected in a row with plastic tubes. Two hundred termite workers including ten soldiers were released into central cup having no food while EPN were applied in one side cup (treated) and simple water to the other side cup (control). Both side cups were provided with a piece of blotting paper as food. The apparatus was designed to provide equal chance to the termites for moving in either side cup. Two concentration of EPN i.e. 2000 and 4000 were applied. Results showed that termites did not avoid the EPN treated cup, and, their population gradually decreased over the time as in control cups indicating inability of termites to initially detect EPN treated areas. Thus EPN can further be exploited for sustainable control of termite colony through trophallaxes behavior of termites.

Food preference of subterranean termite for developing bait matrix

Four cellulose materials i.e. blotting paper, maize cob, popular wood and sugarcane slices were evaluated for termites feeding preference in choice test in single and separate arenas. All cellulose materials were oven dried and equal weight of these cellulose materials was placed in both the arenas. Two hundred termite workers and ten soldiers were released to record the food preference. Findings revealed that *H. indicola* showed maximum aggregation of termite workers toward sugarcane dry slices (69%) followed by maize cob (53%), poplar wood (35%) and blotting paper (28%) after 15 days. Similar trend was found regarding weight consumption in which maximum consumption of sugarcane (72 mg) was found followed by maize cob (48 mg), blotting paper (35 mg) and popular wood (33 mg) after 15 days. Sugarcane oven dried slices found to be most attractive cellulosic food which can be used as bait matrix in future.

iii. 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 problem, farmers are using insecticides which are ineffective, enhance environmental pollution, increase pest resistance to chemicals and cost of production. Therefore, our control methods should be directed towards an effective and ecofriendly management of fruit fly.

Establishment of peach fruit fly culture on artificial larval diet

Three egg collecting devices Pepsi bottle (250 ml), black bottle (500 ml) and plastic container (6 x 14 x 10 cm^3) were evaluated for oviposition during November, 2019. Results indicated that maximum number of eggs were oviposited in Pepsi bottle (92) followed by black bottle (87) and the least number of eggs were recorded in plastic container (23). However, using extracts of peach, mango and guava as oviposition stimulants,, no significant differences in attraction were observed.

Monitoring of adult fruit fly population and development of degree day based prediction

The investigations were undertaken (January-December, 2019) in guava orchard at NIFA farm. Seven lure baited traps were randomly installed in the orchard for trapping and data recording of adult fruit flies. The overall insect activity was correlated with the temperature and cumulative degree days (CDD) were estimated. Results indicated that *Bactrocera zonata* started emergence on 14-March with CDD (131.8) and (0.1 flies/trap). The population peak was observed on 01-August with CDD (2171.7) and (33.9 flies/trap). Thereafter, population declined and lasted on 05-December with CDD (3730.6) and (0.3 flies/trap).

Ovipositional preference of peach fruit fly on different fruits

Ovipositional preference of fruit flies indicated that banana was the most preferred host with mean pupal recovery of (99 pupa/fruit) followed by persimmon (41 pupa/fruit) in a free choice experiment. However, tomato was the least preferred host (2 pupa/fruit). Maximum number of adult flies were emerged from banana (61/fruit), followed by persimmon (34/fruit) and apple (7/fruit), while tomato was the least (1 fly/fruit). Banana and persimmon fruits were heavily infested by *B. zonata* and therefore can be used for laboratory rearing of *B. zonata.*

iv. Aphids

Aphids represents a scary threat for cereals and oilseed brassica worldwide, since they de-sap the plant by inserting their proboscis into the leaves, stems and spikes that results in distortion, chlorosis and curling of leaves and ultimately stunted growth of the plant. Moreover, aphids act as a vector of various plant viral and fungal diseases. These have become a notorious pest of wheat and oil-yielding brassica in Pakistan and are responsible for economic losses.

Aphid population and resistance of Pakistani wheat

Aphid, *Schizaphis graminum* population was studied during February-March, 2020 on 129 wheat genotypes which were raised at NIFA farm. High variability in *S. graminum* population was recorded on the studied genotypes. Highest mean population of *S. graminum* was recorded on 2nd of March (48) while lowest was recorded on 16th of March (16). Number of wheat genotypes were grouped with aphids/tiller with range in parenthesis, 38 (11.2-23.2 aphids/tiller), 40 (23.2-35.2), 24 (35.2-47.2), 16 (47.2-59.2), 6 (59.2-71.2) and 2 each (71.2-83.2 and 83.2-95.2) and one genotype with 113 aphids/tiller. Maximum mean aphid population of *S. graminum* was recorded on NIA Sarang (113 aphids/tiller) while minimum was recorded on Imdad-01 (11.2 aphids/tiller). Diversity in field resistance levels of the studied 129 genotypes was observed. Aphid resistance categories were assigned with genotypes numbers in parenthesis which include moderately resistant (27), lowly resistant (44), lowly susceptible (17), moderately susceptible (25) and highly susceptible (16).

Aphid population and abiotic factors relationship in Pakistani wheat

Population of *S. graminum* recorded on 43 wheat genotypes were correlated with temperature (°C) and % relative humidity. Aphid population on different wheat genotypes showed significant and negative correlation with maximum relative humidity. Moreover, Bahawalpur 2000, Kirin 95, Lasani 08 and Mehran 89 also showed significant and negative correlation with minimum relative humidity. Similarly, maximum and minimum temperature showed significant and positive correlation with aphid population build-up on NARC 2009 while Auqab 2000 and NIA Sunder showed significant and negative correlation with minimum temperature.

Screening of oil-yielding brassica against aphid, *Brevicoryne brassicae*

Twelve advanced rapeseed lines raised at NIFA farm were evaluated for resistance against *B. brassicae.* Data of *B. brassicae* were recorded on both inflorescence and leaves of each rapeseed genotype. Maximum infestation ranged between 5-7 aphids/ inflorescence on three genotypes (i.e. RR-41-4, RM-2-2 and RR-1-4) while minimum value reached up to 0.4 aphids/inflorescence on three genotypes (RM-1-2, RM-1-5 and RM-3-5). Maximum infestation ranged between 5-6 aphid/leaf was found on two genotypes (RM-1-9 and RM-2-2) while minimum was one aphid/leaf on RR-8-1 and 011-K respectively.

B. PLANT PATHOLOGY

Agriculture is changing fast and with it the landscape through which disease spreads. This imposes new demands on our understanding of epidemiology if we are to control disease efficiently. This requires an understanding of what controls the variability of pathogens and epidemics between one location and another and from one season to another, and how this impinges upon local, national and sometimes international crop loss. Such epidemic prone wheat diseases which are important historically to Pakistan economy included yellow rust, leaf rust, stem rust and powdery mildew which are caused by airborne obligate fungi. Research on these airborne and other vector borne and seed borne diseases and collaborative efforts are under way with national wheat improvement program in developing diseases resistant germplasm and varieties.

Status and seasonal progress of airborne and vector borne diseases

Set of 260 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. Yellow rust was intially observed with less than 1% severity in February and over time disease reached its peak severity of 55% during April. Seasonal apparent infection rate for yellow rust was 0.24. Leaf rust and powdery mildew were not recorded during the season at NIFA farm. Aphid borne barley yellow dwarf disease of wheat was wide spread during the season at NIFA farm and its patchy incidence were observed with high severity upto 100%.

Temporal variability, fixation and consequences of *Puccinia striiformis* f. sp. *tritici* virulence's

Information of cryptic wheat pathogen *Puccinia striiformis f. sp. tritici* virulence's, availability of resistance sources and cultivation value of resistance genes/sources are the prerequisite for rust management and fostering host resistance development and deployment. Temporal variability in *P. striiformis* f. sp. *tritici* races were recorded during the season at NIFA. Four different races were recorded with one each during late-February (0E0), early-March (55E13), mid-March (63E174) and late-March (63E223). Two more study periods including early-April and mid-April reveled no change in races and the race pattern remained same as recorded during late-March. Up to 13 virulence's were associated with these four *P. striiformis* f. sp. *tritici* races. Virulence's of *P. striiformis* f. sp. *tritici* including *v1, v6, v7, v8, v9, v25, v27, v32* appears to be fixed in the local pathogen population and the corresponding yellow rust resistance genes were considered ineffective. Two epidemiological parameters were investigated in thirteen high temperature adult plant resistance (HTAP-R) genes in susceptible avocet background. Relative infection rate and relative area under disease progress curve values were considerably low for *Yr35*, PI660084, PI660110 and AVR-*YrA* (*Yr73*, *Yr74*) in comparison with susceptible control and could be useful in the current rising temperature scenario.

Slow rusting wheat

To manage allo and auto infection cycles in 70% of the wheat acreage of low altitude districts of KP, reduction of initial inoculum of *P. striiformis* f. sp. *tritici* from source area i.e. mid and high altitude regions is essentially required. To achieve this goal, 222 registered/approved wheat cultivars and elite CIMMYT genotypes were tested and analysed using area under disease progress curve (AUDPC) for slow rusting resistance trait. Values for AUDPC were normally distributed and ranged from 0 to 1880. Fifty percent of the AUDPC values fall between 800-1300 while 25% of the values were below 800 and were considered as better slow rusting genotypes. Genotypes having AUDPC below 800 could be deployed in the source area for rust management.

Yellow rust resistance in national elite and candidate varieties

Under this national collaborative program, NIFA is fostering the development of disease resistant wheat germplasm & varieties and have received 583 elite genotypes set in National Wheat Disease Screening Nursery (NWDSN) and a set of 66 candidate varieties for testing during the period under report. Yellow rust severity varied from 0-100% in NWDSN and 10-100% in candidate wheat varieties. Disease distribution was not normal and was skewed towards lower disease severity in both sets of studied germplasm.

Wheat seed health analyses

One hundred and forty one wheat varieties were tested for black point disease in lab. One thousand seed of each variety were manually analyzed for black point incidence using magnifying lens with built in light source.

Black point distribution was not normal among the tested varieties and incidence skewed towards lower values. Eight five varieties have up to 3% black point incidence while in the remaining 56 varieties, black point incidence reached up to 14%. Varieties having black point incidence below 3%.

Oilseed brassica disease screening

Under coordination with oilseed improvement program at NIFA, 100 genotypes were screened against two diseases of economic importance including white rust and alternaria blight. Response to white rust of 3, 13, 76 and 5 genotypes was immune, highly resistant, resistant and moderately resistant, respectively. Similarly, response to alternaria blight of 1, 78 and 18 genotypes was immune, highly resistant and resistant, respectively.

C. MEDICAL ENTOMOLOGY

Insect vector borne human diseases are increasing and dengue fever is one of them which has become endemic in Pakistan. There is no effective vaccine available 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 development of an environment friendly vector control, such as Sterile Insect Technique (SIT) has become indispensable for integration with other available conventional control methods. Research efforts are directed in carrying out environment friendly collaborative activities for vector control.

Hunt for naturally existing tsl mutation in Aedes species for construction of more robust Genetic Sex Strain (GSS) for SIT.

A new research contract funded by IAEA is started in which hunt for naturally existing tsl mutation in *Aedes aegypti* and *Ae. albopictus* for construction of more robust Genetic Sex Strain (GSS) for SIT" will be carried out. Research work on installation of ovi-traps for collection of eggs of both dengue vector species from different climatic and topographic zones of Pakistan is under way. Area-wise colonies will be developed to look for naturally existing temperature sensitive lethal mutation for construction of genetic sexing strain for SIT purpose of dengue vector.

Development of larval diet for Anopheles, Culex and Aedes species

Three diets (NIFA larval diet, IAEA diet and NIFA modified larval diet) were tested for growth and development of three mosquitoes, one each belonging to Anopheles, Culex and Aedes. Each diet was replicated five times and 640 µl of each diet was supplied daily. Larval developmental from 1st instar to pupa and to adult and their survival was recorded. Results indicated shortest larval duration, maximum survival rate from 1st instar to pupa for NIFA modified diet followed by NIFA diet. Significant reduction in development time of Anopheles was recorded from modified diet at 2 & 3 % concentration followed by NIFA diet @ 3 % concentration. Larger size females of *Anopheles, Culex* and *Ae. aegypti* were recorded from NIFA modified diet @ 3% concentration. IAEA diet @ 3% concentration resulted in larger size females.

Naturally occurring predators efficacy against mosquitoes

Predatory insects such as water bug, diving beetles, wild fish and water scorpions were collected from various mosquito breeding sites. They were maintained in the aquariums at medical entomology laboratory and supplied fish food till their use. Predatory potential of each predator was investigated in separate experiment. Single naid of water bug consumed 79 to 85 larvae and 53-75 pupae per day. Water beetles consumed 39-65 larvae and 33-59 pupae per day and dragon fly consumed 19 to 35 larvae and 21-29 pupae daily. Predatory potential of each predator increased with the increase in the number of mosquito juvenile stages in the breeding habitats.

Tilapia fish predatory efficacy against mosquito's

Tilapia fish species were obtained from National Fisheries Research Center Karachi and were kept in the artificially maintained aquariums. Prior to initiation of experiments, they were divided into different groups according to their body size (length) and held in separate beakers without food for 24 hours. Predatory potential from 500-1000 larvae, at different water temperatures (30, 25 and 20^{o}C) and timing of day (afternoon and evening) was investigated. The numbers of mosquito larvae consumed was counted after every hour. Tilapia consumed from 83 and 72 % larvae. Temperature of 30^{o}C was found as most suitable with high predation activities followed by 25^{o}C with no significant effect by the timing intervals.

Effect of pesticides on predators' larvae

The effect of pesticides on juvenile stages of predators in mosquito breeding sites was evaluated from commonly used pesticides. Juvenile stages were exposed to various doses of pesticides. It was found that 5 ppm of Pyriproxyfen, 4 ppm of emamectin, 1 ppm of lambda and acetamiprid resulted in over 50% mortality of water bugs.

Exploiting Pyriproxyfen as safe insecticides

Insect growth regulators (IGRs) are usually used in low concentrations for growth inhibition of insects at immature stage. In laboratory studies higher doses of Pyriproxyfen resulted in mortality to mosquito aquatic stages. Similarly in field studies, application of Pyriproxyfen @ 1.5 ppm/m^3 was found as safe and effective larvicide under emergency outbreak conditions.

Laboratory cage experiment on attraction potential of gravid female to various baited traps

Utilizing scrap bottles as indigenous ovi-traps and plant infusion plus other materials (fish meal, yeast, urea) for attraction of mosquitoes eagling was tested. In free choice lab. trials, trend for maximum ovi-position was found in 5% fish meal followed by 2% yeast and 3% urea as compared to control treatment.

SOCIO-ECONOMIC IMPACT

PLANT BREEDING AND GENETICS DIVISION

A total of 11250 kg quality seed of wheat varieties NIFA Awaz, NIFA Insaf, NIFA Lalma and NIFA Aman was produced and certified with the assistance of FSC & RD officials. The seed will be distributed to agriculture extension, seed companies and farming communities of Khyber Pakhtunkhwa. The wheat group has contributed Rs.1.80625 million to NIFA for the sale of wheat seed and its by-products (mix grain and wheat straw). The oilseed group contributed Rs. 177,500/- to NIFA exchequer through sale of quality seed/grain and oilseed analytical services. One hundred and forty (140) kg of pre-basic / basic seed of NIFA Mungbean varieties 'Ramzan and NIFA Mung-2019' was sold to KP agriculture extension department and KP Agric. Research systems through PSDP Pulses Project for further multiplication in kharif 2020. Improved varieties of peach (Early Grand and Florida King) were produced and distributed among the progressive orchard growers. The disease free and true to type nursery has earned Rs. 310000/- as income generation during 2019-20.

FOOD AND NUTRITION DIVISION

Development and dissemination of technologies for 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. 3.30 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. 0.730 million from gemstone irradiation services. Limited scale production of food products within the institute yielded around Rs. 0.570 million during year 2018-2019. FND is providing analytical services 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.

SOIL AND ENVIRONMENTAL SCIENCES DIVISION

The scientific team of Soil and Environmental Sciences Division is developing cost-effective and eco-friendly production technologies of field and horticultural corps, which are readily adopted by the farming community of the province. Farmers are making better use of available farm labour and inputs under the farm friendly practices being identified through applied research activities of the division with the consequences of enhancement in socio-economic conditions. It has resulted in improving yield and productivity of their farms and ultimately uplifting of their life standard. 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 10 to 15 times more net returns than conventional vegetable production.

PLANT PROTECTION DIVISION

Technologies and products developed at PPD along with specialized professional services are regularly transferred/extended to academia, researchers, agriculture extension, community leaders, farmers and other stakeholders through interactive visits, farmer days, trainings, workshops, awareness seminars and print materials. Dengue Guard, a mosquito repellent product for protection against mosquitoes and other biting insects, is supplied to various PAEC establishments. NIFA Fly Guard, Fruit Fly Traps, NIFA Termap, Trico-chard and Rat Nil are also being provided to end users against their demand. The sale of these products on approved rates has generated income for the institute besides its positive effect on environment and economic returns to farmers in terms of low cost and environment friendly properties. Crop diseases have a serious and wide impact as they can spread readily within season and also from season to season. Costs arise directly from yield losses, chemical control and maintenance of disease resistance preemptive control program to mitigate the risk of new pathotypes and virulences. Major damaging wheat diseases prevalent in the Khyber Pakhtunkhwa include yellow rust, leaf rust, powdery mildew, barley yellow dwarf and blights which are suspected to have caused >1% yield losses in different production zones. Under the national wheat improvement subprogram on rust resistance, it contributes annually $12.3 million to the total economic value ($123 million) of the control provided by resistance to rusts in Pakistan.

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2. Ahmad, S. and Y. Guo. 2019. Signal Transduction in Leaf Senescence: Progress and Perspective. Plants, 8(10): 405. doi:10.3390/plants8100405
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4. Ali R., S. J. A. Shah and S. Ullah. 2019. Role of onion weed in tomato root knot nematode management. LAP LAMBERT Academic Publishing, Germany. 61pp.
5. Khan G. Z., I. Khan, Alamzeb, T. Badshah and M. Salman. 2019. Exploiting the larvicidal potential of Indigenous plant extracts against *Aedes aegypti*. Oral Presentation in 39th Pakistan Congress of Zoology (International), Department of Zoology, Islamia College University, Peshawar (March 04-06, 2019).
6. Gul, S., R. Uddin, N. U. Khan, S. U. Khan, S. Ali, N. Ali, M. S. Khan, M. Ibrahim, R. Goher, M. Saeed and D. Hussain. 2019. Heterotic response and combining ability analysis in F1 diallel populations of *Brassica napus* L. Pak. J. Bot., 51(6): 2129-2141.
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8. Hassan B., S. Ahmed, N. Mehmood, M. E. Mankowski and M. Misbah-ul-Haq. 2019. Toxicity potential of heartwood extractives from two mulberry species against *Heterotermes indicola*. Maderas Cienc. y Tecnol, 21: 153–162. doi.org/10.4067/S0718-221X2019005000203.

9. Jabeen F., S. Wahab, M. S. Hashmi, Z. Mehmood, A. Riaz, M. Ayub and M. Muneeb. 2019. Liquid stevia extract as a substitute of sucrose in the preparation of guava drink. Fresenius Environmental Bulletin, 28: 233-243.
10. Khan I. 2019. Effect of Storage, Waxing and Gamma Irradiation on the Quality of Kinnow *Citrus reticulata* Blanco. J. Agri. Sci. Food Tech., 5(8): 170-177. https://doi.org/10.36630/jasft_19039.
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12. Khattak, G. S. S., I. Saeed, M. Abbas, G. Ullah and M. Ibrar. 2020. High yielding mungbean [*Vigna radiata* (L) Wilczek] variety "NIFA Mung-2017. Pure and Applied Biology, 9(4): 2617-2627.
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14. Li, X., C. Guo, S. Ahmad, Q. Wang, J. Yu, C. Liu, Y. Guo, 2019. Systematic Analysis of MYB Family Genes in Potato and Their Multiple Roles in Development and Stress Responses. Biomolecules, 9: 317.
15. Saeed M., T. Badshah, I. A. Khan, M. Alam and G. Z. Khan. 2019. Effect of Selected Plant Extracts on the Mortality of Red Flour Beetle *Tribolium castaneum* (Coleoptera; Tenebrionidae). Proc. 194th International Conference Dubai, UAE. 67-69.
16. Shah S. A., Haroon and M. Amin. 2019. Nutrient management of deciduous Orchards (plum) through foliar feeding. Acad. J. Agric. Res., 7(8): 192-197.
17. Shah S. J. A., R. Ali, M. Ibrahim and M. Sawood. 2019. Cultural characteristics of *Venturia inaequalis* Cooke (Wint.) isolates sampled from apple growing areas of Swat and Chitral in Pakistan. Presented & Abstracted in the Proceedings of 5th International Multidisciplinary Research Conference, October 29-31 Peshawar, Pakistan.
18. Siddique N. R., A. Muhammad, G. M. Ali, , M. R. Khan, A. Shehzad and T. Mahmood. 2020. Deformational gene expression pectin esterase and change in pectin during

development and ripening stage of fruit in selective cultivar of Banana. Food Sci. Technol, Campinas, Ahead of Print, 20201/5 Food Science and Technology. DOI: https://doi.org/10.1590/fst.20719

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FUNDED RESEARCH PROJECTS

Sr. #	Project Title	Project Duration	Total Funds	Principal Investigator	Funding Agency
1.	Wheat Productivity Enhancement Program	2011-2021	US $ 148572	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.	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
5.	Adaptation of Electron Beam and X-ray applications to treat MRE and fruits and vegetables in Pakistan	2016-2021	€ 21000	Mr. Alamgeer Khan	IAEA
6.	Commercialization of existing technology of mushroom cultivation among farming and landless communities of KP, Punjab and Baluchistan	2017-2019	Rs. 4.166 M	Dr. Ibrahim	PSF
7.	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
8.	Production of indigenous food bio-preservatives from the microflora isolated from fermented dairy products.	2018-2021	Rs. 2.87 M	Dr. Talat Mahmood	ALP-PARC
9.	Pilot scale production and popularization of compost tea as organic fertilizer nutrient source	2018-2020	Rs. 2.7 M	Mr. Zahid Ali	PSF
10.	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

11.	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 / PS
Dr. Fazle Subhan, Ph.D. Crop Science	PS
Mr. Hafiz Munir Ahmad, M.Sc. (Hons.) Plant Breeding & Genetics	PS
Dr. Muhammad Irfaq Khan, Ph.D. Biology	PS
Mr. Shahid Akbar, M.Sc. (Hons.) Horticulture	PS
Dr. Farooq-i-Azam, Ph.D. Crop Genetics & Breeding	PS
Dr. Muhammad Amin, Ph.D. Statistics	PS
Dr. Syed Tariq Shah, Ph.D. Crop Genetics & Breeding	SS
Dr. Iqbal Saeed, Ph.D. Crop Genetics & Breeding	SS
Dr. Salman Ahmad, Ph.D. Crop Genetics & Breeding	SS
Dr. Akhtar Ali, Ph.D. Crop Genetics & Breeding	SS
Mr. Khurshid Ahmad, M.Phil. Chemistry	JS
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
Dr. Maria Kanwal Ali, Ph.D. Microbiology	JS
Mr. Tauqeer Ahmad, M.Sc. (Hons.) Food Science and Technology	JS
Mr. Asim Irshad, M.Sc. (Hons.) Food Science and Technology	JS
III. SOIL & 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. Zahid Ali, M.Sc. (Hons.) Soil Science	PS
Mr. Parvez Khan, 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
Mr. Muhammad Salman M.Sc. (Hons.) Entomology	SS
Mr. Muhammad Arfan, M.Sc. (Hons.) Entomology	JS
Mr. Usman Khaliq, 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. Abdul Hadi Khattak, M.B.A. & M.A. English	Pr. Accounts Officer
Mr. Raufullah, M.L.I.Sc.	Pr. Librarian

PROMOTIONS/ TRANSFERS/ RETIREMENTS/ APPOINTMENTS

Promotions:

S. No.	Name	From	To	On
1.	Dr. M. Misbah ul Haq	Sr. Scientist	Pr. Scientist	01.12.2020
2.	Mr. Rauf Ullah	Sr. Librarian	Pr. Librarian	01.12.2020
3.	Mr. Ali Raza	Jr. Scientist	Sr. Scientist	01.12.2020
4.	Mr. Muhammad Salman	Jr. Scientist	Sr. Scientist	01.12.2020
5.	Mr. Zar Ali Khan	Pr. Scientific Assistant	Research Associate	28.05.2020
6.	Mr. Israr Khan	Pr. Tech	Foreman	28.05.2020
7.	Mr. Muhammad Ahsan Taqveem	Computer Tech	Sr. Computer Tech	28.05.2020
8.	Mr. Umme Kulsoom	Scientific Assistant-II	Scientific Assistant-I	28.05.2020
9.	Mr. Sajjad Ahmad	Driver-III	Driver-II	28.05.2020
10.	Mr. Fazal Ghafoor	Driver-III	Driver-II	28.05.2020
11.	Mr. Muhammad Arshad	Scientific Assistant-IV	Scientific Assistant-III	28.05.2020
12.	Mr. Parvez Khan	Scientific Assistant-IV	Scientific Assistant-III	28.05.2020
13.	Mr. Muhammad Tariq	Pr. Scientific Assistant	Research Associate	28.05.2020
14.	Mr. Nabiullah	Pr. Tech	Foreman	28.05.2020

Transfers / Postings;

S. No.	Name	From	To	On
1.	Mr. Dawood Khan, Sr. Scientist	NIFA, Peshawar	NIA, Tandojam	31.01.2020
2.	Mr. Altaf Hussain, Sec. Supervisors	C-2, Kundian	NIFA, Peshawar	25.03.2020
3.	Mr. Sher Zaman, Driver-I	NIAB, Faisalabad	NIFA, Peshawar	03.07.2020
4.	Mr. Muhammad Rafique, Sec. Solider	NIFA, Peshawar	REO, Peshawar	13.08.2020

5.	Mr. Muhammad Waqas, Jr. Assistant-I	PAEC HQs. Islamabad	NIFA, Peshawar	24.08.2020
6.	Mr. Muhammad Sadaqat, Sec. Soldier	DTD, Islamabad	NIFA, Peshawar	26.08.2020
7.	Mr. Fateh Khan, Sec. Soldier	NIFA, Peshawar	ICCC, Islamabad	11.09.2020
8.	Mr. Fazal e Subhan, Hav.	PCENS, Rawalpindi	NIFA, Peshawar	25.11.2020
9.	Mr. Muhammad Sajjad, Driver	NIFA, Peshawar	PINSTECH, Islamabad	30.11.2020
10.	Mr. Anwar Ali, N/Sub	KANNUP Karachi	NIFA, Peshawar	30.11.2020

Retirements:

S. No.	Name	Date
1.	Syed Ruidad Shah, Sr. Assistant (Admin)	01.04.2020
2.	Mr. Saeed Gul, Research Officer	01.05.2020
3.	Mr. Ihsan ul Haq, Security Supervisor	03.05.2020
4.	Dr. Wisal Mohammad, CS/ Director	20.06.2020
5.	Mr. Khan Muhammad, General Attdt-II	01.07.2020
6.	Mr. Altaf Hussain, Security Supervisor	08.09.2020
7.	Mr. Sajjad Ali, Pr. Scientific Assistant	12.11.2020
8.	Mr. Aslam Khan, Scientific Assistant-I	31.12.2020

Deaths;

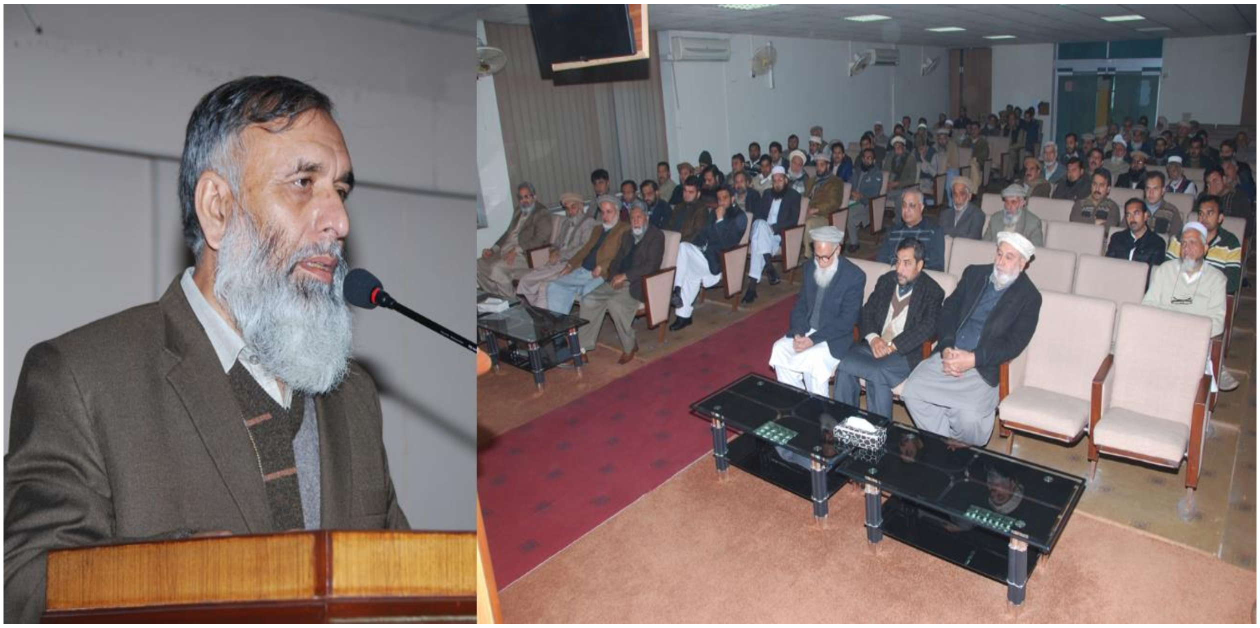
S. No.	Name	Date
1.	Mr. Zar Ali Khan, PSA	23.07.2020
2.	Mr. Parvez Khan, SA-III	13.08.2020
3.	Mr. Amin-ul-Haq, General Attendant-I	30.08.2020

Appointment:

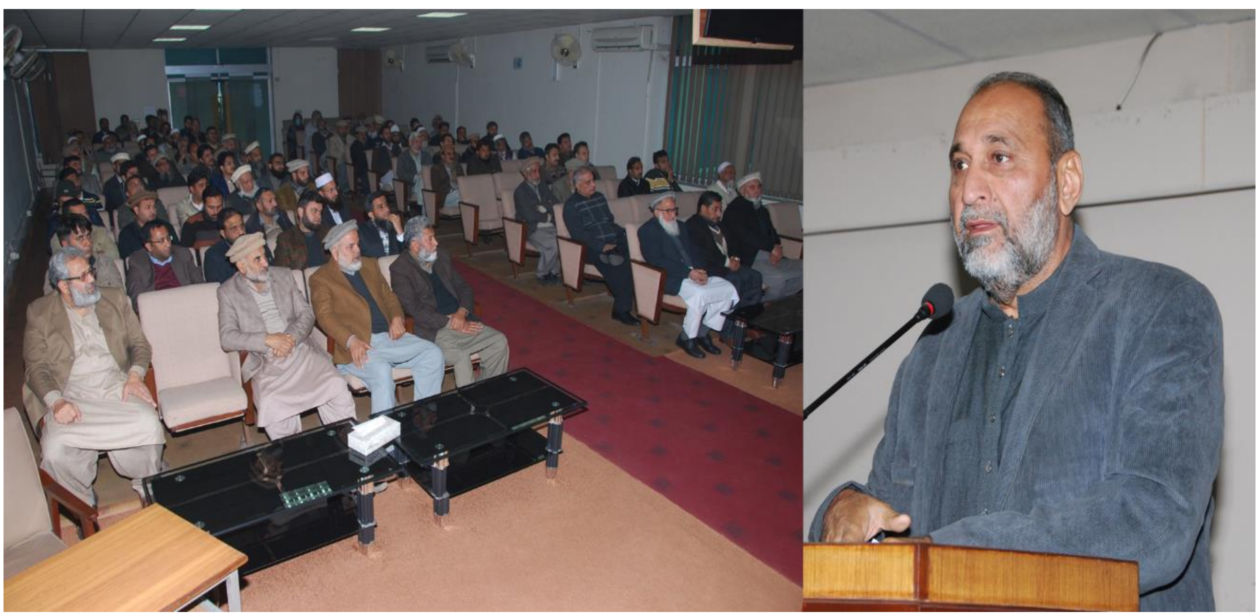
S. No.	Name	Date
1.	Mr. Ashiq Mehmood, Driver-III	20.10.2020

SCIENTIFIC EVENTS/ TECHNOLOGY TRANSFER PICTORIAL VIEW

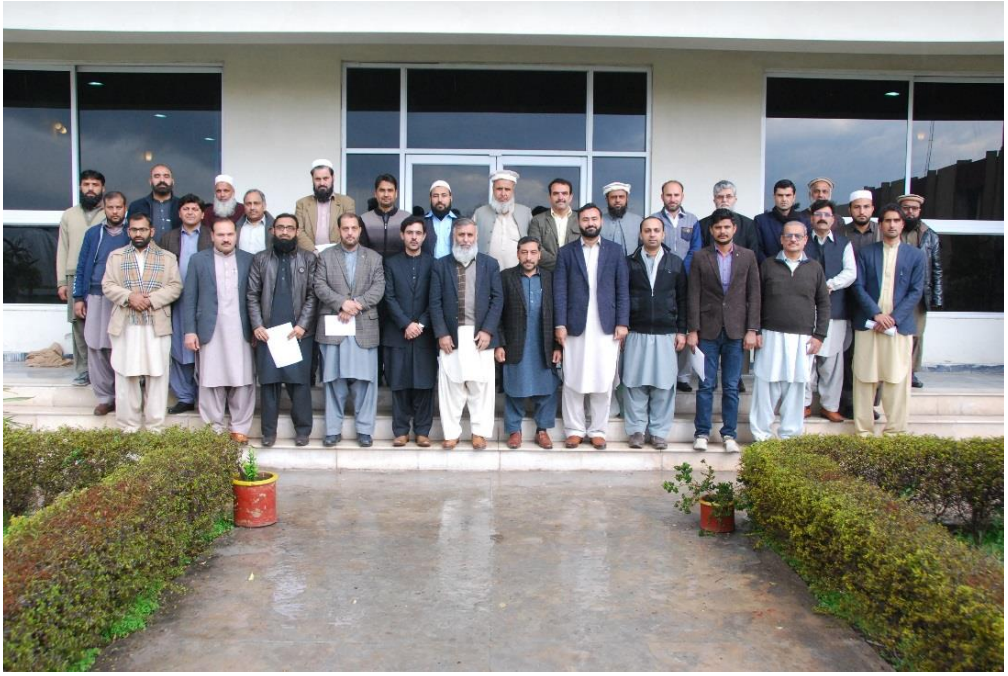
Farewell Party of Mr. Alam Zeb, DCS



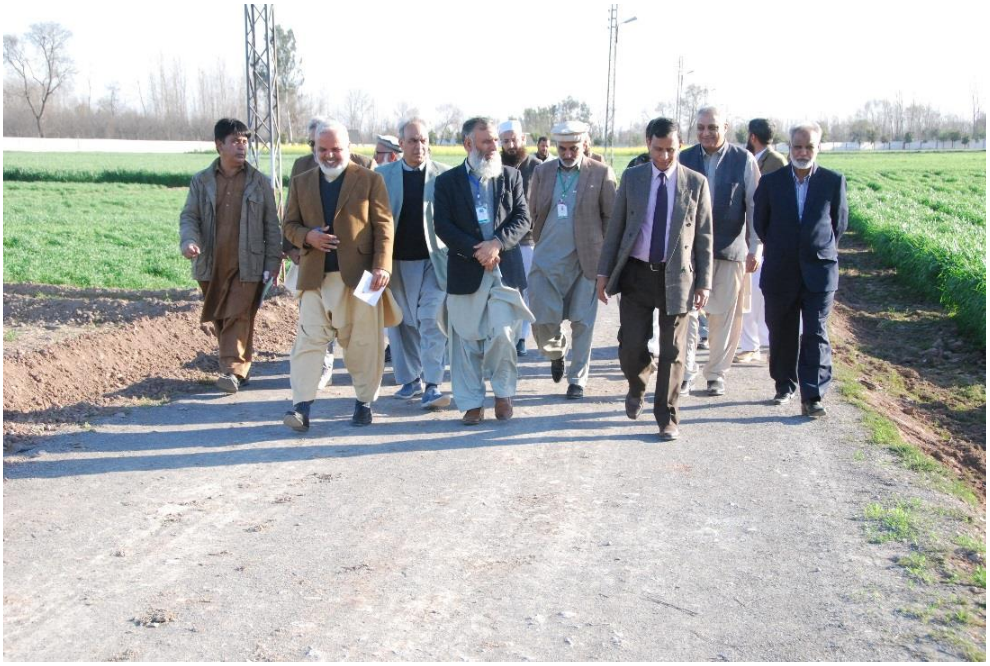
General Body Meeting



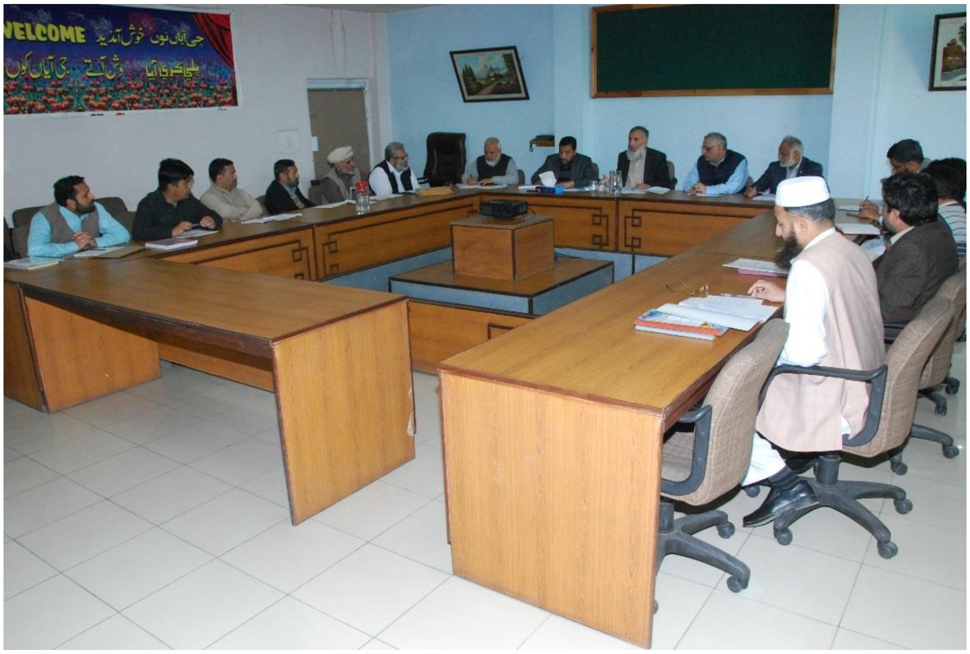
Lecture on safety by Col (R) Ahsan-ud-Din



Lab Technicians Training

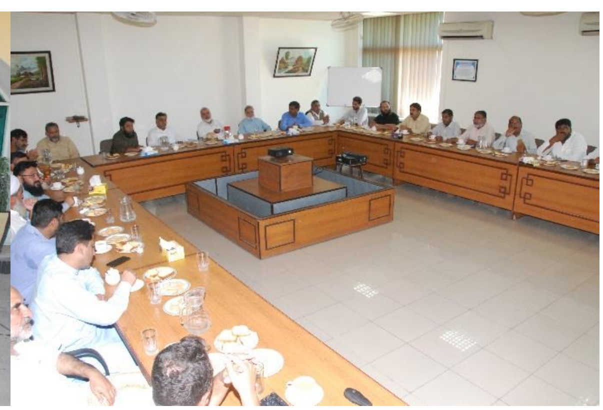


Member Science Visit

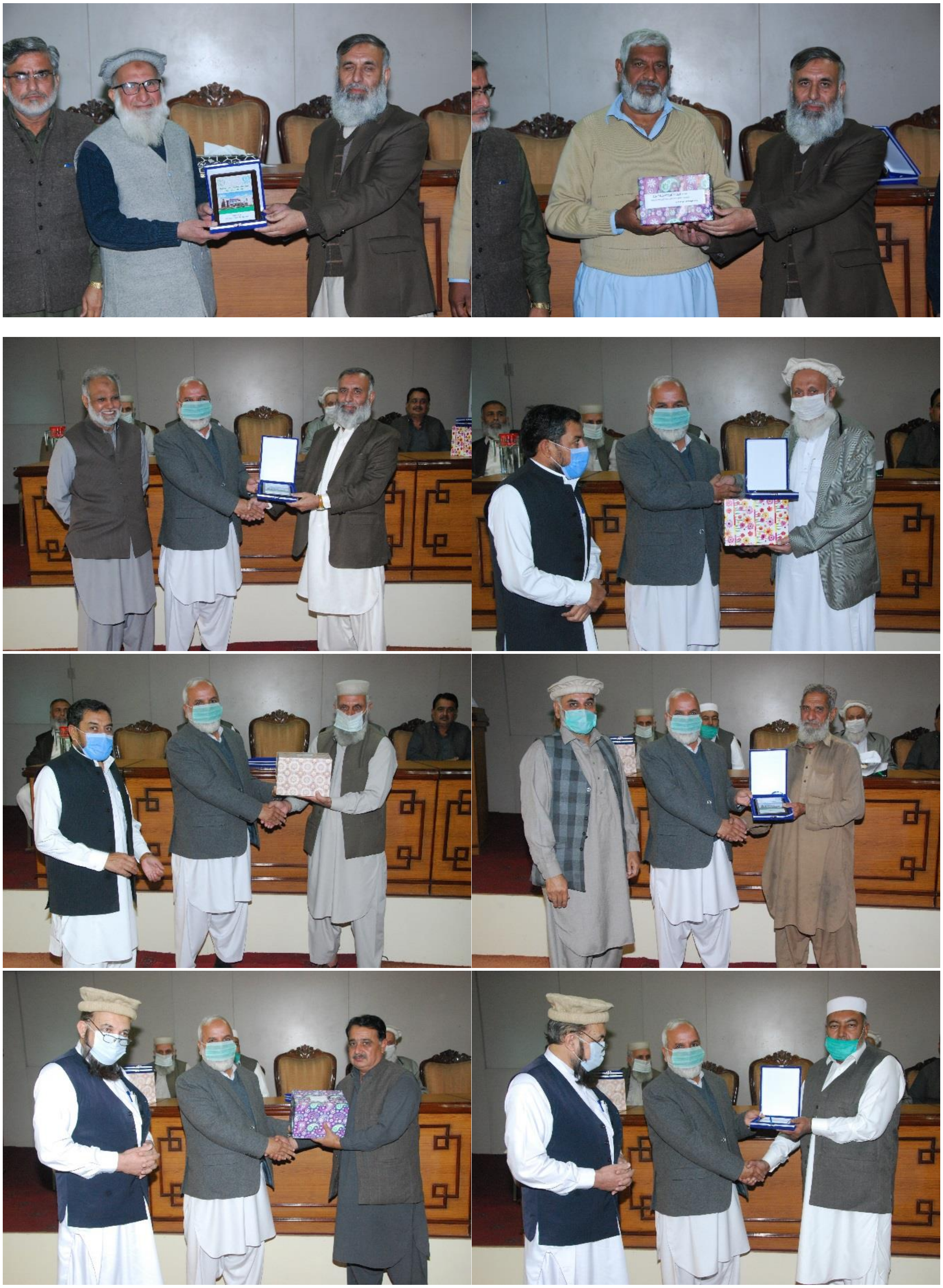


Mid Year Review 2020

Participants of the Training on QMS requirements and implementation on ISO 9001:2015

Participants of Kharif Pulses Traveling Seminar 2020



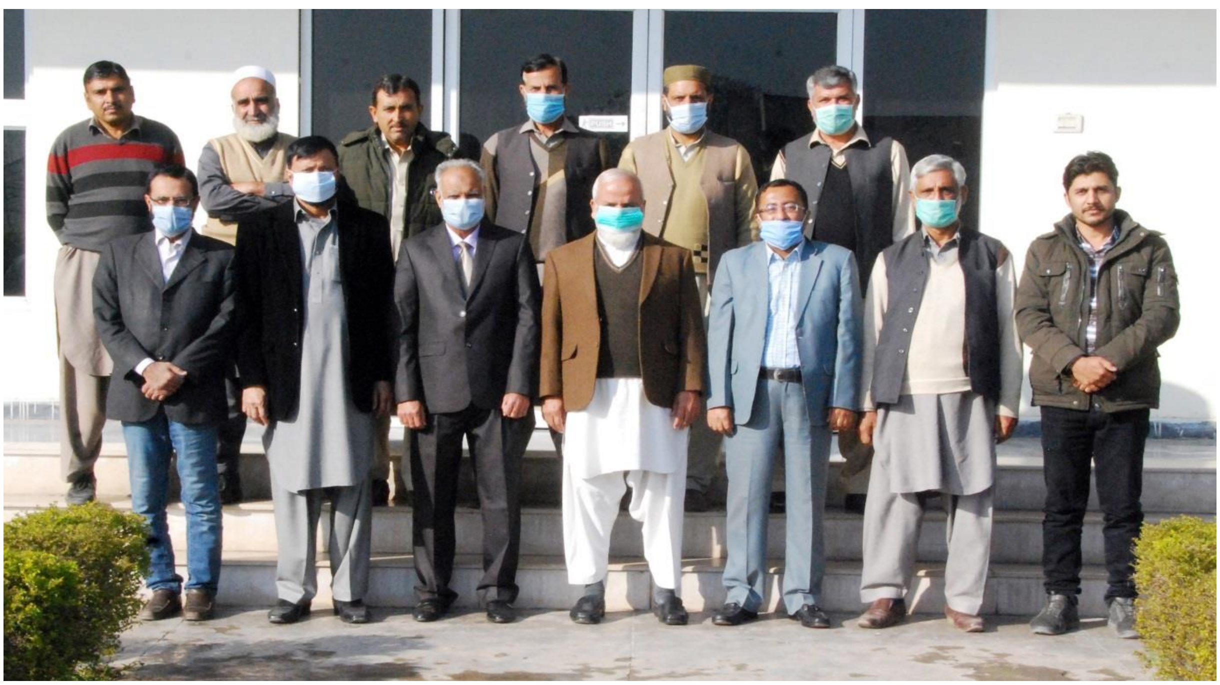
Farewell Party of officers and staff 2020

GROUP PHOTOS

Director Office

Plant Breeding and Genetics Division

Food and Nutrition Division



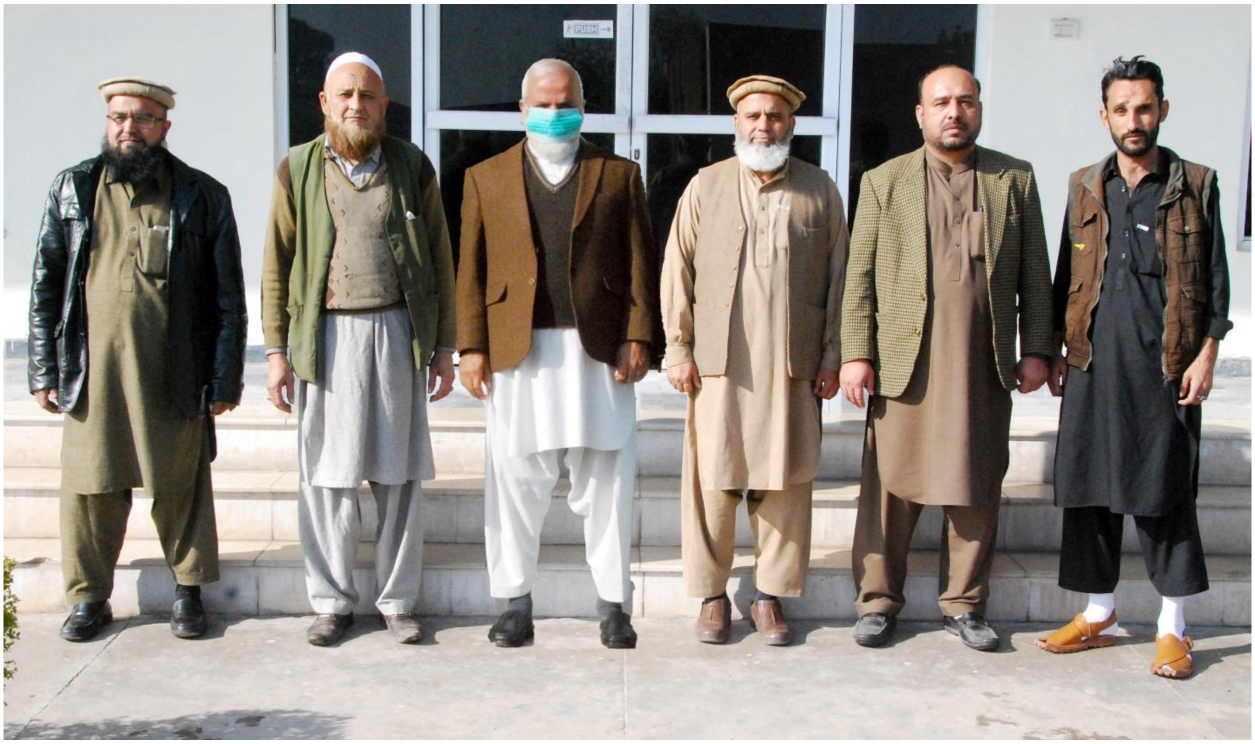
Soil and Environmental Sciences Division

Plant Protection Division

Accounts Branch

Administration

Technical Services Division



Director with Canteen Staff

Director with Farm Staff

Director with Beautification Staff

Director with Sanitary Staff

Nuclear Institute for Food and Agriculture
PESHAWAR

ISO Certified 9001-2015

Scientific Events Calendar 2021

January

January 27, 2021
One Day Seminar on "Recent Trends in Food Safety and Bacteriocin based Bio-Preservation

Organizer: Food & Nutrition Division
Venue: NIFA, Peshawar
Contact: Dr. Talat Mahmood, SS
Dr. Maria Kanwal Ali, JS
Cell: 0334-0505586
0332-4210102
E-mail: drtalat@nifa.org.pk
maria.kanwal.ali@outlook.com

February

February 09, 2021
Training on Value Addition of Fruits and Vegetables
Organizer: Food & Nutrition Division

Venue: NIFA, Peshawar
Contact: Mr. M. Zubair Shah, PE
Mr. Alamgeer Khan, SS
Cell: 0333-9201652
0346-9322294
E-mail: mzshah2001@gmail.com
alamgeer_khan86@yahoo.com

February

February 23, 2021
Training workshop on Mushroom Cultivation & Popularization as Cottage Industry

Organizer: Food & Nutrition Division
Venue: Upper Punjab, Choa S.Shah
Contact: Dr. Muhammad Ibrahim, PS
Mr. Aurang Zeb Khan, PSA
Cell: 0334-9180642
0333-5950937
E-mail: ibra786pk@yahoo.co.uk
Zebkhan_75@yahoo.com

February

February 24, 2021
Workshop on use of compost and compost tea for off-season vegetables production in tunnels
Organizer: Soil & Environmental Sciences Division
Venue: NIFA, Peshawar
Contact: Dr. Amir Raza, PS
Mr. Parvez Khan, PS
Cell: 0304-0501455
0333-9386824
E-mail: amir.boku@gmail.com
parvez_08@yahoo.com

February

February 25, 2021
Training workshop on Mushroom Cultivation & Popularization as Cottage Industry

Organizer: Food & Nutrition Division
Venue: Kotli Satian
Contact: Dr. Muhammad Ibrahim, PS
Mr. Aurang Zeb Khan, PSA
Cell: 0334-9180642
0333-5950937
E-mail: ibra786pk@yahoo.co.uk
Zebkhan_75@yahoo.com

March

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

Organizer: Plant Protection Division
Venue: Agriculture Training Institute (ATI), Jamroad Road, Peshawar
Contact: Mr. Muhammad Zahid, PS
Dr. M. Misbah-ul-Haq, SS
Mr. Muhammad Salman, JS
Cell: 0336-5352529
0300-5511402
0333-9854670
E-mail: zahidnifa200028@yahoo.com
misbah_nifa@yahoo.com
sufisaib@gmail.com

March

March 16,18, 2021
Training workshop on Mushroom Cultivation & Popularization as Cottage Industry

Organizer: Food & Nutrition Division
Venue: Quetta Baluchistan
Contact: Dr. Muhammad Ibrahim, PS
Mr. Aurang Zeb Khan, PSA
Cell: 0334-9180642
0333-5950937
E-mail: ibra786pk@yahoo.co.uk
Zebkhan_75@yahoo.com

March

March 18, 2021
NIFA Farmers Day

Organizer: Plant Breeding & Genetics Division
Venue: NIFA, Peshawar
Contact: Dr. Roshan Zamir, Head, PBGD
Dr. Farooq-e-Azam, PS
Cell: 0301-8580109
0300-9006616
E-mail: roshanzamirhort@gmail.com
fazamcaas@gmail.com

April

April 01, 2021
Seminar on Use of Electron Beam/X-rays Technology for Value Addition of Food Products and Gemstones

Organizer: Food & Nutrition Division
Venue: NIFA, Peshawar
Contact: Mr. Alamgeer Khan, SS
Mr. M. Zubair Shah, PE
Cell: 0346-9322294
0333-9201652
E-mail: alamgeer_khan86@yahoo.com
mzshah2001@gmail.com

May

May 26, 2021
Training on development of low cost zero-energy cooling chambers for field heat removal and storage of fruits and vegetables
Organizer: Food & Nutrition Division
Venue: NIFA, Peshawar
Contact: Dr. Zahid Mehmood, SS
Mr. Tauqeer Ahmad, JS
Cell: 0333-5033898
0333-9800972
E-mail: zahidnifa@gmail.com
toqeersaqi2853@gmail.com

October

October 04-15, 2021
36th Postgraduate training course on the use of Nuclear and Other Techniques in Food & Agricultural Research
Organizer: NIFA, Peshawar
Venue: NIFA, Peshawar
Contact: Dr. Gul Zamin Khan, PS
Mr. Muhammad Irfan, JS
Cell: 0331-3811979
0336-6449394
E-mail: gulzaminkhan@yahoo.com
mirfan_ramdani@yahoo.com

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Dr. Syed Azam Shah, PS
Incharge Outreach Cell
Ph: 091-2964060-62 Ext: 263
Cell: 0334-5337825,
E-mail: azamsbpn3@gmail.com

CeSP ISO 9001:2015 QMS Certified Q-67

PNAC Pakistan National Accreditation Council CB 005 QMS

NIFA PAEC Nuclear Institute for Food & Agriculture Peshawar

ISO 9001 : 2015 Certified

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