NIFA

ISO 9001 : 2008 Certified

Annual Report

2015

Nuclear Institute for Food & Agriculture, Peshawar
Pakistan Atomic Energy Commission

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ISBN: 978-969-8198-05-2

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C O N T E N T S

HIGHLIGHTS

Nuclear Institute for Food and Agriculture (NIFA) has played an active role to help ensure sufficient, nutritious and environment friendly food production in the country as food, nutrition, environment and livelihood security are the biggest challenges faced by the country. The main focus is to meet rather exceed the expectations of end-users through human resource development and the use of nuclear and other contemporary advanced research techniques. Results of the R & D efforts of four research divisions of the institute accomplished during the report period are summarized below:

Plant Breeding & Genetics

The Plant Breeding and Genetics Division deals with genetic improvement of crop varieties, in particular, wheat, oilseed brassica, chickpea, mungbean and sugarcane through already set priorities for productivity enhancement and stress management (biotic/abiotic) under the existing climatic / environmental conditions in the province.

Wheat breeders in addition to already released 07 improved varieties achieved currently another landmark for developing a new yellow rust resistant genotype NRL 0707 by accumulating genes of diverse parents Tatara & Inqilab-91 through hybridization and further advancement through shuttle breeding at Kaghan. The Khyber Pakhtunkhwa Provincial Seed Council (KPSC) formally approved this newly developed high yielding yellow rust resistant wheat variety "INSAF-2015" in its 35th meeting held on September 08, 2015 under the chairmanship of Mr. Ikramullah Khan Gandapur, KP Minister for Agriculture. The variety meets all the quality standards with high protein bold grains and possesses ample potential to express under moisture stress. In addition, 02 candidate wheat lines (SRN-09111 and NRL 1123) proved worth for higher yield / and disease resistance during mandatory testing in the national trials. The line SRN-09111 secured 2nd position across 31 locations under irrigated conditions and NRL 1123 ranked 1st by producing 11% higher grain yield than the check variety under moisture stress conditions on Pakistan basis. The line also showed excellent performance under irrigated conditions in KPK by producing grain yield of 4187 kg/ha (ranked 1st).

Oilseed brassica varieties i.e. Abasin-95, Durr-e-NIFA, NIFA Raya and NIFA Gold were multiplied to produce genetically pure seed for varietal popularization through demonstration plots on farmer's field. Three candidate lines of rapeseed were included in National Uniform Yield Trials that expressed promising potential under diverse environments. More than hundred mutants / recombinants got evaluated for agronomic parameters in yield trials.

Pulses program developed 29 mungbean recombinants and mutants that produced statistically significant ($p \leq 0.05$) higher seed yield compared to check variety Ramzan along with raising of F1 to F4 generations of different cross combinations. Seed of 71 true breeding mutant lines derived from NFM 5-91-21 (gamma rays at 400 Gys) was increased to evaluate these lines in replicated preliminary yield trials.

The biotechnology group identified / isolated the potential sugarcane lines CPSG-1550, CPSG-93, HOSG-945 &104 that expressed for highest brix (21%), sugar recovery (11.2%) and highest commercial cane sugar (CCS) of 13.6 % for CPSG-1004. In addition, 07 Stevia mutants were selected on the basis of high yield & higher steviosides along with molecular characterization of 18 promising guava accessions.

The Plant Pathology group after field studies concluded for detection of no virulence for Leaf and stem rust. Yr5, Yr10 and Yr15 still have potential for use and Yr3 virulence is common and increasing in KPK. Twenty eight wheat genotypes carried race none specific high YR resistance. BYDV surveillance indicated its presence in KPK and 04 BYDV vectors were identified.

Entomology

The division is actively involved in the risk reduced management of mosquitoes, fruit flies, termites; chickpea pod borer and other insect pests of vegetables and crops. Among the insects pest of fruits and vegetables, fruit flies are the most destructive pest and distribute throughout the world including Pakistan. Similarly, chickpea pod borer and subterranean termites are pests of economic importance. Termite is also an urban pest and causes lot of damage to wood work in residential building and structures. In the present scenario of dengue spread in Pakistan control of vector (Mosquitoes) is of utmost importance. The recent spread of dengue vectors show the risk in areas where the dengue vectors are present. Under Integrated Pest Management (IPM) approach we are employing different control measures like cultural, physical, phytosanitory, irradiation and chemical controls to keep insect pests population below economic injury level. A number of projects are running in the division which are funded by national and international funding agencies like IAEA, PSF etc. Moreover, technologies and methods developed by adopting IPM components at division are continuously transferred to other researchers, students and farmers through trainings, workshops, seminars and publications.

Food Science

The experimental work on MI funded project on stability of iodine in iodized salt in different packing materials under different climatic conditions indicated good stability of iodine in all types of salts except in the “poor quality rock salt from KPK that showed drastic iodine losses during storage and was found unfit for fortification purpose. Under the ALP- PARC project “Development of Market Life Enhancement Technology of Persimmon and its Dissemination to Growers”, the astringency removing technology developed / optimized was disseminated to farmers, traders and end users. Seven workshops were arranged in the persimmon growing areas of Swat and Charsadda through lectures / practical demonstration that got high acceptance by the growers / traders. Resultantly, for the first time some small quantities of persimmon fruit were exported to Middle East for fast popularization. Thus, valuable foreign exchange earnings, job creation and expansion of persimmon cultivation are expected.

Cultivation of Oyster, Milky, King Oyster and Button mushrooms developed technologies were disseminated through farmers workshops at Hazara valley, Haripur, Chitral, Swat valley, Balakot, Shinkiyari, Batagram, Bunner, Charsadda, Mardan, Peshawar and Nowshera distircts of KPK.

As part of the IAEA funded project on irradiated food for immuno-compromised patients, fresh and healthy apples were irradiated and stored at ambient room condition. Quality of apples treated up to 2 kGy was within acceptable limit after 30 days. Effect of irradiation on preservation and storage quality of energy dense foods for disaster affected areas was also studied and bacterial load in the samples irradiated at the dose of 10 kGy were found at the permissible level after of 45 days.

Pesticide residue monitoring in fruit and vegetables under PSF funded research project resulted with highest frequency (80%) residues in okra samples followed by eggplant 70%), tomato (50%), cucumber (30%), cauliflower (20%) and cabbage (10%). Among fruits, peach had higher frequency of residues (40%) than guava (20%)

Three products Cardio NIFA, Nutra N and Gastronif were developed under PSF funded project with overall satisfactory acceptance (> 75 %). Initial studied were conducted on color enhancement of topaz, its analytical and microstructure analysis before and after gamma irradiation for increase their commercial value. Presence of impurity (Fe) for topaz Skardu and Calcium (Ca) for Katlang topaz was noted. Successful color enhancement in the topaz was achieved.

SOIL SCIENCE

The scientists of the Soil Science Division have developed climate smart agricultural practices which mitigate the adverse effects of climate change. These practices include the integrated management of nutrients and water for field and horticultural crops and have been transferred to the growers of various districts of KPK through workshop and Farmers' day held at NIFA during 2015.

Other salient findings include the identification of Zn and P efficient wheat genotypes. Among the tested genotypes NRL-1306 and NRL-1316 were found as Zn efficient while NRL-1301 and NRL-1302 were ranked as Zn-inefficient. Wheat genotypes NRL-1302, NRL-1306 and NRL-1313 were P-efficient while NRL-1303, NRL-1314 and NRL-1317 were P in-efficient genotypes. The results from field study suggested that integration of FYM with rock phosphate generated positive impact for wheat yield and phosphorus release from RP.

Under PSF funded project, the economic package of integrated nutrients management (1/2 recommended NPK, soil application, ½ recommended FYM, 0.5% urea spray and 0.05% humic acid spray) was developed for plum orchards that produced 24 to 41 % increase in yield. Similarly the optimum and economical levels of fertilizer were formulated for new wheat varieties evolved at NIFA.

Technical support was provided to Pakistan Academy for Rural Development, Peshawar for the establishment of a pilot-scale composting facility and small scale biogeyser. Model biogysers were practically demonstrated to Chairman Pakistan Science Foundation and delegate from Turkish Coordination and Cooperation Agency, Islamabad on the eve of their respective visits to the institute.

Acknowledgments

The valuable guidance and continued support of Honorable Member Science (PAEC), Director (A&B) and Head of Divisions (NIFA) are commendable and admirable. The Annual Report compilation committee along with NIFA scientists/staff members for their valuable contributions certainly deserves high appreciation.

(Dr. Ihsanullah,CS)
Director NIFA

WHEAT- Irrigated

Seed production / maintenance of released wheat varieties:

Consistent efforts are being made by the wheat breeding team at NIFA to maintain the seed purity and produce quality seed in the best interest of the farming community. Progeny rows / blocks of NIFA wheat varieties were planted on the available land at the institute. Breeder nucleus seed was planted for production of Pre-basic / Basic seed duly inspected by the FSC & RD officials. A total of 3192 kg quality seed of NIFA irrigated varieties (Fakhre Sarhad and Bathoor) was produced. After processing and certification by FSC & RD the seed was distributed to Agric. Extension Department, and farming communities of KPK. As we all know that agriculture benefits can only be harvested if weather conditions are favorable. Unfortunately, 2015 cropping season was the worst of the decade as we experienced wind gust exceeding 120 km / hour with 64 mm rain and hail storm on 26th April 2015 with the result of production decrease to half.

Popularization and demonstration plots on Farmer`s field:

Selected demonstration plots (98) half acre each of the released/pre-released varieties were planted in 10 districts of KPK on farmers field for fast popularization/seed proliferation. Source seed along with fertilizer were provided to the farmers through WPEP project. A total of 70.65 tons of seed was produced which was sufficient for planting on 1766 acres during 2015-16 season.

Evaluation of candidate wheat lines in National Uniform Yield Trials:

The country-wide field evaluation of candidate varieties provided by wheat breeders' are a vital link between genetic improvement and the production environment. NIFA candidate lines, i.e. CT-09137 and SRN-09111 on the basis of its yield performance and disease resistance were included for the second year mandatory evaluation. The line SRN-09111 secured 2nd position across 31 locations on Pakistan basis. The line also found resistant to all three types of rusts; i.e Leaf Rust, Yellow Rust and Stem Rust (CDRI report 2014 and 2015). On the basis of its yield performance and disease resistance the proposal of SRN-09111 will be compiled / submitted to the seed council for release as a new variety for the irrigated areas.

Advanced wheat lines evaluation in KPWYT under irrigated conditions:

Six promising genotypes i.e. CT 10035, CT 12016, CT 12176, CT 12201, CT 12225 and IC 1206 along with local commercial check (NIFA Bathoor) were subjected for testing across 13 different locations in the KPK. The high yielding and disease resistant lines CT 12016 and CT 12176 showed stable performance.

Agronomic evaluation of elite wheat genotypes in advanced yield trials:

A total of 36 genotypes were evaluated in two advanced selection yield trials (ASYTs) under both normal and late planting conditions. In

ASYT-1, none of the genotypes out yielded both the check cultivars, however, WL15 in ASYT-2 out yielded (3487 kg/ha) the low yielding check Pirsabak-13. Nine genotypes out yielded the check cultivar Bathoor-08 (2788 kg ha^{-1}). Genotype CT-13186 (4276 kg ha^{-1}) was the second highest yielder followed by CTRN 13121(4010 kg ha^{-1}) and CT-13121(3754 kg ha^{-1}).

Preliminary testing of new genotypes:

One hundred genotypes were evaluated in preliminary yield trials (PYT-I & PYT-II) including two check varieties (Bathoor-08 and Pirsabak-2013) under normal / late planting conditions. Based on yield performance and disease reaction, 15 genotypes were selected in both trials. In PYT-I three genotypes produced higher grain yield than the high yielding check Bathoor 08 (3866 kg ha^{-1}), while 18 genotypes out yielded the low yielding check Pirsabak 13 (2900 kg ha^{-1}). CTRN-14085 (4666 kg ha^{-1}) followed by CT-14041 (3916 kg ha^{-1}) were found as the high yielding genotypes. The genotype CT-14293 produced the highest grain yield (3966 kg ha^{-1}) followed by CT-14287 (3933 kg ha^{-1}) in PYT-II.

Field evaluation of exotic wheat germplasm:

Global exchange of wheat germplasm, in particular, CIMMYT / ICARDA through provision of observation nurseries to cooperating institutions always play a positive role for selecting desirable ideotypes. International Bread Wheat Screening Nursery (47th IBWSN) consisting of **304** genotypes received from CIMMYT, Mexico, was evaluated with local checks Bathoor-08. Based on plant type, yield performance and disease reaction (*Yr* and *Lr*) a total of **58** genotypes were initially selected The selected genotypes out yielded the check cultivar Bathoor-08 and produced grain yield in the range of 5399 to 8266kg ha^{-1}

9th Stem Rust Nursery (SRN) consisting of **250** genotypes was also evaluated for yield performance and disease (*Yr*) reaction with local check Bathoor-08. Forty six genotypes were selected that produced grain yield in the range of 5750 to 6799 kg ha^{-1}.

35th Elite Spring Wheat Yield Trial (ESWYT) consisting of 50 genotypes was also evaluated for yield performance and disease (*Yr*) reaction with local check Bathoor-08. Seven genotypes were selected for further evaluation and confirmation of their desired traits.

SABWGPYT-04 consisting of 60 genotypes was evaluated for yield performance and disease (*Yr*) reaction with local check Bathoor-08. Nineteen genotypes were initially selected for further evaluation and confirmation of their desired traits.

15th ESBWYT (CWANA) consisting of 24 genotypes was also evaluated for yield performance and disease (*Yr*) reaction with local check Bathoor-08. Out of 24 genotypes, 07 were selected for further evaluation and confirmation of their desired traits. The selected genotypes out yielded the check variety (4166 kg ha^{-1}) by producing grain yield of 4666 kg ha^{-1}.

Heat Yield Trial / Multiplication nursery consisting of 335 genotypes was also evaluated for yield performance and disease (*Yr*) reaction with local check Bathoor-08. Out of 335 genotype 41 genotypes, were selected for further evaluation and confirmation of their desired traits.

Genetic variability and selections from segregating populations:

A crossing block consisting of 180 variable genotypes was planted at different dates for acquiring floral synchrony. Twenty-nine cross combinations among desirable wheat genotypes were attempted. F_2 generation resulted from 28 successful cross-combinations was planted and 26 desirable recombinants were harvested. These were raised at Summer Wheat Research Station (SWRS) Kaghan for advancement. **F_3** population resulted from 22 cross-combinations were raised and 22 desirable families were selected. Twenty five uniform families from **F_6** and **F_7** populations were

retained and were planted at Kaghan.

WHEAT- Rainfed:

Release of New Rainfed Wheat Variety:

Another landmark was achieved by NIFA breeders through the development of a new yellow rust resistant genotype NRL 0707 by accumulating genes of diverse parents Tatara & Inqilab-91 through hybridization and further advancement through shuttle breeding at Kaghan. The Khyber Pakhtunkhwa Provincial Seed Council (KPSC) formally approved this newly developed high yielding yellow rust resistant wheat variety "**INSAF-2015**" in its 35th meeting held on September 08, 2015 under the chairmanship of Mr. Ikramullah Khan Gandapur, KP Minister for Agriculture. The variety meets all the quality standards with high protein bold grains and possesses ample potential to express under moisture stress.

Post / Pre-release seed production of NIFA rainfed wheat varieties:

The wheat area in Khyber Pakhtunkhwa under NIFA released wheat varieties Lalma and Tatara is regularly increasing due to their attractive grain size, chapatti making quality, drought and disease resistance. Under seed multiplication program 3991 kg Pre-basic / Breeder nucleus seed of these varieties were produced after necessary inspection by FSC & RD officials. The quality seed produced will meet to some extent the increasing demand of the farming community and agricultural departments in KPK.

Candidate wheat lines in National Uniform Yield Trials (NUWYT-R):

Two outstanding NIFA wheat lines NRL 1123 and NRL 1130 were tested in the National wheat yield trials for 1st year mandatory evaluation at different sites (moisture stress environments) in the country. NRL 1123 ranked 1st by producing 11% higher grain yield than the check variety under moisture stress conditions on Pakistan basis. The line also showed excellent performance under irrigated conditions in KPK by producing grain yield of 4187 kg.ha^{-1} (ranked 1st).

Evaluation of candidate wheat lines in KPWYT-R:

Four promising genotypes, i.e. NRL 1206, NRL 1207, NRL 1213 and NRL 1306) along with 02 commercial check cultivars (Lalma and Shahkar) were tested at different locations (moisture stress areas) in the Khyber Pakhtunkhwa. NIFA elite line NRL 1206 showed outstanding field performance and ranked 1st throughout province by producing higher grain yield.

Evaluation of Advanced lines in Micro-plot Test:

Agronomic and physiological screening of 10 promising genotypes along with commercial check "Lalma" was carried out under moisture stress conditions. The trail was planted in RCB design with 04 replications. The data on agronomic parameters was recorded at different physiological growth stages. Three genotypes i.e. NRL-1205, NRL-1206 and NRL-1213 were selected as produced optimum grain yield. All the selected lines showed resistance against the prevailing fungal diseases.

Evaluation of elite wheat genotypes in advanced barani trials (ABT):

Twelve promising genotypes were evaluated for grain yield, yield components and disease resistance along with check cultivar Lalma in advanced barani trial (ABT) at the institute. Based on grain yield and disease resistance 05 promising genotypes were selected. NRL-1301 produced the highest grain yield (3580 kg/ha) followed by NRL-1303 (3065 kg/ha).

Preliminary testing of new genotypes (PBT):

Forty eight wheat genotypes along with local check NIFA Lalma were tested for grain yield, disease resistance and other agronomic traits in 04 preliminary yield trials (PBT-1, PBT-2, PBT-3 and PBT-4) under moisture stress conditions at the institute. Twenty two genotypes were selected on the basis of higher

yield and disease resistance (*YR & LR)*. Highest grain yield (3586 kg/ha) was produced by NRL-1424 followed by NRL-1438 (3426 kg/ha) and NRL-1411 (3247 kg/ha).

Field evaluation of exotic wheat germplasm:

NIFA regularly receives CIMMYT/ ICARDA nurseries that effectively being used for help in the ongoing breeding activities. A total of 420 entries with different genetic background were screened for grain yield, disease resistance and other agronomic traits in non-replicated observation nurseries under rainfed conditions. Based on field performance 162 best genotypes were identified and selected. These entries also expressed resistance against the prevailing rust diseases.

Hybridization activities:

Different cross combinations were raised (F_1 - F_4) at NIFA experimental farm. Desirable selections were made in the segregating populations. The selected genotypes were planted at SARS-Kaghan in the month of June 2015 for generation advancement. To create genetic variability for high yield and disease resistance, fresh crosses were also attempted among 10 promising wheat lines. The crossing blocks were planted at different dates in order to get maximum possible cross combinations, to achieve floral synchrony between early and late flowering parents and to make the crosses possible for longer duration.

Mutation activities:

M_2, M_3 and M_4 generations of different wheat varieties (Lalma, Barsat and Insaf) were sown at the institute. Single plant selections were made in M_2 generation. Uniform progeny rows were identified in M_3 and M_4 generation. Within each identified row 2-3 best plants were tagged on the basis of possessing desirable morphological traits and disease resistance in the field under natural epiphytotic conditions. Confirmation of the desired traits will further be made in the next generation.

Selection / assessment of improved wheat germplasm for higher yield and Water / N- use efficiencies:

The response of newly released rainfed wheat variety Insaf 2015 to different levels of nitrogen was studied at farmers' fields in DI Khan, Kohat, Peshawar, Charsadda, Mansehra and Swat areas of Khyber Pakhtunkhwa. By comparing different experimental sites it was observed that maximum grain yield was produced at 90 kg/ha followed by 45 kg/ha while the minimum yield was obtained at 0 kg/ha. In high rainfall areas wheat yield was in the range of 959 to 2980 kg/ha, whereas, in the medium rainfall areas it was in the range of 1003 - 3443 kg/ha. In the low rainfall areas the yield observed was in the range of 626 - 2096 kg/ha. It was noted that comparatively higher yields were obtained in the medium rainfall areas of Peshawar and Charsadda.

OILSEED BRASSICA IMPROVEMENT

Genetic purity maintenance and popularization of released varieties:

Maintaing genetic purity of approved/ commercial varieties is indispensable to ensure quality seed production. Twenty progeny blocks of rapeseed varieties viz., Abasin-95, Durr-e-NIFA and NIFA Gold along with the same number of progenies rows of mentioned varieties inclusive of NIFA Raya were raised to produce Breeder Nucleus Seed (BNS). True to type progeny blocks were selected on the basis of varietal characteristics. A total of 68 kg BNS and 45 kg PBS of Abasin-95, NIFA Raya, Durr-e-NIFA and NIFA Gold were produced.

Following Varietal Popularization Programme among the farming community of KPK, 10 demonstration plots of NIFA Gold, Durr-e-NIFA and Abasin-95 were planted at the progressive farmers' fields in the districts of Swabi and Buner. The programme yielded encouraging results as farmers harvested 1800-4000 kg per ha with average seed yield of 2400 kg per ha. The demand of NIFA source seed among farming community is ascending by fetching more economic benefit

to the farmers with least input.

Performance of new candidate lines in National Uniform Rapeseed Yield Trial (NURYT):

Three candidate lines of rapeseed (DNC-23, RM-I/08-39& 08-1/2-7) were evaluated for the first year mandatory testing in National Uniform Rapeseed Yield Trial (NURYT) at 10 locations across Pakistan. The candidate line 08-1/2-7 showed maximum 57.76% yield advantage at Barani Agricultural Research Station (BARS), Kohat over commercial check. RM-I/08-39 and DNC-23 out yielded the commercial check at Barani Agricultural Research Institute (BARI), Chakwal and Oilseed Research Station (ORS) Khanpur with 21 and 5% yield advantages respectively.

Multi-locational performance of recombinants and mutants:

The best performing 12 rapeseed mutants / recombinants viz., RM-I/09-1, RM-I/09-22, RM-II/09-7, RM-II/09-6, RM-III/10-19, RM-I/10-22, RM-III/011-3, RM-III/011-7, 011-5/6-11-1/14, 011-5/6-11, 011-5/6-13, 011-5/6-15 and a commercial check Faisal canola were evaluated for genetic stability and adaptability at Peshawar; Sarinaurang, Bannu; Buffa, Mingora, Swat, Kohat, Faisalabad, D.I. Khan, Bahwalpur and Chakwal .

Rapeseed mutant line RM-II/09-7 significantly out yielded all entries and showed moderate stability over all locations with a high adaptability for Potohar region of the Punjab. RM-I/09-1also significantly out yield the rest of the entries with a moderate stability and high adaptability for central and southern rapeseed growing areas in the KPK.

Evaluation of mutants/recombinants in Advanced Yield Trials (AYTs):

Eight rapeseed mutants/recombinants (RM011K-16-3, RM011K-17-1, RM011K-17-2, RM011K-18-2, RC011K 1/11- 5-1, RC011K 1/11-5-3, RM011K-22-2 & RM011K-22-3) and five mustard mutants (MM-I/011-18, MM-I/011-25, MM-I/011-40, MM-I/011-43 and MM-I/011-56) were evaluated separately in two Advanced Yield Trials (AYT-I, & AYT-II) along with commercial controls Faisal Canola (rapeseed) and Khanpur Raya (mustard), respectively at NIFA experimental farm during 2014-15. Five rapeseed mutants / recombinants displayed high seed yield viz., RM011 K-16-3 (3361 kg ha^{-1}), RM011 K-17-1 (3222 kg ha^{-1}), RM011K-18-2 (3139 kg ha^{-1}), RC011 K 1/11- 5-1 (2972 kg ha^{-1}) and RC011 K 1/11-5-3 (3167 kg ha^{-1}) compared to control Faisal Canola (2889 kg ha^{-1}) in AYT-I. With regards to AYT-II (mustard trial), four genotypes produced more seed yield MM-I/011-18 (2056 kg ha^{-1}), MM-I/011-25 (1861 kg ha^{-1}), MM-I/011-40 (2028 kg ha^{-1}), and MM-I/011-56 (1917 kg ha^{-1}) than control Khanpur Raya (1472 kg ha^{-1}).

Performance of mutants for yield and other agronomic characteristics in Preliminary Yield Trials (PYTs):

Stable and high yielding 10 rapeseed recombinants (RC-DNC-23,RC-44-1,RC-33-1,RC-33-2,RC-33-3,RC-34-1,RC-34-2,RC-40-1,RC-41-1 & RC-41-2); ten rapeseed mutants/recombinants (RC-41-3, RC-41-4, RM-41-5, RM-13-1, RM-13-2, RM-13-3, RM-13-4, RM-14-1, RM-14-2 & RM-14-3) and four mustard mutants (MM-27-2, MM-31-3, MM-31-4 & MM-31-5) were evaluated in the preliminary yield trials; (PYT-I to PYT-III) along with a commercial checks Faisal Canola (rapeseed) and Khanpur Raya (mustard), respectively. The trail was laid out in RCBD, replicated thrice. In PYT-I, five rapeseed recombinants harbored high seed yield RC-DNC-23(3167 kg ha^{-1}), RC-33-1(3611 kg ha^{-1}), RC-33-2 (3583 kg ha^{-1}), RC-33-3(3361 kg ha^{-1}) and RC-34-1(3472 kg ha^{-1}) than control Faisal Canola (2916 kg ha^{-1}) while in PYT-II; six rapeseed recombinants / mutants viz., RC-41-3 (1097 kg ha^{-1}), RC-41-4(1375 kg ha^{-1}), RM-41-5(1153 kg ha^{-1}), RM-13-2(1361 kg ha^{-1}), RM-13-3(1153 kg ha^{-1}), RM-13-4(1208 kg ha^{-1}) out yielded the check Faisal Canola (764 kg ha^{-1}). In PYT-III, two mustard mutant viz., MM-27-2 (1445 kg ha^{-1}) and MM-31-4 (1555 kg ha^{-1}) produced more seed yield with marginal edge over the control Khanpur Raya (1208 kg ha^{-1}).

Assessment of mutants / recombinants in non-replicated yield trial:

Sixty six rapeseed and mustard entries comprising of 44 rapeseed recombinants / mutants and 22 mustard recombinants were evaluated in F_5/M_5 for stability of yield and other economic traits in a non-replicated trial planted in augmented design along with a commercial check Faisal Canola (C1) and NIFA Raya (C2). The results indicated that four rapeseed recombinants and seven mutants out yielded the commercial check Faisal Canola by producing 20% to 69% higher seed yield. The maximum yield was observed for RM/NRPT2-45 (2759 kg ha^{-1}) followed by RR/NRPT2-4 (2407 kg ha^{-1}) against the control (1204 kg ha^{-1}). In case of mustard entries, 13 recombinants outclassed the control by securing 25% to 61% more seed yield. The maximum seed yield exhibited by MR/NRPT2-21 (2870 kg ha^{-1}) followed by MR/NRPT2-13 and MR/NRPT2-25 (2407 kg ha^{-1}) against NIFA Raya (1111 kg ha^{-1}).

F_0 / F_1 generation:

A crossing block consisting of 43 rapeseed and mustard germplasm was raised including the parental material for developed breeding population and advanced rapeseed & mustard genotypes. Five diversified mustard lines viz., EMH-274, KJ-206, CORAL-432, NM-16/2015 and NM-18/2015 were utilized in different combinations (EMH-274 x NM-16/2015; KJ-206 x NM-16/2015; CORAL-432 x NM-16/2015; EMH-274 x NM-18/2015; KJ-206 x NM-18/2015; CORAL-432 x NM-18/2015) to incorporate earliness, reduced plant height and uniform maturity coupled with high seed yield. Two hundred and eighty two stigmas were pollinated. Pods were harvested cross wise as F_0 generation and F_1 seed. Three intra-specific crosses planted as F_1 (NIFA GOLD X ECH; Pb. SARSON X NIFA GOLD;SHIRALEE X NIFA GOLD) were also bulk harvested cross combination wise.

Plant-progeny rows (F3 / M3):

Sixty seven plant-to-progeny rows of rapeseed recombinants / mutants (F_3 / M_3) were planted to confirm inherited desired selected traits on visual performance basis. Three meter long two rows per entry were planted. Re-selection and isolation of potential entries could not be exercised as handicapped by lodging due to heavy rains and storms; however, potential genetic material was saved by drawing representative samples from each entry. The material may be re-selected as families in the following generations.

Shuttle breeding:

Summer Agricultural Research Station (SARS), Kaghan is used for generation advancement programme to curtail the breeding cycle for varietal development. Due to heavy rains and storms, BNS development at NIFA was affected too. Therefore, progeny block seed of Abasin-95, Durr-e-NIFA and NIFA Gold developed at NIFA during 2014-15, was increased at SARS, Kaghan during 2015 with view to have an adequate amount of quality seed for Rabi plantation during 2015-16.

Quality characterization of oilseeds:

Near Infrared Reflectance Spectroscopy (NIRS) technique established at NIFA, Peshawar is the most cost, time and labor-effective. No negative impacts on original seeds structure or texture or on the environment were observed. For ongoing project at NIFA, about 300 samples of oilseed germplasm and breeding materials were analyzed for fatty acid profile and glucosinolates contents. The Routine Quality Analysis Service (oil, protein, fatty acid profile and glucosinolate) of 3914 samples of brassica, 814 samples of sunflower, 219 sesame and 54 samples of *Eruca sativa* were also provided to different stakeholders in the country.

PULSES IMPROMENT

Mungbean:

Forty four advanced mungbean recombinants and mutants developed were evaluated in 03 sets of replicated yield trials for seed yield and yield components at NIFA.

Seven recombinants i.e., 3-3, 6-5, 8-1, 8-22, 5-63-2, 5-63-3 and 5-63-5evaluated in set-1 produced statistically significant ($p \leq 0.05$) higher seed yield (1356-1744 kg ha^{-1}) as compared to the check variety Ramzan (1158 kg ha^{-1}). In case of set-2, the recombinants 5-63-30, 5-63-48, 5-63-49, 5-63-54, 5-36-1, 5-36-2, 5-36-4, 5-36-11, 5-36-24, and 5-36-27 showed statistically significant ($p \leq 0.05$) higher seed yield (1475-1906 kg ha^{-1}) compared to the check variety Ramzan (1189 kg ha^{-1}). Similarly, 12 advanced recombinants and mutants i.e., 5-36-30, 5-36-48, 5-36-50, 5-36-55, 5-36-63, 5-91-8, 5-91-19, 5-91-21, 5-91-26, 5-91-33, 92-2-31, and 92-4-12 produced statistically significant ($p \leq 0.05$) higher seed yield (1614-2178 kg ha^{-1}) compared to the check variety Ramzan (1394 kg ha^{-1}). The advanced recombinants and mutants which produced statistically significantly ($p \leq 0.05$) higher seed yield exhibited 46-60g/1000 seed weight and better plant type. Their days to maturity ranged from 75-91 days. Two promising recombinants namely NIFA Mung-4, and NIFA Mung-5 have been contributed to evaluate for seed yield and stability in National Uniform Yield Trials during kharif 2015, which are being conducted by National Pulses coordinator, NARC, Islamabad.

F_1 generation of 7 cross combinations i.e., ML-5 x NM 2006, Kuram green mung x Ramzan, Sona mung x NM 2011, ML-5 x NM 2011, Kuram green mung x NM 2011, Kuram black mung x NIFA Black mung, and Kuram green mung x NM 2006were raised and 45 hybrid plants were picked from all crosses and threshed individually. F3 populations of 6 different cross combinations i.e., V 2709 x NM 92, Var. 6601x Ramzan, NM 51 x NM 98, NM 98 x NFM 5-36-24, NFM 5-36-24 x NFM 5-36-18 and V 2802 x NM 92 were raised during kharif 2015 and made457 single plant selections on the basis of more pods per plant. Similarly, F4 populations derived from 7 cross combinations i.e., V 1128 x Ramzan, V 2802 x Ramzan, V 2817 x Ramzan, V 1128 x NM 2006, V 2802 x NM 2006, V 2817 x NM 2006, V 2709 x NM 2006 were evaluated in Kharif 2015 and selected 357 single plant recombinants on the basis of more pods and good plant type.

Seed of Kuram green mung, Kuram black mung and NIFA black mung were irradiated using gamma rays at the rate of 400Gys and raised M_1 generation during 2015. 290 and 430 M_1 mutant plants were picked from Kuram green mung and NIFA black mung, respectively whereas Kuram black mung did not produce flowers and thus could not pick mutant plants from it. 370 mutant plants were selected from M_3 generation of V 2802 on the basis of more pods per plant and tolerance to mungbean yellow mosaic virus to raise M_4 generation during 2016. Seed of 71 true breeding mutant lines derived from NFM 5-91-21 (gamma rays at 400 Gys) was increased to evaluate these lines in replicated preliminary yield trials during next year.

Chickpea:

Chickpea breeding material planted during 2014-15 was severely damaged by hailstorm on April 26, 2015. Therefore, nothing was harvested during this season and obviously no data was recorded.

BIOTECHNOLOGY

Sugarcane improvement:

Buds collected from mother plants of CP77/400, CSSG-668 and CPSG-1550 were surface sterilized and cultured on Murashige and Skoog (MS) medium containing different plant growth regulators. The effects of various PGRs such as BA, GA_3, 2,4-D alone or in combination with BA 0.5-1.0 mg l^{-1} were evaluated. Bud explants of all lines responded to all PGRs. Best callus induction (85%) was recorded on MS medium supplemented with 3.0 mg l^{-1} 2, 4-D. Callus induction recorded on 1 and 4 mg l^{-1} 2, 4-D were 56% and 60%,

whereas 70% callus was observed on 2 mg l^{-1} 2, 4-D respectively. On 1 mg l^{-1} 2,4-D(56%) was significantly lower than other PGRs, and no callus was observed on MS control. Data on organogenesis was determined after 5 weeks of sub-culture and the best shooting 92% was recorded on media containing 2.0 mg l^{-1} BA alone followed media containing 2.0 mg l^{-1} BA and 0.5 mg l^{-1} GA_3. Contrarily, addition of 2, 4-D to medium incorporated with BA inhibited % shooting significantly. Shoots grown on shoot organogenesis medium were transferred to MS medium incorporated with different concentrations of IBA, IAA, NAA and BA for rooting. Optimum (89%) rooting, were obtained on media having 2 mg l^{-1} of BA followed by 0.5 mg l^{-1} IAA (87%) and NAA (80%) respectively.

Plantlets acclimatization:

Three hundred and forty six plantlets of sugar cane lines CSSG-668 and CPSG-1550 produced through tissue culture were successfully acclimatized and transplanted to the field for testing. The agronomic data has been collected and frost tolerance data will be completed in due course of time.

Screening / evaluation of sugarcane fuzz:

Self-pollinated fuzz of 09 different varieties of sugarcane received from NSCRI, Thatta were sown in controlled environment at NIFA lathe house. The seedlings raised were transplanted to the field for evaluation and selections. One hundred and ten seedlings were raised from fuzz of self-pollinated sugarcane variety HoTh-326.

Seed multiplication of advanced lines

Seed of sugarcane lines CSSG-1402, CPSG-468 and CPSG-169 was multiplied. The plot size of each line was 10 x 10 meter, one meter apart. The line CPSG-1550 was sent to National sugar crops coordinator to be tested in different locations for confirmation in the National trials for varietal development

Sugarcane agronomic evaluation through advanced yield trial:

Thirteen genotypes with a commercial check CP 77/400 were field evaluated in advanced yield trial. The trial was sown using standard plot size of 6x4 m^2 in RCBD. The highest plant height of 224.2 cm was recorded in line CPSG-468 followed by 203.1cm in line CPSG-1550. The Longest internode length of 10.4 cm was recorded in the line CPSG-1004. Similarly the highest number of nodes (19.3) was recorded in line CPSG-676 followed by CPSG-468 with internode length of 19.1 cm. The highest stalk/plant (5.3) was recorded in line HOSG-1145. The highest cane thickness of 36.3mm was recorded in line CSSG-668. In quality characters, the highest recovery of 11.2% was recorded by CPSG-1004. This was followed by Line CPSG-1550 with 11.01% recovery. Similarly the highest commercial cane sugar (CCS) of 13.6 % was recorded by line- CPSG-1004. The highest purity of 84.6 % was recorded in line CPSG-1004.

Preliminary yield trials:

Twenty seven sugarcane genotypes were evaluated in 02 PYTs at NIFA for high cane and sugar yield. CP 77/400 was included as a check variety and the plot size was 6x4m^2. The experiment was laid out according to RCBD. Out of 27 genotypes, the highest number of nodes (19.2) was recorded in line HOSG-955 followed by HOSG-1257 with 18.5 and 18.1 in line HOSG-1021. The highest inter-node length of 16 cm was recorded in line HOSG-945 followed by HOSG-1021 with 15 cm inter-node length. The lowest inter-node length of 9.5 cm was recorded in line CPSG093.The maximum cane thickness of 29.3 mm was recorded in line CPSG-159 followed by line CPSG-90 with cane thickness of 28.2 mm. The lowest cane thickness of 22.2 mm was recorded in line HOSG-945. The highest stalk/plant (5.4) was recorded in line HOSG 315. This was followed by line HOSG1257 with 5.3 stalk per plant. The lowest stalk/plant of 3.3 was recorded QSG-69. The data on plant height of all the genotypes showed significant variation. The highest plant height (189.6 cm) was

recorded in Line HOSG-315 followed by line HOSG 945 with height of 189.1cm. The lowest plant height of 127.1 cm was recorded in line QSG-69. Significant variations in yield were observed among all the genotypes under study. The highest yield of 91.1 t/ha was recorded in line CPSG-159 followed by line HOSG-315 with 91 t/ha. The lowest yield of 35.8 t/ha was recorded in line CPSG-93.

Sugarcane Quality evaluation:

Quality evaluation of advanced genotypes was carried out during the period under report. The highest brix of 21.8% was recorded in line CSSG-239, CPSG93 and US 469. This was followed by line HOSG-104, HOSG-945 and QSG-669 with 21.3 % brix. The data regarding sugar recovery of all the genotypes showed significant variation. According to the results, highest recovery of 10.5 % was recorded in line US 165 and Aus 384 followed by Line QSG-69 with recovery of 10.8 %. The lowest recovery of 5.8 % was recorded in line SP 576. The highest purity of 81.8 % was recorded in line Aus 384 followed by line HOSG-1021 with purity of 79.82% whereas, the lowest purity of 64.4% was recorded in line SP 576. The highest Pol of 17.3% was recorded in line US 165 followed by line QSG69 with17.0 % Pol.

National Uniform Varietal Trial:

National uniform varietal trial consisted of ten lines; three lines were received from ARRI, Faisalabad, four lines from NARC and two from NSCRI Thatta. The trial was sown using standard plot size of 7 m^2. The commercial variety CP77/400 was used as check**.** The highest Stalk/plant (5.0) was recorded in line Aus 104, the highest Internodes (19.3) was recorded in line CPSG-85, Internodes length of (11.5cm) was recorded in line US 469 and plant height (201.3 cm) was recorded in line NARC-1. The highest cane thickness (29.9mm) was recorded in line CPSG 85. The highest yield of 89.3 t/ha was recorded in line CPSG 1550. In sugar recovery all the lines were inferior and could not compete with check. The highest recovery of 10.2 % was recorded in line NARC-1 followed by Aus 383 with recovery of 10 %. The highest brix of 20.7% was recorded in line Aus 104.

Guava molecular markers studies:

Eight micro-satellite (SSR) primers were used to assess molecular variation and diversity in 18 promising Pakistani guava accessions. Results showed that all guava accessions were polymorphic and percent polymorphism ranged from 40 to 82%. The size of reproducible and scorable bands ranged from 100 to 1500 bp. Out of total 146 amplification profiles (18 genotypes and 8 primer pairs) a total of 80 bands were obtained in which 52 were polymorphic. The total 80 bands amplified by 8 different primers in 18 accessions of guava ranged from 9 to 11.The average number of putative allele per locus were 8.0. The highest polymorphism 82% and identification percentage (11.3 %) was detected by primer mPgCIR10 and mPgCIR11 respectively. Cluster analysis indicated that 8 SSR primers used in this study revealed a wide range of genomic DNA diversity among 18 Pakistan guava (*Psidium guajava* L.) accessions. All the guava accessions, clustered into two main groups. The first group have a total of 8 accessions consisted of all the accessions of Safada collected from Peshawar, Charsadda and Kohat. The second group consisted of eight guava accessions collected from Sher khana, Malakand Agency. Dandrogram showed that accessions Riali and Kazi both were of the same origin. Similarly Sindhi and PG005 were clustered in to the same sub group while PG005 Ramzani PG013, Thadarami and Gulabi clustered into the same sub group.

Stevia Improvement:

Efficient and cost effective regeneration system was established from leaf explants of *Stevia rebaudiana* Bertoni using different PGRs. Maximum callus induction (91.67%) was observed when suitable leaf portions were placed on MS-medium augmented with 2.0 mg l^{-1} of 2,4-D with 3.5 g l^{-1}agar concentration. Significantly, a similar callus induction response was observed on a medium containing a combination of 2,4-D

and NAA (2.0 mgl^{-1}) along with 7.0 g l^{-1} agar concentration. Good-quality callus (< 80%) was observed when the MS-medium was augmented with 2,4-D and NAA (1.0 or 2.0 mg l^{-1}) with 3.5 g l^{-1} agar concentration. No callus was observed on the MS0 medium. The 2,4-D alone or in combination with NAA was more effective in callus induction than 2,4-D and IAA. Furthermore, these results suggested that a lower quantity of agar accelerates the formation of a good friable callus more than the addition of a higher amount of agar to the medium.

Effect of different PGRs and agar on shoot organogenesis of stevia:

A fresh and good-quality callus was shifted to a new medium augmented with different concentrations and combinations of PGRs and agar for shoot organogenesis. The highest (100%) shoot regeneration potential was observed when the agar concentration was kept at 7.0 g l^{-1} and the MS-medium was augmented with different BA concentrations (1.0, 2.0, and 4.0 mg l^{-1}). However, the addition of similar PGRs to a 3.5 g l^{-1} medium induced a shooting response of more than 80% after four weeks of callus culture. The combination of BA with Kin (2.0 $mgl^{-1)}$ also showed a better regeneration potential of 93.33% when 3.5 g l^{-1} agar was added to the MS-medium. It has been observed that lower concentrations of agar significantly reduced the length of micro-shoots, but that higher concentrations promoted shoot elongation. In this experiment, a lower concentration of BA (1.0 mg $l^{-1)}$ and a higher concentration of agar showed a maximum shoot length of 13.03 cm. Under similar PGRs condition, lower agar concentration reduced shoot length to 2.12 cm. Moreover, addition of BA in combination with Kin (1.0 mg l^{-1}) also showed higher mean shoot length (12.3 cm). The highest (28) number of shoots per explant was documented when the medium was supplemented with 1.0 mg l^{-1} BA along with a higher agar concentration. Furthermore, BA alone (2.0 and 4.0 mg) or in combination with Kin (1.0 $mgl^{-1)}$ produced > 15 number shoots per explants. However, 8.35 shoots per explant were obtained when the medium was augmented with 3.5 gl^{-1} agar and 1.0 mg l^{-1} of BA. Lower concentration of agar in this condition is less effective in shoot multiplication. The number of leaves per explants under the influence of different PGRs and agar was also investigated. The addition of BA and Kin (1.0 mg l^{-1}) to the MS-medium containing a higher agar concentration produced a significantly higher (132.67) number of leaves per explants. Lower BA concentrations (1.0 and 2.0 mg l^{-1}) also produced 109.67 and 131 leaves per explant. However, MS-medium containing lower agar concentrations with different PGRs produced a lower number of leaves as compared to the higher agar concentration. A reduction in shoot length is directly proportional to a reduction in the number of leaves, but the plantlets obtained were comparatively vigorous and strong enough for acclimatization.

Effect of different PGRs and agar on root organogenesis of stevia:

Vigorous shoots with suitable length were transferred to a fresh MS-medium containing two agar concentration for root organogenesis. Nine treatments have been applied for root organogenesis. 100% root induction was observed when the MS-medium was augmented with 2.0 mgl^{-1} of IAA along with 3.5 and 7.0 g l^{-1} gar concentrations after four weeks of culture. The IBA alone (2.0 mgl^{-1}) also showed better rooting (93.3%) as compared to control and NAA augmented media. However, the combination of IBA (1.0 and 2.0 mg l^{-1}), IAA (1.0 and 2.0 mg l^{-1}) and NAA (1.0 and 2.0 mg l^{-1}) was found less effective in percent root induction. But maximum shoot length (2.9 cm) with 26.33 roots per plantlet was observed when the MS medium was augmented with 2.0 $mgl^{-1}$of NAA along with 3.5 gl^{-1}agar concentration. Similarly root length with same number of roots per shoot was also observed with the addition of 1.0 mg l^{-1}IBA, but the agar concentration was higher. It has been observed that application of similar PGRs and different agar concentrations in the medium

greatly affects root organogenesis.

Acclimatization of regenerated plantlets of stevia:

Regenerated plantlets were successfully transferred to pots containing a combination of soil, sand, and manure in a ratio of 2:1:1. The establishment of plants in pots was confirmed after the emergence of new leaves on the shoot tips. The leaves on the lower part of the plants underwent welting due to lower humidity. Similarly, new leaves emerge from after four weeks of establishment. The pots containing the plantlets were kept in a growth chamber for five weeks and then transferred to the greenhouse.

Major steviol glycoside production:

Major steviol glycosides (Dulcoside-A, Steviosides and Rebaudioside-A) were determined in in vitro shoots obtained from media augmented with different PGRs and agar treatments. It has been observed that the combination of BA and Kin (3.0 mg l^{-1}) along with 3.5 g l^{-1}agar significantly increased the dulcoside-A content (71.8 mg/g-DW) compared to control (50.81 mg/g-DW). As the agar concentration increases with similar PGRs, the dulcoside-A content decreases from 71.8 mg/g-DW to 54.0 mg/g-DW. The addition of a lower concentration of BA (1.0 mgl^{-1}) into the medium with 7.0 g l^{-1} agar showed 53.6 mg/g-DW dulcoside-A content. However, a significant reduction has been observed in the content (12.70 mg/g-DW) with the addition of a 3.5 g l^{-1} agar concentration. It has been clearly observed from these results that different agar concentrations in the medium make the dulcoside-A content fluctuate. A higher dulcoside-A content (60.24 mg/g-DW) was observed in a medium containing 3.5 g l^{-1}agar and 3.0 mg l^{-1}BA, but when the agar concentration was increased, the dulcoside-A content significantly decreases (13.24 mg/g-DW). Furthermore, higher stevioside (82.48 mg/g-DW)content was observed in shoots on a medium containing a combination of BA and Kin (3.0 mgl^{-1}) with a 7.0 g l^{-1} agar concentration. However, lower steviosides content (22.2 mg/g-DW) was noted with lower agar concentration with similar PGRs. It means that the agar concentration significantly influenced stevioside production under in vitro conditions. The addition of BA (3.0 mg l^{-1}) alone into the MS-medium with 3.5 g l^{-1} also influences the steviosides content (63.77 mg/g-DW) as compared to the higher agar concentration (30.89 mg/g-DW). From these results, it was observed that the combination of BA and Kin is very effective for major SGs production than BA alone with different agar concentrations. A lower amount of rebaudioside-A content was observed in all treatments as compared to dulcoside-A and steviosides content. A maximum rebaudioside-A content of 12.35 mg/g-DW was obtained with shoots grown on a medium containing BA (1.0 mg l^{-1}) with 7.0 g l^{-1} agar compared to control (07.39 mg/g-DW).

PLANT PATHOLOGY

Yellow/leaf rusts and powdery mildew:

Occurrence of yellow rust, leaf rust and powdery mildew were monitored in sentential plots raised at six locations in southern, central and northern zones of Khyber Pakhtunkhaw. Yellow rust was the most prominent disease observed at all six locations of the province. Highest mean yellow rust severity was observed at Peshawar-1 (31%) which was followed by Nowshara (29%), Abbotabad (26%), Swat (24%) and Bannu (3%). Frequency of entries with >40% yellow rust severity in sentential plots were found to be increasing when compared with previous years. Leaf rust was not observed at Peshawar-2, Nowshara, Bannu and Abbotabad while <1% severity was recorded at Peshawar-1 and Swat. Powdery mildew was observed at Swat and Abbotabad with 49 and 27% mean severity respectively which indicated its geographical limits.

Wheat yield prediction model under yellow rust:

As yellow rust epidemics regularly occur in the country so it becomes much more

important to estimate and predict wheat yield prior to harvest. This information is very useful for the decision makers to secure national food demand by adopting appropriate measures. A study in this direction was carried out in which yield of 15 wheat genotypes was estimated at around 25-30 days prior to harvesting in the standing crop following yellow rust epidemic at NIFA in replicated experiment. Yield prediction was based on three estimation components i.e. heads per square foot, seeds per head and seed weight. Results indicated considerable arithmetic differences in the estimated yield of 15 genotypes and the actual yield which was obtained after harvest. A two factor F-test revealed significant difference in two yield types. However, a non-significant difference was observed between types of yield and genotypes which rendered yield forecast method feasible for use. However, multi-location and multi-season study is needed to confirm and further validate the results obtained in the current study.

Rust virulences and effectiveness of resistance genes:

Breeding for rust resistance require information regarding the presence of rust pathotypes and associated virulences. In this regard, biological trap nurseries were used to monitor wheat yellow rust in the southern, central and northeren zones of Khyber Pakhtunkhaw which is the most vulnerable region in Pakistan. Virulences were observed for various tested genes. Maximum number of yellow rust virulence factors of 21 was recorded at Peshawar-2 while lowest was at Abbotabad. Twelve virulence factors each were recorded at Bannu, Peshawar-1 and Swat while 14 virulence factors were recorded at Nowshara. Yellow rust virulence *V3* was recorded during 2013 in our field tests and it was consistently observed during 2014 and 2015 in Khyber Pakhtunkhwa. Cultivars based on *Yr3* resistance should not be promoted as presence of *Vr3* was also confirmed from various countries of the region. However, resistance gens *Yr5*, *Yr10* and *Yr15* can be used in combination with other adult plant resistance genes for wheat improvement. Leaf rust and stem rust differentials were studied only at Peshawar-1 but no virulence was detected for either rust.

Stability of rust resistance:

Presence of different virulences, infection levels and environmental conditions differ from area to area which complicate identification and selection for yellow rust resistance. Performance stability is one of the most desirable criteria for identification of rust resistant stable germplasm. Following this strategy, 35 rainfed and irrigated wheat lines were tested in replicated trials at six locations under diversified conditions in Khyber Pakhtunkhwa. Finlay-Wilkinson stability analysis was carried out for over location yellow rust severity data. Regression coefficients (bi) was used as criteria for stability and those lines were considered better which had low rust severity and bi values close to unity. Lines falling in this category included NRL-0808, NRL-0820, CT-08183 and SRN-6019 which can be used in wheat improvement program.

Slow rusting resistance:

More than 600 genotypes were evaluated for slow rusting trait at NIFA along with a standard susceptible check Morocco. Several assessments of yellow rust severity were made at weekly intervals which are used to measure quantitative resistance that is considered to be essential for selecting and identifying durable resistance.Temporal field disease data was used to measure area under yellow rust progress curve (AUYRPC). Relative AUYRPC values upto 30 or <30 indicated the probability of carrying slow rusting durable resistance. Approved cultivars from Khyber Pakhtunkhwa carrying this trait were Suleman 96, Fakhar-e-Sarhad, Tatara, Saleem 2000, Pirsabak-2004, Pirsabak-2005, BARS-2009, Dera-98, Nasir-2k and Hashim-08. Further improvement of these cultivars is needed by incorporating effective adult plant

resistance genes for deployment in the province.

Novel sources of resistance in national and PAEC material:

Under this national collaboration, novel lines and candidate varieties from all breeding programs of the country were tested for yellow rust resistance under National Wheat Disease Screening Nursery (480 entries) and National Uniform Wheat Yield Trial (NUWYT) Nursery (40 entries) which is coordinated by the National Agriculture Research Center (NARC), Islamabad. Both experiments were raised at NIFA under yellow rust infection experiments. Yellow rust severity data was recorded at appropriate stage of the crop and results revealed that most of the genotypes (65%) in the National Wheat Disease Screening Nursery carried effective race specific resistance. This nursery had 140 PAEC genotypes (66: NIFA Peshawar; 41: NIA Tandojam; 9: NIAB Faisalabad and 24 from NIBGE Faisalabad). Variability in PAEC genotypes was observed that varied between susceptibility to effective race specific resistance. Twenty eight genotypes were suspected to carry race nonspecific high resistance which is believed to be more durable and is suggested for further development. Performance of four NIFA candidate varieties was acceptable in NUWYT nursery at NIFA and was proposed to carry *Yr18*, *Yr27*, *Yr31*+ (CT 09137),*Yr18*, *Yr31*+ (SRN 09111), *Yr8*, *Yr31*+ (NRL-1123) and *Yr18*+ (NRL-1130).

Powdery mildew resistance:

Powdery mildew has been noted since late sixtys' in the plains immediately adjacent to the Himalayan Mountains but its occurrence away from this region was witnessed and is being considered as a future challenge for sustainable wheat production in the country. In order to identify, sources of powdery mildew resistance, 35 old cultivars and 55 elete wheat lines were tested in replicated experiments at two hot spot location, one each at Hari Pur and Swat. Tested material behaved differentially at two locations. Less than 30% leaf area was infected in Punjab-96, Nowshera-96, Chakwal-86, Kirin-95, Kohistan-97, Sind-81, Maxi-Pak, WL-711, Zargoon-79, Kaghan-93, Pasban-90, Inqilab-91, Faisalabad-83, Kohinoor-83, Shahkar-95, Watan-94, Tandojam-83, Sariab-92, Pak-81, Saleem-2000, Fakhar-e-Sarhad, Tatara, Frontana, Karwan, Wafaq-2001, BATOOR-08 ,NRL-0517, NRL-0707, NRL-0709, NRL-0715, NRL-0731, NRL-0751, NRL-0809, NRL-0818, NRL-0820, NRL-0834 and NRL-0842 at Hari Pur while the corresponding powdery mildew damage was high at Swat. Around 41 loci with more than 60 genes/alleles for resistance to powdery mildew have been identified and located on various chromosomes in bread wheat and its relatives, effectiveness of these genes may be explored for use & improving resistance of germplasm.

Seed diseases:

Seed constitutes the main propagate for plant growth and at the same time, one of the main vehicles for the dissemination of plant pathogens. Seed health is therefore one of the most important attributes of seed quality and a key factor in wheat development and production chains. Among wheat seed diseases, black point was investigated in 110 wheat cultivars produced during 2014-15 at NIFA. Natural black point incidence was recorded in 500 seed sample of each cultivar. Average number of infected seeds was 15 (3%). Highest and lowest number of black point infected seeds was 50 (10%) and 2(0.4%) respectively with standard deviation of 8.4. K-means clustering indicated the distribution of cultivars in five clusters based on black point incidence data. Based on black point incidence data, number of inoculated loci per square meter (inoculum density).was estimated for field if such seeds are sown. Number of inoculated loci per square meter ranged from 2-40 in wheat cultivars (i.e.Bakhtawar-92, Nowshara-96, Suleman-96, Fakhar-e-Sarhad, Tatara, Takbeer,

Pirsabak-2005, Saleem 2000, Khyber 87,Pirsabak-2004, Bathoor-08, NIFA Barsat 09, Daman-98, Dera-98, Nasir-2k, Gomal-08, Hashim-08, Pirsabak-08, KT-2000, Janbaz and Pirsabak-13) capable of causing disease under field situation. It is suggested that seed of wheat cultivars and upcoming lines should be examined for seed treatment prior distributing to farming communities

Barley Yellow Dwarf threat assessment to wheat:

Barley Yellow Dwarf (BYD) is an economically important aphid transmitted viral disease of cereals in the world including Pakistan. Its importance was realized by the Government of Khyber Pakhtunkhwa who provided financial support to address this neglected threat to wheat crop in the province. Results achieved under this initiative are described below.

Prevalence, phenotyping and impact assessment:

More than 1800 acres of wheat growing area was surveyed for BYD occurrence and impact assessment in southern, central and northern zones of the province using standard surveillance procedures. BYD was prevalent in all 386 wheat fields inspected in the province. Mean BYD incidence ranged from 5-7% among three zones while it reached up to 50% at certain locations. Mean BYD severity was maximum in the central zone (70%) which was followed by southern (49%) and northern zone (43%). Maximum impact at field level was observed in southern zone and it was followed by central and northern zone.

Vector identification:

Aphids were observed in all 386 wheat fields inspected in the province. Aphid samples were collected as per standard procedure and were subsequently identified. Two BYD virus vectors were identified from the southern zone samples including Oat bird-cherry aphid (*Rhopalosiphum padi*) and Corn leaf aphid (*Rhopalosiphum maidis*). Four BYD virus vectors were identified from the central zone; two were common to the southern zone while the other two were English grain aphid (*Sitobion avenae*) and Green bug (*Schizaphus graminum*). English grain aphid was the only BYD virus vector identified from the northeren zone samples.

Virus strain detection:

A batch of 188 BYD virus suspected wheat samples from 12 districts of the southern, central and northern zones were indexed using DAS-ELISA technique. Out of the total tested samples, 146 (80%) were found positive for BYDV-PAV. Due to limited funding, only BYDV-PAV was addressed. Further studies are needed to investigate the occurrence of other BYD/CYD viruses in the province.

Zero gravity instrument project:

This project was awarded by the United Nations Office for Outer Space Affairs (UNOOSA), Vienna, Austriaunder United Nations Human Space Technology Initiative (UN-HSTI). Under this project, Zero-gravity simulation instrument (Clinostat) along with related accessories was received from UNOOSA. Clinostat was successfully installed and commissioned. Relevant facilities including uninterrupted power supply system (UPS) and clean flow bench station were the prerequisites for initiating clinorotation experiments which were established during the period under report.

FRUIT FLY CONTROL

Fruits and vegetables are important cash crops of Pakistan especially of KPK. Hundred of fruit fly species are damaging all fruits, vegetables as well as a large number of wild plants through out the world. In Pakistan there are 11 identified species of fruit flies, amongst which Oriental fruit fly, *B. dorsalis* and peach fruit *B. zonata* are the two most destructive species attaching a wide verity of fruits and their males are attracted to methyle ugenol while melon fly, *B. cucurbitae* is damaging cucurbitaceous vegetables, and cue-lure is used as lure for male annihilation for this species in the orchards.

Different IPM component such as Male annihilation, Bait application, bio-pesticides, release of bio-control agents, sterile insects and cultural practices etc. are used for fruit fly in the fields. Radiation and vapor heat treatments are used as post-harvest tactics for the managements of these serious pests. MAT provides an easy, environmentally safe approach of fly control in fruit and vegetable orchards if applied properly on area wide basis to kill the male population. Our efforts are directed to improve MAT by adding various chemicals in commercial lure to attract males as well as female flies in low cost lure.

Effect of mixing various chemicals in methyl eugenol for capturing fruit flies in pear orchard at Nowshera:

Methyl eugenol is used world widely for the male annihilation of different fruit flies species of genus Bactrocera, infesting various fruits. Different chemicals attractants such as molasses, yeast extract powder, DAP, protein hydrolyzate, natural yeast, ethyl acetate, ammonium acetate and casein were mixed in Methyl eogenol @ 90% i.e. 9:1 ratio to see their effect on the efficacy of lure under field condition in pear orchard. Each chemical was compared with its combination with ME and standard commercial trap.

The results showed that in case of molasses, pure molasses was found more attractive to flies than both checks. Yeast extract powder in combination caught 3.2 flies /trap/week as compared to 1.4 and 1.8 flies/trap week in both checks. DAP in pure form attracted 3.34 flies/trap/week as compared 1.43 flies in mixture of two and 1.8 in commercial trap. Protein hydrolyzate and natural yeast in combination with methyl eugenol while ammonium acetate and casein in pure form proved better attractant of fruit flies. Overall results indicated that molasses and DAP has antagonistic effect on methyl eugenol efficiency while synergistic interaction was recorded between yeast extract, protein hydrolysate with methyl eugenol. Ammonium acetate and Casein in pure form can be used to attract more flies than both checks.

Effect of mixing Maro, host of melon in Cue-lure for male annihilation of fruit flies in bitter gourd at Charsadda:

Maro (Long tida) is one of the most susceptible host of melon fly, B. cucurbitae. Cue-lure is available as commercial male attract for this species and used for its

annihilation in the field. To enhance the attraction of Cue-lure, maro squash was blended in cue-lure @ 70, 80, 90, 95, and 99%. For this purpose maro was crushed in electric mixer and the squash was passed through fine cotton cloth to collected extract. Sodium benzoate @ 1g/kg extract was added as preservative. 5% Dipterex was added and killing agents. There were 8 treatments; each replicated four time.5 ml of each test material was applied on cotton wick in the trap. Traps were installed in 5 acre bitter gourd field at Charsadda in RCB Design. Only pure extract and cue-lure commercial trap were also include as treatments for comparison of results. Flies captured and killed in each trap/week were brought in polythene bags for counting and species identification in laboratory. Data was recorded for 9 weekly observations.

The results showed that besides one major species i.e. *B. cucurbitae,* one unidentified species was also recorded. Interaction of test material and weeks showed variation. However over all mean number of flies captured in 9 weeks indicated that maximum number off 122.5 flies/trap/week was captured in trap containing 30% cue followed by 111.5, 106 flies/trap/week in traps containing 1 and 5% Cue respectively as compared to minimum number of 22.8 flies were found in pure Maro extract and 80.7flies in standard trap. Relative abundance study showed that major species responsible for bitter gourd infestation was melon fly , however, out of 21320 specimens collected in all treatments, only 6 specimens of an un-identified species were also collected in test traps containing 20, 30 and 100% cue-lure.

New Record of Fruit Fly Bactrocera tau (Walker):

Experiments were conducted by mixing cue-lure (1-100%), luffa squash juice (70-95%), sugar (10%) & Diptrex (5%) for attraction of melon fruit fly *Bactrocera cucurbitae* (Coquillett) under field conditions at Charsadda (Khouro Kalay). A new record of fruit fly *Bactroceratau* (Walker) belonging to genus *Bacterocera* had been found in luffa squash/ gourd field. Body of fly was balanced mixture of black and yellow colors, and thorax scutum with a pair of lateral vittae (stripes) and an unpaired medial vitta. Wing partly bare, dominant wing pattern costal-banded, cell bc microtrichia absent, and cell c microtrichia present in apical area. Abdomen ovate or parallel sided, abdominal tergites separated, and abdomen in lateral view arched and dome-like. Fruit fly *B. tau* appeared to show a preference for attacking the fruits of host species belonging to the family Cucurbitaceae in male attractant cue-lure and luffa squash juice. The variations for adult's density were detected with population tended to peak in the last week of May when crop was typically ripe, pest declined to low levels by start or mid-June, and very low numbers captured during the end of month.

Morphological Response of Bitter Gourd (*Momordica charantia*) to Melon Fruit Fly:

The undertaken research consisted of field and laboratory experiments to investigate the morphological basis of resistance in fruit of bitter gourd (*Momordica charantia* L.) to melon fruit fly *Bactrocera cucurbitae* (Coquillett). The variety Pali showed significant field tolerance to fruit flies compared to Hybrid that was highly susceptible. There were significant differences in test varieties for fruit infestation, and larval, pupal and adult densities per fruit. Melon fruit fly field infestation was significantly lower (10%) in Pali compared to 18% infestation in the susceptible Hybrid in both no choice and free choice oviposition trials. Fruit attributes length (cm), width (cm) and number of teeth/ cm^2 showed a positive association with fruit fly infestation and noted the important biophysical fruit traits contributing antixenosis in bitter gourd against pest. There were significant differences in test varieties for fruit infestation and pest multiplication when bittergourd was exposed to fruit flies for 1, 2 and 3 days having a positive association

with pest density and increase in exposure time. The variety Pali was identified as tolerant source to melon fruit fly under field and laboratory conditions, and can be further used in resistance breeding programs to have a diversify basis of resistance for evolving tolerant varieties against fruit fly *B. cucurbitae*.

Quarantine pests and their control:

Pakistan has a wide range of tropical, sub-tropical and temperate fruits and stands among the top ten citrus growing countries in the world. Pakistani Kinnow has good demand abroad, as foreign fruit vendors generally prefer it due to its peelable nature. Mango is ranked as second important fruit for export after citrus. The citrus psylla, *Diaphornia citri* Kuawayama, is the key pest of citrus in Pakistan and declared as quarantine pest in many parts of the word. Mango scales are quarantine pests of secondary importance. Pakistan consequently loose export of citrus and mangoes to the pest free countries as the immature stages, particularly eggs and nymphs, can be transmitted with fresh fruits to the importing countries. The WTO regulations for export of fresh commodities require disinfestations of the pests before export. Recently irradiation has been adopted as safe measure for disinfestations of the quarantine pests. Research data on the quarantine pests (citrus psylla and scale insects) is very limited. Experiments were conducted to determine irradiation doses for the control of these pests prior to their export to foreign countries.

Effect of gamma irradiation on the quality tributes of kinow:

Irradiation was examined as a potential phytosanitary treatment to control *A. aurantii*. The effect of radiation followed by storage at room temperature (15^0C ± 2, RH 65 ±5) on the quality attributes of wax and un wax kinnow was examined. It was found that taste and visual quality decreased within thirty days storage at room temperature but these were still in acceptance range. Increasing storage duration resulted in significant increase in weight loss, total soluble solids and TSS/Acid ratio, while ascorbic acid content and percent acidity decreased with extension in storage duration. Percent weight loss varied significantly with storage time but insignificantly among the irradiation doses for waxed and un waxed fruit. The interaction among the treatments and storage time on weight loss was also insignificant. Overall results revealed that irradiation of fresh fruits applied for the control of quarantine pests up to 0.5kGy is safe and does not cause any significant change in the biochemical and organoleptic properties of fresh fruits. Waxing of fruits in association with irradiation was found effective in better maintaining the sensory quality of kinnow for a storage period of 30 days.

Effect of gamma irradiation on physiochemical and organoleptic properties of mango fruit:

Physiochemical analysis and sensory quality of mango fruit (*Langra varity*) was examined after their exposure to gamma irradiation at different doses in the range (100-250 Gy) for the control of *Aspidiotus destructor*. All fruits were stored after irradiation at temperature of 29.0±1 and R.H. 42±2.6 % for 8 days to check the quality of irradiated and un irradiated mango fruits. Insignificant decrease in weight loss, firmness and TSS was noted in fruits irradiated at 250 Gy after eight days storage. However, increase in acidity, and decrease in vitamin C content was recorded after eight days storage period. Sensory evaluation through odour, appearance and taste decreased with storage duration but fruits were still in acceptable range. However, fruits in control had low scoring as compared to irradiated fruits by the trained observers. Thus irradiation of mango with gamma rays doses not have any adverse effect on the quality of mangoes and may be used safely as phytosanitary control measures for export to other countries.

MEDICAL ENTOMOLOGY

Vector borne diseases are emerging threats in Pakistan and require special attention. The recent spread of dengue vectors to the non-endemic areas in Pakistan show the potential challenge of dengue vectors in the country. Mosquito surveillance studies are required in the current situation of environmental and climatic changes occurrence worldwide. Vaccine is not available for many vector-borne diseases and chemical control of vectors is not safe. Therefore, environment friendly approaches including Sterile Insect Techniques (SIT) are needed to reduce vector populations.

Evaluating attractancy of various botanicals in ovitraps:

Extracts of botanicals such as cinnamon, eucalyptus, burmoda grass and lime were tested for attractancy in ovitraps at two sites; NIFA Peshawar and SINOR Swat. Weekly Record of oviposition/ larval counts was taken. Preliminary data from these sites indicated that eucalyptus and cinnamon are consistently better in attraction than lime and grass after 15 days in traps. Lime did not attract any mosquito. Attractancy starts after 2 weeks.

Community participation in the campaign of dengue vector control:

Under IAEA TC 5066 on promoting the sharing of expertise and infrastructure for dengue vector surveillance towards Integration of the Sterile Insect Technique with conventional control methods among South and South East Asian Countries. This division organized four workshops on prevention and management strategies of vectors and their associated diseases at different locations of KPK. One workshop was held at the Abdul Wali Khan University Bunir campus, second at the district agriculture extension office Swat, third at the Swat public school (SPS) Swat and forth at the office agriculture research station Bunir. Students, faculty members of the university, principals and teachers from elementary schools/ colleges and district extension officers, agriculture field assistants and community leaders participated as master trainers in these workshops to combat dengue vectors.

Dengue vector Surveillance and their environment friendly management:

Mosquitoes surveillance was carried out in Swat district of KPK. From our surveillance of vector species from different sites in Swat, both *Aedes aepypti and Aedes albopictus* were found as the potential dengue vectors in the study area with the House Index (HI= >5.8%) and Breteau index (BI = >22%) during September to November. Under conventional control strategies for Integrated Vector Management (IVM), we tested the larvicidal efficacy of different plant extracts against the different developmental stages (3-4th instars) of the *Culex* and *Aedes* species as an environment friendly control method and found the crude extracts of *Parthenium hysterophorous* (an invasive weed) @ 3% as an effective and safe larvicide. We are also testing its efficiency under field conditions.

Sex separation using nutritional, behavioral, mechanical means for an effective SIT program of Dengue vectors:

Different sources of carbohydrates and proteins were tested in single and combined diets experiments. Male/female size and ratio, larval duration and other developmental period were recorded for the tested diets. Different light intensities were also tested for the possible separation of male/female pupae. The movement of the pupae into top and bottom direction was noticed followed by the separation of pupae into 2 categories (Top/Bottom) due to different light stimuli. Male/female ratio were recorded for the respective positions resulted by different tested light intensities. Different mesh size were tested for the possible effective separation of sexes at pupal stage. Low temperatures in combinations of different

treatments were tested for possible sheathing in female pupae and thus increase in chances of induced dimorphism. Results revealed that the diet comprising mainly of carbohydrates were conducive for the growth of male sexes of *Aedes alobopictus.* These diets favored the male size (270-310μm) and percent number of males ratio (60-67%). However, the protein based diets skewed in favor of females both in term of size (380-390 μm) and mean percent number (50-60%). This was good idea to exploit for sexing, however, single diet did not resulted in remarkable difference in male/female size that may be exploited for the sex separation. However, it gave a clue for the potential of a distinct dimorphism. The developmental period was also prolonged (up to 11.65 days) due to single diet inputs especially the carbohydrate based ingredients. We therefore, tested the combination of protein and carbohydrates in different ratio. The combined diets in deferent concentration and ratios favored the dimorphism ranging (360 μm male, 590 μm female) remarkably for subsequent mechanical separation. However, these results are being confirmed by the repeated trials and need standardization. We also exploited the Photosensitivity behaviour of male/female for mechanical separation. The female pupae being more photosensitive to the light, their tendency of mechanical separation through different flush of lights were tested in a mix culture of the male and females in the rearing plastic tubs. The pupae on the top and bottom were kept separately and the percent number of sexes (male/female) were recorded. Among the different light intensities tested 100 watt of Inflorescent and 1000 watt of Incandescent light were found effective in separating the sexes. The pupae selected from the top resulted in 76.60% to 86.67% males. Similarly, in case of females the bottom positions resulted in significantly higher number of females 78.93-87.80 %. However, efforts are continued to minimize the percent of the unwanted sexes in the respective position. Different sieve (locally available) of different mesh sizes were tested for the mechanical separation in the repeated trials. The mesh size (12) was relatively more effective (90.67 males and 9.33% females) in sex separation. We have received the mesh set of various mesh sizes from IAEA, we will try to standardize its use for mechanical separation after the development of the appropriate diet formula. We found some traces of sheath formation at low temperature, necessary confirmation tests needed. The sheath resulted in increased size and thus will help in separation.

Dengue Guard

Dengue Guard a repellent product for personal protection against mosquitoes, ticks, mites, fleas, louse, bed bugs and other biting insects has been formulated for use on expose body parts. The product is stain free, safe, environment friendly with no side effects such as eye or skin irritation. Thirty three thousand three hundred twenty two bottles of 50 ml were prepared during 2014-2015 and supplied to various PAEC organizations on demand. The product has good popularity and demand for application by PAEC security & Pak. Army. The product is also useful during flood and other crises situation for internally displaced and naturally exposed people during crises situation.

TERMITE MANAGEMENT

Termites cause considerable losses to agricultural crops, orchards and buildings of Pakistan. Most of these termites are subterranean and cryptic in nature. Unlike aerial insects which can easily be traced and controlled, termites live hidden as underground colonies with millions of workers spread over a large area which may be hundreds of square meters. Conventional use of repellent insecticide beneath the structures is considered to be major resort for control of termites for last many decades, but it's very expensive and environmentally hazardous method. Use of non-repellent insecticides and IGRS in slow acting toxicant

baits are considered to be cheap, more effective, permanent and environment friendly control of subterranean termites. Therefore, experiments were done to evaluate commercial formulations of several non-repellent termiticide and IGRs to see their potential for use as slow-acting toxicants against subterranean termites.

Lab evaluation of commercial grade Hexaflumuron and Lufenuron:

The studies were conducted to test various concentrations ranging from 100–10,000 ppm (wt/wt) of hexaflumuron and lufenuron to determine dose response relationship. It was recorded that hexaflumuron caused <50% mortality in termites exposed to 100 – 5000 ppm whereas at 10,000 ppm it caused >70% mortality after 25 days and ELT_{90} projected was 74 days. In dose-response study of lufenuron all the concentrations equal or greater than 250 ppm caused > 50% mortality but maximum mortality recorded was >70% which was caused by 10,000 ppm and ELT_{90} recorded was 49.2 days. Over all we concluded from our study that both hexaflumuron and lufenuron were dose dependent and showed characteristics of slow acting toxicant. The concentration of 10,000 ppm seemed to be appropriate with required results of killing termites in effective period of time. The lufenuron was comparatively more toxic but hexaflumuron showed potential to be used in slow acting toxicant bait against *H. indicola*.

Evaluating effectiveness of a range of sand mixtures as termite barriers:

Experiments were conduct to evaluate the effectiveness of a range of sand mixtures as cheap and environmentally safe physical barrier against *Heterotermes indicola* and correlation of the aggregate properties of mixed sand and body size of termite workers were determined in relation with tunneling behavior. The construction sand was sieved through standard mesh analysis using sieve numbers 20, 30, 40, 50, 60, 70, 80 (ASTM standards). These sized particles were then used individually and in different ratios and to find out the effective sand barrier. Sand of Mesh Size 20 was found to be effective physical barrier for blocking *Heterotermes indicola* entry. Similarly those mixtures of sand that were having high ratios of 20 and 30 size sand particles were more resistant to termite entry.

BIOLOGICAL CONTROL

Establishment of egg parasitoid, *Trichogramma chilonis* (Ishii) & *Sitotroga cerealella* (Hub.) culture at Laboratory:

Trichogramma chilonis were reared on the eggs of the Angoumois grain moth, *S. cerealella*. Wheat grains were used as a rearing medium for *S. cerealella*. The moths were collected through an electrically operated suction apparatus and caged in oviposition chambers (2 kgs of plastic jars with a wire mesh of 25 holes/ sq. inch size at the bottom). Wheat starch was used as an oviposition substrate and eggs of *S. cerealella* were collected daily by sieving the wheat starch. Egg cards were prepared by gluing *S. cerealella* eggs to paper cards (9×4 cm) & were then exposed to *T. chilonis* in a 300 ml glass jar for 24 h. Parasitoids were fed with 50% honey solution provided as small drops on the walls of the glass jar. The cards were removed from the jar & kept in petridishes at laboratory conditions (23 ± 2^{o}C, 16L: 8D & 60% R.H.) for further use in the experiments.

Effect of *Sitotroga cerealella* (Oliv.) eggs age on oviposition preference of the female parasitoid, *Trichogramma chilonis* (Ishii)

Sitotroga eggs of 8-10, 24, 48 and 72 hours of age were exposed to parasitize by *T. chilonis* females in a no-choice experiment. A prepared egg card containing approximately 1500 host eggs of each age were introduced in a parasitization 300 ml glass jars containing 50 pairs (male & female) of freshly emerged less than one day *T. chilonis* & were removed

after 24 hrs. The parasitized egg cards were maintained at 23-25±2ºC, 16 L: 8 D until melanization of the parasitized eggs. The parasitized & unparasitized eggs were counted and then % parasitism of *S.cerealella* eggs was calculated. According to the obtained results, the effect of host egg age on parasitism by *T. chilonis* did not reveal an overall treatment effect (F= 0.95). This implies that *T. chilonis* does not discriminate between host ages of less than one day. The developmental period of inside the host eggs remains almost the same in both the experiments i.e. 11 days.

Parasitism of *Sitotroga cerealella* (Oliv.) eggs as influenced by the age of the female parasitoid, *Trichogramma chilonis* (Ishii):

The effect of age of *Trichogramma chilonis* female on the extent of parsitization of the host eggs *S. cerealella* was investigated. *T. chilonis* females of different age groups (treatments), 8-10, 24, 48, 72 & 96 hours were used after emergence and expose to fresh eggs (4-6 hrs. old) of *S cerealella which were* glued on hard paper card (9 x 4 cm) at 1500 eggs/card. Fifty pairs (males & females) of each age groups of *T. chilonis* were introduced into each of the 300 ml of glass jar containing a prepared egg card and were allowed to parasitize for 24 hrs. The egg card was removed and the extent of parasitism was noted by counting the total number of the parasitized and un-parasitized eggs. A second experiment on investigating the effect of parasitoid age on parasitism showed that *T. chilonis* laid significantly the highest average numbers of eggs at 80.6 and 69.4% during the first 8 and 24 h of its age respectively. Later, the parasitization decreased to 35% by the end of day 4. Thus, for the highest yield of parasitoid production, it is important to use younger *Trichogramma* for parasitization.

Stability of Iodine in Iodized Salt in Different Packing Materials under Different Climatic Conditions:

The Recommended Daily Allowance (RDA) for iodine is 100 µg/day for newborn children and 150 µg/day for adults. Iodine Deficiency Disorders (IDD) is a generic name given to all imperfections because of absence of iodine in the diet. Iodine insufficiency is the main reason of brain damage and mental retardation in the world. In addition to mental retardation, iodine deficiency causes endemic goiter, cretinism, dwarfism, mental retardation, muscular disorders, spontaneous abortions, sterilization, and stillbirths. In Pakistan IDDs are affecting about 50 million population of whom 6.5 million are seriously affected. IDD is not confined only to the hilly areas of the country, it is also prevalent in the plain areas like Swabi, Peshawar, Islamabad, Lahore, Karachi and Quetta.

Table salt is a suitable vehicle for iodine fortification, due to its limited sources, habitual use, simple technology for salt iodization, adoptable at local level and low cost. Universal salt iodization is, therefore, the recommended intervention for preventing and correcting iodine deficiency. Salt is iodized by the addition of fixed amount of potassium iodate as an aqueous solution at the production stage. In Pakistan, the law mandates that salt for human consumption must have iodine levels of more than 30 ppm at the production level and 15 ppm or more at the consumer level. This gap of iodine content between the production and consumer end is to allow for losses of iodine which take place in transit and storage from the production of salt to its consumption at the household. There has been a significant increase in the price of potassium iodate in the international markets which significantly increases the cost of iodization, highlighting the need to minimize the use of iodate and cost. In this context, there is a need to quantify the exact losses of iodine in different types of salt in the typical environmental conditions of Pakistan. This will inform the policy on the optimal level of salt iodization that will ensure the recommended level of iodine intake by the population at the household level. In this backdrop, current MI funded studies were undertaken to evaluate the stability of iodine in iodized salt types packed in different packing materials and stored under different climatic conditions of Pakistan.

Iodine stability was studied in the six major types of salt in Pakistan, namely washed and dried lake salt, refined lake salt, good quality rock salt, poor quality rock salt with impurities, refined rock salt and sea salt. Four types of packaging materials which are in common use for salt storage namely; (i) High Density Polyethylene (HDPE), (ii) Low Density Polyethylene LDPE (iii) Laminated and (iv) Woven polypropylene (PP) packaging were used. Iodization of all salt types at a level of 30 ±2 PPM was carried out in the R& D facility of Hub Salt Refinery at Hub Industrial State. Salt samples were then transported to the following storage sites

a. Swat Institute of Nuclear Oncology and Radiotherapy (SINOR) Saidu Mingora Swat
b. Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad
c. Atomic Energy Medical Center (AEMC) Karachi
d. Nuclear Oncology and Radiotherapy Institute (NORIN), Nawabshah

These locations were selected as representative of the 4 climatic zones of Pakistan. The salt samples were analyzed in the beginning (0-day) of storage and subsequently at 3 months intervals for a total storage period of one year. Samples were analyzed through accredited laboratory of Qarshi Research International (QRI) at Hattar.

Initial results on iodine retention by different salt types packed in different packing materials and stored at various locations indicated highest iodine retention in the PP packed salts and lowest with HDPE. Very little inter-location differences were noted. Among the salt types, the washed dried lack salt showed the highest iodine retention followed by good quality rock salt from Punjab. The refined rock salt, refined lake salt and sea salt showed some small iodine losses whereas the poor quality rock salt from KPK mines exhibited the highest iodine losses.

Although the exact reason for quick iodine losses from the poor quality rock salt could not be ascertained, it seems that the poor quality rock salt from KPK mines contains such impurities which do not allow iodine to stay adsorbed on the surface of the salt particles. It was noted in the initial stage of storage that the laminated pouches of this salt turned yellow after a few days of storage. That might be due to the fact that the lamination layer did not allow iodine molecules to leave the packing after it had already sublimed. This led to the deposition of iodine on the packing and resultantly gave it a yellow color. This extraordinarily high iodine loss may not be related to salt pH, moisture contents, Mg as chloride and Ca as sulphate contents because data does not support that. However, it was noted that this salt contained the lowest concentration (97.2%) of pure NaCl indicating the highest concentration of impurities. However, merely the total concentration of impurities may not fully explain the phenomenon because the washed dried lake salt also had almost similar amount of impurities (97.6%). However, the poor quality rock salt obtained from KPK mines seems to be unfit for iodization. It may however, be fit for industrial uses.

Development of market life enhance-ment technology for persimmon fruit and its dissemination to growers:

The tropical agro climatic conditions of this province are well suited for production of persimmon fruit. However, persimmon plantation on commercial scale has been undertaken in KPK relatively recently. The fruit has gained much popularity in Peshawar, Mardan, Malakand, Dir and Swat valleys.

In spite of the agro climatic blessings and very obvious export potentials, only few persimmon growers are earning foreign exchange by exporting the fruits to Far East and Middle East markets. The global volume of persimmon export has been rather insignificant (less than 8000 tons in 1999) of which 82% was from Israel. The main hurdles encountered are its short market life, the presence of astringent taste due to phenolic in this fruit and lack of awareness among growers regarding the technologies for astringency removal of persimmon.

Current studies were undertaken under an ALP funded project which consisted of R&D work on astringency removal from persimmon fruits, development of a pilot scale facility for astringency removal treatment of persimmon fruits and finally its popularization. During the current (3rdproject year), fabrication of the Modified Atmosphere Chamber was completed and studies were conducted for a). optimization of the chamber conditions, b). removal of astringency from persimmon fruit and c). time required for the astringency removal treatment of the fruit.

Optimization of the chamber conditions:

To summarize the results of these experiments, following parameters were standardized for optimization of chamber

- Time required for the vacuum =10-15min
- Pressure after vacuum = -20 inch Hg
- Nitrogen consumed in each trial = 2bar.

Studies conducted for removal of astringency from persimmon fruit:

For studies conducted for removal of astringency by treating the fruits (greenish yellow) for 48 hrs (activity 1), 90 hrs (activity 2) and 96 hrs (activity 3) in modified atmosphere chamber while for studies conducted for removal of astringency/ value addition hard yellow fruits were treated for 96 hours (activity 4) in modified atmosphere chamber. Persimmon from orchard at Chukha Gujar Chimkani were collected at pre picking stage (greenish yellow) followed by sorting, washing, keeping for removal of adhering water and dividing in to two lots i.e. Control fruit kept in open crates and treated fruits, kept in modified atmosphere (created by evacuation of chamber and addition of nitrogen gas after evacuation) for 48 hrs with addition of nitrogen gas. All the samples were analyzed for quality parameters (acidity, ascorbic acid, pH, TSS, water extractable total phenols) after 01, 07, 14, 21 and 28 days to check the effect of treatment and storage in comparison to untreated (control) fruits.

The results of activity 1 revealed that mean values of acidity for control samples were 0.2967% which decreased to 0.27, 0.1633, 0.1433 and 0.12 %, respectively, during four weeks of ambient storage. The mean values for acidity of treated samples significantly ($P<0.05$) decreased from 0.2967 to 0.0933% during storage. The effect of treatment as well as storage on acidity was significant. The effect of ART chamber treatment and storage on the pH, total phenol, vitamin C, hardness and weight loss were significant ($P<0.05$). The effect of storage on TSS was significant while the effect of treatment was non-significant. The effect of ART chamber treatment and storage on the sensory evaluation (taste) were significant

The results of activity 2 revealed that mean values of acidity for control samples were 0.19% which decreased to 0.17, 0.16, 0.14 and 0.12 % respectively during four weeks of ambient storage. The mean values for acidity of treated samples significantly ($P<0.05$) decreased from 0.19 to 0.0933% during storage. The effect of treatment as well as storage on acidity was significant. The effect of ART chamber treatment and storage on the pH, total phenols, vitamin C, hardness, weight loss were significant ($P<0.05$). The effect of storage on TSS was significant while the effect of treatment was not significant. The effect of ART chamber treatment and storage on the sensory evaluation (taste) was significant.

The results of activity 3 revealed that the effect of ART chamber treatment and storage on acidity pH, TSS, total phenol, vitamin C, hardness and weight loss were significant ($P<0.05$). The effect of ART chamber (treatment) and storage on the sensory evaluation (taste) were significant. The effect of treatment time and improvement in taste showed linear correlation.

The results of activity 4 revealed that mean values of acidity for control samples were 0.15% which decreased to 0.0867 % during four weeks of ambient storage. The mean values for acidity of treated samples significantly ($P<0.05$) decreased from 0.15 to 0.05% during storage. The effect of treatment as well as storage on acidity was significant. The effect of ART chamber treatment and storage on the pH, TSS, total phenol and hardness were significant ($P<0.05$). The effect of storage was not significant and the effect of treatment on the taste were significant. The data of all these experiments revealed an improvement in taste, reduction in phenol contents and extension of shelf life of persimmon fruits.

The results of the four experiments were pooled together for comparison and for

selection of the treatment time. The data revealed that considering the important parameters, astringency and weight loss, texture and taste/ consumers acceptability, treated fruits for 96 hrs collected at pre picking stage could be beneficial for the removal of astringency and extension of storage period.

Extrusion Cooking for Development of Snack Product

Formulation containing rice flour (40 to 50%), wheat flour 20 to 25%), corn starch (5%), sugar (10%), dried citrus peel powder (5, 10, 15%), salt, baking soda and maltodextrin (1%) were prepared according to the experimental plan. The ingredients were dry mixed, ground and passed through a 40 mesh screen. Moisture content was adjusted to 30%. The extruder was run at 150 rpm and heating was provided through the extruder barrel. The product temperature measured with thermocouple inside the die reached up to above 100^{o}C at the die and the extrudate expanded. Some of the treatments resulted in relatively acceptable products.

Development of Method for Preservation of Strawberries

Effect of vacuum packaging, irradiation and combination of the two was studied on storage life of fresh strawberries. The samples were packed in polyethylene pouches and glass bottles without addition of water or anything else. They were vacuum packed in pouches for vacuum and vacuum plus radiation treatment as well as radiation treatment. The control samples had spoiled in one day while the treated samples survived up to one week but showed fungal growth to varying degrees. pH of the fruits was 3.5 while its TSS was around 5.

Color Enhancement of Topaz, its Analytical and Microstructure analysis before and after Gamma Irradiation

There are almost 4000 known minerals, of which only about 50 are commonly used as gemstones. Precious stones suitable for jewelry are seldom encountered in nature; however, there are great resources of colorless types of these stones which are of little value. Therefore, with respect to the growing demands for jewelry, it is necessary to study different methods for stone color enhancement. Treated gemstones such as topaz, Kunzite, Tourmaline and quartz are very common frequently subjected to various treatments in order to improve their appearance in terms of color and transparency, and hence increase their commercial value.

- Our XRD study is validated by the software database of ICDD (International Center for Diffraction Data)
- EDX study gave us the composition of the sample in which the major elements were already specified by our XRD study
- SEM analysis support both XRD and EDX by providing us some new micro structures after irradiation (different grain sizes and orientation)
- The change in weight% occurs after irradiation of the samples
- Due to irradiation effect concentration of the impurities increases
- Concentration of the impurities causes color enhancement in the gem
- Our study shows the presence of impurity/trace element which is iron (Fe) for topaz Skardu and Calcium (Ca) for Katlang topaz
- This investigation of iron (Fe) as a impurity is supported by literature

Cultivation and growth of oyster mushroom on wheat straw substrate with different sterilization methods and its nutrient analysis

The economic importance of mushroom lies primarily in its use as food for human consumption. It is rich in Vitamin C and B complex and the protein content (on dry weight basis) varies between 16 to 25 percent. It has most of the mineral salts required by the

human body. The niacin content is about ten times higher than any other vegetables.

Folic acid present in oyster mushrooms helps to cure anemia. It is suitable for people with hyper-tension, obesity and diabetes due to its low sodium: potassium ratio, starch, fat and calorific value. Alkaline ash and high fiber content makes them suitable for consumption for those having hyperacidity and constipation. A polycyclic aromatic compound pleurotin has been isolated from *P. griseous* which possesses antibiotic properties.

NIFA has successfully developed cultivation technologies for the following strains of mushrooms and standardized compost making for the following species:

- Oyster
- Milky
- King Oyster
- Button

The developed oyster strain and its cultivation technologies were disseminated through one day workshops to the farmers in the following different areas of KPK.
Hazara valley, Hari pur, Chitral, Swat valley , Balakot, Shinkiyari, Batagram , Bunner, Charsadda, Mardan, Peshawar and Nowshera.

Development of Irradiated Foods for Immuno-compromised Patients and Other Target Groups:

In continuation of the previous work under IAEA funded project, experiment was carried out on shelf life extension of fresh fruits. The aim of the study was the provision of clean fruit with low bacterial counts to immuno-compromised patients. Fresh and healthy apples of uniform maturity were selected at picking stage and were brought to NIFA laboratories. They were cleaned, washed thoroughly with potable water and packed in polyethylene pouches. All the samples were irradiated at the doses of 1,2,3,4, 5 KGy and stored at ambient room condition for 30 days.

The results show that the ascorbic acid content decreased significantly with the advancement of storage time. The mean values at zero day were 3.59 (mg/100g) which decreased to 2.62 (mg /100g), after 30 days of storage, while irradiation treatments had also significantly affected the ascorbic acid contents of the samples. Minimum decrease was noted in the sample irradiated with a dose of 1 kGy while maximum decrease was observed in 4 kGy irradiated samples.
The results show that the total soluble solids were increased significantly with the advancement of storage time. The mean values at zero day were 11 % which increased to 17 % after 30 days of storage. Statistically the increase in the total soluble solids during the storage period was significant in all the samples but there is no significant effect of radiation treatments on total soluble solids of fresh packed apples store at ambient condition.
The mean score noted by the panel of judges for the appearance of samples were 7.66 (T_1), 7.53 (T_2), 6.44 (T_3), 6.14 (T_4). The result shows that maximum score was obtained by the samples treated with 1.0 kGy and the minimum score was obtained by the samples treated by 4.0 kGy. Samples irradiated with 1 kGy and 2 kGy were still acceptable after 30 days of storage while samples irradiated with 3.0 kGy and 4.0 kGy were disliked by judges.

Acceptability of gamma irradiated apples

The mean values for overall acceptability of fresh apples, treated with different doses of gamma radiation were 7.21, 7.16, 5.33, 4.98 packed in transparent package and 7.35, 7.20, 5.30 and 4.91 packed in opaque packaging. Samples irradiated at 1.0 and 2.0 kGy received the highest score and sample receiving 3.0 and 4.0 kGy of gamma rays scored the lowest. It is also stated that the samples irradiated with 1.0 kGy and 2.0 kGy were still acceptable after 30 days of storage while samples irradiated with 3.0 kGy and 4.0

kGy were disliked by the panel of judges at the end of the storage time.

Effect of Irradiation on Preservation and Storage Quality of Energy Dense Foods for Disaster Affectees

The aim of the study was to check the storage quality of energy dense packed foods for victims of natural disaster. Different meals like honey spread, energy bites and wheat cupcake were prepared aseptically, packed in polyethylene (Opaque) and vacuum sealed. The samples were divided into three lots. Two of them were irradiated at doses of 5 & 10 kGy, while the third was kept controlled for comparison. They were stored at ambient condition for a period of 45 days. Data regarding the result of total bacterial count, shows that the initial count of control samples was $8.0x10^4$ per gram of sample but after 24 hrs, they were discarded and excluded from the experiment due to spoilage. The initial bacterial count of the samples irradiated in the dose of 5 kGy was $6.4x10^2$ per gram of sample which increased to $5.5x10^3$ after a storage period of 30 days, but these samples were also found highly contaminated with bacteria and spoiled after one month storage period, so they were also discarded. The bacterial load in the samples irradiated at 10 kGy were found at permissible level during the entire storage period of 45 days. No bacterial count was observed initially in the samples irradiated at the dose of 10 kGy while after 45 days, total bacterial count was as less than 20 TBC per gram of sample. The samples were also analyzed for Coliform bacteria and no count was observed in any sample irrespective of treatments and storage intervals. Consistent decreases in overall acceptability score of all the samples was recorded with the increasing storage time. However the decrease was within the acceptable level.

Pesticide Residues Monitoring and Management in Fruit and Vegetables

Pesticide residue monitoring in fruits and vegetables was carried out under the PSF funded research project "Development and Validation of Technologies for Pesticide Residue Management in Fruit and Vegetable Produce". Vegetable samples were collected from suburbs of Peshawar and Charsada areas. Modified QuEChERS extraction and clean-up method was used as sample preparation method for the analysis of organo chlorine, organophosphate, carbonate and pyrethroid pesticide residues in spinach, cabbage and cauliflower by gas chromatography with electron capture detection (GC/ECD) and HPLC-UV/VIS. Samples of okra, eggplant, cucumber, cabbage, tomato, spinach, cauliflower, guava ad peach were collected form Peshawar, Charsadda, Nowshera, Swat and Hazara division. Highest frequency (80%) of residues were detected from okra samples, followed by eggplant 70%), tomato (50%), cucumber (30%), cauliflower (20%) and cabbage (10%). Residues of cypermethrin and endosulfan were detected in okra with 60% and 50% samples exceeding MRL, respectively. This was followed by cauliflower with residues of λ –cyhalothrin and chlorpyrifos exceeded MRL in 40% and 20% samples respectively; cucumber with residues of cypermethrin exceeding MRL in 30 % samples; eggplant with residues of λ –cyhalothrin and chlorpyrifos exceeding MRL in 20% samples each; and tomato with residues of chlorpyrifos exceeding MRL in 10 % samples. In the guava and peach samples predominantly residues of chlorpyrifos and cpermethrin were detected. Peach had higher frequency of residues (40%) than guava (20%) with 13% and 3% samples with residues exceeding MRL respectively.

Dissipation studies were conducted for imidachloprd in cucumber fruit. Cucumber samples were sprayed with imidachlorprid solution @ 3X MRL. Samples were collected at 0, 5, 10, 15, 20 and 25 days after spray. Each samples was divided to get subsamples i.e. whole cucumber to investigate pesticide residues dissipation at different intervals;

cucumber peel and pulp to study the imidachloprid migration between peel and pulp. Samples were processed by modified QuEChERS with simultaneous cleanup for analysis by HPLC-UV detector and the chromatographic separation was carried out using C-18 column. The dissipation of imidachloprid on cucumber has goodness of fit r^2 = 0.96 and r^2 = 0.95 zero-order ($R = k(A)^0$) and first-order ($R = k(A)^1$) models respectively indicating more than one factor involved in the dissipation. The half-life of imidachloprid was calculated as 3.4 days by both the models. The migration studies indicated a similar behavior of imidachloprid in cucumber as was observed in peach and higher migration of imidachloprid from peel to pulp was observed.

Previous studies revealed that the pesticide migration lead to inefficiency of the residue removal methods like washing with water or surfactant and peeling due to higher concentration deposition in pulp portion. Therefore the efficacy of penetrating treatment like gamma irradiation was studied in the removal of imidachloprid. Aqueous solution of dimethoate, heptachlor, chlorpyriphos, α-endosulfan, β-endosulfan and profenofos @ 2MRLconcertation were prepared and exposed to irradiation doses (0.15, 0.25, 1, 4, 6, 8, 10 and 16 kGy) in three replicates each. The samples after irradiation were analysed by GC/ECD to investigate the effect of gamma irradiation on the dissipation of pesticides over control where no irradiation treatment was applied. A variable effect of irradiation was observed different pesticides (figure 1). Liner effect negative of irradiation doses and the residue concentration was observed (Table 1). Profenofos was found most sensitive to irradiation with ED_{50} (> 1 kGy) followed by dimetjoate (ED_{50} = 5.5 kGy), chlorpyrifos (ED_{50} = 6.5 kGy), β-Endosulfan (ED_{50} = 7.5 kGy), α-Endosulfan (ED_{50} = 10.2 kGy) and heptachlor (ED_{50} = 12.6 kGy). These result indicate potential of irradiation as pesticide removal technique for certain pesticides.

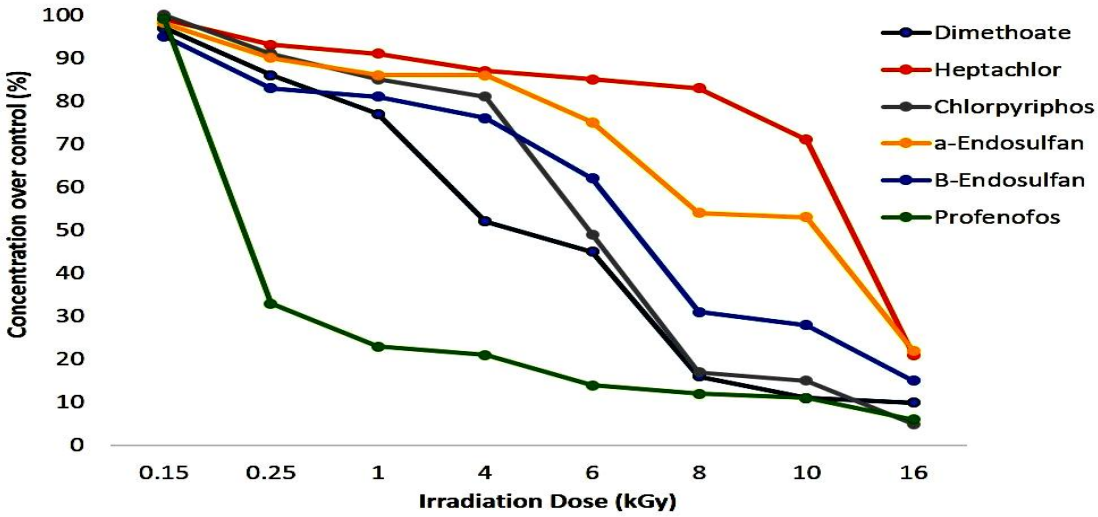

Figure 1. Pesticide dissipation pattern in response to irradiation treatment.

Development of Innovative Neutraceutical products from indigenous Herbal Ingredients to Improve socio-economic status of the communities

The main objective was to formulate and develop, safe and efficacious nutraceutical products from local precious underutilized herbal resources

To promote local health, herbal and pharmaceutical industries by motivating them to use indigenous plant based resources for the development of innovative health/nutraceutical products

Technology transfer

Three products were developed under this project, i.e. Cardionifa, Nutra N and Gastronif. These products were tested on 48 volunteers to study their efficacy. Feedback Performa has been taken from all volunteers using the products. The overall acceptance was very satisfactory (above 75%). However some improvements suggested in the feedback were rectified and solved

- In "Cardionifa" the bad and pungent smell or bad breath of garlic was removed with grinded caraway (sonf) and carom seed (Ajwain) with grinded garlic and mixing in apple cidar.
- Viscosity: The use of pectin as thickener is not recommended as pectin has to be dissolved in syrup with constant shaking at high temperature which is not recommended as high temperature above 60º C may leads to destroy active ingredients. Use of Sodium Alginate to increase viscosity has shown good results
- The shelf life of the products has been increased from 5 months to 1 year after irradiation of the individual dry herbs along with commonly used preservative like pot. meta bisulfate
- All products were analyzed microbiologically for total bacterial count (TBC) and total fungal count (TFC). No growth was observed in any sample and found them safe for human consumption.
- Similarly the products were also tested for different toxic heavy metals and found that no metal was present above the permissible daily intake limit.

The clinical trials for the three products were carried out for different parameters like liver function test, lipid profile and complete blood picture etc. The basic idea behind these tests was to check, whether these products cause undesirable change to any parameter. There was no parameter which could be out of range by using these products, indicating safety of these products for human.

Green Growth Technologies:

The environmental protection group of Food Science Division (FSD) has developed Green Chemicals, largely based on herbal and organic raw (petroleum based) materials and tested on fruits, vegetables and crops at NIFA and farmer fields in KPK. A study was conducted on pea crop to evaluate the level of synthetic and bio-pesticide residues. The level of pesticide residues analyzed on Gas Chromatograph in synthetic chloropyrifos was much above the Maximum Residues Limit, while in bio-pesticides and biosynthetic pesticides it was below MRL level. Another study was conducted on okra crop to study the effect of bio-pesticides and synthetic pesticides on controlling pest attack. Such experiments have proved to be very effective in controlling the pests attacking these fruits; vegetables and crops without polluting the environment and leaving no residues. These bio-pesticides are cost effective and very economical as compared to the commercially available inorganic pesticides.

Different methods were taken to observe the effect of different pesticides used in this study.

1. Insect Count

This was done by counting the numbers of insects on 20 different plants from each plot. We took 5 leaves from each plant, 2 from top, and 2 from bottom and from middle (5 leaves / plant).While at first time the counting of insects was done twice / week and then once / week.

2. Damaged leaves count

We found three damaged leaves per plant to study the effect of treatments on the insets

3. Infested plants count:

Twelve infested plants were recorded in each plot out of 20 plants.

4. Yield

Orkra fruits was plucked for 40 to 45 days and total yield per plot were calculated

Table 1: The count of infested plants in each plot

Control group	12 Infested Plants / 20 Total selected plants
Synthetic treatment group	→ 1210 7 / 202020 →
Curcuma treatment group	→ 12 9 6 / 202020 →
Neem treatment group	→ 12 7 3 / 202020 →

Table 2: The effect of different treatments against pests (Insects) on Okara:

Control group	38 individual leaves	25leaves	30 leaves	21 leaves
Synthetic treatment group	38 individual leaves	22 leaves	19 leaves	17 leaves
Curcuma treatment group	38 individual leaves	20 leaves	23 leaves	10 leaves
Neem treatment group	38 individual leaves	19 leaves	21 leaves	06 leaves

Table 3: The total yield (kg/plots) of the control, synthetic, curcuma and neem treatments of okra:

Pesticide Treatment	Okra Yield (kg/m^2)
Control group	33.8
Synthetic treatment group	39.0
Curcuma treatment group	47.7
Neem treatment group	53.3

The potential to increase crop production is a critical issue as the adverse effects of climate change are bringing extreme weather events such as drought, floods, heat waves and undesirable rainfall distribution. The scientists of the Soil Science Division are helping farmers to adopt climate smart agriculture practices and farming system for reducing ill effects of climate change on natural resources (soil, water and nutrients) use efficiency, crop yield and to minimize the green house gases emission. The scientists of this division are also providing help to Plant Breeding and Genetics Division in screening of genotypes/cultivars for drought/nutrient stress to cope with the effects of climate change.

Integrated management of nutrients and water for growing off-season vegetables in high and walk-in tunnels:

Vegetables are an important component of daily meals in Pakistan and there is a great demand of vegetables round the year. It is a rich source of vitamins and carbohydrates which are essential ingredients for growth of human body. Off- season vegetables farming under tunnel is highly profitable as compared to traditional vegetables farming. Off-season vegetables can be cultivated with limited moisture supply using high tunnel technology having efficient irrigation system in which temperature is partially controlled during winter. The irrigation water and fertilizers are efficiently utilized in this package of technology.

The technology is very suitable for small land holders having limited water source and in return they will get maximum profit compared to traditional farming. The livestock is a major component of rainfed farming system and farmyard manure is easily available in these areas that will be utilized properly in integrated nutrients management for growing off-season vegetables/nursery. However, the current practices of irrigation, fertilizer and fungicide application in tunnel farming are without any scientific basis which led to a great economic loss and cause environmental pollution and health problems. Therefore, use of fertilizer through fertigation not only ensures nutrient and water use efficiency but also curtail economic losses of currently used fertilizer practices. It is also helpful in reducing fungicide application by controlling humidity and disease susceptibility. Other potential benefits of cultivation of off-season vegetables under tunnels are higher yield and better quality. In addition to higher food production and improvement in socioeconomic status of small growers, this technology will also enhance the water/fertilizer use efficiency with minimum use of fungicide. Thus the technology of growing off season vegetables in tunnel has been established at NIFA to demonstrate its pros and cons to the growers. Four experiments were conducted under high and walk in tunnels on off-season tomato, cucumber, squash gourd and sweet pepper to improve fertilizer, nutrient and water use efficiency in these vegetables using fertigation and other management practices.

A workshop was arranged during April, 2015 to demonstrate the high tunnel farming

technology to the vegetable farmers. About 60 growers of districts Peshawar and Nowshera participated in the work shop. The crops attained the fruiting stage and we were planning to collect the data but unfortunately all crops were destroyed by severe hail and thunder storm. The tomato fruit samples collected during 2013-14 were analyzed for NPK and quality parameters. The results showed that NPK uptake was significantly higher in the treatment NPK (80:80:90) after each 30 and 45 day's interval respectively.

BIOFORTIFICATION OF ZINC IN WHEAT FOR BALANCED HUMAN NUTRITION

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

In the 21st century, nutrient efficient plants will play a major role in increasing crop yields compared to the 20th century, mainly due to limited land and water resources available for crop production, higher cost of inorganic fertilizer inputs, declining trends in crop yields globally and increasing environmental concerns. Furthermore, at least 60% of the world's arable lands have mineral deficiencies or elemental toxicity problems and on such soils fertilizers and lime amendments are essential for achieving improved crop yields. Fertilizer inputs are increasing the cost of production of farmers and there is a major concern for environmental pollution due to imbalanced use of fertilizer. Higher demands for food and fiber by increasing world populations further enhance the importance of nutrient efficient cultivars that are also higher producers. Nutrient efficient plants are defined as those plants, which produce higher yields per unit of nutrient, applied or absorbed than other plants (standards) under similar agro-ecological conditions. During the last three decades, much research has been conducted to identify and/or breed nutrient efficient plant species or genotypes/cultivars within species and to further understand the mechanisms of nutrient efficiency in crop plants. However, success in releasing nutrient efficient cultivars has been limited. The main reasons for limited success are that the genetics of plant responses to nutrients and plant interactions with environmental variables are not well understood. In view of these considerations a study was undertaken to assess the relative Zn-efficiencies of a various wheat cultivars.

Ten wheat cultivars were grown in chelate-buffered nutrient solution in a net house under prevailing environmental conditions. The seeds 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. Zn^{2+} activities of 2, 10 and 40 pM were employed to the plants. 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 results revealed that wheat plants exhibited the usual symptom of Zn deficiency like stunted growth and whitish-brown necrotic spots developed on the middle parts of the leaves. Different levels of Zn^{2+} activity showed a significant effect on the growth of wheat plants that led to enhanced growth and dry matter production. The genotype NRL-1302 has the maximum dry matter production at 40 pM Zn^{2+} which was 14.58 g/pot. In the Zn deficient solutions (2 pM Zn^{2+}), shoot dry matter production was distinctly lower and the

same genotype (NRL-1302) produced the lowest DM of 3.4 g/pot. Zinc efficiency of genotypes under study was determined by taking into account this variation in dry matter production at different Zn activities that varied between 23 to 53 %. The genotypes ranked as Zn-inefficient (NRL-1301 and NRL-1302) produced significantly lower dry matter yields than the Zn-efficient cultivars NRL-1306 and NRL-1318 at the Zn-deficient level. Zinc concentrations in the shoots of the different cultivars varied between 11.2 µg g^{-1} and 44.7µg g^{-1}. Generally, the Zn-inefficient cultivars (NRL-1301 and NRl-1302) had lower Zn concentrations (11.2 and 11.3 µg g^{-1}) than the Zn-efficient ones. In general, Zn efficient genotypes (NRL-1306 and NRL-1316) translocated higher amount of Zn from root to shoot and Zn translocation ratio was found to be 64.4 and 66.9 respectively.

Evaluation of Zn efficiency under field conditions:

Although the technique used to determine Zn efficiency in solution culture provides the same growth conditions and Zn activity as in soil, however there are many other factors which are suppressed in solution and affect plant growth. On the basis of above hypothesis an experiment was executed under field conditions with 10 genotypes, (4 Zn-efficient, 2 medium, 4 Zn-inefficient) and two levels of Zn (0, 5 kg ha^{-1} to observe 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 to select Zn deficient site. The available Zn in experimental site was 0.29 µg g^{-1}. The soil also contained 0.94% O.M, 6.8 µg g^{-1} Olsen P having pH 7.8 and ECe 1.9 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 outcome of the study is as under;

In general yield of all genotypes increased with Zn application, however, the response of each genotype was variable to the applied Zn. The wheat genotype NRL-1201 produced the highest biological yield of 14.5 t ha^{-1} with application of 5 kg Zn ha^{-1} which was significantly higher than rest of the genotypes. As for grain yield, NRL-1213 produced maximum yield of 2387 kg ha^{-1}. Under Zn stress conditions NRL-0707 (Zn efficient genotype) depicted higher grain yield of 1947 kg ha^{-1} which was significantly higher than all other genotypes. 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.

Differential growth and phosphorus uptake by wheat cultivars at different P levels:

Application of P fertilizers is recommended to cope with the wide spread P deficiency in agricultural soils around the globe. However, ever-rising prices of P fertilizer and its low use efficiency makes this practice uneconomical and environmentally unsafe. A wide variation exists among crop species and even cultivars for P acquisition form soil and its utilization within plant body. This variation can be exploited through selection and breeding for P efficient crop genotypes to sustain crop productivity and soil health. Therefore, solution culture study was planned to evaluate genetic variation among ten advance lines of wheat which is an important cereal crop of Pakistan.

Seeds of 10 wheat genotypes were sown in plastic trays containing distilled water washed gravel. After germination, five days old seedlings were transplanted in foam plugged holes of thermo-pore sheet floating on a continuously aerated modified Johnson nutrient solution contained in two stainless steel tubs of 50 L capacity. Two phosphorus levels were established by using ammonium phosphate ($NH_4H_2PO_4$) salt; adequate (250 µ M) and deficient (25 µ M) P levels. The pH of the solution was maintained at 5.5 ± 0.5 with

HCl or NaOH. Treatments were arranged according to completely randomized factorial design. Each treatment had three replications. Two seedlings were transplanted in one hole of a thermo-pore sheet and each hole was considered as one repeat. Experiment was harvested 30 days after transplanting and the data were recorded for dry biomass. Substantial differences in growth parameters such as total plant dry matter (TDM), shoot dry matter (SDM), root dry matter (RDM), root: shoot ratio and some phosphorus related parameters were obvious at deficient and adequate P levels. Total dry matter ranged from 0.60 to 2.53 and 1.34 to 2.70 g plant^{-1} at deficient and adequate P levels, respectively. Genotype NRL-1302 produced four times more SDM than NRL-1314 at deficient P level while NRL-1312 produced the highest RDM at adequate P level. Differences in SDM indicated that 60% of genotypes produced SDM less than the mean average shoot dry matter at both the P levels. The differences for phosphorus utilization efficiency and phosphorus stress factor (PSF) were also observed among these genotypes. Three out of ten genotypes depicted PSF greater than 50% and the rest less than 50%. Only three genotypes NRL-1302, NRL-1306 and NRL-1313 showed PSF<10%. Significant ($P \leq 0.05$) differences in P uptake, absorption rate and utilization rates were also observed in wheat genotypes at deficient and adequate P levels. Maximum root shoot ratio was exhibited by NRL-1317 and minimum by NRL-1313 at deficient P level, however, root to shoot ratio was higher at adequate P level than that at deficient levels of P. Wheat genotypes NRL-1302, NRL-1306 and NRL-1313 were found P-efficient while NRL-1303, NRL-1314 and NRL-1317 were found P in-efficient genotypes. Results showed the existence of genetic differences among wheat genotypes with regard to P absorption and utilization. A field study was executed during 2014-15 to confirm the results of 2013-14 hydroponic experiment. The results showed that wheat genotypes NRL-1120 and NRL-1220 were found P-efficient while NRL-1201 and NRL-1205 were found P in-efficient genotypes.

The effect of integrated P-management on wheat yield and P uptake:

Soils of Pakistan are generally alkaline and calcareous in nature and deficient in available phosphorous where wheat crop mostly suffers from P deficiency. In alkaline calcareous soils various factors including high pH, nature and amount of clay minerals, Fe and Al oxides and presence of free calcium carbonate control P availability. Application of inorganic P fertilizer in combination with organic fertilizer (FYM) was found effective in enhancing the use efficiency of inorganic P fertilizers. Organic acids are released during decomposition of organic matter which dissolve soil mineral P. Repeated incorporation of FYM can decrease soil bulk density, increase soil aggregation and moisture retention. All these factors may also help to increase P uptake by increasing root growth and mycorrhizal activity. Therefore, judicious and efficient use of inorganic P fertilizer and recycling of organic amendments is inevitable to maximize agricultural productivity on sustainable basis. This study was therefore, initiated with the objective of increasing the use efficiency of applied P fertilizers through integration with organic matter using wheat as a test crop.

Bulk surface soil (0-15 cm) samples were collected from NIFA, experimental research farm. Five kilograms of prepared soils was weighed and filled into glazed pots. The treatments included; control, FYM (5 and 2.5 t ha^{-1}), TSP @ 60 kg P ha^{-1}, SSP@ 60 kg P ha^{-1}, RP@60 kg P ha^{-1}, TSP+ 5 t FYM ha^{-1}, SSP+ 5 t FYM ha^{-1}, RP+ 5 t FYM ha^{-1}, TSP+ 2.5 t FYM ha^{-1}, SSP+ 2.5 t FYM ha^{-1},RP+ 2.5 t FYM ha^{-1}. Soil in pots was irrigated up to saturation percentage. After a week when soil reached to field capacity, pots were emptied and soil was remixed and refilled in the pots. Wheat *cv*. NIFA- Lalma was sown and five uniform plants per pot were allowed to grow after germination. Moisture contents in pots were maintained with distilled water at about 60% of the water-holding capacity during the growth period of plants. Experiment was harvested at maturity and the yield data were recorded. The results

indicated that wheat yield was significantly increased by the application of Rock phosphate (RP) + farmyard manure (FYM) as compared with control. The maximum grain yield of (58.3 gm/pot) was recorded in treatment where TSP + 5 t FYM ha^{-1} was applied followed by the treatment SSP + 5t FYM ha^{-1}. The minimum yield was observed in control treatment. The wheat yield from the pots treated with RP + 5 t FYM ha^{-1} was also higher than where only TSP and SSP was applied however, the difference was found non-significant. Maximum P uptake (417, 371 and 324 mg pot^{-1}) was observed in TSP, SSP and RP + 5 t FYM ha^{-1} respectively.

Effect of various level of NPK on yield of advance wheat lines:

Fertilizer use and its management are of crucial importance in irrigated wheat production system of Pakistan to achieve high yield. Two advance wheat lines of NIFA (CT-09137 and SRN 09111) 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 soil analysis showed that experimental field was silty loam in texture with pH of 7.7, organic matter 0.85%, 0.041% N and 5 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 yield of both wheat lines increased with increasing levels of nitrogen up to 140 kg ha^{-1}. The data showed that wheat line SRN-0911 produced maximum grain yield (3.07 t ha^{-1}) with application of 140-90-60 kg NPK ha^{-1} followed by wheat line CT-09137 that gave a yield of (2.95 t ha^{-1}). The maximum N and P uptakes by these lines were also found in the above treatment. It is concluded from the study that wheat line SRN 09111 performs better at 140-90-60 kg NPK ha^{-1} when applied in splits and at proper time.

Nutrient management of deciduous orchards (plum) through foliar feeding (PSF funded project No.253):

Foliar feeding is one of the best options to supply essential nutrients to plum orchards for improving fertilizer nutrient use efficiency yield and quality of fruits. Three field experiments (one at NIFA and two at farmer's field in Peshawar and Nowshera districts) are in progress. Plum bearing orchards of uniform size and age were selected. There are total seven treatments with three replications in RCB design and two trees per treatments. Treatments are as follows; T1 NPK (360 gm N +250 g P + 360 g K $tree^{-1}$) T2 (Farm yard manure (FYM) soil application (on N basis 360 gm N $tree^{-1}$) T3 (½ NPK + ½ FYM soil application, T4 (½ NPK+ ½ FYM (soil appln.) + foliar N (0.5% N) T5 (½ NPK+ ½ FYM (soil appln.) + foliar N (0.5% N) + Zn (0.1%), T6 (½ NPK+ ½ FYM (soil appl) + foliar N (0.5% N) + humic acid (0.05%) and T7 (½ NPK+ ½ FYM (soil appl) + foliar N (0.5%N) + Zn 0.1% + humic acid (0.05%). All soil applied mineral fertilizer and FYM were applied to the periphery of tree canopy. Half N fertilizer was applied before flowering and half with combination of P and K after fruit picking. According to the treatment plan half dose of inorganic N (urea) with farm yard manure were applied before bud sprouting in January 2015 to the periphery of tree canopy in soil. Leaves samples from the orchards were collected in mid of August to November 2014 and from mid of April to August 2015. Results showed that fruit yield was significantly increased by all treatments over control at all experimental orchards. Among the sites Mera kachori orchard produced maximum fruit yield than NIFA and Khushmuqam. The application of ½ NPK+ ½ FYM (soil appln.) + foliar N (0.5% N) + humic acid (0.05%) resulted in a significantly higher fruit yield at all sites than the rest of treatments. The fruit yield produced by this application at NIFA, Khushmuqam and Mera Kachori was 44.6,42.8 and 70.9 kg $tree^{-1}$ respectively. Increase in yield over other treatments was found to be 24, 26 and 41% at

respective locations. The N concentration was increased from 2.3 to 2.5% while Zn from 18.8 to 31.2 ppm observed at the end of July 2015. It is concluded from the experiment that combination of foliar and soil application of fertilizer significantly improved the yield of plum fruits and concentration of nutrients in leaves.

Studies on water and nutrient uptake of wheat genotypes in relation with root traits:

Field experiments were conducted at experimental farm of the institute during Rabi 2014-2015 to evaluate the yield performance of wheat varieties (Fakhr-e-Sarhad, Bathoor, Barsat) in conjunction with water use efficiency, nitrogen, phosphorus, potassium uptake and root yield. Experiments were laid out in randomized complete block design with three replications under both irrigated and rain-fed conditions. Neutron scattering moisture probe was used to monitor changes in soil water content (0-90cm) for determining water use efficiency. Non-significant differences were observed among varieties and irrigation treatments. Bathoor produced the highest grain yield (3.7 t ha^{-1}) under irrigated conditions while Fakhr-e-Sarhad produced the highest grain yield (3.7 t ha^{-1}) under rain-fed conditions.

Significant ($P \leq 0.05$) differences were observed between irrigation treatments while varieties did not differ significantly in water use efficiency. Varieties had higher water use efficiency under rain-fed conditions than under irrigated conditions. Barsat (26 kg ha^{-1} mm^{-1}) and Bathoor (9 kg $ha^{-1}mm^{-1}$) were the most water use efficient varieties under rain-fed and irrigated conditions, respectively. Significant differences ($P \leq 0.05$) were observed among varieties and irrigation treatments for root yield (0-50cm). Varieties had higher root yield in irrigated conditions than under rain-fed conditions. Fakhr-e-Sarhad was the leading root yielder and produced 3.97 and 2.96 t ha^{-1} under irrigated and rain-fed conditions, respectively.

Significant differences ($P \leq 0.05$) were observed among varieties and irrigation treatments for nitrogen uptake. Varieties exhibited higher nitrogen uptake under irrigated conditions than under rain-fed conditions. Fakhr-e-Sarhad exhibited the highest nitrogen uptake under irrigated conditions (87 mg $plant^{-1}$) while Barsat had highest nitrogen uptake under rain-fed conditions (74 mg $plant^{-1}$).

Significant differences ($P \leq 0.05$) were observed among varieties and irrigation treatments for P uptake. Varieties had higher P uptake under irrigated conditions than under rain-fed conditions. Barsat maintained relatively higher P uptake than other varieties under both rain-fed (20 mg $plant^{-1}$) and irrigated conditions (22 mg $plant^{-1}$). Non-significant differences were observed among varieties and irrigation treatments for K uptake.

Based on high grain and root yield under rain-fed conditions, Fakhr-e-Sarhad can be a suitable parent for further use in breeding program dedicated towards development of drought tolerant varieties. Barsat performed better than other varieties under rain-fed conditions in terms of its relatively higher water use efficiency and uptake of N, P and K. This study provided base line data for further use in simulation studies to hypothesize an ideotpye for water limited conditions.

Popularization of dual technology of agro-waste composting and biogeyser:

Technical support was provided for the establishment of a pilot-scale composting facility and small scale bio-geyser at Pakistan Academy for Rural Development, Peshawar. Model bio-geysers were practically demonstrated to Chairman, Pakistan Science Foundation and delegate from Turkish Coordination and Cooperation Agency, Islamabad on the eve of their respective visit to the institute. Based on effective presentation and merits of the technology, Pakistan Science Foundation has awarded a project worth Rs. 3.5 million to popularize the dual technology in selected districts of Khyber Pakhtunkhwa. Efforts are in progress to patent the dual technology of composting

and agro-waste bio-geyser.

Effect of boron application on oil seed brassica yield:

The experiment was conducted at NIFA experimental farm. Two varieties NIFA-Raya (juncia) and NIFA Gold (napus) evolved at NIFA were sown as an inter crop in eight years old plum orchard in RCB design with four replicates. Recommended distance between row to row for sowing was maintained along with other standard cultural practices. The basal dose of NP was applied as per recommendation at the time of sowing. Boron @ 1000 g ha^{-1} as foliar was applied on the crop at three different growth stages i.e vegetative (T_1), flowering (T_2) pod formation (T_3) and Control (T4). The results showed that the plant height was comparatively higher when boron was applied at vegetative growth stage compared to other stages. Maximum increase in grain yield over control (7.7%) was recorded for NIFA-Gold when boron was applied at flowering stage. Boron concentration in brassica leaves varies from 56 to 108 ppm in NIFA Raya while 51 to 105 ppm in NIFA Gold, respectively.

Effect of Foliar Application of Boron on Fruit Productivity of Orchards:

Forty-eight newly fruit bearing plants of uniform size were selected for the study at NIFA experimental farm. The trees were arranged in four replicates having 12 trees per replication and subjected to four B treatments in RCB design. The treatments T_1 (No B) control, T_2 (25 mg B/tree), T_3 (50 mg B/tree) and T_4 (100 mg B/tree) in the form of boron in solution were sprayed twice in a year on each tree at flowering stage and after fruit picking. Composite soil samples from 0 to 60 cm depth i.e (0-15, 16-30 and 31-60 cm) and leaves samples were collected from plum orchard. The physio-chemical properties of the soil show that pH of the soil ranged from 7.44 to 7.57, ECe from 0.45 to 0.5 dsm^{-1}, SOM from 1.2 to 0.2 %, P from 5.6 to 13.5 ppm, K from 100 to 20 ppm and B < 0.4 ppm in all soil depths. The leaves analysis showed that boron concentration was 30.4, 36.2, 44.6 and 48.3 ppm in T_1, T_2, T_3 and T_4 respectively. Application of B as a spray on plum orchard up to 100 mg/tree showed no positive effect on the fruit yield.

Effect of fulvic acid along with inorganic fertilizer on the yield and quality of potato:

Fulvic acids are excellent supplement to fertilizers to improve nutrient absorption. They can be applied to soil as well as to leaves. These acids act as chelating agent and hold nutrients for the plant to be absorbed over the time. Fulvic acids improve cell permeability when applied through foliar at relatively low concentrations. Very little work has been done in Khyber Pakhtunkhwa on this aspect. A study was designed to bridge this knowledge gap and to identify suitable treatment combination of foliar applied fulvic acid in conjunction with inorganic fertilizers for enhancing potato yield.

A field experiment was conducted at experimental farm of the institute during winter 2015. The experiment comprised of seven treatments and three replications. Experiment was laid out in randomized complete block design(RCBD) with sub-plot size of 15 m^2 for each treatment. Treatments included T1) control T2) NPK full dose T3) Fulvic acid @ 0.1 % (foliar) T4) Fulvic acid foliar @ 0.1% +ascorbic acid @ 50ppm T5) Fulvic acid foliar @ 0.1% +ascorbic acid @ 100 ppm T6) Half NPK + Fulvic acid foliar @ 0.1% +ascorbic acid @ 50ppm T7) Half NPK + Fulvic acid foliar @ 0.1% +ascorbic acid @ 100 ppm. The data revealed that maximum tuber yield (6.7 t ha^{-1}) was attained in treatment receiving half NPK + fulvic acid (0.1%) foliar+ ascorbic acid @ 100ppm foliar. It was followed by 5.5 t ha^{-1} yield in treatment receiving Half NPK + Fulvic acid foliar @ 0.1% + ascorbic acid @ 50ppm. Findings from the study revealed that fulvic acid has positive effect on yield of potato. These results need further confirmation to develop reliable recommendations for end-users.

SOCIO-ECONOMIC IMPACT

Plant Breeding and Genetics Division

This division is working on economically important crops i.e. wheat, oilseed and pulses regularly paying wider socio-economic impact in terms of boosting the farm productivity coupled with improving the financial status of the farming community. The NIFA released crop varieties are cultivating on appreciable area in the province as showing yield advantage up to 20% over other commercial varieties. A total of 7.5 tons quality wheat seed was provided to the stake holders despite adverse climatic conditions and limited available piece of land at the institute. The indirect effect of the availability of improved NIFA wheat varieties to private seed companies may generate employment opportunities for the local farming communities. Wheat diseases can have a wide impact therefore effective race non-specific germplasm was identified that will have visible economic benefits for growers.

Entomology Division

Developed and reported irradiation doses for control of citrus and mango pests will ease in export barriers. The fruit flies traps were also introduced to provincial Agric. extension department, farmers and training, workshops, were organized at NIFA. Adoption of fruit fly traps as an IPM component at field level and irradiation of harvested fruit for control of various pests will lead to positive socio-economic impact on farmer's life and pesticide free fruits and vegetables to the end users. More than 500 participants from hospitals, researchers, entomologists, and biologists from universities various R&D organizations and schools were trained in the disease epidemiology and vector surveillance of dengue vectors. NIFA Dengue Guard was developed for personal protection against vector borne diseases. The use of dengue guard against deadly vectors has led positive impact on living style of PAEC security personal and will provide added protection to internal displaced people affected by flood / unexpected disasters.

Soil Science Division

Integrated nutrients and water management technologies devised at NIFA for field, horticultural crops and tunnel farming are economical and environment friendly. By adopting these technologies, farmers of the Khyber Pakhtunkhwa are getting 15-30 % higher produce of different crops. The technology of bio-geyser was popularized by establishing of a pilot scale composting facility and small scale bio-geyser facility at Pakistan Academy for Rural Development, Peshawar. The technology of bio-geyser was practically demonstrated to Chairman, PSF and delegate from Turkish Coordination and Co-operation agency, Islamabad which resulted in award of a PSF funded research project for adoption of this technology at community level at 05 districts of KPK.

Food Science Division

The food technology section, through its ongoing projects on products development, food preservation, market life extension of persimmon fruits, has attracted interest of relevant stakeholders. Similarly, the Nutrition section is working on nutrition related problems of the society. By taking part in the national programmes on iron fortification of wheat flour and universal salt iodization, the section strives in its capacity for better health and nutrition standards among the masses. Technology on "Meals Ready to Eat" (MRE) for the immuno-compromised individuals and disaster hit communities with a view to help these segments of the population for better nutrition. Gemstone irradiation is undertaken by the Division for optimum utilization of the irradiation facilities available in the institute for value addition of the precious stones, enabling the local gemstone industry and traders for better economic returns.

PUBLICATIONS

1. Abid Farid, Maid Zaman, Muhammad Saeed, Maazullah Khan and Tahir Bad shah. 2015 Evaluation of boric acid as a slow-acting toxicant against subterranean termites (Heterotermes and Odontotermes). Journal of Entomology and Zoology Studies 3 (1): 160-164.

2. Ahmed H.M. and I. Ali, 2015. Meethi sarson ke kasht NIFA Gold ke Saath. Monthly ZARAAT NAAMA (Sep-Oct); Bureau of Agric. Information, Agric. Ext. , Peshawar, KPK. Pp 12-15. (Popular article in Urdu)

3. Arif M, Khan W, Ibrahim M and Fahim M (2015) Citrus tristeza virus: An increasing trend in the virus occurrence and distribution in citrus fruits of Northwest, Pakistan. African Journal of Biotechnology 14(30): 2352-2360 [IF: 0.57]

4. Bitani S, Habib Ur Rahman, Khan I, M.K. Daud 2015. Incidence and management of coconut scale, *Aspidiotus destructor* signoret (Hemiptera: Diaspididae), and its parasitoids on mango (Mangifera sp.) J. Crop Protection 74: 103-109. (impact factor 1.66).

5. Bitanni S, Habib ur Rahman, Khan I, M.K. Daud, , M.M Rashid 2015. Biology of Coconut Scale, *Aspidiotus destructor* Signoret (Hemiptera: Diaspididae), on Mango Plants (*Mangifera* sp.) Under Laboratory and Greenhouse Conditions. Pak. J.Zool. 47(4): 1163-1170. (impact factor 0.45).

6. Hanif M , Mansoor Khan Khattak, Masood Ur Rehman, Maazullah Khan. 2015. Evaluation of existing thin layer drying models on drying kinetics of persimmons (*Diospros Kaki*). Pakistan Journal of Agricultural Research; 53(2):1-5.

7. Hanif M., M. K. Khattak, M. Rahman, M. Aamir, M. Ramzan, M. Amin, Maazullah Khan, and S. Shiekh. 2015. Convective Drying of Chilies Using a Concentrating Solar Collector. Proceedings of the Pakistan Academy of Sciences 52 (2): 103–107.

8. Hanif M., Mansoor Khan Khattak, Masood-Ur-Rahman, Maazullah Khan, Muhammad Amin and Muhammad Ramzan. 2014. Performance Evaluation of a flat Plate Solar Collector as a Drier for Chillies and Tomatoes. Science Technology and Development. 33 (2): 63-67.
9. Hina, H.K., M. Sarwar, M.K. Lohar. 2015. Repellence Activity of Plant Oils against Red Flour Beetle *Tribolium castaneu*m (Herbst) (Coleoptera: Tenebrionidae) in Wheat. International Journal of Animal Biology, 1 (3): 86-92.

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11. Ibrahim M, Shah SJA, Hussain S, Ahmad M, Farhatullah, 2015. Virulence patterns of wheat yellow rust and effective resistance genes to *Puccinia striiformis* f. sp. *tritici* in Pakistan. International Journal of Development Research 5:3651-3657 [IF: 1.235]

12. Islam S, Inayatullah M, Jan S, Ibrahim M, Shah SJA, 2015. *Aphis craccivora* Koch on wheat in Pakistan. Int J of Farm & Alli Sci 4 (2): 86-88 [IF: 1.125]

13. Kamran S., I.A. Khan., M. Misbah-ul-Haq., M. Usman., S. F.Shah., A. Mehmood., T. Iqbal., Fakhruddin. 2015. Insecticidal studies on Heterotermis indicola Wasmann (Isoptera: Heterotermitidae) under laboratory conditions. JEZS. 3 (3): 348-350

14. Khalid, P.A., M. Hussain, M. Hassan, M. Sarwar and N. Sarwar. 2015. Evaluation of Bt-cotton Genotypes for Resistance to Cotton Leaf Curl Disease under High Inoculum Pressure in the Field and Using Graft Inoculation in Glasshouse. The Plant Pathology Journal, 31 (2): 132-139. (IF0.718)

15. Khalil S. A., N. Ahmad and R. Zamir. 2015. Gamma radiation induced variation in growth characteristics and production of bioactive compounds during callogenesis in Stevia rebaudiana (Bert.). *New Negatives in Plant Science.* 1(2):1-5.

16. Khan G.Z, I. A. Khan and Khan, I. 2014. Outdoor breeding of Mosquito species and its potential implication in Khyber Pakhtunkhwa. PJAR 27 (4): 303-3011

17. Khan GZ, Salman M, Khan I, Alam Zeb, Jawad Ali Shah, Azhar H, Ilyas Akbar, Aisha B, Sajjad Anwar, Badshah T, Saifullah, Amir Zaman 2015. Assessment of irradiation doses for sterility of vector mosquito and subsequent mating compatibility with wild females Journal of Entomology and Zoology Studies. 3 (2): 138-141.

18. Khan I, Badshah T, Saeed M, Khan GZ 2015. Testing efficacy of botanical and mineral kerosene oils on *Culex quinquefasciatus* mortality and their repellency in field ovitraps. *Science Postprint* 1(2): e00050. doi:10.14340/ spp.2015.05A0001.

19. Khan, G.Z., I. A. Khan and Khan, I. 2014. Exploiting the larvicidal properties of *Parthenium hysterophorus* (L.) for control of dengue vector, *Aedes albopictus*. Pakistan Journal of Weed Science Research. 20(4): 431-438.

20. Khan, I., Dameins, D., Soliban, S., Gilles, J. 2014. Effect of drying eggs, and eggs storage on hatchability and development of *Anopheles arabiansis* Malaria Journal 12: 318 (impact factor 3.40).

21. Khan, J., Ishtiaq, Syd A., KhanI. 2015. Effect of hexane crude extract of *Otostegia limbata* on 3rd instar larvae of *Drosophela melangaster* Meign (Diptera: Drosophilidae) Journal of Entomology and Zoology Studies 2 (2): 133-137.

22. Khattak G. S. S., Colin Webster,Iqbal Saeed and Abdul Jabbar Khan. 2015. Effect of soil strength on roots and vegetative growth of wheat at seedling stage.Pakistan Journal of Botany. 47 (2): 523-526.

23. Liusha H, Zaifeng L, Jiazhen W, Lingzhi S, Lin Z, Xing L, Daqun L, Shah SJA. 2015. Molecular mapping of leaf rust resistance genes in the wheat line Yu 3569. Journal of Integrative Agriculture 14(7): 1223-1228 [IF: 0.833]

24. Maazullah Khan, Nizakat Bibi and Aurang Zeb. 2015. Optimization of Process Conditions for Pectin Extraction from Citrus Peel. Science, Technology and Development 34 (1): 9-15

25. Maazullah Khan**,** Shahid Akbar Khalil and Nizakat Bibi. 2015. Effect of Dipping in Sugar Solutions on Drying Behavior of Cantaloupe. Science, Technology and Development 34 (2): 86-89.

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27. Misbah-ul-Haq. M., I. A. Khan.2015.Study of trail-following behavior of subterranean termite, *Heterotermes indicola* (Isoptera: Rhinotermitidae) after exposure to various concentrations of insect growth regulators . JEZS. 3(5): 406-411

28. Moghaddam A., Raza A., Vollmann J., Ardakani M.R., Wanek W., Gollner G., Friedel J.K. (2015). Biological nitrogen fixation and biomass production stability in alfalfa (Medicago sativa L.) genotypes under organic management conditions. Biol. Agric. Hort. 31 (3): 177-192

29. Raza A., Imtiaz M., Mohammad W., 2015. Wheat root selections for sustainable production. In: Licthfouse, Eric (Ed.), Sustainable Agriculture Reviews 18, DOI 10.1007/978-3-319-21629-4, Springer International Publishing, Switzerland. pp. 295-315.

30. Sarwar, M. 2015. Categorization of Some Advanced Local Wheat Lines against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). International Journal of Life Science and Engineering, 1 (3): 108-113.

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33. Sarwar, M. 2015. Species Diversity, Seasonal Variation and Abundance of Rodents (Mammalia: Rodentia) Along With Their Burrow Distribution Pattern in Wheat Farmland. Journal of Basic and Applied Research International, 5 (1): 48-55.

34. Sarwar, M., N. Ahmad, A. Rashid, S.M.M. Shah. 2015. Valuation of gamma irradiation for proficient production of parasitoids (Hymenoptera: Chalcididae & Eucoilidae) in the management of the peach fruit-fly, *Bactrocera zonata* (Saunders). International Journal of Pest Management, 61 (2): 126-134 (IF0.962).

35. Sehrish F. K, N.U. Khan, S. Gul, I. Ali. 2015. Fatty acid profile of upland cotton genotypes through near infrared spectroscopy. The Journal of Animal & Plant Sciences, 25(1): 212-225.

36. Shah SJA, Hussain S, Ahmad M, Farhatullah, Ibrahim M (2014) Characterization of Slow Rusting Resistance against Puccinia striiformis f. sp. tritici in Candidate and Released Bread Wheat Cultivars of Pakistan. Journal of Plant Pathology and Microbiology 5: 223. doi:10.4172/2157-7471.100022 [IF: 2.28]

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38. Wang J., Li Z., Shi L., Zhu L., Ren Z., Li X., Liu D., Shah SJA (2015): QTL mapping for adult-plant leaf rust resistance genes in Chinese wheat cultivar Weimai 8. Czech J. Genet. Plant Breed., 51: 79-85 [IF: 0.535]

39. Zahid M, Alamzeb, Salman M, Khan SA,and Khan I., 2015. Surveillance and Control of Peach flat-headed borer, *Sphenoptera dadkhani* (Oben.) in Plum orchard at Khyber Pakhtunkhwa (KPK). Sarhad Journal of Agriculture 31 (1): 30-36.

40. Zahid, M., Salman, M. Farid, A., Alamzeb and S.A. Khan. 2015. Degree-Day Forecasting Method: A Tool for Increasing the Precision of chemical ontrol for managing Peach flat-headed borer, *Sphenoptera dadkhani* (Oben.) (Coleoptera: Buprestidae). Pak. J. Zool. 47(6): 1771-1776. (IF:0.45).

Presentations/Proceedings

1. IAEA/RCA Regional Training Course on Application of Mutation Breeding and Screening of Target Traits in Bioenergy Crops from 24-28 August, 2015 in Beijing, China under TC Project RAS/5/070 (Attended by Hafiz Munir Ahmed, PS).

2. Mr. Iqbal Saeed is abroad for his Ph.D. studies in College of Agronomy, Northwest A&F University, Yangling, Shaanxi, P. R. China

3. Dr. Inamullah Khan Principal Scientist received PAEC Gold Medal Award on account of best performance

4. Dr. Gul Zamin Khan Completed Ph.D studies under HEC Indigenous fellowship programme. He completed his thesis on "surveillance and management of mosquito species with special emphases on dengue vectors in Peshawar'

5. Dr. Muhammad Misbah ul Haq completed Ph.D studies under HEC indigenous fellowship programme. He completed his thesis on "Caracterization of some non-repellent insecticides for the management of subterranean termite, *Hterotermes indicola* (Wsmann) (Ioptera: Rinotermitidae)"

TECHNOLOGY TRANSFER

Nuclear Institute for Food and Agriculture

Scientific Events Calendar 2015

Workshops | **Farmers'/Field Day** | **Trainings** | **Conferences**

http://www.nifa.org.pk

January

14 JAN
One-day Workshop on Popularization of Mushroom Cultivation Technology among the Farmers'
Organizer: Food Science Division
Contact: Fazal Mahmood, Head FSD
Cell: 0301 8580108
E-mail: fazalmahmood55@yahoo.com

February

10 FEB
One-day Workshop on Environment Friendly Farming & Biopesticides
Organizer: Food Science Division
Contact: Tariq Nawaz, ARO
Cell: 0300 9360856
E-mail: tariq_libra34@yahoo.com

March

20 MAR
Farmers' Field Day
Organizer: Plant Breeding & Genetic Division
Contact: *Abdul Jabbar Khan, Head PBGD*
Cell: 0301 8580083
Email: abduljabbarnifa@yahoo.com

April

8 APR
One-day Workshop on Integrated Nutrient Management of Plum and Off Season Vegetables
Organizers: Soil Science Division
Contact: *Dr. Wisal Mohammad, Head SSD*
Dr. S. Azam Shah, PS
Cell: 0345 57666611
0346 9072113
E-mail: wisalyasir@hotmail.com
azambpn3@gmail.com

15 APR
One-day Workshop on Insect Pests of Agricultural Importance
Organizer: Entomology Division
Contact: *Alam Zeb, Head ED*
Cell: 0333 9407406
E-mail: alamzeb@nifa.org.pk

May

20 MAY
One-day Workshop on Drying of Fruits & Vegetables
Organizers: Food Science Division
Contact: *Dr. Maazullah, PE*
Mrs. Nizakat Bibi, DCS
Cell: 0300 583409
Phone: 091 2964673
E-mail: maaznifa@yahoo.com
nizakatbibi@yahoo.co.uk

June

9 JUN
One-day Training Course for Lab Technicians on Analysis of Iodine in Iodized Salt
Organizer: Food Science Division
Contact: *Dr. Aurang Zeb, DCS*
Dr. Taufiq Ahmad, DCS
Cell: 0333 9014498
0333 9327561
E-mail: drzebkhattak@gmial.com
taufiqnifa@yahoo.com

August

19 AUG
One-day Workshop on Management Strategies for Insect Pests of Medical Importance
Organizer: Entomology Division
Contact: *Dr. Gul Zamin Khan, PS*
Dr. Inamullah Khan, PS
Cell: 0331 3811979
0334 9059180
E-mail: gulzaminkhan@yahoo.com
inamullah_nifa@yahoo.com

31 AUG - 11 SEP
31st Postgraduate Training Course on the Use of Nuclear and other Techniques in Food and Agricultural Research
Organizer: NIFA
Contact: *Dr. Azhar Rashid, PS*
Zahid Mehmood, SS
Cell: 0334 5326024
0333 5033898
E-mail: azoo74@yahoo.com
zahidnifa@gmail.com

September

16 - 17 SEP
Two-day Conference on Development of Bio-Energy Crops in Pakistan - Challenges & Opportunities
Organizer: Plant Breeding & Genetic Division
Contact: *Dr. Iftikhar Ali, DCS*
Hafiz Munir Ahmad, PS
Cell: 0333 9102990
0300 3090563
Email: iali63@yahoo.com

October

7 OCT
One-day Workshop on Value Addition on Persimmon Fruits by Astringency Removal
Organizer: Food Science Division
Contact: *Dr. Aurnag Zeb, DCS*
Mrs. Nizakat Bibi, DCS
Cell: 0333 9014498
091 2964673
E-mail: drzebkhattak@gmail.com
nizakatbibi@yahoo.co.uk

20 OCT
One-day Symposium on Irradiation as a Sanitary and Phyto-sanitary Treatment of Medicinal Herbs/Plants
Organizer: Food Science Division
Contact: *Dr. Ihsanullah, Director*
Dawood Khan, SS
Cell: 0301 8580029
0333 9295839
E-mail: ihsanullahdrnifa@yahoo.com
dawoodnifa2013@gmail.com

November

10 NOV
One-day National Workshop on Salt Iodization in Pakistan
Organizer: Food Science Division
Contact: *Dr. Aurang Zeb, DCS*
Cell: 0333 9014498
E-mail: drzebkhattak@gmial.com

December

03 DEC
One-day Workshop on Development of Irradiated Meals for Immuno-compromised Patient and Other Vulnerable Groups
Organizer: Food Science Division
Contact: *Misal Khan, PS*
Saeed Gul, ARO
Cell: 0334 8807660
0333 9375638
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saeedgul60@gmail.com

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Pectoral View of NIFA Scientific Events in 2015

Workshop on Popularization of Mushroom Cultivation, (January – 2015)

Workshop on Environment Friendly Farming & Biopesticides. (February – 2015)

Farmers' Field Day, (March – 2015)

Integrated Nutrient Management of Plum and Off Season Vegetables. (April – 2015)

Management Strategies for Insect Pests of Medical Importance, (August – 2015)

31st Postgraduate Training Course on the Use of Nuclear and other Techniques in Food and Agricultural Research. (August – 2015)

Workshop on Value Addition of Persimmon Fruits through Astringency Removal, (October – 2015)

Symposium on Irradiation as a Sanitary and Phyto-sanitary Treatment of Medicinal Herbs/Plants. (October – 2015)

Director NIFA giving overview of the activities of the institute in the concluding session of National Workshop on Salt Iodization in Pakistan (November – 2015)

Prof Dr. Salim ur Rehman, VC SUIT presenting a souvenir to Director NIFA delivered a lecture on “The State of Food Safety in Pakistan: Opportunities & Challenges” (November, 2015)

IAEA Expert and Director NIFA addressing participants of the Seminar on Preparation of Projects in the Current Scenario (December 2015)

Director NIFA, Mr. Zamir Ahmad, PAO and Mr. Latif Zaman DCAO addressing the participants in concluding session of Training Programme for Administrative/Secretariat Staff. (December, 2015)

FUNDED RESEARCH PROJECTS – ONGOING

S#	Project Name	Amount	Duration	Principal Investigator
1.	Wheat Production Enhancement Program (WPEP)	Rs. 13.608 m	2011 - 17	Mr. Abdul Jabbar Khan
2.	Development of Wheat Mutants for Higher Yield and Improved Efficiency of water and Nitrogen use (IAEA RC-17077)	Rs. 3.875 m	2011 - 15	Mr. Abdul Jabbar Khan
3.	Use of Irradiation as Phytosanitary Treatment for the Control of Citrus Psyllids Diaphoronia Citri and Scale Insects (RC-16894)	Rs. 2.503 m	2011 - 15	Dr. Inamullah Khan
4.	Exploring Mechanical and Nutritional Methods of Sex Separation in Aedes Albopictus Specie of Mosquitoes (RC-17926)	Rs. 1.179 m	2014 - 17	Dr. Gul Zamin Khan
5.	Selection of Irradiation Doses and Packaging Materials to Enhance Market Life of Sterile & Hygienic Meals for Patients and other Specific Communal Groups (RC-15116)	Rs. 1.982 m	2010 - 15	Mr. Misal Khan
6.	Development of Innovative Nutraceuticals Products from Indigenous Herbal Ingredients for Improving Socio-Economic Status of the Communities (PSF-178)	Rs. 4.000 m	2012 - 15	Dr. Ihsanullah
7.	Development of Locally Adapted Canola FI Hybrid using Induced Mutations and Doubled Haploidy Techniques (PSF-202)	Rs. 2.464 m	2012 - 15	Dr. Iftikhar Ali
8.	Development and Validation of Technologies for Pesticide Residue Management in Fruit and Vegetable Produce (PSF-203)	Rs. 2.844 m	2012 - 15	Dr. Azhar Rashid
9.	Nutrient Management of Deciduous Orchards through Foliar Feeding (PSF-253)	Rs. 2.91 m	2013 - 16	Dr. Azam Shah
10.	Development of Market Life Enhancement Technology to Persimmon and its Dissemination to Growers (ALP-056)	Rs. 4.737 m	2012 - 15	Mrs. Nizakat Bibi
11.	Stability of Iodine in Iodized salt in Different Packing Materials under Different Climate Conditions (MI)	Rs. 7.294 m	2014 - 15	Dr. Aurang Zeb

12.	Breeding High Yielding Mungbean (*Vigna Radiata) L.Wilczek) G*enotypes for the Agro-climatic Conditions of Kuram Agency (PSF)	Rs. 2.219 m	2016 - 19	Dr. Gul Sanat Shah
13.	Zero-Gravity Instrument Project (UN)	-	2015 – 16	Dr. S. Jawad Ali Shah
14.	Barley Yellow Dwarf Threat Assessment in Khyber Pakhtunkhwa and Identification of Resistant Sources for Wheat Improvement (DoST)	Rs. 0.50 m	2014 - 15	Mr. M. Ibrahim
15.	Promoting the Sharing of Expertise and Infrastructure for Dengue Vector Surveillance towards Integration of the Sterile Insect Technique with Conventional Control Methods among South and South East Asian Countries (IAEATC Regional)	EU 2,000.00	2014 - 18	Dr. Inamullah
16.	Plant Mutation Breeding of Bio-energy Crops for Optimizing Marginal Land Productivity-(RAS 05/070 IAEA),	EU 68,400.00	2015 - 18	Dr. Iftikhar Ali
17.	Development of locally adapted canola (Brassica napus L.) F_1 hybrids using induced mutations and doubled haploidy techniques. (PSF)	EU 2.473	2012 - 15	Dr. Iftikhar Ali
18.	Development of Application of Electron Beam and X-Ray Machine for Different Types of Food Products in Pakistan (IAEA CRP)	EU 30,000.0	2015-20	Dr. Ihsanullah

MANPOWER

A. Details of Present Scientific Strength:

CS	DCS	PS	PE	SS	SE	JS	ARO	Total
02	09	16	01	13	02	03	04	**50**

B. Scientists / Officers:

S#	Officers	Sanctioned	In Position	Vacant	Total
1.	Scientists	48	47	01	48
2.	Engineer	03	03	-	03
3.	Non-technical	05	05	-	05
		56	**55**	**01**	**56**

C. Staff (Technical/Non-technical):

S#	Staff	Sanctioned	In Position	Vacant	Total
1.	Scientific Staff	51	49	02	51
2.	Technical	19	17	02	19
3.	Non-technical	76	75	01	76
4.	Security & Chowkidars	24	21	03	24
		170	**162**	**08**	**162**

D. Detail list of Officers:

	Name	Designation
I.	Dr. Ihsanullah, Ph. D (Chemistry)	CS/Director
II.	**PLANT BREEDNG & GENETICS DIVISION**	
	Mr. Abdul Jabbar Khan, M.Sc. (Botany)	DCS / Head PBGD
	Dr. Iftikhar Ali, Ph. D (PBG)	DCS
	Dr. Gul Sanat Shah Khattak, Ph.D. (Botany)	DCS
	Dr. Babar Manzoor Atta, Ph.D (Breeding)	PS
	Mr. Roshan Zamir, M.Sc. (Hons. Agric.)	PS
	Dr. Syed Jawad Ahmad Shah, Ph.D. (Pathology)	PS
	Dr. Fazle Subhan, Ph.D. (Agronomy)	PS
	Mr. Hafiz Munir Ahmad, M.Sc. (Hons. Agric.)	PS
	Dr. Muhammad Irfaq Khan, Ph.D. (Breeding & Genetics)	PS
	Mr. Muhammad Amin, M.Sc. (Statistics)	SS
	Mr. Shahid Akbar, M.Sc. (Hons. Agric.)	SS
	Dr. Farooq-i-Azam, Ph.D (Genetics & Breeding)	SS
	Mr. Muhammad Ibrahim, M.Sc. (Hons. Agric.)	SS
	Dr. Syed Tariq Shah, Ph.D (Genetics & Breeding)	SS
	Mr. Salman Ahmad, M.Sc (Hons. Agric.)	SS
	Mr. Iqbal Saeed, M.Sc. (Hons. Agric.)	JS
	Mr. Akhtar Ali, M.Sc. (Hons. Agric.)	ARO
	Mr. Mumtaz Ahmad, M. Phil (Biotechnology)	ARO
III.	**FOOD SCIENCE DIVISION**	
	Mr. Fazal Mahmood, M.Sc. (Chemistry)	DCS / Head
	Dr. Aurang Zeb, Ph.D. (Nutrition)	CS / Head TSD
	Mrs. Nizakat Bibi, M. Phil. (Physical Chemistry)	DCS
	Dr. Taufiq Ahmad, Ph.D. (Chemistry)	DCS
	Dr. Maazullah, Ph.D. (Agricultural Engineering)	PE
	Mr. Misal Khan, M.Sc. (Hons. Agric.)	PS
	Dr. Azhar Rashid, Ph.D. (Biology)	PS
	Mr. Zahid Mehmood, M.Sc. (Hons. Agric.)	SS
	Mr. Mishbah Ahmad, (M.Sc.) Medical Physics	SS
	Mr. Dawood Khan, M.Sc (Chemistry)	SS
	Mr. Alamgir, (M.Sc.) Medical Physics	SS

	Dr. Muhammad Yaseen Ph.D (Food Science and Technology)	SS
	Mr. Ali Raza, M.Sc	JS
	Mr. Saeed Gul, B. Sc. (Chemistry)	ARO
	Mr. Tariq Nawaz, M. Sc. (Chemistry)	ARO

IV. ENTOMOLOGY DIVISION		
	Mr. Alam Zeb, M.Sc. (Hons. Agric.)	DCS / Head
	Mr. Amanullah Khan, M.Sc. (Zoology)	DCS
	Mr. Muhammad Zahid, M.Sc. (Hons. Agric.)	PS
	Dr. Inamullah Khan, Ph.D. (Entomology)	PS
	Dr. Gul Zamin, M. Sc. (Entomology)	PS
	Mr. Misbahul Haq, M.Sc. (Hons. Agric.)	SS
	Mr. Muhammad Salman M.Sc (Hons. Entomology)	JS
V. SOIL SCIENCE DIVISION		
	Dr. Wisal Mohammad, Ph.D. (Soil and Environment)	DCS/Head
	Dr. Imtiaz Ahmad, Ph.D. (Soil Science)	PS
	Mr. Mukhtiar Ali, M.Sc. (Hons. Agric.)	PS
	Dr. Syed Azam Shah, Ph.D. (Agronomy)	PS
	Dr. Amir Raza, Ph.D. (Agric. Sciences)	PS
	Mr. Zahid Ali, M.Sc. (Hons. Agric.)	SS
	Mr. Parvez Khan, M.Sc. (Hons. Agric.)	SS
VI. ADMINISTRATION & ACCOUNTS		
	Mr. Latif Zaman, B.Sc. MBA	DC Admin Officer
	Mr. Riaz Hussain	Pr. Admin Officer
	Mr. Raufullah, M.L.I.Sc.	Sr. Librarian
	Mr. Ihsan-Ul-Haq, MBA	Admin Officer
	Mr. Muhammad Fawad, MBA (Finance), CFA Level – 1	Acct. Officer
	Mr. Wahid Gul, BA, LLB	Superintendent

Promotion:

S#	Name	From	To	On
1	Dr. Aurang Zeb	DCS	CS	01.12.2015
2	Dr. Gul Sanat Shah	PS	DCS	01.12.2015
3	Dr. Muhammad Irfaq Khan	SS	PS	01.12.2015
4	Dr. Amir Raza	SS	PS	01.12.2015
5	Mr. Muhammad Islam	Sr. Tech	Pr. Tech	23.02.2015
6	Mr. Nasim Khan	Sr. Tech	Pr. Tech	23.02.2015
7	Mr. Arshullah	Assistant (Admin)	Sr. Assistant (Admin)	23.02.2015
8	Mr. Mehtab Shah	Tech-I	Sr. Tech	23.02.2015
9	Mr. Abid Munir	Tech-I	Sr. Tech	23.02.2015
10	Mr. Abdullah	Mali-II	Mali-I	23.02.2015
11	Mr. Maqsood Iqbal	Sr. Comp. Tech.	Pr. Computer Tech.	28.05.2015
12	Mr. Muhammad Nisar	Sr. Sci. Assistant	Pr. Scientific Assistant	28.05.2015
13	Mr. Mushtaq Ali	Sr. Sci. Assistant	Pr. Scientific Assistant	28.05.2015
14	Mr. Fazli Rabi	Sci. Assistant-I	Sr. Scientific Assistant	28.05.2015
15	Mr. Essa Khan	Sci. Assistant-I	Sr. Scientific Assistant	28.05.2015
16	Mr. Tariq Khan	Sci. Assistant-I	Sr. Scientific Assistant	28.05.2015
17	Mr. Muhammad Tariq	Sci. Assistant-I	Sr. Scientific Assistant	28.05.2015
18	Syed Manzoor Shah	Sci. Assistant-I	Sr. Scientific Assistant	28.05.2015
19	Mr. Hikmat Shah	Security Soldr-II	Security Soldier-I	28.05.2015
20	Mr. Luqman Shah	Tech-IV	Tech-III	01.07.2015

Transfer / Posting:

S#	Name	From	To	On
1	Mr. Umar Javid, JE-III (Admin)	KCP Hospital	NIFA, Peshawar	23.01.2015
3	Mr. Asif Murad, SE	ICCC, Islamabad	NIFA, Peshawar	16.03.2015
4	Mr. M. Younas Khan, Sr. Tech	NMC-II, Qabul Khel	NIFA, Peshawar	16.03.2015
5	Dr. Muhammad Sarwar, PS	NIAB, Faisalabad	NIFA, Peshawar	30.03.2015
6	Dr. Babar Manzoor Atta, PS	NIAB, Faisalabad	NIFA, Peshawar	20.04.2015
7	Mr. Salman Ahmad, SS	NIA, Tandojam	NIFA, Peshawar	28.04.2015

8	Mr. Fazli Ghafoor, Driver	NIA, Tandojam	NIFA, Peshawar	25.05.2015
9	Mr. Masood Khattak, Pr. Tech	DGRE-T, Islamabad	NIFA, Peshawar	25.05.2015
10	Mr. Sajjad Ahmad, Driver	BINOR, Bannu	NIFA, Peshawar	25.05.2015
11	Mr. Zafar Ali, Assistant (Admin)	PAEC HQs.	NIFA, Peshawar	05.06.2015
12	Mr. Umar Sajjad, AO	NIFA, Peshawar	NILOP, Islamabad	17.06.2015
13	Mr. Jahangeer Khan, SE	KCP, Jauharabad	NIFA, Peshawar	10.07.2015
14	Mr. Muhammad Islam, Sr. Assistant (Accounts)	IRNOR, Abbotabad	NIFA, Peshawar	13.07.2015
15	Mr. Nafees Hassain, Tech-II	CENAR, Quetta	NIFA, Peshawar	23.07.2015
16	Mr. Muhammad Ejaz, Security	NIFA, Peshawar	K-2/3, Karachi	31.07.2015
17	Mr. Muhammad Yousaf Khattak, PAO	NIFA, Peshawar	PAEC HQs	10.08.2015
18	Mr. Fawad Muhammad. Ac.O	NIAB, Faisalabad	NIFA, Peshawar	07.08.2015
19	Mr. Inayatullah, Gen.Attd.	PAEC HQs.	NIFA, Peshawar	24.08.2015
20	Dr. Samreen Shehzadi, SS	NIFA, Peshawar	PINSTECH, Islamabad	31.08.2018
21	Mr. Mishbah Ahmed, SS	NIFA, Peshawar	IRNUM, Peshawar	04.09.2015
22	Mr. Rahid Parvez, Gen.Attd.	WASO, Islamabad	NIFA, Peshawar	07.09.2015
23	Mr. Muhammad Karim, Sr. Computer Operator	PINSTECH, Islamabad	NIFA, Peshawar	05.10.2015
24	Mr. Noor Muhammad, Driver	PIEAS, Islamabad	NIFA, Peshawar	05.10.2015
25	Mr. Muhammad Hasnain Pasha, DEO	NILOP, Islamabad	NIFA, Peshawar	08.10.2015
26	Mr. Ahsan Taqveem, Computer Technician	ICCC, Islamabad	NIFA, Peshawar	18.11.2015
27	Mr. Riaz Hussain, SAO	DINAR, D.I.Khan	NIFA, Peshawar	01.12.2015
28	Mr. Amanullah, Driver	NIFA, Peshawar	DESTO, Islamabad	31.12.2015

Retirement:

S#	Name	Date
1	Mr. Haider Khan, DCS	05.01.2015
2	Mrs. Tasnim Sharafat, SRO	03.02.2015
3	Mr. Muhammad Ali, Tech-III	05.03.2015
4	Mr. Zafar Iqbal, Security Soldier	05.03.2015
5	Mr. Fazle Mabood, General Attendant	03.03.2015
6	Mr. Duran Shah, Pr. Tech	18.03.2015
7	Mr. Behram Khan, Driver	04.04.2015
8	Mr. Shehzad Victor, Driver	12.05.2015
9	Mr. Mehboob Ali, Driver	01.10.2015

Appointment:

S#	Name	Date
1	Dr. Muhammad Yasin, SS	16.07.2015
2	Mr. Ali Raza, JS	14.07.2015
3	Mr. Muhammad Salman, JS	14.07.2015
4	Mr. Latif-ur-Rehman, Jr. Executive-1 (Admin)	29.05.2015
5	Mr. Syed Muhammad Usman Shah, Mali-ll	01.10.2015