NIFA

Annual Report 2013

ISO 9001 : 2008 Certified

Nuclear Institute for Food & Agriculture
Peshawar, Pakistan

www.nifa.org.pk

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Pakistan Atomic Energy Commission

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HIGHLIGHTS

This report covers the R & D activities of NIFA for the year 2013. During this period, the aims of research and development efforts were i) enhancement of crop productivity through a) development of new varieties, b) integrated plant nutrient and soil management practices c) improved crop protection measures/approaches, and ii) Preservation and value addition of food commodities. Salient research and development activities carried out during the report period are described below:

Plant Breeding & Genetics

The research endeavors of Plant Breeding and Genetics Division culminated into the release of improved crop varieties of wheat and oilseed Brassica i.e. NIFA Lalma-2013 and NIFA Gold. These varieties were unanimously approved by the Provincial seed council in its 33rd meeting held on 5th March 2013 for general cultivation in Khyber Pakhtunkhwa. NIFA Lalma-2013 is high yielding and widely adapted to a range of environments in the country. NIFA Gold due to its high seed yield potential and canola quality will surely attract the farmers of KP and its cultivation by growers will increase the domestic production of edible oil. In addition, newly developed recombinant wheat lines NRL0707 and WL 08169 secured second position and also approved its worth for yellow rust resistance in the national trials for rainfed and irrigated conditions respectively. Eleven (11) tons quality wheat seed of NIFA released varieties was produced and duly certified by Federal Seed Certification and Registration Department. As per standard procedure the seed was then collected by provincial agricultural extension coupled with selected progressive growers in Khyber Pakhtunkhwa. The pulses program progressed well by developing chickpea and mungbean mutants. Eighteen elite chickpea mutants showed significantly ($p \leq 0.05$) higher seed yield as compared to the commercial checks. Mungbean advanced lines developed through hybridization and induced mutations produced statistically significantly ($p \leq 0.05$) higher seed yield (1583-1830 kg.ha-1) as compared to the check variety Ramzan (1333 kg.ha-1). Three promising recombinants namely NIFA Mung-1, NIFA Mung-2 and NIFA Mung-3 have been contributed for seed yield and stability evaluation in National Uniform Yield Trials. The biotechnology group is actively involved in the improvement of sugarcane and stevia. Frost tolerant sugarcane mutants were developed by creating genetic variability in the commercially cultivated sugarcane variety CP-77/400 through gamma rays. A couple of putative mutants were developed which are undergoing field testing at different ecological zones in the province. High yielding and high brix sugarcane lines CPNSL-034, CPNSL-005 and CPNSL-002 were multiplied prior to evaluation in national trials. The pronounced effect of irradiation on stevia crop was observed and desirable selection regarding higher biomass and steviosides contents was carried out. Similarly, hormonal effects were also observed during in vitro studies and potential clones were isolated. The plant pathology group dealt with occurrence of wheat diseases using stationary and mobile survey in southern, central and northern zones of Khyber Pakhtunkhwa. Highest average rust severity was recorded at Peshawar2 (33%) followed by Hari Pur (29%), Peshawar1 (19%), Swat (19%), Bannu (16%) and Nowshara (16%). Studies on Powdery mildew, Barley yellow Dwarf virus, and Black point were also carried out in different zones of the province. Pronounced occurrence of Powdery mildew and Black point was observed at Swat. BYD was only observed at Peshawar. Nine yellow rust pathotypes including 0E0, 96E0, 115E160, 59E240, 102E24, 106E88, 102E176, 98E16 and 102E16 were established using field data. Yellow rust resistance genes Yr1, Yr5, Yr6, Yr7, Yr8, Yr9, Yr10, Yr15, Yr17, Yr18, Yr24, Yr2, Yr27, Yr32 and YrSp in Avocet background behaved differentially across Khyber Pakhtunkhwa. No virulence was found against Yr10 which is reported in number of genotypes that can be used in wheat improvement program.

Entomology

The Entomology Division is engaged in integrated control of fruit flies, termites, peach flat-headed borer, and chickpea pod borer bruchid beetles. Under the Integrated pest management (IPM) system, we have been using different IPM components such as, biological, cultural, chemical, phytosanitary and irradiation to reduce crop losses. Citrus and mangoes are the two leading fruits of Pakistan in terms of area, production, and export. The division has close collaboration with the international atomic energy agency (IAEA) on development of generic irradiation doses for insect pests of quarantine importance and in post-harvest life extension of fresh commodities. In the field of medical entomology, integrated vector management control (IVM) program, the division has active collaboration with the national and international organizations in devising short and long term control strategies for the medically important disease carrying insects including mosquitoes and house flies.

Food Science

Scientists in the Food Science Division are working on value addition and shelf life extension of food/agricultural commodities through gamma radiation and other modern techniques and thus play their due role in achieving food safety and security. Results of the efficacy trial of irradiated MRE carried out at IRNUM hospital Peshawar, showed some very useful and positive indicators especially weight gain and increase in hemoglobin level in test groups of patients. Development and validation of analytical procedures/protocols for the determination of new and abundantly used pesticide residues in the fruit and vegetable matrices was carried out. Under the mushroom popularization program, 3 training were arranged at different locations of Chitral district. A total of 170 master trainers belonging to both genders were trained in these trainings whose written feedback about NIFA and PAEC was over whelming. They wowed to popularize this highly need-based technology at the grass root level of Chitral. Three model farms were established at different localities to meet the spawn requirement of the growers. Radiation treatment did not have any adverse effect on the broilers' biological performance; whereas mortality was higher in groups fed on control feed packed in commercially in vogue packing. Total phenolic content of persimmon showed that modified atmosphere treatment caused reduction in total phenol/astringency. Blending is the only option which could be used to prepare edible oils nearest to WHO and American Heart Association (AHA) recommendations that ratio of saturated, monounsaturated and polyunsaturated fatty acids should be as 1:1.5:1 and Omega6/Omega3 ratio of 5-10 in the diet. It is safe to predict that oils with balanced chemical composition of fatty acids in their triglyceride may pass as the nearest prototypes. Incorporation of whole wheat flour with milk thistle seed brought about a desirable improvement in the nutritional and sensory characteristics of chapatti. Thus, it could be inferred that Milk Thistle seed (an underutilized, indigenous, economical plant) could be used as a suitable functional ingredient in whole wheat flour chapatti with several benefits. In order to develop a nutritious snack product through extrusion cooking, corn starch, sugar, chickpea flour, peanut flour and Sodium-bi-Carbonate formulation was prepared. The product temperature measured with thermocouple inside the die reached up to 134^{o}C at the die. Inclusion of dry milk powder in the formulation significantly improved the texture and color of the product. Fresh oyester mushroom were obtained from NIFA mushroom farm and jamman fruit purchased from the Peshawar were packed in tin cans. These products retained their original color and texture during storage.

Soil Science

Scientists of the Soil Science Division are endeavoring for proper management and conservation of these natural resources to enhance crop productivity and to protect the environment. The scientists of this division are also helping plant breeders in developing nutrient efficient varieties and providing technical information to breeders about the nutritional requirements of their candidate varieties. During the period of this report different research activities remained in progress and the technology on growing of off-season vegetables in high and walk-in-tunnels was further refined by fabricating a drip irrigation system in one of our high tunnels. The integrated effect of NPK and FYM studied on hybrid tomatoes and cucumbers in high and walk-in tunnels indicated that maximum tomato fruit yield of 160 t.ha^{-1} was recorded in the treatment receiving NPK at 80, 80 and 90 kg.ha^{-1} at 30-day intervals and likewise the maximum tomato fruit yield (127 t.ha^{-1}) was recorded in the same treatment with additional soil application of 5 kg Zn.ha^{-1} in walk-in tunnel. Cucumber fruit yield of 240 t.ha^{-1} was recorded in the treatment receiving NPK at 125, 200 and 250 kg.ha^{-1} (soil application) with B spray (0.1%) at 15 day-intervals till crop maturity. Another study revealed that that NRL-1130 and NRL-1139 were Zn while NRL-1137 was B efficient genotype when screened out in pot culture where as the results of another field study showed that wheat NRL- 0517 and NRL- 0832 were found Zn and B efficient. Similarly out of ten wheat genotypes NRL-1105, NRL-1120 and Yecora were found Phosphorous efficient genotypes that can extract higher P from P deficient soil. Hydroponic study on Zn efficiency in wheat Zn-efficient genotypes produced 45% higher biomass and scavenged 36% more Zn from Zn-deficient medium as compared to Zn-inefficient genotypes. The study on drought tolerance assessed in wheat germplasm based on root traits revealed that maximum rooting depth was obtained by accession 11277 (76 cm) followed by accession 11144 (71 cm) and Fakhr-e-Sarhad (65 cm). The study on bio-compost preparation and application revealed that agro-waste compost improved the yield and quality of vegetables due to its slow-release nutrients supply. The residual effect of compost application was realized in tomato crop for three consecutive years with 38%, 25% and 15% increase in yield respectively and almost similar beneficial effect was observed in potato. The study on the effect on fulvic acid and inorganic fertilizer on yield and quality of tomato and potato showed that application of 1/2 of NPK + Zn (2.5 kg.ha^{-1}) + fulvic acid (150 ppm) gave 50% increase in tomato yield over control while increase was 43% for potato tuber.

Publications

Thirty six (36) research papers were published in national and international journals (Pages 36-38).

Funded Projects

Nineteen (19) research projects funded by national as well international agencies (PSF, ALP, and IAEA) are going on at NIFA (Page 39-40).

Training Courses/Workshops

Twenty eight (28) national/international training courses/workshops were organized by NIFA scientists including those given on page 45.

Acknowledgments

The team work of NIFA scientists and staff members has been commendable throughout the report period and certainly deserves appreciation and acknowledgment. On behalf of NIFA employees and myself, I sincerely thank the PAEC authorities for their continued support in helping the Institute to achieve its objectives.

Director NIFA

PLANT BREEDING & GENETICS DIVISION

Wheat Improvement

Wheat being the staple food crop occupies strategic space in the agricultural policy and covering about 58% of the food crop area in Khyber Pakhtunkhwa (KPK) Province. It is grown in diversified agro-climatic zones like north western hilly tracts, the central irrigated/semi-irrigated plans and southern mixed dry/hot areas in the province. The crop is always exposed to different biotic and abiotic stresses on account of which per acre yield is the lowest as compared to that achieved in other provinces of the country. Realizing the facts, NIFA wheat breeders are making concerted efforts for developing potential cultivars to meet the need of the farming communities for breaking the yield barriers coupled with tolerating the adverse climatic conditions. The research efforts to entertain the problems of irrigated/rainfed areas during the reported period are summarized as under:

Improvement for Irrigated Areas

Creation and exploitation of genetic variability

Genes recombination through crossing, induced single gene mutation and continuous selection of desirable recombinants/mutants with respect to disease resistance, higher yield and wider adaptability from different segregating populations is the prior and most important breeding strategy that ultimately results in the availability of economically important homozygous genotypes. A crossing block consisting of 178 variable genotypes was planted on two different dates. Based on transfer of genes for disease resistance and other economically important traits to otherwise well adapted cultivars/genotypes, fresh cross combinations among desirable wheat genotypes were attempted and F_0 seeds were harvested from 29 successful cross combinations. F_1 seeds resulted from 29 cross-combinations were separately harvested. Sixteen desirable F_2 recombinants were selected from F_2 population resulted from 18 different cross combinations. Similarly, eighteen putative mutants were selected from M_2 population resulted from the seed treatment of three wheat varieties with different doses of gamma radiation. Thirteen desirable F_3 families were selected from the population resulted from 16 cross combinations. Twenty two and seventy three desirable families of the previous cropping season were retained from F_4 and F_5 populations, respectively. Excluding F_0, selections from the above mentioned generations were planted at SARS Kaghan for generation advancement.

Field evaluation of exotic & indigenous wheat germplasm

Acquisition of wheat germplasm under global exchange program, (CIMMYT / ICARDA) in the form of observation nurseries by cooperating institutions always perform pivotal role for having desirable idiotypes by the breeders. NIFA regularly receives such kind of nurseries for evaluation under local conditions and utilizes the desired genotypes for further boosting the ongoing breeding activities.

International Bread Wheat Screening Nursery (45th IBWSN) consisting of 350 genotypes received from CIMMYT, Mexico, was evaluated with local check Bathoor-08. Based on plant type, yield performance and disease reaction (Yr and Lr) a total of 43 genotypes were selected. The selected genotypes, out yielded the check genotype Bathoor 08 (6549 $kg.ha^{-1}$) by producing grain yield in the range of 6387 to 9600 $kg.ha^{-1}$.

Stem Rust Nursery (7th SRN-2012-13) consisting of 150 genotypes was also evaluated for yield performance and disease (Yr) reaction with local check Bathoor-08. Out of 150 genotypes, 32 were selected for further evaluation and confirmation of their desired traits. The selected genotypes out yielded the check variety (5278 $kg.ha^{-1}$) by producing grain yield in the range of 5553 to 8600 $kg.ha^{-1}$.

NIFA observation nursery (NON-2013) consisting of 94 test entries including the check cultivar NIFA Bathoor-08 was evaluated under both normal and late planting conditions at NIFA. Based on yield performance and disease reaction (Yr), 19 genotypes were selected for further evaluation. These genotypes out yielded the check (7120 $kg.ha^{-1}$) by producing grain yield in the range of 7300 to 8613 $kg.ha^{-1}$.

Performance of new wheat genotypes in preliminary yield trials (PYT's)

Preliminary evaluation of newly developed genotypes through hybridization / induced mutation for yield performance is a prerequisite for attaining the elite status. These lines are regularly evaluated in preliminary yield trials on both normal and late planting dates at NIFA.

One hundred and twenty (120) genotypes were evaluated in PYT-I to PYT- 6 including the two check varieties (Bathoor-08 and Pirsabak-2008) in each trial under both normal and late planting conditions at NIFA. Based on yield performance and disease reaction, 32 genotypes were selected

for further evaluation. Out of the selected genotypes, 18 produced higher grain yield (4267 to 5833 kg.ha^{-1}) than the average of high yielding check, Pirsabak-08 (4170 kg.ha^{-1}) while 14 of the selected genotypes out yielded the low yielding check Bathoor-08 (3927 kg.ha^{-1}). The highest yield was produced by CT-12043 (5833 kg.ha^{-1}) followed by CT-12110 (5758 kg.ha^{-1}) and CT-12090 (5629 kg.ha^{-1}).

Performance of promising genotypes in advanced selection yield trials (ASYT's)

A total of 40 genotypes were evaluated in two advanced selection yield trials under both normal and late planting conditions at NIFA. In ASYT-1 16 genotypes out yielded the low yielding check cultivar; Pirsabak-2008 (3087 kg.ha^{-1}). However, none of the tested genotypes included in the trial could exceed the high yielding check cultivar (Bathoor-08; 4559 kg ha^{-1}). In ASYT-2, 6 genotypes viz. SRN-10102 (5078 kg.ha^{-1}), SRN-10113 (4812 kg.ha^{-1}), SRN-10013 (4653 kg.ha^{-1}), SRN-10103 (4642 kg.ha^{-1}), SRN-10095 (4454 kg.ha^{-1}) and SRN-10010 (4359 kg.ha^{-1}) produced higher yield with no disease symptoms. However, their yield was lower than both the check varieties (5139 and 5078 kg.ha^{-1} for Bathoor-08 and Pirsabak-08, respectively).

Performance of candidate wheat genotypes in micro plot yield trials (MPT)

Fourteen (14) advanced wheat genotypes including two checks (Bathoor-08 and Pirsabak-08 were evaluated in MPT at NIFA and three other locations in KPK. Two lines SRN-09111 and CT-09137 out yielded the high yielding check Pirsabak-2008 (3959 kg.ha^{-1}) by producing grain yield of 4222 kg.ha^{-1} and 3977 kg.ha^{-1}, respectively. Based on higher yield performance and disease resistance, these lines were selected to be included in National Uniform Wheat Yield Trials 2013-14.

Maintenance and seed production of NIFA irrigated varieties

In order to maintain the genetic purity of NIFA irrigated varieties, progeny rows / blocks of NIFA Bathoor-08 and Fakhre-Sarhad were planted on limited area. Desired uniform rows / blocks were harvested and threshed for production of BNS. Five and half metric tons of BNS and pre-basic seed were produced at NIFA and provided to the agricultural department and progressive farmers in the province.

Demonstration / popularization activity

Under the Wheat Productivity Enhancement Program, 23 plots one acre each of NIFA irrigated variety i.e. Bathoor-08 was planted in 9 districts of KPK that yielded 81.5 tons of seed. This seed has been distributed /exchanged with the neighboring farmers and is sufficient for 2000 acres.

Evaluation of candidate wheat lines in national uniform wheat yield trials (NUWYT)

Two candidate wheat varieties, i.e. WL-08169 and CT-09095 were evaluated in NUWYT- Normal and Short trials. The recombinant genotype WL-8169 produced the second highest grain yield (4225 kg.ha^{-1}) among the candidate varieties at 34 sites across the irrigated locations in the country. The line also expressed the desirable RRI (7.17) against Yr which is the main culprit for yield reduction in KPK.

Two new lines SRN-09111 and CT-09137 out yielded the high yielding check Pirsabak-2008 (3959 kg ha^{-1}) by producing grain yield of 4222 kg.ha^{-1} and 3977 kg.ha^{-1}, respectively. Based on higher yield performance and disease resistance, these lines were selected to be included in National Uniform Wheat Yield Trials 2013-14.

Khyber Pakhtunkhwa wheat yield trials (KPWYT)

A total of 05 elite genotypes developed at NIFA were evaluated in provincial yield trials (i.e. KPWYT-N, S) for the first time and proved their worth for higher yield coupled with disease resistance: WL-08169, WL-08109, CT-09056, CT-08055 and SRN-55 out yielded both the checks (Bathoor: 3271 kg.ha^{-1} and local check: 3225 kg.ha^{-1}) under both normal and late planting conditions. SRN-55 produced the highest grain yield (3477 kg.ha^{-1}). CT-09056, CT-08055 and SRN-55 were also found resistant to Yr across 05 locations in KPK.

Improvement for Rainfed Areas

Release of new wheat variety (NIFA Lalma-2013)

NIFA Lalma-2013, a new improved wheat variety, is the most recent addition. The variety was approved in the 33rd meeting of Khyber Pakhtunkhwa Seed Council meeting held on 5th March 2013 under the chairmanship of Provincial Agricultural Minister. NIFA Lalma-2013 is high yielding and widely adapted to a range of environments in the country. It has exceeded the commercial checks i.e. Tatara, Chackwal-50, NARC-2009 and Pirsabak-2005 in NUWYT-

Rainfed. It tolerate high temperature and drought stress. The candidate variety showed high level of resistance against stripe and leaf rusts from 2003 to 2011. It has been identified as a source of resistance against stem rust (RRTTF) as reported by CDRP and meets the quality standards as well. It was the most efficient genotype with 70% Zn efficiency. The variety also showed good stand coupled with lodging and shattering resistance. The variety is genetically different having Aegilops Squarrosa in its composition.

NIFA new candidate line "NRL0707" in NUWYT-R

NIFA recombinant wheat line NRL0707 was subjected for 2nd year mandatory evaluation in NUWYT- Rainfed at different sites in the country. The line showed excellent performance and secured 2nd position on Pakistan basis (15 sites) by producing grain yield of 3272 kg.ha^{-1}. Furthermore the candidate variety expressed high level of resistance with RRI value of 9 to the prevailing yellow rust. The candidate variety also showed resistance against local stem rust race RRTTF with 8.4 RRI value. NRL0707 showed coefficient of infection 0.19 for karnal bunt and was categorized as resistant.

Botanical characterization of NIFA candidate lines

Four candidate lines (NRL 0903, NRL 0913, NRL 0922 and NRL 0707) that showed high yield performance and wider adaptation were grown for plant characterization. As a pre-requisite for varietal release, detailed botanical characteristics were recorded for each individual line at different growth stages.

Khyber Pakhtunkhwa wheat yield trials (KPWYT)

For assessment of grain yield stability 14 promising genotypes along with two commercial checks were tested at 08 different locations in the province. NIFA elite lines NRL 0903 and NRL 0913 produced at par yield with both the check varieties and also showed resistance to yellow rust. These were found promising and selected on the basis of grain yield stability and disease resistance. NRL 0913 was selected for testing in national trials during 2013-14.

Advanced barani trials (ABT)

Twelve (12) promising genotypes were evaluated for grain yield, yield components and disease resistance along with check cultivar Barsat in advanced barani trial (ABT) at the institute. Based on grain yield and disease resistance 04 promising genotypes were selected. NRL1130 produced the highest grain yield (4478 kg.ha^{-1}) followed by NRL1123 (4244 kg.ha^{-1}), NRL1139 (4194 kg.ha^{-1}) and NRL1120 (4039 kg.ha^{-1}) respectively. The overall percent increase over the check cultivar was 8.4 to 20.2 %.

Preliminary barani trials (PBT)

Forty eight (48) newly genotypes were tested for grain yield, disease resistance and other agronomic traits in 04 preliminary yield trials (PBT-1, PBT-2, PBT-3 & PBT-4) under moisture stress conditions at the institute. One international check i.e., Berkut and other local check Barsat were included as standard checks in each trial. Nineteen genotypes have exceeded both the check varieties in grain yield and were found resistant to Yr & Lr. Highest grain yield (5090 kg.ha^{-1}) was produced by NRL1232 followed NRL1238 (5017 kg.ha^{-1} and NRL1240 (4878 kg.ha^{-1}). These selected lines will be further tested in advanced barani trial in the coming year.

Semi-arid wheat screening nursery (30th SAWSN)

A total of 108 entries with new genetic background were screened for grain yield, disease resistance and other agronomic traits in non-replicated nursery under rainfed conditions. Based on field performance 30 best genotypes were identified and selected. These entries also expressed resistance against the prevailing rust races.

Development and selection of new germplasm

Segregating population of Tatara/Tdm, Tatara/Seher, Tatara/SGMT, Marvi/Tatara, Tdm/Tatara, Lalma/Tatara, Lalma/Marvi, RIL0815/WX58 and Marvi/Tatara//WX58 and Barsat/WX175 were raised as F_2 generation at NIFA experimental farm. Desirable ideotypes were selected and seed was threshed in bulk. These populations were planted as F_3 generation at SARS-Kaghan in the month of June, 2013. Desirable plants were selected in different segregating populations. In order to create genetic variability for high grain yield and disease resistance, 10 fresh crosses of wheat cultivars / genotypes were carried out. Seventeen F_1 generation of different recombinants were raised. Seed of the F_1 populations were harvested and seed was bulked and stored after proper labeling.

Response of wheat genotypes to disease reaction

In the province of Khyber Pakhtunkhwa yellow rust is the one of the major factors that limits grain yield. A set of 21 rainfed wheat genotypes were sent to crop diseases research institute for testing

against stripe / leaf / stem rusts at hot spots in the country in NWDSN. Five promising genotypes i.e., NRL 1101, 1243, 1105, 1201, 1123 were selected as they showed desirable or acceptable ACIs to all the three rusts i.e. yellow, leaf and stem rust.

Selection and assessment of wheat germplasm for higher yield and improved water and nitrogen use efficiencies (IAEA Research Project)

Wheat breeding programs have been struggling to improve the drought resistance and N use efficiency using conventional procedures of testing breeding lines. Efforts have been made to develop water and N use efficient wheat varieties using nuclear techniques. Three wheat genotypes i.e, Barsat (approved variety), NRL 0707 (recombinant line) and PM-376-HY (mutant) were evaluated for yield, agronomic and physiological traits at two experimental research stations (NIFA and CCRI) and their response to different Nitrogen fertilizer levels was studied. Climatic conditions were favorable for crop growth and significant differences for grain yield were observed among wheat genotypes and N levels at experimental / farmers field. Genotypes expressed good performance in terms of plant height, tillers.m^{-2}, 1000 grain weight, and grain yield at N 45 kg.ha^{-1} whereas maximum chlorophyll content was expressed when nitrogen was applied at the rate of 90 kg.ha^{-1}.

Maintenance and seed production of NIFA rainfed varieties

During 2012-13 rabi season a total of 5350 kg quality seed of Tatara, Barsat and Lalma was produced at NIFA experimental farm after necessary inspection / certification by FSC&RD officials. All these cultivars showed excellent performance with regards to grain yield and quality. In addition to high yield cultivars Tatara and Lalma showed resistance to prevailing yellow rust. Seed requests have been received from the provincial agriculture departments, seed companies and progressive growers and seed will be distributed prior to next rabi season.

Popularization / Demonstration of NIFA rainfed wheat varieties

Since its establishment NIFA has released a number of varieties like Tatara, Takbeer, Barsat and Lalma for the moisture stressed areas that are continuously performing very well and there is an increasing seed demand from the government organizations, NGO's and farming community. Consistent efforts are being made by the NIFA wheat breeders to maintain seed purity and produce quality seed in the best interest of the farming community. Twenty seven farmers (one acre each) in 10 districts were selected and involved by providing the source seed (Barsat, Lalma) and necessary inputs (fertilizer) under WPEP. The varieties showed excellent performance in these demonstration blocks and gained popularity in the province. The farming community produced 90 tons of seed which is sufficient for 2200 acres in the subsequent year.

Oilseed Brassica

Development of a new rapeseed variety "NIFA Gold"

Nuclear Institute for Food & Agriculture (NIFA), Peshawar, achieved another milestone when Khyber Pakhtunkhwa Seed Council in its 33rd meeting on March 05, 2013 approved a new rapeseed (canola quality) variety "NIFA GOLD" for general cultivation in the province. This variety is developed through hybridization technique at Nuclear Institute for Food & Agriculture (NIFA). It performed excellently during the series of trials at station and throughout the country. It is an early maturing, short stature (180-190 cm) and tolerant to sucking complex especially aphids and jassid. It is featured with high seed yield (>3300 kg.ha^{-1}) and high oil contents (> 44%) of canola quality and suitable for cultivation in rain-fed and irrigated areas of KP. Its cultivation by growers will increase the domestic production of edible oil. The proposed variety NIFA Gold due to its high seed yield potential and canola quality may be able to attract the framers of KP to sow their lands to this variety. This will squeeze the seed yield gap at KP level which at present is 472 kg.ha^{-1} and enhance domestic edible oil production and curtail expenditures on imports.

Quality seed production of oilseed brassica varieties

Maintenance of the genetic purity of approved/commercial varieties is mandatory to produce certified seed. In the follow up programme of released varieties during 2012-13, 15 progeny blocks and 06 increased plots of Durr-e-NIFA, 14 progeny blocks of Abasin-95, 24 and 26 plants to progeny rows of NIFA Raya and NIFA Gold, respectively were raised to produce BNS/PBS. True to type progeny blocks/progeny rows were selected. A total of 205 and 86 kg PBS of Durr-e-NIFA and Abasin-95, 10 and 08 kg BNS of NIFA Raya and NIFA Gold were produced, respectively.

Brassica seed production technology transfer to growers

Oilseed Brassica Group initiated rapeseed and mustard seed production to address the need for

oilseed crop production technology transfer to growers. This seed technology transfer program is a joint effort between oilseed breeders of NIFA, oilseeds progressive growers, extension personnel of provincial agriculture department and Federal Seed Certification and Registration Department. The continue co-operation of all these stakeholders coordinated by Plant Breeding and Genetics Division at NIFA, Peshawar ensures the success of the seed technology transfer program in KP province. A series of demonstration plots of rapeseed varieties released by NIFA were planted during last two Rabi seasons (2011-12 and 2012-13) in District Sawabi. High yielding rapeseed varieties Durr-e-NIFA and Abasin-95 were planted on 29 demonstration plants on the fields of progressive oilseed growers. Oilseed growers with an average yield 1215 kg per acre earned an additional income of Rs. 24, 886 per acre from the cultivation of NIFA rapeseed varieties as compared to cultivation of conventional rapeseed varieties with an average yield of 800 kg per acre.

Improvement of rapeseed (*Brassica napus*) and mustard (*Brassica juncea*) through induced mutations and classical breeding techniques

Performance of four new candidate lines in national uniform rapeseed yield trial (NURYT) & national uniform mustard yield trial (NUMYT)

Four candidate lines two each of rapeseed (04 K 8/13-18-2 and 04 K 9/13-9-2) and mustard (MM-III /06-3 and MM- III /06-12) were evaluated for the first year mandatory testing in NURYT and NUMYT along with other twenty one rapeseed and nine mustard candidate lines of other breeders of the country, respectively at ten locations in Pakistan. The trial was laid out in RCBD, replicated thrice. Rapeseed line 04 K 8/13-18-2 produced high seed yield (1935 kg ha^{-1}) as compared to average seed yield of the two national checks Hyola-401 and Punjab Sarson (1933 $kg.ha^{-1}$) on mean basis. While mustard mutant MM-III/06-03 also yielded higher (1993 kg ha^{-1}) than the national check Khan Pur Raya (1941 $kg.ha^{-1}$).

Performance of recombinants and mutants of rapeseed and mustard in multi-location adaptation yield trial

Following extensive evaluations for all relevant agronomic and quality characteristics at NIFA, best performing eleven rapeseed mutants/ recombinants viz., RM-I/09-2, RM-I/08-4, RM-I/08-6, RM-I/08-29, RM-I/08-35, RM-I/08-39, RM-I/08-43, 08 1/2-7, 08 1/2-9, 08 2/1-7 and 08 1/2-21 including check (Punjab Sarson) were evaluated for genetic stability and adaptability in multi-location adaptation yield trial at eight diversified locations viz., Nuclear Institute for Food & Agriculture (NIFA), Peshawar , Agricultural Research Station(ARS), Sari Naurang, Bannu; Agricultural Research Station (ARS), Buffa; Agricultural Research Institute (ARI), Mingora, Swat; Barani Agricultural Research Station (BARS), Kohat; Nuclear Institute of Agriculture & Biology (NIAB), Faisalabad ; Arid Zone Research Institute (AZRI), D.I. Khan and Barani Agricultural Research Institute (BARI) Chakwal. The trial was laid out in RCBD, replicated thrice. RM-I/08-29 produced highest seed yield (1754 $kg.ha^{-1}$) followed by 08 2/1-7 (1716 $kg.ha^{-1}$), RM-I/08-4 (1706 $kg.ha^{-1}$), RM-I/08-35 (1621 $kg.ha^{-1}$) RM-I/09-39 (1584 $kg.ha^{-1}$) & RM-I/09-2 (1563 $kg.ha^{-1}$) as compared to Punjab Sarson (1269 $kg.ha^{-1}$).

Agronomic evaluation of mutants/ recombinants in advanced yield trials (AYTs) at NIFA, 2012-13

Top ten rapeseed mutants (RM-III/10-29, RM-II/10-59, RM-III/10-19, RM-I/10-21, RM-I/10-22, RM-I/09-3, RM-II/09-6, RM-II/09-8, RM-I/10-31 and RM-I/10-33) and four mustard mutants/recombinants (MM-6/10-32, MM-6/10-33, MM-6/10-78 and 010-10/9-8 were advanced from preliminary yield tests (PYT) and evaluated separately in three advanced yield trials (AYT-I, AYT-II & AYT-III) along with rapeseed checks Durr-e-NIFA and Punjab Sarsoon, while NIFA Raya was used as mustard check respectively, at NIFA experimental farm. The trial was laid out in RCBD, replicated thrice. .The results revealed that all the rapeseed mutants in AYT-I and AYT-II significantly out yielded their respective checks anchoring seed yield 1866 – 3556 kg ha^{-1}, while four mustard entries in AYT-III out yielded NIFA Raya by significant margin achieving seed yield 1496 – 2678 kg ha^{-1}.

Performance of stable mutants for yield and other agronomic characteristics in preliminary yield trial (PYT), 2012-13 at NIFA

Stable and high yielding eight rapeseed recombinants/mutants (RM-3/011-3, RM-3/011-4, RM-3/011-7, RM-3/011-47, 011-4/6-3, 011-5/6-11, 011-5/6-13, and 011-5/6-15) and seven mustard mutants (MM-1/011-18, MM-1/011-25, MM-1/011-35, MM-1/011-40, MM-1/011-43, MM-1/011-56 and MM-1/011-88) were evaluated in the preliminary yield trials; PYT-I and PYT-II, along with commercial checks, Punjab Sarson and NIFA Raya, respectively, at NIFA experimental farm, during 2012-13. The trial was laid out in RCBD, replicated thrice. Three rapeseed recombinants

and four mutants performed excellently well against the check and achieved seed yield 2108 – 3131 kg.ha^{-1}, while in PYT-II, three mustard mutants significantly out yielded the check by harboring 2114 – 2734 kg ha^{-1} seed yield.

Assessment of rapeseed and mutants/ recombinants

Forty rapeseed mutants (M_4) were evaluated for yield and other agronomic traits in a non-replicated trial planted in augmented design along with a commercial check Durr-e-NIFA which was replicated ten times in the experimental blocks. The results indicated that twenty three entries produced seed yield 2342 - 4633 kg.ha^{-1} and out classed the check Durr-e-NIFA that harbored 2180 kg.ha^{-1} (on mean basis).

Development of segregating populations

M_0/M_1 & F_0/F_1 generation

Healthy and uniform seeds of three rapeseed lines viz., NR-2/2011, NR-3/2011 and NR-22/2011 were exposed to three doses of gamma radiation (1 and 1.2 and 1.4 kGy) with the view to incorporate earliness and reduced plant height. The treated seeds were directly planted in the field in isolation, dose/variety wise. Normal cultural practices were carried out. Plots were bulk harvested dose/variety wise at maturity and seed were manually threshed and bagged separately. First filial generation of selected eleven crosses attempted in 2011-12 were bulk harvested cross wise with some notable phenotypic observation on yield and yield contributing factors.

The intra-specific crossing was achieved by hand pollination of 1295 rapeseed buds 10 cross combinations developed to incorporate earliness, short stature, low erucic acid, glucosinolates and high yield in otherwise adapted varieties. Crossed pods were harvested combination wise separately as F_1 seed.

M_2 /F_2/F_1M_2 generation

The M_2 /F_2/F_1M_2 generation were developed from thirty rapeseed and four mustard genotypes. More than 150 single plant selections were made based on plant height, number of primary branches per plant, number of pods, pod length, number of seeds per pod and seed yield per plant. The potential material was tried to be saved by taking more than two hundred representative samples on the basis of visual performance as the single plant selection was hampered due to intermingling/ entangling of the material with in the same population to avoid mixing. The oilseed quality will be tested on NIRS before the material is sown to raise plant to rows population ($M_3/F_3/F_1M_3$).

Plant-progeny rows (F_3/M_3)

Seventy five plant-to-progeny rows of rapeseed/mustard recombinants/mutants (F_3/M_3) were planted to evaluate inherited desired selected traits on visual performance basis. About fourty entries were selected to be re-evaluated/ confirmed for genetic stability and also seed yield potential to screen out better genotypes in a non-replicated trial (F_4/M_4) during 2013-14.

Quality characterization of oilseeds through NIRS

Seed of valuable breeding materials of oilseed brassica species from fresh harvest of advanced and preliminary yield trials of Rabbi 2012-13 was screened for oil content, fatty acid composition and glucosinolate content through non-destructive Near Infrared Reflectance Spectroscopy (NIRS) in Oilseed Brassica Lab. A total 624 seed sample of genetically stable lines of *Brassica napus* and Brassica juncea were analyzed during the period under report. Sixteen putative mutants and/or hybrid brassica lines produced more than 45% oil content. More than 50% highly desirable monounsaturated fatty acid 'oleic acid' was found in 30 genetically stable lines of rapeseed and mustard. The essential 'linolenic fatty acid' with a range of 6-7% was produced in seeds of 10 mutant lines of *Brassica napus*. Canola quality i.e. low erucic acid in oil content and low glucosinolate in seed meal was determined in 40 advanced lines.

During the period under report quality analysis service through NIRS for oilseed crops was provided to the following agricultural research institutes and agricultural universities.

- Ayub Agricultural Research Institute (AARI), Faisalabad
- Hazara University, Haripur
- Oilseed Research Program, NARC, Islamabad
- University of Agriculture, Faisalabad
- The University of Agriculture Peshawar
- Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi
- Barani Agriculture Research Institute, (BARI), Chakwal
- Plant Genetic Resources Institute (PGRI), NARC, Islamabad
- Agriculture Research Station, Srai Nourang, Bannu
- Azad Kashmir University, Rawalakot

Development of locally adapted canola (*Brassica napus* L.) F_1 hybrids using induced mutations and doubled haploidy techniques

Pakistan Science Foundation funded project entitled 'Development of locally adapted canola (*Brassica napus* L.) F_1 hybrids using induced mutations and doubled haploidy techniques' is commenced from June 2012. The major objective of this project is the development of Cytoplasmic Male Sterile (CMS) female lines in rapeseed (*Brassica napus*) through the use of induced mutations and in vitro culture. During first year of this PSF project cytopalsmic genetic male sterility is induced in selected rapeseed genotypes through gamma irradiation. The mutagenized rapeseed generation (M_1) was raised in field. At flowering stage M_1 male sterile mutant plants (anther-less/with deformed anthers) were observed and tagged in field. At maturity, experiments were harvested and seeds were threshed, cleaned and collected genotype-wise and gamma radiation dose-wise. The gamma irradiation almost showed a depressive effect on the rapeseed plants in first mutant generation (M_1). Weak and stunted plant population was observed in gamma mutagenized population as compared to the control plants. Gamma mutagenesis reduced the emergence and survival percent and increased the lethality as the irradiation doses increased, respectively in mutant population as compared to untreated control plants. The gamma irradiation dose of 1.6 KGy reduced the emergence (85%) and survival (74%) compared to control (100%) at the highest level that lead to the greater lethality (28%).

Pulses Group

Mungbean

Mungbean advanced lines developed through hybridization and induced mutations were evaluated in various replicated yield trials for seed yield and important yield components during kharif 2013. Out of 15 recombinants derived from 8 different crosses evaluated in an advanced yield trial, 9 genotypes produced significantly ($p \leq 0.05$) higher seed yield (1583-1830 $kg.ha^{-1}$) as compared to the check variety Ramzan (1333 $kg.ha^{-1}$). Out of 45 recombinants developed from the cross VC 1482C x NM 92 and evaluated in three sets of advanced yield trials, 21 recombinants showed significantly ($p \leq 0.05$) higher seed yield (1470-1882 $kg.ha^{-1}$) as compared to the check variety Ramzan (average yield of 1300 $kg.ha^{-1}$). In case of preliminary yield trials, 45 recombinants of two combinations i.e., VC 1560D x NM 92 and NM 98 x VC 3902A were evaluated in three sets of replicated trials. In these trials, 9 recombinants produced significantly ($p \leq 0.05$) higher seed yield of 1024-1951 $kg.ha^{-1}$ as compared to the check variety Ramzan which showed average yield of 1288 $kg.ha^{-1}$. Similarly, out of 23 advanced mutants derived from irradiating NM 92 and NM 98 through gamma rays and evaluated in 2 sets of replicated preliminary yield trials, 8 mutants showed significantly ($p \leq 0.05$) higher seed yield (1326-1559 $kg.ha^{-1}$) as compared to the check variety Ramzan (average yield of 1158 $kg.ha^{-1}$). Three promising recombinants namely NIFA Mung-1, NIFA Mung-2 and NIFA Mung-3 have been contributed for seed yield and stability evaluation in national uniform yield trials during kharif 2013, which are conducted by National Pulses coordinator, NARC, Islamabad.

The F_1 generations of seventeen cross combinations i.e., V 1128 x Ramzan, V 2709 x Ramzan, V 2802 x Ramzan, V 2817 x Ramzan, V 1128 x NM 2006, V 2709 x NM 2006, V 2802 x NM 2006, V 2817 x NM 2006, V 2709 x NM 92, V 2802 x NM 92, V 2817 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, NFM 5-36-24 x NFM 6-63-18, and NM 51 x NFM 6-63-18 were planted along with their parents during kharif 2012 and all hybrid plants were harvested individually, threshed separately and bagged individually. The exotic parents and their F_1s were susceptible for MYMV whereas the local parents were resistant to MYMV. F_2 populations of the eight combinations i.e., V 1128 x Ramzan, V 2709 x Ramzan, V 2802 x Ramzan, V 2817 x Ramzan, V 1128 x NM 2006, V 2709 x NM 2006, V 2802 x NM 2006, and V 2817 x NM 2006 were raised during summer 2013 and made 877 single plant selections on the basis of more pods per plant and semi erect plant type. Selections from segregating populations during this season were badly affected due to unfavourable environmental conditions for mungbean growth and flower retention. For new cross combinations i.e., NM 2006 x Kuram Green, Ramzan x Kuram Green, ML-5 x Kuram Green, Ramzan x var. 6001 and Kuram Green x Kuram Black were attempted during summer 2013 to improve seed yield and plant type of mungbean grown in Kuram agency.

Chickpea

Twenty four chickpea advanced mutants derived from C-44 and developed at NIFA were evaluated for seed yield and some other important yield components in two sets of replicated preliminary yield trials during 2012-2013. In both sets, 7 mutants i.e., 4-25-9, 4-25-10, 4-30-3, 4-30-4, 6-15-1, 6-15-6 and 6-15-9 showed significantly ($p \leq 0.05$) higher seed yield (3865-4583 $kg.ha^{-1}$) as compared to the check variety NIFA 2005 (average yield of 3609 $kg.ha^{-1}$). Seven advanced mutants derived from Pb-91and developed at

NIFA were evaluated in replicated preliminary yield trial during the same year for seed yield and its components. Four mutants i.e., 15-1, 20-5, 20-6 and 30-16 produced significantly ($p \leq 0.05$) higher seed yield (3875-4302 $kg.ha^{-1}$) as compared to the check variety NIFA 2005 (3573 $kg.ha^{-1}$).

The F1 generations of six cross combinations viz., Thal-2006 x NIFA-2005, Balksar x NIFA-2005, Dasht x NIFA-2005, NIFA-88 x NIFA-2005, NIFA-2005 x NDC-6-I-6 and NIFA-2005 x NDC-6-I-7 were planted along with their parents and picked all hybrid plants individually, threshed separately and bagged individually during 2012-2013.

Sugarcane Improvement

Seed multiplication of advanced lines

Seed of high yielding and high brix content sugarcane lines CPNSL-034, CPNSL-005 and CPNSL-002 was multiplied. The plot size of each line was 20X10 m, one meter apart. The lines will be tested in different locations for confirmation of traits and testing in the national trials for varietal development.

Raising of seedling from sugarcane fuzz

50 grams seed (fuzz) of 10 self-pollinated sugarcane varieties were received from National Sugar Crops Research Institute, Thatta. Seed was sown in control environment in the lathe house in February, 2013. The germination of all the varieties was satisfactory. The highest germination was shown by HoTh-326 followed by CPSG-3453. The seedling plants were successfully transplanted to the field for evaluation.

Creation of genetic variability in sugarcane/ raising of M_1 generation

The commercially cultivated sugarcane variety CP-77/400 was subjected to gamma rays for creation of genetic variability for frost tolerance, early maturity with high cane and sugar yield potential. Five hundred buds were exposed to 0.05, 0.1, 0.15 and 0.20 KGy gamma rays using ^{60}Co gamma source. The radiated material was sown in the field along with control to raise the M_1 generation.

Evaluation of sugarcane genotypes in preliminary yield trial

Promising sugarcane genotypes were evaluated at NIFA for frost tolerant, high cane and sugar yield. The trial consisted of 9 lines with CP 77/400 as a check variety. Plot size was 6 m2 with three replications. The performances of the genotypes are summarized below:

Agronomic evaluation

Cane thickness: The data on cane thickness indicated variation among all the genotypes. The maximum cane thickness (29.18 mm) was recorded in line CPNSL-026 followed by line CPNSL-028 with cane thickness of 28.34 mm. The lowest cane thickness of 25.11 mm was recorded in line CPNSL-024.

Stalk/plant: The highest stalk/plant (5.0) was recorded in line CPNSL-028 followed by line CPNSL-024 and CPNSL-001 where 4.89 stalk/plant were recorded. The lowest stalk/plant of 4.1 was recorded in Line CPNSL-032.

Number of internodes/plant: The highest number of nodes (17.89) was recorded in Line-CPNSL-008 followed by line CPNSL-027 with 17.78 nodes/plant.

Plant height: The data on plant height of all the genotypes showed significant variation. The highest plant height (235.0 cm) was recorded in Line CPNSL-028 followed by line CPNSL-024 with plant height of 231.33cm. The lowest plant height of 180.0 cm was recorded in line CPNSL-026.

Cane yield: Significant variations in yield were observed among all the genotypes under study. The highest yield of 93.58 $t.ha^{-1}$ was recorded in line CPNSL-027 followed by line CSNSL-002 with 91.0 $t.ha^{-1}$. The lowest yield of 72.08 $t.ha^{-1}$ was recorded in line CPNSL-034.

Quality evaluation

Sugar Recovery (%): The data regarding sugar recovery of all the germplasm showed significant variation. According to the results, highest recovery of 12.37% was recorded in line CPNSL-005 followed by Line CPNSL-015 with recovery of 11.80%. The lowest recovery of 9.89% was recorded in line CSNSL-002.

Purity (%): The highest purity of 96.57 % was recorded in line CPNSL-015 followed by line CPNSL-050 with purity of 94.82%. While the lowest purity of 90.73% was recorded in line CSNSL-001.

Brix (%): The highest brix of 20.0% was recorded in line CPNSL-005 followed by line CPNSL-001 with 19.0% brix.

Pol (%): The highest Pol of 18.37% was recorded in line CPNSL-005 followed by line CSNSL-001with 17.0% Pol.

Performance of National Uniform Varietal Trial

National uniform verietal trial consisted of five lines; three lines were received from ARRI, Faisalabad and 02 lines from NARC. The trial was sown in September, 2012 using standard plot size of 7 m^2 in three replications. The commercial variety CP77/400 was used as check. The highest Stalk/plant (5.65), Internodes (14.44), Internodes length (11.05 cm) and plant height (197.78 cm) was recorded in line S-2006-US-469. The highest cane thickness (27.71 mm) was recorded in line S-2006-US-272. The highest yield of 94.75 $t.ha^{-1}$ was also recorded in line S-2006-US-469. The highest recovery of 12.04% was recorded in line S-2006-US-54followed by S-2006-US-469 with recovery of 11.94%. The highest brix of 19.5% was recorded in line S-2006-US-54 followed by line S-2006-US-469 with 19.0% brix.

Stevia Improvement

Effect of irradiation on stevia seed germination

The effects of different doses of gamma rays on stevia seed germination were evaluated. Seeds were germinated on 3 different media for comparison including petri plates, soil and on MS-medium. In Petri plates experiment, higher seed germination of 20% was observed in seeds irradiated with 10 Gy dose. The lower most seed germination potential was observed for 7.5 Gy dose. As compared to 7.5 Gy, 18.23% seed germination was recorded for 5 Gy dose as compared to control (23.31%). The higher seed germination of 13.44% in soil was observed when seeds were irradiated with 2.5 Gy dose. Significantly similar seed germination percentage was recorded for 5.0 and 7.5 Gy doses, however, 4.92% germination rate was recorded for 10 Gy dose. Lowest seed germination potential was observed on MS-medium than Petri plates and soil. In this experiment, maximum of 9.4% seed germination was observed in seeds irradiated with 7.5 Gy dose while control seed showed 24.83% germination.

Selection in M_2 population for higher biomass and Steviosides contents

After LD50 calculation, seeds were irradiated with 8.75 Gy dose for creation of genetic variability. About 2000 seeds were selected for creation of genetic variability for higher yield and Steviosides contents through gamma irradiation. Irradiated seeds were sown in the field to raise M_1 generation. A total population of 800 plants was obtained successfully in the field. After flowering, seeds were collected from M_1 mutant plants and sown to raise M_2 generation. In M_2 generation plants with best growth parameters will be selected for steviosides content and higher biomass production in due course of time.

Propagation through stem cuttings

Stem cuttings of suitable length with 3-4 leaves were dipped for 1 minute in NAA (500, 1000 ppm) and IBA (500, 1000 ppm) solutions respectively. Stem cuttings were then planted in pots containing combination of soil, sand and manure in 2:1:1 ratio. Data regarding % survival (data taken after two months), Length of cutting, no. of leaves per cutting, no. of branches per cutting and internodes length was taken after 90 days of planting. Maximum survival percentage (33.33) was exhibited by cuttings dipped in 1000 ppm solution of IBA than control cuttings (11.11%). 1000 ppm IBA solution was followed by 1000 ppm NAA solution and showed 22.22 % survival. No survival was observed in 500 ppm NAA treated cuttings. Similar survival percentage (11%) was recorded for 500 ppm IBA and control cuttings. Maximum of 33.56 cm mean shoot length was recorded when cutting were dipped in IBA 500 ppm solution. Similarly 29.833 and 19.63 cm mean shoot length were recorded for IBA and NAA 1000 ppm solutions as compared to control (20.83 cm). Maximum of 107.67 numbers of leaves per cutting was recorded when cutting was dipped in NAA 1000 ppm solution. Similarly 102.33 numbers of leaves per cutting was recorded for IBA 500 ppm solution. Significantly similar number of leaves per cuttings were recorded for IBA 1000 ppm treated cutting and control (90 and 91.3). Maximum of 10.3 branches was observed when cutting were dipped in NAA 1000 ppm solution. However, both the IBA solution showed 6 and 8.67 branches per cutting as compared to control (6.67). Significantly similar internodal length was recorded for cutting dipped in IBA and NAA solutions (2.67, 2.83 and 2.29) as compared to control (1.65).

Before data collection on rooting, roots were collected and carefully washed with distilled water to remove soil particles. Maximum of 24.0 roots per cutting was recorded when dipped in IBA 500 ppm solution as compared to control (12.35). Similarly 15.0 and 13.0 roots were recorded for cuttings dipped in IBA and NAA 1000 ppm solutions. IBA treated (500 ppm) roots showed maximum length of 67.0 cm as compared to control (47.15). Significantly similar root length of 53.6 and 54.5 cm was recorded for IBA and NAA

(1000 ppm) treated cuttings. For fresh roots weight, roots were carefully dried on the filter paper. All the roots taken from cuttings which was treated with IBA and NAA (1000, 500 and 1000 ppm) showed significantly similar fresh weight (1.65, 1.64 and1.68 g) as compared to control (1.21 g).

Plant Pathology Group

Pre-breeding for wheat disease resistance

Disease resistance in wheat is an important factor for attaining sustainable food security in the country. It is therefore, an integral component of the crop improvement program at NIFA focusing on pre-breeding activites such as surveillance, pathotyping, detection, monitoring and enhancement of novel sources and candidate genes.

Occurence of wheat diseases in Khyber Pakhtunkhaw

Occurrence of wheat diseases using stationary and mobile survey approaches were carried out at hot spot locations in southern, central and northeren zones of Khyber Pakhtunkhaw.

Yellow and leaf rusts

Yellow rust developed well at all test locations in Khyber Pakhtunkhaw (two in Peshawar and one each in Bannu, Nowshara, Hari Pur and Swat) with variable disease levels. Rust severity within each location at Peshawar, Bannu, Nowshara, Hari Pur and Swat ranged from 0-70%, 0-55%, 0-75%, 0-80%, 0-60%, respectively. Highest average rust severity was recorded at Peshawar2 (33%) which was followed by Hari Pur (29%), Peshawar1 (19%), Swat (19%), Bannu (16%) and Nowshara (16%). Leaf rust was rarely recorded with low severity in Peshawar only.

Powdery mildew and barley yellow dwarf

Powdery mildew of wheat is caused by an obligate parasitic fungus Blumeria graminis f. sp. tritici which had its prevalence confined to the two studied locations during the season. Disease spread was observed less in Hari Pur with maximum damage of leaf area reached upto 40%. Pronounced occurrence of Powdery mildew was observed at the studied location in Swat where average disease severity reached 52% while the maximum severity was 90%. Barley Yellow Dwarf (BYD) has become a prominent aphid borne viral disease of wheat in the Khyber Pakhtunkhaw but occurrence and distribution of BYD was less pronounced and severe during the cropping season as compared to the previous year. BYD was only observed at Peshawar with maximum severity of 80%.

Seed diseases

Many of the wheat diseases have been reported as seed borne. Black point is one such fungal disease caused by *Alternaria alternata* (Fr.) Keissler. Field survey and seed sampling was carried out through collaborators in district Swat and Kohat (66 farmers/locations). Results obtained up till now indicated that black point was prevalent in all genotypes/locations sampled from Swat district with maximum incidence of 14%. Further study is in progress.

Pathotyping and effectiveness of yellow rust resistance genes in Khyber Pakhtunkhaw

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. Nine yellow rust pathotypes including 0E0, 96E0, 115E160, 59E240, 102E24, 106E88, 102E176, 98E16 and 102E16 were established using field data. Yellow rust resistance genes Yr1, Yr5, Yr6, Yr7, Yr8, Yr9, Yr10, Yr15, Yr17, Yr18, Yr24, Yr2, Yr27, Yr32 and YrSp in Avocet background behaved differentially across Khyber Pakhtunkhaw. No virulence was found against Yr10 which is reported in number of genotypes that can be used in wheat improvement program.

Characterization of multiple disease resistance in Khyber Pakhtunkhaw

In order to search for novel sources of multiple disease resistance, more than one thousand wheat genotypes consisted of Set I (released cultivars: 37; candidate varieties: 37 and NIFA rainfed/irrigated germplasm: 35) & Set II (national elite genotypes: 551, CIMMYT advanced germplasm: 350 and local land races: 163) were studied and characterized at six hotspot locations across Khyber Pakhtunkhaw. Set I was assessed at six locations while Set II at Peshawar only.

Yellow and leaf rust resistance

Yellow rust resistance in Set I genotypes including V-00125, 93T347, RWM-9313, V13, NRL-0709, NRL-0818, NRL-0820, NRL-0842, CT-08054, CT-08147, CT-09056, CT-08022, WG-08018, SRN-6019, WL-08058, CT-09074, Bahawalpur-95, Chakwal-86, Kaghan-93, Faisalabad-85, Soughat-90, Bakhtawar-93, Pak-81, F-Sarhad, Tatara and Karwan remained consistent and

disease severity never crossed 30% limit or remained less than 30% across six test locations in Khyber Pakhtunkhaw. Leaf rust evaluation of Set I genotypes was possible only at Peshawar where it was observed on a limited number of genotypes including SN-122, 7_03, NRL-0808, CT-08088, Bahawalpur-95, Sarsabz and Kaghan-93. All these genotypes displayed moderately susceptible reaction with leaf rust severity upto 20%. Exotic genotypes viz. Lee, Spaldings Prolific, Hybrid 46 and Federation X4 Kav were also found sensitive to leaf rust at Peshawar.

One thousand and sixty four indigenous and exotic genotypes of Set II displayed variability in resistance against yellow rust. One hundred and sixty genotypes (15%) were postulated to carry effective race specific resistance while 546 genotypes (51%) were inferred to carry race nonspecific high resistance. NIFA genotypes of Set II which fall in this category of race nonspecific high resistance included NRL 1003, NRL 1027, NRL 1028, NRL 1241, NRL 1242, NRL 1101, NRL 1105, NRL 1117, NRL 1119, NRL 1120, NRL 1123, NRL 1124, NRL 1129, NRL 1130, NRL 1137, NRL 1139, NRL 0157, WL 0916-2, CT-096065, CT-09117, CT-09137, CT-09141, SRN-09048, SRN-09065, SRN-09087 and SRN-09102. Future germplasm (CIMMYT advanced germplasm of Set II) introduced recently into the national wheat research system of Pakistan indicated the presence of an undesirable defeated rust genes (i.e. Lr26, Yr9, Sr31) translocation “1BL.1RS” in 28 genotypes which should not be selected and promoted for further development in the country.

Powdery mildew and BYD resistance

Resistance studies against wheat powdery mildew in Set I genotypes was possible at two locations in Hari Pur and Swat. Disease was patchy at Hari Pur while it was uniformly developed on Set I genotypes at Swat. Five cultivars including Bahawalpur-95, Suleman-96, Punjab-96, Frontana and Kirin-95 were resistant to the disease while all remaining genotypes of Set I were found susceptible to Powdery mildew. Set I genotypes i.e. V-01180, NRL-0820, CT-08054, NRL-0715, NRL-0806, NRL-0808, NRL-0809 and WG-08018 were found susceptible to BYD in Peshawar as the disease was observed at this testing site only. Resistance to BYD was assessed in Set II and it was found that about 80 genotypes were found sensitive which included AZRC-14, 10C016, 11C003, 11C023, 9C037, B5, B-2 (RF)-6, B-2 (RF)-9, B-2 (RF)-11, B-2 (RF)-17, B-3 (RF)-19, MPT (N)-11, MPT (RF)-13, PR-103, PR-104, TW86014, TW86001, 11BT009, NRL 1027, NRL 1242, NRL 1105, CT-09117, CT-09137, SRN-09048, NN-51, NN-56, NN-60, NIA-54-03, SD-1000, SD-3, SD-1009, NIGAB-8, V-08314, Bathoor-08, Faisalabad 83, Faisalabad 85, Khyber 87 and Morocco.

Identification of slow rusting durable resistance

Adult plant resistance is long lasting and is often associated with slow development of rusts and is considered as a key strategy for its management. About 589 genotypes were studied for slow rusting trait. Slow rusting variables for yellow rust development were assessed at NIFA Peshawar over time in the presence of virulence’s v1, v2, v5, v6, v7, v8, v9, v15, v17, v18, v26, v27, v32, vA, vSP, vGaby, vSoissonnais vTP 981 along with standard susceptible control. Several assessments were made at weekly intervals to understand pattern of disease development during the season. Based on area under disease progress curve, studied germplasm can be classified into four groups including undesirable, slow ruster, medium slow ruster and fast ruster with percentages of genotypes in each was 32%, 50%, 15% and 3% respectively. Slow ruster group can be good source for selecting and development of future cultivars carrying durable rust resistance.

ENTOMOLOGY DIVISION

The Entomology Division of NIFA Peshawar is engaged in the integrated control of fruit flies, termites, peach flat-headed borer, and chickpea pod borer, and in honey bee management. Under the Integrated pest management (IPM) system, we are employing different IPM components such as chemical, biological, cultural, phytosanitary and irradiation to reduce pest losses. Citrus and mangoes are the two leading fruits of Pakistan in terms of area, production and export. This division has close collaboration with the international atomic energy agency (IAEA) on the development of generic irradiation doses for pests of quarantine importance and post-harvest life extension of fresh commodities. Under the integrated vector management control (IVM) program, the division has active collaboration with national and international organizations in devising short and long term control strategies for medically important disease carrying insects including mosquitoes and house flies.

Fruit Fly Control

Fruit flies are the most destructive insect pests of fruits and vegetables throughout the world. Among various species of fruit flies, Bactrocera are predominant in Pakistan attacking pear, peach, plum, apple, guava, mango and other fruits and vegetables. Their pre-harvest control largely depends on the application of male annihilation techniques and post-harvest as irradiation or hot treatment. Research on fruit flies is therefore, directed towards improvement in the control strategy through environment friendly techniques such as cultural control, biological control, male/ female trapping and fruit irradiation for larval mortality.

Effect of mixing torula yeast in bitter gourd extract on trapping of melon fly

Torula yeast, a chemical attractant of fruit flies was mixed @ 0, 1, 2, 5 and 10% in the extract of bitter gourd, one of the natural hosts of melon fly. Sodium benzoate was added @ 1 $g.kg^{-1}$ extract as preservative to avoid spoilage of the extract. In this material, torula yeast was added 0, 1, 2, 5 and 10%. Traps were loaded with the above baits and installed in completely randomized design at height of 2-2.5 meter above ground level for 10 weeks in bitter gourd crop for attracting/ killing *B. cucurbitae.* To compare traps efficacy, traps with only torula yeast were also installed. Cue-lure standard traps were installed to check natural population of fly in the test area. The experimental field was surrounded by more than 100 kanals sponge gourd. The results showed that squash of natural host with-out torula captured minimum number of 16.7 flies /trap/week as compared to 67.7 and 98.2 flies/trap /week in 1 % torola and 1 % torula mixed with host extract respectively. Maximum number of 119.7 flies/ trap/week was trapped baited with 2 % torula only while 51 flies were captured in its combination with the extract. In the remaining treatments, the trend of enhancing the efficacy of fly trapping with torula was gradually maximized. Cue-lure standard trap attracted and killed 80.5 flies. The results indicated that torula alone or mixed with natural host extract can be used as alternative of Cue-lure for management of melon fly in field growing crops by farmers/end users.

Impact of oils on cue lure efficiency for management of melon fly

Five oils such as canola, sun flower, olive, citronella and clove were blended @ 25, 50, and 75 % in Cue-lure as extender in order to see it efficacy in comparison with commercial Cue- lure trap. The trial comprised of five main treatments (5 oils) and 4 sub treatments (concentrations.) i.e. 0, 25%, 50% and 75% of each oil, added in Cue lure. The mixture had 10% sugar and 5% dipterex as killing agent. 4 ml of each combination /trap was applied on cotton wick. Traps were installed CRB design in bitter gourd fields at a height of 1.5-2.00 m above ground level for 11 weeks at the vicinity of Peshawar. Standard Cue-lure was also installed randomly for the comparison of results. Data were recorded weekly for number of flies /trap. Data Showed that none of the oil in pure form was effective for trapping melon fly, however, in 50% canola and sunflower,18 and 13.4 flies were captured respectively as compared to standard Cue-lure trap (12.7 flies). In case of citronella oil, 19.8 and 25.3 flies were trapped with 25 and 50 concentration mixed with lure, which trapped more flies than standard trap. 75 % Olive oil attracted 12.2 flies and was at par with standard trap. This indicated t hat addition of oils up to75% did not affect the attractancy of lure and, hence these oils can be mixed in Cue-lure to reduce the cost of male annihilation technology for melon fly.

Testing hydrolysed protein to enhance the attraction of mixture of methyl eugenol and cue-lure against fruit flies

Melon fly *Bactrocera cucurbitae*, Oriental fruit fly *B. dorsalis* and peach fruit flies *B. zonata* are the major fruit fly species in KPK attacking various fruits and vegetables causing tremendous losses. The idea behind the present studies is to develop technology for attracting the three dominant species in a single trap installed in the field. To attract and kill these three species and some other minor species, both these lures were mixed in

equal ratio (50:50) with one another to see the effect of mixing fly lures on attraction and killing of important fly species in a single trap. Protein is an essential food ingredient required for sexual maturity and good health of flies. To enhance the attraction of the mixture of two lures, protein hydrolysate was mixed in this lure combination @ 10, 20, 30, 40 and 50% v/v. Dipterex as killing agent was mixed in the test material @ 5%. In each treatment, the quantity of lures remained constant while only protein varied percentage wise. The test mixture was applied on cotton wick, the quantity ranged from 5 ml to 10 ml depending upon the percentage of protein. To compare the results, traps having only protein hydrolysate (10 ml) were also installed. There were seven treatments, each replicated 4 times. The traps were installed in completely randomized design in bitter gourd field. Data on fly attracted and killed were recorded weekly for seven weeks and counted species wise in the laboratory.

The results showed that maximum mean number of 24.7 flies were captured in the test material containing 30% protein followed by 23.3, 18.5, 16.9 and 15.62 flies/trap/week in traps having 10% protein , only mixture of 2 lures, 40% and 20% protein mixed with synthetic lures. Minimum number of 3.32 flies/trap/week were caught in traps loaded with only protein hydrolysate followed by11.33 flies in lure mixture with 50% protein. Relative abundance studies indicated that peach fly, *B. zonata* was found dominant species followed by melon fly, *B. cucurbitae*. The population of Oriental fruit fly was negligible i.e. 0-0.6 flies /trap/week throughout study period. It is concluded that only protein was found less effective than check i.e. mixture of 2 lures while adding 10 to 30% protein (without mixture) enhanced lure attraction and can be used to attract comparatively more flies than check.

Chickpea and Mungbean

Evaluation of mungbean genotypes for resistance to bruchid beetle (*Callosobruchus maculatus*)

Bruchid beetle is the principal post-harvest pest of stored mungbean. Damage occurs in stored mungbean by bruchids where several cycles of egg laying and adult emergence lead to complete destruction of mungbean seed within 3-4 months.

In the present study, 83 mungbean genotypes /varieties were screened for resistance to Bruchid beetles. The resistance was evaluated by determining % damage to mungbean seeds. The % damage was calculated using the following formula.

$$\% \text{ Seed damage} = \frac{\text{No. of damaged seeds}}{\text{Total No. of seeds}} \times 100$$

The results indicated that none of the genotypes/varieties was completely resistant to bruchids attack. Out of 83 accessions, coded genotypes 31-7-12 followed by V2812 had lowest % seed damage i.e. 8.82% and 7.5% respectively. Both the accessions exhibited high suppression of bruchid development and adult emergence. These findings support & strengthen the selection of best genotypes utilized for crossing in the subsequent breeding program which is already being carried out with close coordination between Mungbean Breeding Group & Entomology Division at NIFA.

Chickpea varietal screening against chickpea pod borer *Helicoverpa armigera*

Under coordinated research program with Provincial Agric. Research system, chickpea varieties were supplied by Chickpea Research Station Ahmadwala, Karak for screening against chickpea pod borer at the experimental farm of NIFA. Seven different chickpea (Desi & Kabuli types) genotypes were sown during November 2012 in a RCBD with four replications. Seasonal larval populations were recorded from randomly selected 7 plants in each genotype at weekly interval at the onset of pest attack. Pods infestation and grain yield data were recorded. Some of the varieties exhibited chlorosis and resulted in minimum pod setting during cropping season.

On the basis of pods infestation, chickpea variety KK-3 followed by KK-2 resulted in 38.83% and 41.34% pods infestation respectively. Maximum grain yield (1996.87 $kg.ha^{-1}$) was recorded in KK-3 followed KK-2 with 1658.33 $kg.ha^{-1}$ yield. Grain yield and percent infestation can be used as selection criteria for tolerant genotype in an integrated part of management program against *Helicoverpa armigera*.

Comparative efficacy of insecticides to control pod borer on chickpea crop

A chemical control trial was conducted. It comprised of four insecticides and a check having 3 replications in RCB design with a plot size 18 m^2. Chickpea variety NIFA-95 was used as a test variety. All the insecticidal treatments were applied at the recommended doses at the onset of pod borer attack. Two sprays of each insecticide were made at 7-day intervals. Data on larval population and total pods versus damaged pods were recorded per plant from 7 randomly selected

plants in each treatment. Grain yield data was recorded after harvesting the crop.

Maximum pod infestation (55.38%) and minimum grain yield (576 kg.ha^{-1}) was recorded in check (untreated) plots. All the insecticides were found effective in reducing the pod borer infestation as compared to check. Curacron with 20.37% infestation was found best followed by Delegate 23.10% pod infestation with corresponding grain yields of 2337 kg.ha^{-1} and 1927 kg.ha^{-1}, respectively as shown in Table 1.

Table. 1. Effect of insecticides on pod borer infestation and grain yield of chickpea

Treat-ments	Formu-lation (%)	Dose ha^{-1}	% pod infes-tation	Grain yield Kg ha^{-1}
Curacron	50 EC	800 ml	20.37	2337.0
Delegate	25 WG	40 g	23.10	1927.0
Thiodan	35 EC	1000 ml	24.27	1868.0
Methyl parathion	50 EC	400 ml	30.37	1232.0
Control (untreated)	-	-	55.38	576.7

Stone fruit Insect pests and their control

Rearing of Peach flat-headed borer, *Sphenoptera dadkhani* (Oben.) on different artificial diets

Three different artificial diets were evaluated for successful rearing of peach flat-headed borer. First artificial diet consisted of nutritional ingredients (sucrose, wesson's salt mix, yeast, bactoagar, cortex dry; pre-autoclave portion (boiled soybeans); post-autoclaved portion (casein, sorbic acid, vanderzant vitamin mix, methyl paraben) and texurizing agent (cellulose, plum bark sawdust). The second artificial diet consisted of the above ingredients with the addition of leaves extract of peach/plum. The third artificial diet consisted of simple saw dust of poplar. A significant effect of artificial diets in vitro condition was observed on the survival of different life stages of borer. Maximum larval survival (60%) was recorded in artificial diet-1 followed by artificial diet-3 (46.66%) and minimum was observed in diet-2 (6.66%). Maximum pupal recovery (40.0%) was recorded in artificial diet-1 followed by diet-3 (20.0%) & none of the larvae were able to reach the pupal stage in diet-2. In case of adult, maximum adult emergence was recorded from diet-1 i.e., 40% followed by diet-3 (13.33%). In all tested artificial diets, diet-1 was found suitable for laboratory rearing followed by diet-3.

Chemical control of peach flat-headed borer, *Sphenoptera dadkhani* (Oben.)

For confirmation of results of effective insecticides i.e., Nurelle-D 505EC (75 ml), Fyfenon 57EC (75 ml) and Camphor (20 gm) in Bordeaux mixture (Copper oxychloride 75 g + Lime 3 kg + water 10 L) tested in Bordeaux mixture against borer in plum orchard in the month of January (2013), their field efficacy was tested and found effective against borer infestation (gum points/exit holes) as after 30 days. Other botanical extracts/ oils i.e., Neem oil (100 ml), Jamama oil (100 ml), Hing (25 g) and Hing + Neem + Jamama oil (25 g +25 ml +25 ml) in Bordeaux mixture were also tested against the borer. Hing + Neem oil + Jamama oil in Bordeaux mixture was found very effective in reducing the adult population and coupled with minimizing level of gummosis.

Field efficacy of different synthetic insecticides i.e., Lorsban 40EC (Chlorpyrifos), Perfekthion 57EC (Methyl parathion), Tracer 240SC (Spinosad) and Steward 150SC (Indoxacarb) @ 50 ml, 50 ml, 25 ml and 30 ml per 10 litres of water were sprayed on 4th April, 2013 on tree trunks which showed a significant effect against borer. Based on these results Lorsban 40EC, Perfekthion 57EC were found effective in reducing gum points as compared to other tested insecticides in plum orchard upto 30 days.

Quarantine pests and their control

Development of irradiation doses for quarantine pests

Recently irradiation has been adopted as safe measure for disinfestations of quarantine pests. Research data on the quarantine pestis (*citrus psylla* and scale insects) is very limited. Irradiation as a phytosanitory treatment for exportable fruits and their pests was explored as method to prevent development and adult emergence and mortality of irradiated citrus psylla nymphs and adults. Two year old citrus plants were infested with various nymphal stages of citrus psylla and irradiated with target doses of 50, 100, 150, 200, 250 Gy at a dose rate of 0.367 Gy/minutes and held at control temperature 28 ± 2^{0}C and 60 ± 5 % relative humidity for post irradiation mortality and adult emergence inhibition. Predicted dose (LD 99.99) for 1st, 2nd, 3rd and 4th nymphs were 151.87, 204.05 (P< 0.95) respectively. Mortality of adults when exposed to higher doses of gamma irradiation (300, 400, 600, 800, 1000 Gy) showed predicted dose of LD 99.99= 864.26 Gy for females and 853.08 Gy for males after 8 days of irradiation. Results indicated that females were more radio tolerant than males (Tables 2, 3, 4).

Table. 2. Inhibition (%) of *D. citri* at different development stages after 7 days of irradiation

Development stage	Dose (Gy)						Slope	Predicted dose for 100 % mortality
	0	50	100	150	200	250		
1st, 2nd instar	10.0	77.27	93.86	99.49	100	100	3.51 ± 0.42	151.87
3rd, 4th instar	31.88	83.75	95.45	98.27	99.37	100	2.65 ± 0.32	204.05

Table 3. Mortality (%) of *D. citri* at different development stages after 7 days of irradiation

Development stage	Dose (Gy)					Slope	Predicted dose for 100 % mortality
	0	100	150	200	250		
1st, 2nd instar	9.30	96.08	98.48	100	100	3.66	151.07
3rd, 4th instar	11.63	93.67	100	100	100	7.94 ± 0.90	186.95

Table 4. Mortality (%) of *D. citri* adult stages after 8 days of irradiation

Development stage	Dose (Gy)						Slope	Predicted dose for 100 % mortality
	0	300	400	600	800	1000		
Male	30	72.0	80.0	95.0	100	100	4.73 ± 0.81	853.08
Female	30	84	90	96.0	100	100	3.58 ± 0.83	864.26

Termite Control

Development of slow-acting toxicant bait against subterranean termites

Chlorphenapyr, an aryl-substituted cyanopyrrole with a high binding capacity to soil and a low leaching rate was tested as a slow-acting toxicant against subterranean termite, *Heterotermes indicola*. When offered in a food substrate in choice test, termites fed on it irrespective of the concentration used during the first week. However during the second week a concentration of 100 ppm was avoided but the rest of concentrations (1 to 50 ppm) were as acceptable to termites as the untreated control. The highest acceptable concentration (50 ppm), however, did not produce a significant termite mortality indicating that this termiticide cannot be an effective slow-acting toxicant. Chlorphenapyr was found to have a very high contact toxicity which can make it a good candidate as a barrier treatment as it does not repel termites.

Indoxacarb, a reduced-risk pesticide owing to its relatively low mammalian toxicity and low impact on human health was tested as a slow-acting toxicant against *H. indicola*. In no choice tests, *H. indicola* were exposed to concentrations ranging from 1 to 100 ppm. It took 15-34 days to kill 50% of termites exposed to contact and feeding for 24 h at 1 ppm while at 5 and 10 ppm, estimated lethal time to kill 50% of the exposed termites was 12 and 7 d respectively. As the dose rate exceeded 20 ppm, ELT 50 value was less than 3 d. Projected ELT 90 values were too high for 1 and 5 ppm while at concentrations equal to or greater than 50 ppm, the values were too short (2-3 d). In the choice test, the termites did not distinguish between treated and untreated substrate at all the concentrations used but the only effective concentrations were 70 and 100 ppm that led to a complete mortality of *H. indicola*. This indicates a strong contact effect of indoxacarb but not make it a good slow-acting toxicant.

Field testing of fipronil-based bait was performed against subterranean termites in a lawn found to be severely infested by termites. A total of eight foraging points were detected in the lawn including seven foraging points of *Odontotermes* and two of *Microtermes*. High populations of *Odontotermes* (2000 to 3000 foragers) were observed at five foraging points while two points had *Microtermes* populations. Two weeks after the bait application, *Odontotermes* disappeared from all the foraging points while there was a decline in the population of *Microtermes* at both the foraging points. The data recorded after six weeks showed that at activity of *Microtermes* ceased at its original foraging points but one of the foraging points *Odontotermes* was now occupied by a

small population (380 workers) of *Microtermes*. Similarly, a foraging point originally occupied by *Microtermes* was found to be occupied by 1230 workers of *Odontotermes*. After eight weeks it was observed that termite activity completely ceased at all the foraging points indicating the efficiency of bait in eliminating the colonies of both the species.

Medical Entomology

Efficacy of botanical and mineral kerosene oils on *Culex quinquefasciatus* mortality and their repellency in ovitraps

Control programs using conventional insecticides to target anthropogenic mosquito habitats are very expensive because these habitats are widespread, particularly in cities and rural areas of Pakistan. Additionally, there are serious environmental concerns regarding large-scale application of conventional insecticides. There is need for alternative safe, effective, less expensive, and environment friendly pesticides.

The larvicidal effect of seven botanical oils from Cinnamon *Cinnamomum zeylanicum*, Canola *Brassica napus*, Clove *Syzygium aromaticum*, *Eucalyptus grandis*, pine resin *Pinus sylvestris* (turpentine), mustard *Brassica Juncea*, neem *Azadirachta indica*, and mineral kerosene oil were tested for their toxicity on third instar (L3) and early 4th instar (L4) larvae of *Culex quinquefasciatus* Say and in field ovitraps for their repellency/ attractancy. The 24 h LC50 for these oils as recorded (in ppm) were; canola 679, cinnamon 429, clove 510, eucalyptus 166, mustard 2599, turpentine 199, and kerosene 112. The LC90 values (ppm) at the 24 h post application time were canola 5887, cinnamon 2538, clove 12246, eucalyptus 459, mustard 9131, turpentine 492, and kerosene 219. The 48 hrs LC50 for these oils as recorded (ppm) were eucalyptus 155, canola 321, cinnamon 186, clove 211, mustard 494, turpentine 125, and kerosene 112 respectively while the LC90 values at 48 h post observation time were eucalyptus 479, canola 1372, cinnamon 1124, clove 865, mustard 18326, turpentine 254, and kerosene 219. The 24 and 48 hr LC50 values for eucalyptus, cinnamon, turpentine and kerosene oils did not differ at $p<0.05$ while the 24 hr LC_{90} of eucalyptus and turpentine were at par. The 48 h LC90 for turpentine and kerosene were statistically the same indicating equal toxicity to the *Culex quinquefasciatus* mosquitoes.

The positive oviposition activity index (OVI) for traps treated with eucalyptus, cinnamon, turpentine and kerosene oils indicated that these oils were attractive while neem oil was repellent to both Culex and Aedes mosquitoes. Thus some botanical oils can be attractive and at the same time fatal to the larvae of *Aedes albopictus* and *Culex quinquefasciatus* and may be good candidates for using in attract and kill strategy of mosquitoes control programs.

FOOD SCIENCE DIVISION

The overall focus of R&D in the Food Science Division is to devise ways and means to ensure food safety and security. Scientists in this division are working on value addition and shelf life extension of agricultural commodities through gamma irradiation and other modern techniques. These efforts involve R & D for microbial safety, detoxification and new product development. Furthermore, commonly consumed diets are nutritionally enriched to overcome malnutrition and to meet requirements of special target groups. Training are imparted to generate self-employment opportunity. Also healthy foods and healthy food habits are promoted through awareness programs.

Food Irradiation & Microbiology

Development of irradiated foods for immunocompromised patients and other potential target groups

During the 2nd year efficacy trial of the CRP 15116, different meals were prepared and fortified with vitamins C, A and E. The fortified meals were vacuum packed and irradiated at the dose of 8 KGy. The efficacy trial was conducted on two groups of patients namely brain tumor and breast cancer patients for one month period at Institute of Radiotherapy and Nuclear Medicine (IRNUM) Peshawar. The data regarding physicochemical and microbiological parameters of the prepared meals were obtained. Increase in Hbs along with weight gain was observed in the test patients during the trial.

Patients groups selection

Two groups viz. brain tumor and breast cancer patients were selected for the efficacy study of irradiated diets for immunocompromised patients. The selected patients were in stage III of the disease. Test groups consisted of twelve patients each, that were divided into two groups of six patients each, one was kept control and the other the was test group. The patients were served with a breakfast, a lunch and a dinner. They remained admitted in the hospital during the study period of one month.

The data regarding body weight is shown in Fig. 1, which indicates that in brain tumor patients, drastic decrease in body weight was recorded in control group as compared to test group patients in which the body weight was maintained during the entire period of one month study. In case of breast cancer patients' body weight of test group was increased, while decreasing trend was shown in patients of control group (Fig. 2).

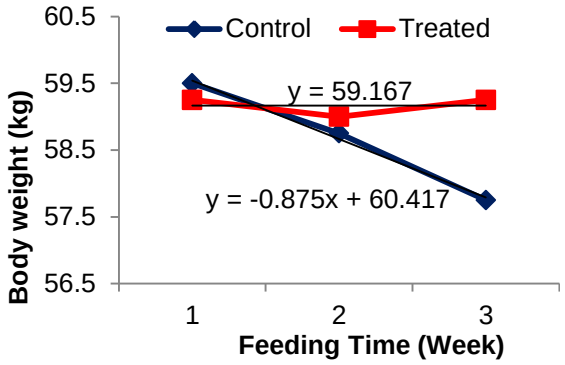


Fig.1. Effect of neuropenic patient diets on average body weight of test group of brain tumor patients

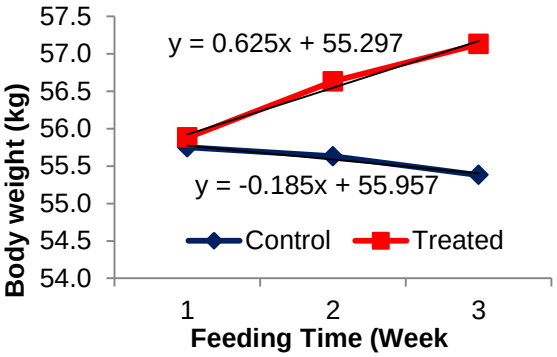


Fig. 2. Effect of neuropenic patient diets on average body weight of test group of breast patients

It was observed that in control group of brain tumor patients, no significant difference in hemoglobin (Hb) content was noted while in test group patients, the Hb content significantly increased during four week study period. The initial Hb level in control group was 13.48 $g.dl^{-1}$ which decreased to 11.75 $g.dl^{-1}$ while in test group the Hb level was significantly increased from 11.9 to 12.46 $g.dl^{-1}$. Similar trend of Hb was observed in the breast cancer patients. (Fig.3, 4) According to the opinion of relevant doctors, increase in weight and Hb content was due to the serving of low bacterial diets and less attack of food borne diseases as compared to the control groups of patients. No clear picture was noted in some of the hematological parameters of both (test, control) groups of patients (Fig. 5, 6). However some trends of increase and decrease were noted in the hematological profile during the efficacy trial on both groups of patients. In breast cancer patients, increasing trend in ALT content in control group was observed while in test group, the ALT was decreased from 30.3 to 24.25 $\mu g.l^{-1}$ after 4 week efficacy study (Fig. 7).

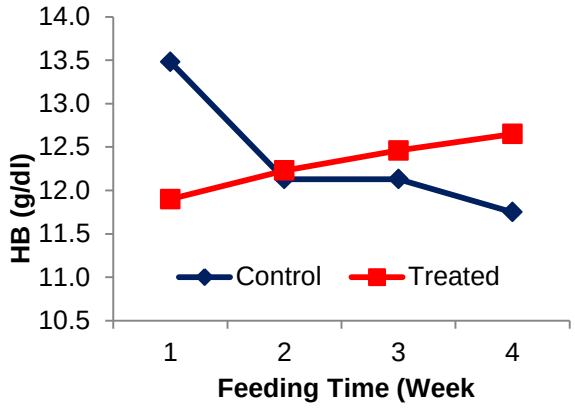


Fig. 3. Hemoglobin (HB) of brain tumor patients

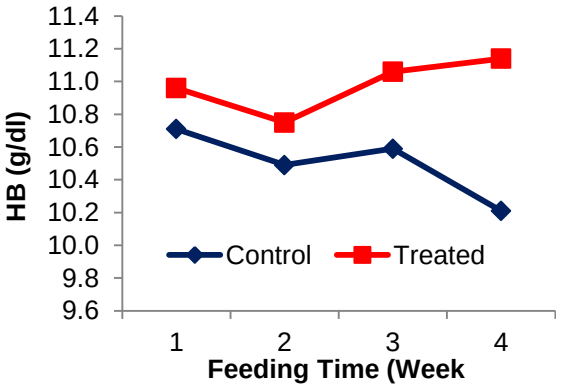


Fig. 4. Hemoglobin (HB) of Breast Cancer Patients.

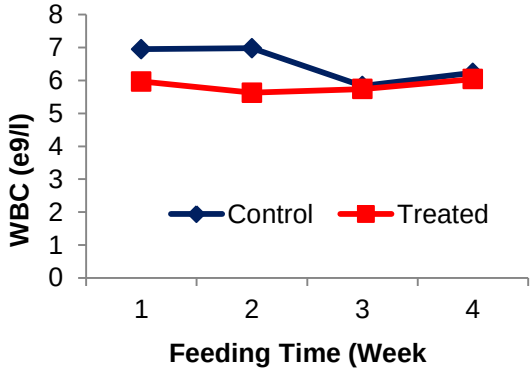


Fig. 5. White Blood Cell (WBC) of Brain Tumor Patients

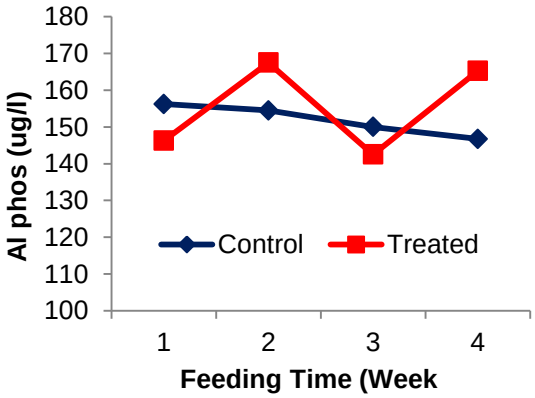


Fig 6. Alkaline phosphatase (Al Phos) of brain tumor patients

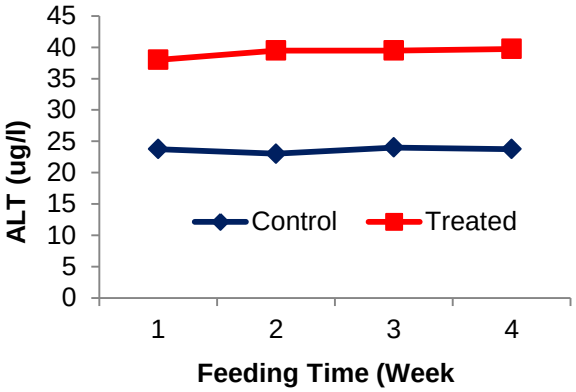


Fig. 7. Alanine aminotransferase (ALT) of brain tumor patients

Pesticide residues in vegetables

Development and validation of analytical procedures/protocols for the determination of new and abundantly used pesticide residues in the fruit and vegetable matrices was carried out under the PSF funded research project “Development and Validation of Technologies for Pesticide Residue Management in Fruit and Vegetable Produce”. QuEChERS extraction and cleanup method was modified for the analysis of pesticide residues of organochlorine, organophosphate, carbamate and pyrethroid groups in tomato and cucumber by gas chromatography with electron capture detection (GC/ECD). The modifications were evaluated for precision, accuracy, sensitive and robustness. Besides, cost economics and high throughput of the procedure were also considered.

The QuEChERS procedure was modified by using ethyl acetate for extraction and NaCl for salting out step replacing acetonitrile and NaAc.3H2O in respective steps. In order to get desirable sensitivity and to avoid chromatographic interferences some modifications were also investigated. The cleanup step was performed by using alumina, florisil and charcoal sorbents as dispersive solid phase extraction (dSPE) procedure. Method validation was performed by using spiked tomato and cucumber samples @ 10, 100 and 200 ug.kg^{-1} concentration levels. Residue extraction by ethyl acetate followed by NaCL salting out step and dSPE cleanup by using florisil and charcoal in 1:3 ratio were found most effective. The modifications were able to achieve desirable precision (70-110% recoveries), accuracy (relative standard deviation <20%) and sensitivity to analyze residues at lower ppm levels by GC/ECD.

Technology transfer of mushrooms cultivation in Chitral

The NIFA mushroom team visualized the idea that if each chitrali house hold grows at least 100 bags of Oyster mushrooms as kitchen gardening activity in his/ her home during the onslaught of winter season, he/she can get an indoor home grown inexpensive alternate of animal proteins for the nutritional sustainability of his/her family during the ravages of inclement weather.

To attain this objective, NIFA mushroom group submitted a proposal to Directorate of Science and Technology (DoST), Government of KPK to transfer the mushroom cultivation technology to the master trainers in Chitral for giving spur to promote the cultivation of this nutritious and highly delicious commodity to the dwellers of Chitral. DoST approved the project and the team visited Chitral from 24th May to 1st June 2013. Secretary Science and Technology, Government of KPK and Director DoST along with other officials also flew to Chitral to inaugurate the ceremony of Technology Transfer Program.

In the 1st spell, 3 training programs were arranged at 3 different locations of the district. A total of 170 master trainers belonging to both genders were trained in these trainings whose written feedback about NIFA and PAEC was over whelming. They wowed to popularize this highly need based technology to the grass root level of Chitral Three model farms were established at different localities to meet the spawn requirement of the growers.

The team will undertake the 2nd spell of mushroom training after Ramadan and will also monitor the outcome of earlier trainings.

Development of package of technology for poultry feed irradiation in Pakistan

Poultry feed is one of the major carriers of disease causing microorganisms and needs to be decontaminated at source in order to avoid huge losses caused by mortality in the flocks. Gamma irradiation is a relatively newer technology applicable as a cool terminal process to inactivate/kill spoilage and disease causing microorganisms of poultry feeds. Industrial level application studies are needed on adopting this technological intervention for better feed provision system. Second year's work of the current project was aimed at studying the influence of gamma irradiation and packaging materials on the biological performance of the consuming broiler flock.

Experimental antibiotic-free broiler feed was prepared in SB Feed Mills, Mandra and packed in 2 layered polypropylene woven + polyethylene (PP+PE) bags, or polypropylene woven (PP) bags. The treatment lot of the samples was irradiated at 5kGy dose of gamma radiation at Pakistan Radiation Services (PARAS) Lahore. All the samples were then transported to NIFA Peshawar for use in a replicated feeding trial on broiler chicks at farmer's shed (Table 1 – 11 & Fig. 1 – 3).

Results indicated none of the two factors significantly influenced the bird's weight, FCR, mortality (%), dressing percentage, carcass yield and gizzard weight. Weight gain and feed consumption was higher in control group resulting in an overall similar FCR in both groups. FCR in bird's groups fed on control feed packed in PP bags was higher than all other groups. The same group has the highest (P<0.05) mortality among all the groups. Radiation treatment did not have any adverse effect on the broilers' biological performance; whereas mortality was higher in groups fed on control feed packed in commercially in vogue packing.

Table 1. Final weight of broilers (g/chick) as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	1577 A	1516 A	1547 A
PP+PE	1524 A	1533 A	1529 A
Mean	1551 A	1525 A	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 2. Total weight gain of broilers (g/chick) as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	1109 A	1047 A	1078 A
PP+PE	1088 A	1051 A	1070 A
Mean	*1099 A*	*1049 B*	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 3. Total feed intake of broilers (g/chick) as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	2444 A	2256 B	2350 A
PP+PE	2307 B	2298 B	2303 A
Mean	2376 A	2277 B	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 4. Feed conversion ratio (FCR) as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	2.22	2.16	2.19
PP+PE	2.12	2.19	2.15
Mean	2.17	2.17	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 5. Mortality (%) in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	18.8 A	8.0 B	13.4 A
PP+PE	10.4 B	10.0 B	10.2 A
Mean	14.6 A	9.0 A	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 6. Dressing percentage in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	75.43 A	72.50 A	73.967 A
PP+PE	68.67 A	62.83 A	65.750 A
Mean	72.05 A	67.67 A	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 7. Weight of eviscerated carcass as % of live body weight in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	42.80 A	53.93 A	48.37 A
PP+PE	55.43 A	42.47 A	48.95 A
Mean	49.12 A	48.20 A	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 8. Gizzard weight (g) in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	27.60A	24.67A	26.13 A
PP+PE	28.73A	25.37A	27.05 A
Mean	28.17 A	25.02 A	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 9. Gizzard weight (as % of live body weight) in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	2.03 AB	1.73 B	2.00 A
PP+PE	2.17 A	1.83 AB	1.88 A
Mean	2.10 A	1.78 B	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 10. Heart weight in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	7.00 AB	6.07 B	6.53 A
PP+PE	7.77 A	6.33 B	7.05 A
Mean	7.38 A	6.20 B	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

Table 11. Heart weight (as % of body weight) in broilers as influenced by gamma irradiated feed packed in two different packaging materials

	Control	Irradiated	Mean
PP	0.50 AB	0.43 B	0.47 A
PP+PE	0.60 A	0.47 AB	0.47 A
Mean	0.55 A	0.45 B	

PP= Polypropylene woven bags, PP +PE = two layered (PP +Polyethylene) bags
Values in the interaction matrix are averages of 5 replicate groups each containing 50 birds.
Values in the interaction matrix, means for treatments or packaging material followed by different letters are significantly (p<0.05) different from each other.

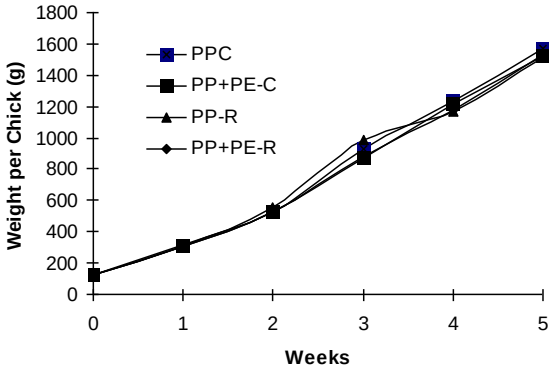


Figure1. Weekly weight per chick as influenced by gamma irradiated feed packed in two different packaging materials

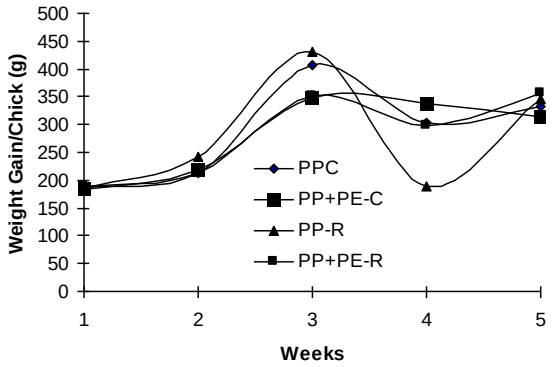


Figure 2. Weekly weight gain as influenced by gamma irradiated feed packed in two different packaging materials

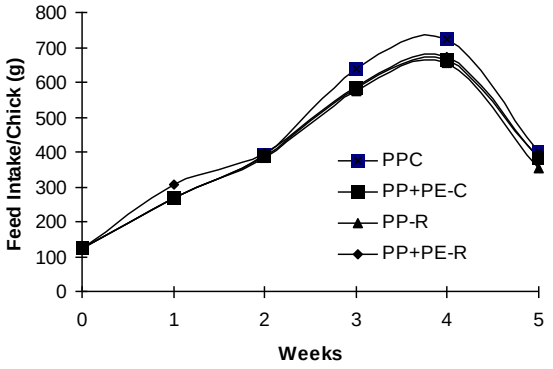


Figure 3. Weekly feed intake as influenced by gamma irradiated feed packed in two different packaging materials

Quality improvement of commonly consumed edible oils by fortification of seabuckthorn oil

Palm oil is an essential part of almost all dietary fats which contain majority of saturated fatty acids and their adverse effects regarding heart related health problems are well proven. Therefore there is an urgent need to explore some indigenous non-conventional, economical plant oils that could be used as fortificants to improve the chemical and nutritional quality of edible which in turn could improve the prevalence of fat related ailments.

Seabuckhorn (*Hippophae rhamnoides*) oil (SBO) which is packed with health giving micronutrients was selected to improve the nutritional quality and stability of palm oil. Sea buckthorn fruit were procured from PCSIR Labs complex, Peshawar dried to separate pulp from seed. The oil was extracted by n-hexane. Palm oil (PO) was procured from Shama Ghee Industries Nowshera. The oil samples were analyzed for quality attributes i.e. peroxide value (POV), free fatty acids (FFA), iodine value (IV), β carotene and vitamin e, applying standard methods.The fatty acid profile of both oils was measured by Gas

Chromatograph as shown in Fig. 1. SBO was blended with PO @ 10%, 20%, 30% and 40%. For Stability studies test and control (Unblended) samples were kept under Auto and Photo oxidative stress conditions (Sun& Artificial Light) for 08 weeks. The stability was measured by POV followed by weekly analysis. Results are presented in Fig 2. It was inferred from the results that a significant improvement in stability was noted in 40:60(SBO: PO) blend under all the test conditions. A significant improvement in concentration of vitamin E and beta Carotene was also found. However, maximum increase in POV was observed in samples stored under sunlight has compared to artificial light.

Blending is the only option which could be used to prepare the edible oils nearest to WHO and American Heart Association (AHA) recommendations that ratio of saturated, monounsaturated and polyunsaturated fatty acids should be as 1:1.5:1 and Omega6/Omega3 ratio of 5-10 in the diet .It is safe to predict that oils with balanced chemical composition of fatty acids in their triglyceride may pass as the nearest prototypes.

Such blended fat would be able to fulfill the body nutritional requirements in a natural, economical and sustainable fashion

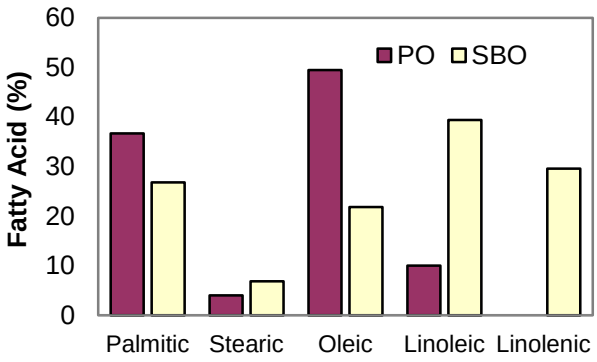
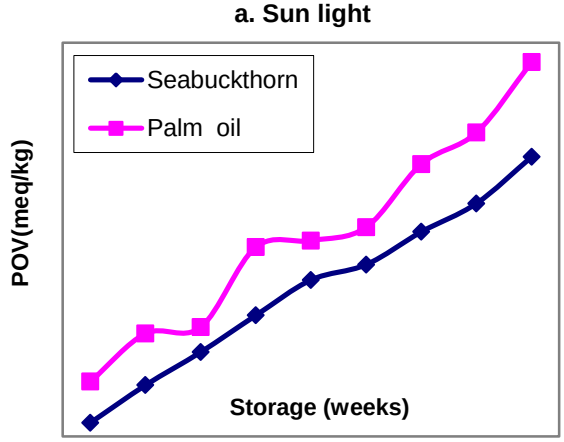


Fig. 1. Fatty acid profile of test oils



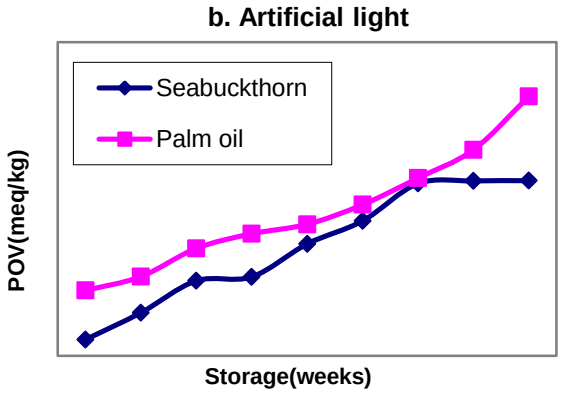


Fig. 2. Effect of photo oxidation (a. Sun light, b. artificial light) on stability of test oils

Improved nutritional and sensory profile of chapatti (flat bread) fortified with milktheistle seed

The prevalence of malnutrition and micronutrient deficiency is continuously spreading in Pakistan. It is a condition due to which the body becomes prone to attack of free radicals, suppresses immune system and reduces resistance to degenerative diseases like obesity, diabetes, hypertension, cardio vascular problems, hepatic disorders and cancer, etc. It is need of time to enhance the value of food products in terms of both quality and quantity along with consumer's safety to identify and incorporate unconventional food sources in diet formulations to improve the prevailing situation and to balance ingredients that offer optimum processing functionality, nutritional value and cost effectiveness

Some local underutilized plant sources like Silybum Marianum (Milk Thistle) is an annual or biennial herb, belongs to family composite. It grows abundantly in Pakistan as a weed with wheat crop as well as on unutilized, barren grounds. It has tremendous potential to be exploited. e.g. presence of significant amounts of bioactive compounds, micronutrients fibers and natural antioxidants which have ability to scavenge free radicals and prevent lipid per oxidation their intakes decreased the risk of coronary heart diseases and increases immunity to infectious cells and inhibit the growth of tumors and lipid oxidation a leading cause of many diseases. Wheat based food products Chapatti Roti, biscuits/ crackers/ etc are considered suitable vehicles for incorporation of functional ingredients that can easily be accessible to masses especially in countries like Pakistan where wheat is staple diet.

Mixture of wheat seed was procured from Plant Breeding and Genetics Division NIFA while Milk Thistle, experimental farm of institute. Seeds were

cleaned to remove any dirt/dust or foreign particle and grinded for flour. The Milk Thistle seeds four was defatted and incorporated into whole wheat flour at the level of 5% and 10% was designated the Milk Thistle test samples(MT).Unincorporated 0 % Whole wheat flour chapattis served as control (C).Water was added and kneaded to soft dough. The dough was then made into a round ball and sheeted on a clean rolling board .The sheeted chapattis were baked on both the sides on a conventional hot plate (Tawa) Samples were prepared in triplicates. Each treatment was individually blended.

Nutritional & sensory analysis

The moisture, ash, protein, total lipid and resistant starch content of control and test chapatti samples were determined using standard AOAC protocols.

The sensory acceptability was carried out for the chapattis made from the incorporated whole wheat flour by using hedonic rating scale from 5 for well to 1 for poor acceptability. The panelists were given the samples and asked to judge them based on their organoleptic qualities. The eating quality of the chapattis was decided based on the taste and flavor of the sample. The overall acceptability of the product was also judged. The mean values obtained from the sensory scores given by all the subjects were calculated.

Texture analysis of the chapattis involved subjective evaluation of the textural properties of the chapattis. The amount of force required to tear the chapattis was used to assess the degree of softness of the chapattis samples. The number of chews required to mash the sample completely inside the mouth was used to rate the ease of chewing (chewability). The ease with which the chapatti samples could be folded without breaking indicated the degree of fold ability.

The results of the nutritional analysis carried out for C & MT. The incorporated chapatti samples are given in Table1.

Moisture content of chapatti C was found to be 29.33 %. With the addition of Milk Thistle flour the moisture content of the samples increased significantly with 5% milk thistle incorporated sample MT exhibiting 33.2 % moisture content.

A significantly higher protein content of 9.18 g% was recorded by MT compared to C. This could be attributed to the addition of milk thistle seed flour which being a good source of protein (27.8 g %). Total fat content of the C and MT samples were found to be 0.48 g% and 0.97 g%, respectively, and was not significantly different.

Available carbohydrate (AC) content of 46.5 g% was recorded by C, significantly ($P<0.05$) higher compared to MT (23.5 g %). The values corresponded with the total dietary fiber (TDF) content obtained wherein a significantly ($P<0.05$) higher TDF content of 10.36 g% was found in MT, compared to C (7.58 g %). This higher TDF and lower AC content found in MT could be attributed to the addition of c milk thistle flour which has been reported to function as a dietary fiber.

The study, thus, indicated that incorporation of whole wheat flour with Milk Thistle seed brought about a desirable improvement in the nutritional and sensory characteristics of chapatti. Thus, it could be inferred that Milk Thistle seed (an underutilized, indigenous, economical plant) could be used as a suitable functional ingredient in whole wheat flour chapatti with several benefits. Such functionally enhanced flours could be used in several other food systems for the formulation of health foods.

Development of market life enhancement technology of persimmon and its dissemination to growers

In order to utilize the persimmon season of 2012 some preliminary experiments were planned and conducted on relatively larger scale by using already available autoclave as close/controlled atmosphere chamber. Persimmon fruits, free from apparent pathogen infection, approximately uniform in shape, weight and color were harvested from Persimmon orchards of Agricultural University, KP at the picking stage. On arrival to the laboratory, fruits were washed with tap water, held for 24 hours for removal of adhering water and divided in to five lots, control fruit kept in open crates (T1), kept for 24 hrs in closed atmosphere (T2), kept for 48 hrs in closed atmosphere (T3), kept for 24 hrs in nitrogen enrich/ modified atmosphere chamber (T4) and kept for 48 hrs in nitrogen enrich /modified atmosphere (T5). All the treatments were conducted in triplicate. Fruit was loaded in to the autoclave bucket with capacity of 40 kg fruit/ treatment. Gas treatment was carried out by creating vacuum (20 psi) into the autoclave, releasing the vacuum by flushing nitrogen gas from nitrogen cylinder followed by treatment of the fruits for 24 and 48 hours seperately. Treated fruits were stored in cardboard cartons for 72 hours at room temperature and assayed for antioxidant content (total phenol and ascorbic acid), nutritional nassay (weight loss, fruit firmness and acidity) and sensory evaluation (color, flavor and overall acceptability). Fruit quality parameters were prior to gas treatment and post-treatment periodically at 5 days intervals up to 20 days.

The results revealed significant effect of N_2 and storage period was observed on most of the parameters. Highest mean values of total phenols (3.28), weight loss (5.11), acidity (0.26) and TSS (21.11) were found in control sample (T1) while lowest mean values of total phenols (2.77), weight loss (4.32) and acidity (0.24) were found in fruits kept for 48 hrs in nitrogen enrich/modified atmosphere (T5). Maximum firmness (3.98), flavor (7.67) and appearance (7.25) values were observed in fruits kept for 48 hrs in nitrogen enrich /modified atmosphere (T5) while minimum firmness (3.75), flavor (6.58) and appearance (5.83) was recorded in control samples. As a whole fruits kept for 48 hrs in nitrogen enrich /modified atmosphere (T5) retained maximum quality attributes and also got maximum score for sensory evolution.

This treatment is meant for application at pre-picking (greenish-yellow) stage of the fruit but it can be concluded from the results that this treatment was slightly beneficial even at the picking stage of the fruit. The total phenol responsible for causing astringency showed slight decrease initially and during three weeks of storage. By comparing total phenolic content of all the treatments it was evident that modified atmosphere caused reduction in total phenol/astringency. Improvement in the treated fruits was not up-to the mark probably because of the fact that the chamber used was not totally air-tight.

Development of snack product through extrusion cooking

In order to develop a nutritious snack product, corn starch, sugar, chickpea flour, peanut flour and Sodium-bi-Carbonate formulation was prepared. Moisture content of the raw ingredients was measured. 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 134 ^{o}C at the die, the extrudate expanded and came out as continuous rope. Inclusion of dry milk powder in the formulation significantly improved the texture and color of the product.

Canning of fruits and vegetables

Mushroom

Fresh Oyester mushroom were obtained from NIFA mushroom farm. pH of fresh mushroom was 6.62 and thus fall in the low acid food category. The mushroom were washed, cut in to pieces and blanched in boiling water for 1 minute. 350 g mushroom were placed in each can and filled with water. pH was adjusted to 4 by adding citric acid solution. The cans were sealed and sterilized in boiling water for 30 minutes. After 4 months storage the can had swollen and on opening gas came out under pressure with a rotten smell. However, color shape and texture of the product looked normal. pH of the cans was about 5.5 and there was also some rusting on the inside of the cans. The cans were discarded.

Janmman Fruits

Fresh jamman fruit were purchased from the Peshawar market. The fruit had an average weight of 7.48 g per fruit while its length and width were 27.89 and 20.13 mm, respectively. Density of jamman fruit as measured by the displacement method was 0.97g.cm^{-3}. TSS of the fruit pulp was 11.5^{o} brix and its pH was 4.85. For canning, the fruit were washed and blanched in boiling water for 1 minute. About 420 g of fruit were packed in each tin can. Tap water was added leaving 0.5" head space. Final weight of cans was 860 g. The cans were sealed in the vacuum can sealer and sterilized in boiling water for 30 minutes. The cans were opened after 2 months. Color of the fruit had changed while its texture and appearance was intact. On exposure to air color of the fruit changed again. The taste of the fruits was normal. However, methods in which the seed and pulp are preserved separately need to be explored.

SOIL SCIENCE DIVISION

The major thrust of soil science division is to devise strategies to combat low soil fertility menace, soil degradation, plants nutrition and water conservation by elevating soil organic matter (SOM) content in soil and by selecting nutrients/water efficient varieties. Several goal oriented research projects have been initiated to enhance crop production, improve nutrients/water use efficiency and soil health. Soil Science Division is also a helping hand for the breeders of NIFA by evaluating newly evolved cultivars for their nutritional requirements and providing fertilizer recommendations for new crop varieties.

Plant Nutrition

Integrated management of nutrients and water for growing off-season vegetables in high tunnels in moisture deficit areas

Demand for fresh water for agriculture, industry and municipal uses is increasing. New techniques and innovations must be developed and introduced to obtain higher yield (more food) with less water and land. Application of balanced fertilizers nutrients is essential to achieve maximum and quality production. However, farmers tend to use imbalanced fertilizers because of high cost that results in low nutrients use efficiency.

Tomato and cucumber are important vegetable crops in Pakistan. The production of off-season tomatoes and cucumbers under low tunnels has assumed great significance in the irrigated areas of Khyber Pakhtunkhwa. However, the high tunnels farming have not yet received proper attention. Although, its initial cost is high but it is suitable and economical for some vegetables including tomato and cucumber in water deficit areas due to durability of the system. The use of drip-irrigation system in these tunnels further improves the fertilizer and water use efficiencies. In high tunnels it is possible to grow tomatoes and cucumbers 6-8 weeks earlier than normal production season with prolonged growing period. High tunnels increase marketing opportunities, improve early and late season cash flow, and yields are often much higher than seasonal vegetables. The fertilizer and water requirements of off-season hybrid tomato are very high due to prolonged growth period and higher yield production compared to conventional cultivars. New technologies in moisture deficit areas of Pakistan must be developed and introduced to increase effective and efficient use of already squeezing water resources for enhancing crop production. The integrated nutrients management may be the environment friendly option to improve fertilizer use efficiency and quality of production.

These problems were well addressed at NIFA and the high tunnel farming having drip or sprinkler irrigation system for growing off-seasons vegetables was popularized among the farming community. The effect of integrated NPK and FYM treatments was studied on the yield of hybrid tomatoes and cucumbers. The properly decomposed FYM @ 50 kg/Marla were applied before transplanting nursery while NPK was applied after establishment of crop (30 days after transplanting) at different intervals. The yield data indicated that maximum tomato fruit yield of 160 $t.ha^{-1}$ was recorded in the treatment receiving NPK at 80 N + 80 P_2O_5 + 90 K_2O $kg.ha^{-1}$ after 30 days interval starting after establishment of crop (30 days after transplanting) till mid of June. In another experiment under walk-in tunnel maximum tomato fruit yield (127 $t.ha^{-1}$) was recorded in the same treatment with foliar application of 5 $kg.ha^{-1}$ Zn. Likely in another high tunnel cucumber was grown and the maximum fruit yield of 240 $t.ha^{-1}$ was recorded in the treatment receiving NPK at 125 N + 200 P_2O_5 + 250 K_2O $kg.ha^{-1}$ (soil application) + B spray (0.1%) at 15 days interval starting after establishment of crop till mid of May (4 sprays). It has been calculated that off-season tomato and cucumber grown in high tunnels gave fifteen times more income compared to conventional ones. The technology of high tunnel farming and nutrients management for tomatoes was demonstrated to vegetable growers in workshops/farmers day held at NIFA during 2012 and 2013.

Screening of advanced wheat genotypes for high yield and quality on low fertility soils

Seed of three advanced wheat lines (NRL-1130, NRL-1137, NRL-1139) suitable for rain fed area was collected from the Plant Breeding & Genetic Division of NIFA and was sown in pots on November 23, 2012 in net house. These lines were screened out under controlled moisture condition for response to different levels of zinc (Zn) and Boron (B). The yield data showed that NRL-1130 and NRL-1139 were found to be Zn while NRL-1137 B efficient wheat genotypes as these genotypes produced significantly (≤ 0.05) higher biomass at micronutrients deficient levels as compared with rest of the genotypes.

The results from pot experiments are only reliable when they have been tested under field conditions. So a field study was executed to confirm the results of previous year pot experiment with the objective to identify

micronutrient-efficient wheat genotypes that can be grown more efficiently on micronutrient deficient soils. The rates of fertilizer application and wheat genotypes were the same as for pot experiment. Among three wheat genotypes (NRL-0517, NRL-0707, NRL-0832) tested for micronutrients efficiencies, NRL- 0517 and NRL-0832 were found Zn and B efficient genotypes. The recommendations about these genotypes were conveyed to plant breeding and genetic division for further testing to release the Zn and B efficient wheat variety for low fertility soils of Khyber Phukhtunkhawa (KPK).

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

Application of P fertilizers is recommended to cope wide spread P deficiency in agricultural soils around the globe. However, ever-rising prices of P fertilizers and its low use efficiency makes this practice both 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. These variations can be exploited through selection and breeding for more P efficient crop species to sustain crop productivity and soil health. Therefore, solution culture study was planned to evaluate genetic variations among ten wheat genotypes which is an important cereal crop of Pakistan. Seed of 10 wheat genotypes was surface sterilized with sodium hypochlorite and germinated on moist filter paper in petri dishes in an incubator at 20±1^{o}C until ready for transplanting. Five days old seedlings were transplanted in foam plugged holes of thermopole sheets 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 µM) and deficient (25 µM) P levels. The pH of the solution was maintained at 5.5±0.5 with HCl or NaOH. Two seedlings were transplanted in each hole of that was considered as one repeat. Experiment was harvested 30 days after transplanting and the data were recorded for different parameters. The results indicated that at low P level, visual symptom of P deficiency appeared as development of dark-green color in leaves along with reduction in shoot elongation and leaf size of most genotypes. Severity and development time of these leaf symptoms greatly differed among wheat genotypes. Low P supply significantly (≤ 0.05) decreased shoot growth of all genotypes. The shoot dry matter (SDM) per 2 plants varied between 1.00 to 2.77 g at 25 µM (deficient) while 1.20 to 3.27 g at 250 µM (adequate) P levels, respectively. Genotype NRL-1120 produced highest SDM at deficient P level while Yecora produced the highest SDM at adequate P level. Unlike SDM, there was 54% reduction in root dry matter (RDM) with the increase in P levels from 25 to 250 µM in the growth medium. More or less all the wheat genotypes produced higher RDM at deficient P level. Among ten wheat genotypes NRL-1105, NRL-1120 and Yecora were found to be P efficient while NRL-1101, NRL-1129 and WL-711 were classified as P in-efficient genotypes.

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

Zinc deficiency in cereal plants is a well-known nutritional problem that causes reduced agricultural productivity all over the world. According to a survey about 50% of the soils used for growing cereals in the world and 70% in Pakistan are Zn deficient, consequently severe reductions in cereal production have been reported. There are also marked differences in sensitivity to Zn deficiency among cultivars of a given species and wheat shows particularly pronounced genotypic differences in tolerance to Zn deficiency. A number of nutritional disorders, not easily cured by soil treatments could possibly be ameliorated by growing presently available cultivars with desirable genetic traits. In view of these considerations, a study was undertaken to investigate the relative Zn-efficiencies of wide range of 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 ^{o}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 50 L capacity filled with 40 L of the chelate-buffered nutrient solution. Zinc activities of 2, 10 and 40 pM were employed to the plants. The plants were initially grown in nutrient solutions containing half strength 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 and when 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 depicted that stunted growth was the first visual symptom of Zn deficiency appeared and then whitish-brown necrotic spots developed on the middle parts of the leaves. Three different levels of Zn^{2+} activity in solution had a significant effect on the growth of the wheat plants. In the culture solutions with higher Zn^{2+} activities, the plants showed enhanced growth and dry matter production. The genotype NRL-1243 has the maximum dry matter production at 40 pM Zn^{2+} which was 7.59 $g.pot^{-1}$. In the Zn deficient solutions (2 pM Zn^{2+}), shoot dry matter production was distinctly lower and varied between genotype to genotype. By exploiting this variation the efficiency of genotypes was calculated that varied between 27 to 70 %. Out of 10 genotypes, 3 have been identified as Zn efficient and 3 as Zn-inefficient. The Zn-inefficient cultivars i.e. NRL-1243 and NRl-1009 produced significantly (≤ 0.05) lower dry matter yields than the Zn-efficient cultivars NRL-0517 and NRL-1242 at the Zn-deficient level. It was also observed that Zn concentrations in the shoots of the different cultivars varied between 10.5 $\mu g.g^{-1}$ and 52.4 $\mu g.g^{-1}$. Generally, the Zn-inefficient cultivars (NRL-1243 and NRl-1009) had lower Zn concentrations (10.5 and 11.0 $\mu g.g^{-1}$) than the Zn-efficient ones at 2 pM Zn^{2+}. The uptake of Zn in plant shoots varied between 15.8 and 301.4µg/pot. The cultivars which had been classed as Zn-efficient showed higher Zn uptake than the Zn-inefficient cultivars in low Zn culture solutions (2 pM Zn^{2+}). The Zn-efficient cultivars NRL-0517 and NRL-1242 had Zn uptakes of 77.6 and 51.1 $\mu g.pot^{-1}$ respectively, whereas the Zn-inefficient cultivars NRL-1243 and NRL-1009, had uptakes of 15.8, and 21.1µg $Zn.pot^{-1}$, respectively. Generally, roots had higher Zn concentrations than shoots. Zinc-inefficient cultivars such as NRL-1243 and NRL-1009 accumulated higher amounts of Zn in the roots compared with Zn-efficient varieties such as NRL-0517 and NRL-1242 but translocated smaller amounts to the shoot. All the cultivars showed marked variations in Fe, Mn and Cu concentrations in shoots at the Zn-deficient level (2pM Zn2+). Zinc-inefficient cultivars showed significantly higher concentrations of these elements at low Zn2+ activity than Zn-efficient cultivars. It can be concluded from the results that Zn-efficint genotypes has the ability to extract more Zn from Zn deficient medium and produce higher biomass.

Screening of wheat germplasm based on root traits for drought tolerance

Declining availability of fresh water sources coupled with high temperatures and increasing incidence of droughts necessitate developing wheat varieties that are efficient in utilizing available water and are drought tolerant. After green revoluation , focus had been to evolve varieties based on selections made for yield with out considering roots. This has lead to the situation that most of the current varieties had small root system with low uptake capacity. Furthermore, genetic improvement in wheat can be made by exploiting existing genetic variation for root traits. Root features like root biomass and maximum rooting depth can be a determinant in making selections for use in breeding program dedicated to improve drought tolerance and resource use efficiency. Therefore, a systematic evaluation of landrace root system diversity will improve our capacity for their targeted search and choice as adapted crossing parents.

During Rabi 2012-13, a pot experiment was laid out to screen fifteen wheat genotypes for root traits with four replicates in a completely randomized design. Entries tested included commercial cultivars, advance lines and drought tolerant accessions. Significant differences (P ≤ 0.05) were observed among the genotypes tested for maximum rooting depth and root dry weight per plant. Maximum rooting depth was obtained by accession 11277 (76 cm) followed by accession 11144 (71 cm) and Fakhr-e-Sarhad (65 cm). Entries PR-98 and NRL-0517 had the lowest rooting depth of 43 cm. Highest root dry weight plant-1 was obtained by accession 11277 (2.8 g) followed by accession 11144 (2.3 g) and Fakhr-e-Sarhad (2.1 g). Entries PR-98 and NRL-0517 produced the lowest root dry weight/plant of 0.9 g and 1.0 g, respectively. Use of entries having high rooting depth and rooting mass in crossing program with those having high yield potential will help to evolve varieties that can extract water from deeper soil layers in water scarce areas and will help the wheat plants to tolerate drought.

Entries that produced more root biomass can be used to evolve water efficient varieties as a part of technologies for sustainable agriculture. Findings from this study have generated information on root traits of wheat that can be exploited by the wheat breeders for further use in breeding program and have provided base for detailed field study on relationship of roots with water and nutrient uptake.

Effect of foliar application of boron on fruit productivity of orchards

An orchard of 48 uniform size and newly fruit bearing plants was selected for the study at NIFA experimental farm with objectives, i) to study the effect of boron application on fruits yield and quality ii) to devise an appropriate application method for micronutrients and iii) to make awareness in farmers community about the use of micronutrients in fruits orchards. The trees were arranged in RCB design having four replicates and 12 trees per replica. Four different treatments

in solution form were sprayed with 3 plants in each treatment at flowering stage and in August after fruit picking. The analysis of samples and data collection is in progress.

Effect of boron application on oil seed brassica yield and quality

The experiment was conducted at NIFA experimental farm. Four varieties/advanced lines, two from Napus group (Durr-e-NIFA and NH-975/2-4) and two from Junccia group (NIFA Raya and 7x1/05-4) were tested. The experiment was laid out according to split plot design, keeping varieties/lines in main plot and B levels in sub plot. Basal dose of NPK was applied to the entire experimental site at the time of sowing. Different levels of boron were applied as foliar spray on crop in three splits at vegetative growth, flowering and pod formation stage. The results showed that maximum increase in grain yield (31.7%) was recorded for NIFA Raya by the application of 1000 g $B.ha^{-1}$ followed by junccia 7x1/05-4 (31%) at 700 g $B.ha^{-1}$, Durr-e-NIFA (27%) at 700 g $B.ha^{-1}$ and NH-97-5/24 (24%) at 1000 g $B.ha^{-1}$. The uptake of B by brassica varied from treatment to treatment and variety to variety. Boron uptake in control plots varied from 0.5 to 0.6 kg..ha^{-1} while it escalated to 1.4 $kg.ha^{-1}$ when 1.6 $kg.ha^{-1}$ B was applied.

Effect of various levels of NPK on yield of advance wheat lines evaluated at NIFA

The experiment was conducted at NIFA research farm, during, 2012-13. The soil analysis showed that experimental field was silty clay loam in texture with pH of 7.9, organic matter 0.98%, 0.043% N and 7 ppm available phosphorus. The experiment was laid out in Randomized Complete Block Design with three replications and 14 fertilizer treatments including control. Two advance wheat lines of NIFA (MPT-7, WL-8169) were sown on a well prepared seed bed in second week of November and harvested at physiological maturity in May 2013. Results showed that the highest wheat grain yield of 4.8 $t.ha^{-1}$ was obtained from the treatment where 70-60-30 $kg.ha^{-1}$ NPK was applied, followed by the treatment where NPK was applied at 140-60-30 $kg.ha^{-1}$ which yielded 4.5 $t.ha^{-1}$ grain. Maximum N-uptake of 83.59 and 81.46 $kg.ha^{-1}$ respectively, was also found in the same treatments. Wheat line WL-8169 performs better than wheat line MPT-7 at NIFA farm. In wheat line MPT-7 maximum grain yield of 3.9 $t.ha^{-1}$ was recorded in the treatment where NPK was applied @ 140-60-60 $kg.ha^{-1}$. It is concluded from the study that wheat line WI-8169 perform better even at low level of nitrogen 70 $kg.ha^{-1}$ when applied in splits and at proper growth stages at sowing time, at 1st irrigation and at spike initiation time.

Nutrient management of deciduous orchards (plum) through foliar feeding

Experiment was conducted on plum fruit orchard during 2012-13 at research farm of NIFA to study the influence of foliar applied NPK, humic acid and Zn on plum fruit. The sources of applied nutrients were urea, TSP SOP, humic acid and Zn sulfate, which were applied in different combinations. The nutrients were sprayed after fruit set in April at the interval of two weeks and three foliar applications were applied. Basal dose of P and K was applied to each plant after fruit picking in month of August along with half dose of N and the rest of N was applied after bud sprouting in February through soil. The soil analysis showed that experimental field was silty loam in texture with pH of 8, organic matter 1.0%, 0.055% N and 10 ppm phosphorus. The experiment was carried out in randomized complete block design with three replications and eight fertilizer treatments. The results revealed that maximum plum fruit yield of 52 kg per tree was obtained from the treatment where foliar applications of NPK and humic acid were applied followed by the treatment where foliar NPK (0.5% N + 0.5% P + 1% K) was applied and it produced 49 kg fruit per tree. Nitrogen, P and K concentration of 2.44%, 0.193%, 1.767%, respectively in plum fruit were also found maximum in the same treatment where foliar NPK and humic acid were applied. It can be concluded from the study that foliar NPK and humic acid treatment is economically more beneficial for farmers of the area.

Soil Biology

Studies on the improvement of agro-waste compost and bio-geyser

Studies were conducted to improve the design and efficiency of NIFA bio-geyser by replacing metallic water drums with brittle plastics (free of corrosion). Moreover, the design of the model bio-geyser was improved by modifying its shape from rectangular to circular and by fixing inbuilt thermometers for indicating the temperatures of composting feed and water in the drums.

Two tons of agro-waste compost (air dried) was converted to a value-added product by suitable supplementation with rock phosphate, humic acid and other nutrients. Value addition was accomplished by spraying 0.5 % urea and 0.1 % humic acid solution and addition of 2% rock phosphate. Effect of this value added compost was investigated in pot and field experiments on vegetables.

A case to make the NIFA bio-geyser a patent was submitted to the patent office Karachi in May 2012. The report/comments of patent examiner have been received and the case is resubmitted along with drawings according to the comments of examiner.

Residual effect of compost tea on tomato

A field experiment was conducted to investigate the residual effect of compost and direct effect of compost tea on tomato hybrid. The experiment was conducted on the same land previously used for studying the effect of direct application of compost on cauliflower. The study revealed that maximum biomass (13.7 kg.plot^{-1}) was recorded in treatment receiving anaerobic tea followed by aerobic tea (9.5 kg.plot^{-1}) and soil applied compost (9.4 kg.plot^{-1}) as compared to control (6.8 kg. plot^{-1}). However, in case of tomato fruit yield, only the treatment receiving anaerobic tea gave 10% higher yield as compared to control. All other treatments gave almost similar fruit yield.

Residual effect of ordinary and value added compost on tomato

Residual effect (on 3rd crop) of ordinary and value added compost with and without NPK was studied on tomato in a field experiment. Seven compost treatments (applied to previous crop of potato) were replicated 3 times in RCB design on the same piece of land. The results revealed that maximum biomass yield (9.0 kg.plot^{-1}) was recorded in treatment receiving ½ NPK (of recommended dose) along with 0.5% value added compost followed by treatment receiving full NPK (7.2 kg.plot^{-1}) as compared to control (6.2 kg. plot^{-1}). The increase over control was 32% and 25%, respectively. Tomato fruit yield was also maximum (26 kg.plot^{-1}) in case of treatment receiving half NPK with 0.5% value added compost.

This long term field experiment was conducted for three consecutive years to determine the beneficial effect (fertilizing effect) of agro-waste compost on vegetables. The study revealed that agro-waste compost application improved the yield and quality of vegetables due to its slow-release nutrients property. The residual effect of compost application can be realized in tomato crop for consecutive three years with 38%, 25% and 15% increase in yield, respectively and almost similar beneficial effect was observed in potato.

Feasibility of preparation of vermi-compost & its use as organic fertilizer

Maintenance or improvement in soil health seems to be a big challenge at present due to lack of availability of organic residues coupled with high cost and environment related issues by the use of chemical fertilizers. Rapid increase in population necessitates developing eco-friendly and cost effective products that can improve soil health and enhance production per unit area. A variety of bio-fertilizers and organic farming products are commercially available but not as vermi-compost. It is imperative to evaluate the feasibility of development of vermi-compost under artificial experimental conditions.

A feasibility study was carried out during 2012-13 to evaluate the efficiency of local earth worms' species for hastening composting process and value addition to the composts. Treatments included preparation of compost with and without the addition of earthworms in 1x1 m^2 pits. Dried maize stalk (48 kg) and green brassica materials (12 kg) were used in 4:1 in each pit. Earth worm species (180 in number) collected from local areas and manure piles were tested in composting process. Initial results indicated that earth worms' species do not hasten the composting process and prefer natural soil conditions over the plant residues being composted. This study indicated that local species are not efficient in composting process. The study provided basis for further studies using diversified inoculums of earth worm form other available resources within the country.

Effect of fulvic acid and inorganic fertilizer on the yield of tomato

A field experiment entitled "Effect of fulvic acid and inorganic fertilizers on the yield of tomato" was conducted at NIFA. The study revealed that maximum fruit yield of 66.29 t.ha^{-1} was recorded in treatment receiving ½ (of recommended) NPK + Zn (2.5 kg) + 150 µg.g^{-1} fulvic acid (as foliar application), and it accounted for 50% increase over control, followed by treatment receiving ½ NPK + Zn (5 kg.ha^{-1}) + 150 µg.g-1 fulvic acid (as foliar application) which yielded 63.66 t.ha^{-1} tomato. Maximum biomass yield was also recorded in the same treatment which was 13.33 kg.plot^{-1} which is 60% increase over control.

Another field experiment was conducted on the "Effect of fulvic acid and inorganic fertilizers on the yield of potato". The data showed that maximum potato tuber yield was 7.24 t.ha^{-1} in treatment receiving ½ NPK + Zn (2.5 kg. ha^{-1}) + 0.05% fulvic acid as foliar application which was 42.8% higher than control followed by treatment receiving ½ NPK + Zn (5.0 kg.ha^{-1}) + fulvic acid 0.05% foliar application.

SOCIO-ECONOMIC IMPACT

Plant Breeding and Genetics Division

High yielding, disease resistant and widely adopted varieties of wheat, oilseed brassica, chickpea and mungbean developed at NIFA are continuously playing a role in boosting per acre yield coupled with upgrading the financial status of the farmers of KPK. These varieties have yield advantage of at least 10-15% over other commercial varieties. Twelve tons quality seed was produced and duly certified by Federal Seed Certification and Registration Department. As per standard procedure the seed was then collected by provincial agricultural extension linked with selected progressive growers in Khyber Pakhtunkhwa. The addition of two recent releases, i.e. NIFA Lalma-2013 (wheat) and NIFA Gold (oilseed brassica) will further fill the gap by their adaptation in a range of environments in the country.

Entomology Division

Fruits and vegetables are Good sources of income for the farmers of KPK. Fresh fruits and vegetables are used both locally and has great potential for export to foreign countries. The developed IPM technologies; male annihilation technique (MAT) for fruit fly trapping coupled with use of irradiation for control of quarantine pests has led to positive socio-economic impact in terms of fruit quality, production and relaxation in the export of fruits and vegetables. Termite surveillance of subterranean termites in the fields and termite proofing of buildings has also put major impact on the socio-economic uplift of the province. Trainings were conducted on basic honeybee keeping to the unemployed youth, fruit growers, farmers and extension workers of agriculture department. Training of beekeepers on beekeeping has created employment opportunities for unemployed youth in the poor rural areas of the province. In view of need for control of emerging vector borne diseases in poor rural community, various trainings were arranged on vector control and disease management strategies. NIFA Housefly bait for fly control was registered for patent. Its application at homes, restaurants, poultry farms and fruit stores will reduce fly population and will have positive impact on living style of farmers and general public. Dengue Guard was introduced for protection against dengue and malaria carrying mosquitoes. Its application by the poor farmers will protect them from vector borne diseases and improve their health for better work environment.

Food Science Division

The activities of Food Science Division are diversified and cover almost all domains of post-harvest scenario of food sector. The primary work of this division revolves round the use of gamma irradiation technology to prolong the shelf life of horticultural commodities. The research work completed at NIFA provided basis for a commercial irradiator with the name PARAS established at Lahore. PARAS is commercially irradiating food items destined for export, thus directly impacting the enhancement of Pakistani food exports to global market. Another break through, which is made by FSD, is the development of Meal Ready to Eat (MRE) that has a shelf life of about 2 years. The MRE technology has been adopted by Pak Army for use as emergency ration for its troops engaged in combat areas. The technology has helped the army to save precious foreign exchange that it spent on importing MREs from Canada. Thus the division has played an important role in import substitution by development of the MRE.

The Nutrition Section of FSD developed a rapid test kit (RTK) that is a quality field test for determination of iodine in commercial salts. Sale of these kits to MI generated Rs. 2.9 m that was deposited in NIFA income generation head. The social impact of the iodine kit project is for more important than the economic benefit. As the iodine kit precisely determines the presence or absence of iodine in commercial iodized salts, these kits play a vital role in ensuring the provision of iodine to the masses in true sense. The establishment of iodine reference lab in FSD is also a joint leap in this direction. The food processing section of NIFA has generated a net income of Rs.0.3 m this year besides providing purely fruit based products to consumers at relatively lower cost. The Mushroom cultivation project is yet another activity of NIFA that has tremendous socio- economic impact largely on the unemployed youth, domestic women and landless farmers. About Rs.0.310 m was deposited in NIFA income generation fund and 280 persons inclusive of women were trained in NIFA as well as in remote areas of Chitral and Swat valleys during the year under repot. These activities have triggered further economic activities which are helping not only in generation of self –employment but also in provision of nutritious diet to consumers. Recently the division has embarked on a new but non-food sector of irradiation of gemstones for value addition. The activity

was started in April 2013 with the approval of worthy Chairman PAEC and in this short duration generated an income of Rs.0.75 m. The planning to enhance the capacity of gemstone radiation is underway.

Soil Science Division

It has been perceived through findings that proper management of natural resources (soil, water and nutrients) and balanced fertilizer application contributes significantly to higher crop productivity. At NIFA, we were able to provide a production technology package for tunnel farming that is more economical for growers of small holdings. By adopting that package of off season vegetable growing, farmers can earn 15 times more than traditional cultivation with minimum inputs. The group has also identified the crop genotypes which can produce 8 to 40% higher yield at low soil fertility. During the period farmers day was arranged by soil science division to benefit the farming community. The technology of agro-waste composting with bio-geyser as a by- product was demonstrated to farmers at different locations at their fields. A patent has been approved for bio-geyser.

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FUNDED RESEARCH PROJECTS

S. No.	Title of the Project	Duration	Allocation	Principal Investigator
1.	Pak-US wheat productivity enhancement initiative. PAK-US.	2011-2013	$ 113,572	Mr. Abdul Jabbar Khan, DCS
2.	Selection and assessment of wheat germplasm for higher yield and improved water and nitrogen use efficiencies. IAEA.	2011-2015	€ 9,000 (PA)	Mr. Abdul Jabbar Khan, DCS
3.	Development of locally adapted canola (*Brassica napus* L.) F_1 hybrids using induced mutations and double haploidy techniques. PSF.	2012-2015	Rs. 2.463 m	Mr. Iftikhar Ali, DCS
4.	Plant mutation breeding of bio-energy crops for optimizing marginal land productivity- RAS201 2011.	2014-2015	IAEA, RCA	Dr. Iftikhar Ali, DCS
5.	Improvement of Stevia through induced mutations and in vitro somaclonal variations. PSF	2011-2014	Rs. 2.170 m	Mr. Shahid Akbar Khalil, SS
6.	Breeding for bruchids resistance in mungbean (*Vigna radiata* (L.) Wilczek). PSF.	2011-2014	Rs. 2.430 m	Dr. Gul Sanat Shah, PS
7.	Development of slow acting toxicant bait for elimination of underground colonies of crop and building termites PSF/ NSLP.	2010-2013	Rs. 2.4 m	Dr. Abid Farid, PS
8.	Development of standardized mass rearing system for male Anopheles mosquitoes used in SIT program. IAEA.	2005-2011	€ 35,000	Dr. Inamullah Khan, PS
9.	Use of Irradiation as Phytosanitary Treatment for the Control of *Citrus psyllids, Diaphoronia citri* and Scale Insects". IAEA.	2011-2014	€ 10,000 (PA)	Dr. Inamullah Khan, PS
10.	Integrated management of Peach Flat-headed borer, Sphenoptera dadkhani damaging trees of stone fruit orchards. PSF.	2011-2014	Rs. 1.9 m	Mr. Muhammad Zahid, PS
11.	Best practice for phytosanitary applications of food irradiation (RAS5057)	2012-2014	-	Dr. Ihsanullah, DCS

12.	Development of package of technology for poultry feed irradiation in Pakistan. PSF.	2010-2013	Rs. 2.834 m	Dr. Aurang Zeb, DCS
13.	Development of irradiated foods for Immunocompromised patient and other potential target group. IAEA.	2010-2015	€ 35,500	Mr. Misal Khan, PS
14.	Design and fabrication of a laboratory size single screw extruder for conversion of agro-based materials into value added food and feed products. PSF.	2007-2013	Rs. 0.718 m	Dr. Maazullah, PE
15.	Standardization of market life enhancement technology of persimmon and its dissemination to growers. ALP	2012-2015	Rs. 4.737 m	Ms. Nizakat Bibi, DCS
16.	Proposal for human resource development through transfer of technology “to arrange training courses for “mushroom cultivation” in various zones of Khyber Pakhtunkhwa DoST.	2012-2013	Rs. 1.2 m	Mr. Fazal Mahmood, DCS
17.	Development of innovative Nutraceutical Products from Indigenous Herbal Ingredient for Improving Socio-economic status of Communities, PSF/NSLP/KP-NIFA	2012-2014	Rs. 3.9 m	Dr. Ihsanullah, DCS
18	Development and validation of technologies for pesticide residue management in fruit and vegetable produce, PSF.	2012-2015	Rs. 2.843 m	Dr. Azhar Rashid, PS
19	Nutrient management of deciduous orchards (Plum) through foliar feeding. PSF/NLSP/KP-NIFA- 253.	2013-2016	Rs. 2.9103	Dr. Azam Shah, PS

SCIENTISTS /ADMINISTRATION

Manpower Position at NIFA

A. Scientists/Officers

S. No.	Officers	Sanctioned	In Position	Vacant	Total
1.	Scientists	48	46	02	48
2.	Engineer	01	01	-	01
3.	Non-technical	06	06	-	06
	Total	55	53	02	55

B. Staff (Technical/Non-technical)

S.No.	Staff	Sanctioned	In Position	Vacant	Total
1.	Scientific Staff	41	41	-	41
2.	Technical	16	14	02	16
3.	Non-technical	66	64	02	66
4.	Security & Chowkidars	24	24	-	24
	Total	147	143	04	147

C. Details of Present Scientific Strength

S.No.	Category	CS	DCS	PS	PE	SS	SRO	JS	ARO	Total
1.	Male	02	09	10	01	15	-	02	04	43
2.	Female	-	01	01	-	01	01	-	-	04
3.	Ph. Ds	-	04	06	01	04	-	-	-	-
4.	Abroad for Ph. D	-	-	-	-	02	-	01	01	-
	Total	02	10	11	01	16	01	02	04	47

D. List of Officers

	Name	Designation
I.	Dr. Ihsanullah	DCS/Director
II.	PLANT BREEDNG & GENETICS DIVISION	
	Mr. Abdul Jabbar Khan, M.Sc. (Botany)	DCS/Head PBGD
	Dr. Iftikhar Ali, M.Sc. (Hons.) Agric.	DCS
	Dr. Syed Jawad Ahmad Shah, Ph.D. (Plant Pathology)	PS
	Mr. Roshan Zamir, M.Sc. (Hons.) Agric.	PS
	Dr. Gul Sanat Shah Khattak, Ph.D. (Botany)	PS
	Dr. Fazle Subhan, Ph.D. (Agronomy)	PS
	Dr. Muhammad Irfaq Khan, Ph.D. (Plant Breeding & Genetics)	SS
	Mr. Hafiz Munir Ahmad, M.Sc. (Hons.) Agric.	SS
	Mr. Muhammad Amin, M.Sc. (Statistics)	SS
	Dr. Farooq-i-Azam, Ph.D (Crop Genetics & Breeding)	SS
	Mr. Shahid Akbar, M.Sc. (Hons.) Agric.	SS
	Mr. Muhammad Ibrahim, M.Sc. (Hons.) Agric.	SS
	Dr. Syed Tariq Shah, Ph.D (Crop Genetics & Breeding)	SS
	Mr. Iqbal Saeed, M.Sc. (Hons.) Agric.	JS
	Mr. Akhtar Ali, M.Sc. (Hons. Agric.)	ARO
III.	FOOD SCIENCE DIVISION	
	Mr. Fazal Mahmood, M.Sc. (Chemistry)	DCS/Head
	Dr. Aurang Zeb, Ph.D. (Nutrition)	DCS/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
	Mrs. Tasnim Sharafat, M. Phil. (Microbiology)	SRO
	Mr. Zahid Mehmood, M.Sc. (Hons.) Agric.	SS
	Mr. Dawood Khan, M.Sc (Chemistry)	SS
	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
Dr. Abid Farid, Ph.D. (Entomology)	PS
Mr. Muhammad Zahid, M.Sc. (Hons.) Agric.	PS
Dr. Inamullah Khan, Ph.D. (Entomology)	PS
Mr. Gul Zamin, M. Sc. (Entomology)	SS
Mr. Misbahul Haq, M.Sc. (Hons.) Agric.	SS

V. SOIL SCIENCE DIVISION

Dr. Wisal Mohammad, Ph.D. (Soil and Envir. Science)	DCS/Head
Mr. Haider Khan, M.Sc. (Botany)	DCS
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)	SS
Mr. Zahid Ali, M.Sc. (Hons.) Agric.	SS
Miss. Samreen Shahzadi, M.Sc. (Hons.) Agric.	SS
Mr. Parvez Khan, M.Sc. (Hons.) Agric.	SS

VI. ADMINISTRATION & ACCOUNTS

Mr. Latif Zaman, B.Sc. MBA (HRM)	DC Admin Officer
Mr. Muhammad Jamil, MBA	Accounts Officer
Mr. Riaz Hussain, M.A.	Sr. Admin Officer
Mr. Raufullah, M.L.I.Sc.	Sr. Librarian
Mr. Rashid Nawaz, MA (English), MBA (HRM)	Jr. Executive (Admin)
Mr. Wahid Gul, BA, LLB	Superintendent

PROMOTIONS/TRANSFERS/RETIREMENT

Promotions

S.No.	Name	From	To	On
1.	Mr. Haider Khan	PS	DCS	01-12-2013
2.	Mr. Amanullah Khan	PS	DCS	01-12-2013
3	Mr. Latif Zaman	Pr. Admin Officer	DC Admin Officer	01-12-2013
4.	Mr. Mukhtar Ali	SS	PS	01-12-2013
5.	Dr. Fazli Subhan	SS	PS	01-12-2013
6.	Dr. Syed Azam Shah	SS	PS	01-12-2013
7.	Dr. Syed Tariq Shah	JS	SS	01-12-2013
8.	Mr. Mumtaz Ahmad	PSA	ARO	02-05-2013
9.	Mr. Sher Ali Khan	SSA.	PSA.	02-05-2013
10.	Mr. Daulat Khan	Jr. Asstt. Admin-II	Jr. Asstt. Admin-I	02-05-2013
11.	Mr. Israr Khan	Sr. Tech.	Pr. Tech	02-05-2013
12.	Mr. Shamshad Khan	SA-1	SSA	02-05-2013
13.	Mr. Fazli Raheem	SA-1	SSA	02-05-2013
14.	Mr. Arshad Hamid Awan	Asstt. Accounts	Sr. Asstt (A/C)	02-05-2013
15.	Mr. Muhammad Ali	General Attd.-1	Tech.III	02-05-2013
16.	Mr. Robin Ruaf	Sanitary Attd.-II	Sanitary Attd.-I	02-05-2013

Transfers/Posting

	Name	From	To	On
1.	Dr. Khanzadi Fatima, PS	NIFA, Peshawar	AWKU, Mardan	11-01-2013
2.	Mr. Ghulam Murtaza, SA-II	NIA, Tandojam	NIFA, Peshawar	11-02-2013
3.	Mr. Imdad Khan, Sec. Sold.-II	NIFA, Peshawar	NMC-1, D.G.Khan	03-05-2013
4.	Mr. Maqsood Iqbal, Sr. C.Tech	ICCC, Islamabad	NIFA, Peshawar	03-05-2013
5.	Mr. Dawood Khan, SS	KCP-1, Juharabad	NIFA, Peshawar	23-05-2013
6.	Mr. Khatab Gul, Sec. Sold.-I	Sec.G. Islamabad	NIFA, Peshawar	10-06-2013
7.	Mr. Amanullah, Driver-III	DESTO (NESCOM)	NIFA, Peshawar	13-09-2013
8.	Mr. Arshad Ali, CLT/SSA	C-1, Kundian	NIFA, Peshawar	25-10-2013

Retirement

	Name	Date
1.	Mr. Muhammad Iqbal, DR-II	10-03-2013
2	Mr. Kifayat ur Rahman, PSA	10-04-2013
3	Mr. Syed Anwar Shah, CS	15-04-2013
4.	Mr. Tila Mohammad, CS/Director	10-09-2013

Abbr.: CS: Chief Scientist, DCS: Deputy Chief Scientist, PS: Principal Scientist, PE: Principal Engineer, SS: Senior Scientist, SRO: Senior Research Officer, JS: Junior Scientist, ARO: Assistant Research Officer, PSA: Principal Scientific Assistant, SSA: Senior Scientific Assistant, SA-I: Scientific Assistant-I, SA-II: Scientific Assistant–II, Pr. Tech.: Principal Technician, Sr. Tech.: Senior Technician, Tech-I: Technician-I, Tech-II: Technician-II, Jr. Asstt. Accts.: Junior Assistant Accounts; Adm. Asstt.: Administration Assistant

Nuclear Institute for Food and Agriculture
Scientific Events Calendar 2013

Workshops | **Farmer's/Field Day** | **Trainings** | **Conference**

http://www.nifa.org.pk

January

31st JAN
One day Workshop on Mushroom Cultivation
Organizer: Food Science Division
Contact: Mr. Fazal Mahmood, DCS
Cell: 0301 8580108
E-mail: fazalmahmood@nifa.org.pk

February

27 FEB
One day Workshop on Mushroom Cultivation
Organizer: Food Science Division
Contact: Mr. Fazal Mahmood, DCS
Cell: 0301 8580108
E-mail: fazalmahmood@nifa.org.pk

March

28 MAR
Farmer's Day
Organizer: Plant Breeding & Genetic Division
Contact: Abdul Jabbar Khan, *DCS*
Cell: 0301-8580083
Email: abduljabbarnifa@yahoo.com

April

09-11 APR
Three Days International Workshop on "Significance of Food Irradiation Technology in Pakistan" at Islamabad
Organizer: Food Science Division
Contact: *Dr. Ihsanullah, DCS / Head FSD*
Cell/phone: 0301-8580029, +92 91 2964796
E-mail: ihsanullahdrnifa@yahoo.com

17-18 APR
Two-day Training on Honey Bee Keeping and Management
Organizer: Entomology Division
Contact: *Mr. Alamzeb, DCS / Head*
Cell: 0333-9407406
E-mail: alamzeb@nifa.org.pk,

May

12-13 MAY
Two-day Training Workshop on Preparation of Value-added Fruit Products and Canning of Vegetable
Organizer: Food Science Division
Contact: *Mrs. Nizakat Bibi, DCS*
Dr. Maazullah Khan, PE
Phone: 091 2964060-2 (Ext) 221
0300-5834039
E-mail: nizakatbibi@yahoo.co.uk

June

12 JUN
One-day Workshop on Nutrient Management of Plum through Foliar Feeding
Organizer: Soil Science Division
Contact: *Dr. Azam Shah, SS*
Mr. Mukhtar Ali, SS
Cell: 0346-90721130
0346 3845854
E-mail: azamsbpn@hotmail.com
mukhtaraliswabi@yahoo.com

August

28-29 AUG
Two-day Workshop on Edible Oil and Oilseed Quality Assessment Techniques
Organizer: Plant Breeding & Genetic Division
Contact: *Mr. Iftikhar Ali, DCS*
Mr. Taufiq Ahmad, DCS
Cell: 0333-9102990
E-mail: iali63@yahoo.com

September

16-27 SEP
29th Postgraduate Training Course on the Use of Nuclear and Other Advanced Techniques in Food and Agricultural Research
Organizer: NIFA
Contact: *Ms. Samreen Shehzadi, SS*
Cell: 0321-5774516
E-mail: sshehzadi11@hotmail.com

October

09-10 OCT
Two-day workshop on IPM Approaches for Insect Pests of Agriculture and Medical Importance
Organizer: Entomology Division
Contact: *Dr. Amanullah Khan, PS*
Cell: 0333-93600389
E-mail: mails@nifa.org.pk

November

27-28 NOV
Two-day workshop on Phytosanitary Treatment of Herbal Materials/Products using Radiation Technology
Organizer: Food Science Division
Contact: *Dr. K. Fatima Khattak, PS*
Cell: 0334-9042823

December

18-19 DEC
Two-day Workshop on Agrowaste Composting & Biogeyser Technology
Organizer: Soil Science Division
Contact: Mr. Haider Khan, *PS*
Cell: 0334-9138064
E-mail: haider_khan@nifa.org.pk

Glimpsis of Some Events Held at NIFA

Contact Information: *Fazal Mahmood*
Cell: 0301 8580108

Nuclear Institute for Food and Agriculture (NIFA), Peshawar, KPK
Mail: P.O.Box 446, Peshawar, 25000 E-mail: mails@nifa.org.pk
Ph: 091-2964058 Fax: 091-2964059

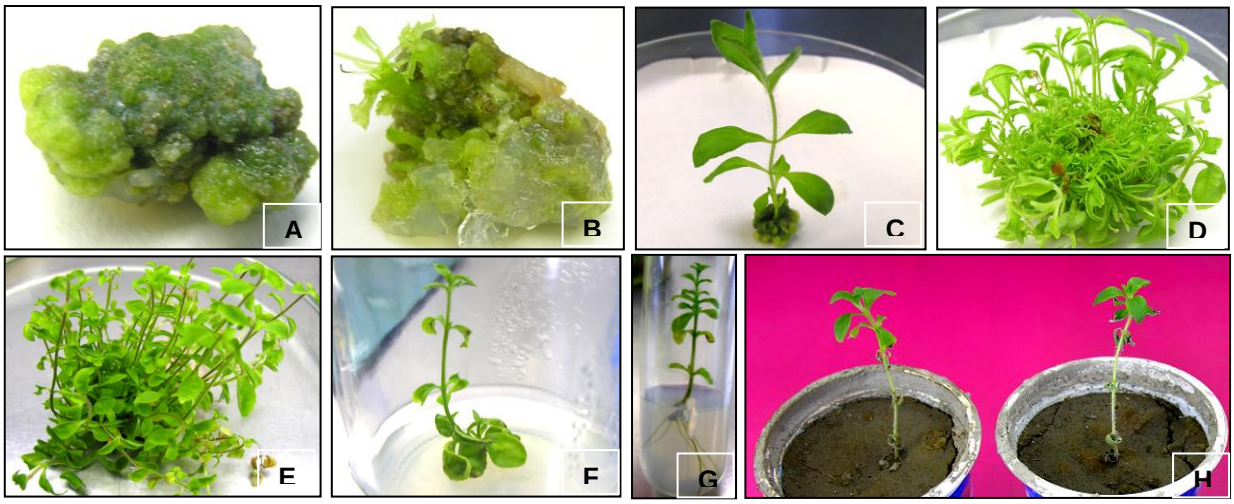
NIFA in Pictures

NIFA Lalma: a new high yielding wheat variety

NIFAGold: a new high yielding rapeseed variety

Mungbean trial at NIFA

Evaluation of sugarcan genotypes at NIFA



Organogenesis in Stevia Rebaudiana
(A) Callus induction in Stevia (B) Shoot initiation from callus (C) Shoot elongation from callus (D) Shoot multiplication (E) Shoot multiplication along with elongation (F) Single shoot elongation (G) rooting (H) Acclimatization of in vitro regenerated plantlet

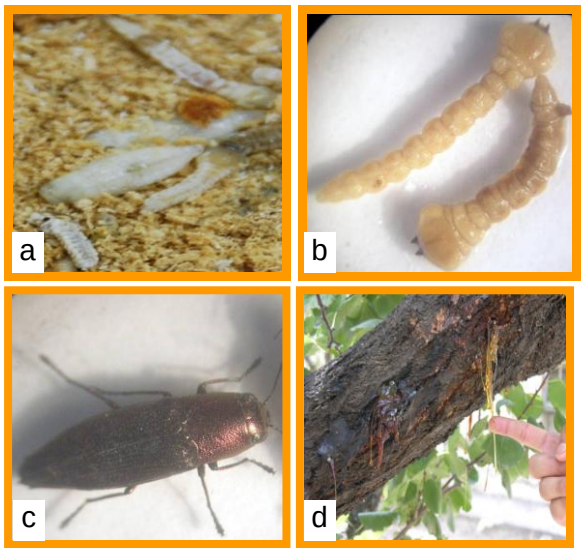
Growing of off season tomatoes in high tunnel at NIFA

Growing of off season cucumber in high tunnel at NIFA

Technical discussion with the farmers

Mungbean grain damaged by Bruchid beetle

A large Helicoverpa larva feeding inside a chickpea pod



a. Larval feed, b. Larva, c. Adult of peach flat-headed borer and d. Gum oozing from plum tree

Partitions for different experimental groups at Poultry shed

Organoleptic evaluation of test Chapattis

Extrusion cooking of starch based product

Preparation of mushroom compost

Meal ready to eat (MRE) prepared for Neutropenic patients at INOR Abbottabad

Organoleptic evaluation of MRE for Neutropenic patients

Visit of Food Scientists to ASC, Nowshera

Group photo of chief guest with organizers of international workshop, Lahore Oct. 2-3, 2013

Director NIFA receiving shield at the international workshop in Lahore

Mr. Minh-long Nguyen, IAEA Offical, visit to NIFA

Diginitories along with Director NIFA and Heads of Divisions

NIFA Scientists along with Director

Plant Breeding and Genetic Division

Food Science Division

Entomology Division

Soil Science Division

Technical Services Division

Administration Section

Accounts Section

IT Cell

Director's Staff

Field Staff

Sanitary Staff

Nuclear Institute for Food & Agriculture

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