NIA

GOLDEN JUBILEE
FIFTY YEARS REPORT

Nuclear Institute of Agriculture
Tando Jam, Sindh, Pakistan

Pakistan Atomic Energy Commission
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FOREWORD

It gives me an immense pleasure in bringing out the fifty year report (1963-2013) of the Nuclear Institute of Agriculture (NIA). The institute made a modest beginning in the year 1963 as ‘Atomic Energy Agricultural Research Center (AEARC)’ under Pakistan atomic Energy Commission (PAEC) and it grew overtime and re-designated as ‘Nuclear Institute of Agriculture (NIA)’ in 1998. NIA is a premiere institute of agriculture in PAEC established at Tandojam, Sindh. The institute has made many important and original research based contributions in the disciplines of Plant Breeding & Genetics, Plant Protection, Plant Physiology and Soil Science.

The present report highlights some of the glimpses of the research achievements made, new methodologies developed, significant advisory and consultancy services provided, dissemination of knowledge acquired and human resource development, linkages with various research institutes, universities and private sector in Sindh particularly and in country generally. The scientists, technical personnel, administrative, finance and other staff of the institute have put in their best efforts in fulfilling the mandate of the institute and also in achieving the targets set during the period.

To fulfill objectives and mandate of the institute, scientists focused on devising methods and evolving crop varieties for increasing agricultural productivity of the country. The institute has evolved 29 improved varieties of different crops. The institute acquired 77 national / international projects.

The physical growth is not the measure of the research achievements. It is left to the readers to go through this report and judge for themselves the achievements of the centre. We are confident that they would not be disappointed.

Dr. Nazir Ahmad
Director
PLANT BREEDING AND GENETICS DIVISION
Genetic improvement of crop plants is necessary in recent years to broaden the narrow genetic base of modern cultivars selected for higher productivity. Such kind of broadening is needed for pest and disease resistance, to increase the productivity and stability in performance. The main objective of the Plant Breeding & Genetics Division is to increase crop productivity that can be achieved by evolving new crop varieties.

1. **WHEAT**

**History of the project:** Wheat is an important cereal crop and a staple diet for more than 35% of the world population. It is a major food crop of Pakistan cultivated around 8.666 million hectares, with annual production of 23.517 million tones and average yield of 2714 kg/ha during the year 2011-12. In Sindh province, wheat is grown over 1.05 million hectares with annual production of 3.76 million tones and average yield of 3585 kg/ha during the year 2011-12. Due to evolution of new high yielding varieties and adoption of better production technology, the grain yield per hectare in the province has gradually increased from 1889 kg/ha in 1980-81 to 3585 kg/ha in 2011-12. Realizing the significant contribution of induced mutations in crop improvement, physical and chemical mutagens have been successfully used as a supplement to wheat breeding at NIA Tando Jam.

Wheat being the staple food finds key priority in research. Wheat production in the country is threatened by drought, high temperature, salinity, diseases, pests, high cost of inputs and scarcity of irrigation water. Besides water shortage, the emergence of new stem rust virulence Ug99 is also a big threat to sustainable wheat production. Leaf rust and new stem rust races are major biotic constraints in Sindh, which may cause a sudden havoc in reducing yield and production.

Wheat breeding programme at NIA, Tando Jam was started in 1963 and being focused to evolve wheat varieties endowed with high grain yield, wide adaptability, tolerance to biotic (diseases and pests) and abiotic (high temperature, water scarcity, salinity) stresses, early maturity and better grain quality. Following projects in wheat have been carried out and are in progress to combat the challenges and develop high yielding cultivars to feed the people.

**a) Breeding of wheat genotypes for semi-dwarf character and high grain yield:** The semi-dwarf varieties are being used worldwide having \( Rht_1 \) or \( Rht_2 \) Norin-10 dwarfing genes. Despite the success, the semi-dwarf genes also possess some undesirable associated traits such as short coleoptile length, smaller grains and susceptible to environmental stresses (high temperature, drought and salinity). There is another source of dwarfism in eastern European countries namely \( Rht_8 \) dwarfism. There was a desire to make dwarfism studies and to improve the existing varieties for high grain yield under stressed environments. The present project was started in 1992 and released a wheat variety NIA-Sunhari in 2010 with the semi-dwarf gene \( Rht_1 \).

**b) Breeding for improvement of yield and yield components and stress tolerance in wheat through conventional and mutation breeding techniques:** The aims of this project are to create the genetic variability through hybridization and physical mutagenesis and to select stress-tolerant, widely adapted, high yielding, better quality, early maturing, heat-tolerant, drought-tolerant and salt-tolerant genotypes with
desired agronomic traits. Terminal high temperature prevailing during grain filling period is one of the main environmental constraints for reduction in crop productivity. Eight high yielding wheat varieties viz., Jauhar-78, Sindh-81, Sarsabz, Soghat-90, Kiran-95, Khirman, NIA-Amber and NIA-Saarang (drought-tolerant) have been released under this project.

c) Transfer of disease resistance in bread wheat (*Triticum aestivum* L.): Isogenic lines and bread wheat genotypes consisting of known leaf, yellow and stem rust resistant genes were planted at different hot spots every year during the period from 1987 to date. The identified functional rust resistant genes were successfully transferred into high yielding susceptible commercial genotypes of wheat.

The virulence of rust has changed in space and time due to large-scale cultivation of wheat varieties possessing same genetic background for rust and powdery mildew resistance i.e. Lr26, Yr9, Sr31 and Pm8. Hence, domination of a single variety or varieties from the same genetic background is at the risk of becoming victims and causing new epidemics. In such conditions, diverse sources of resistance, varieties with genetic diversity and deployment of resistant genes are the only tools for rust management to ensure sustainable crop production. Four varieties Marvi-2000, Bhittai, Sassui and NIA-Sunder have been released under this project.

d) Breeding for low water requirement in bread wheat based on anatomical and morphological traits through hybridization and induced mutations: Water scarcity is a natural environmental factor to reduce agriculture crop production in many areas of the world including Pakistan. A breeding programme was initiated to develop genotypes with high grain yield under low water availability. On the basis of performance in zonal trials two advance lines viz., NIA MB-2 and NIA MN-8 were selected and sent for NUWYT (sowing date & rain-fed) during 2012-2013.

Achievements:

**Jauhar-78:** Jauhar-78 was the first mutant wheat variety developed through mutation breeding (fast neutrons) in year 1979 by NIA, Tando Jam. The variety had high grain yield potential, resistance to shattering, amber grain colour and tolerance to medium saline lands. The variety remained popular in Sindh province for some time.

![Jauhar-78]

**Sindh-81:** Sindh-81 was evolved through conventional breeding in year 1982. The conventionally bred variety had high grain yield potential and was moderately resistant to leaf rust disease. It was cultivated in various parts of Sindh.

![Sindh-81]

**Sarsabz:** Sarsabz, a famous and an ample example of low input oriented variety of NIA was released in year 1986 for the general cultivation in Sindh province. Sarsabz possesses high grain yield potential, wide adaptability and tolerance to environmental stresses. The variety remained popular with farming community of Sindh province for the long time. The variety is still being cultivated at some parts of Sindh and Baluchistan. The variety is
suitable to grow under normal and late sowing conditions in Sindh.

**Soghat-90:** A mutant wheat variety Soghat-90 was developed from widely adapted variety Pavon through mutation breeding (sodium azide) in 1991. Soghat-90 had high protein content, high grain yield, and resistance to diseases. The variety remained popular in Sindh province for some time.

**Kiran-95:** Kiran-95, a popular mutant wheat variety was developed through indirect use of mutagenesis (hybridization cum mutation) in 1996. The variety possesses high grain yield, wide adaptation and stability, golden glumes and resistance to shattering. The variety is also suitable to grow under normal and late sowing conditions in Sindh province. Kiran-95 is a very famous wheat variety of NIA which ranked on second after TD-1 variety in Sindh province.

**Marvi-2000:** It is an early maturing, high yielding wheat variety endowed with resistance/tolerance to biotic and abiotic stresses with good baking and nutrition qualities developed through pyramiding of defeated and functional rust resistant gene(s) in high yielding susceptible genotype (PKV-1600). Marvi-2000 was approved in 2002 for general cultivation in Sindh province.

**Bhattai:** It is high yielding, resistant to diseases (leaf and yellow rust), drought tolerant, possessing high protein and dry gluten percentage wheat variety. Bhattai was developed by pyramiding of defeated and functional rust resistant gene(s) in high yielding susceptible genotypes (Soghat-90). It was released for general cultivation in Sindh, in 2004.

**Sassui:** The high yielding, resistant to diseases (leaf and yellow rusts) and low water requiring wheat variety “Sassui” endowed with high protein content (15.0%), dry gluten (11.3%) and good chapatti making quality, was released in 2006 for general cultivation in Sindh.

**Khirman:** A drought-tolerant wheat variety Khirman was released in 2006. It is a semi-dwarf variety possesses tolerance to water
stress, high grain yield potential, wide adaptability, medium in maturity, amber white and shiny bold grains, excellent grain quality and tolerance to diseases. It has potential to produce sustainable yield (with 1-2 irrigations) under water stress environments. The variety is suitable to grow under normal sowing conditions in Sindh province particularly in rice beet of Sindh.

**NIA-Amber:** Wheat variety NIA-Amber has been evolved through conventional breeding and released in 2010. It is a high yielding, high tillering, short-stature, wide adaptability, possesses excellent grain quality with highest protein (16.0%), the highest wet gluten (37.1%), high dry gluten (12.0%), high SDS value (28.5) and high (76.4 kg/Hl) test weight. Due to its high tillering capacity, less quantity of seed rate (40 kg/ha) is recommended. The variety is suitable to grow under normal sowing conditions in Sindh.

**NIA-Sunder:** It is a high yielding variety evolved through introgression of effective rust resistant genes (Lr24/Sr24) in high yielding commercial variety Sarsabz. The grains of this new variety are amber, bold and contain a high percentage of protein (15.3) and high percentage of dry gluten (11.3) that makes the variety excellent for baking. It is highly zinc efficient variety and performs better in low water regimes. It has long spikes, thick and stiff straw, high tillering capability and also unique in resistance against prevailing virulence of leaf and stem rust.

**NIA-Sunhari:** NIA-Sunhari variety was evolved through conventional breeding and released in 2010. NIA-Sunhari possesses high yield potential, wide adaptability, high tillering capacity, medium plant height and excellent grain quality with high protein content (15.0%). The variety is suitable to grow under normal and late sowing conditions in Sindh.

**NIA-Saarang:** A new wheat variety NIA-Saarang has been evolved through conventional breeding and released in 2013. NIA-Saarang possesses drought tolerance, high grain yield, stiff waxy stem, semi-dwarf plant height, broad leaves, early maturity, wide adaptability, bold shiny ovate amber white grains, excellent grain quality with the highest protein (15.8%), the highest wet gluten (30.4%), high dry gluten (10.9%) and resistant to diseases (leaf, yellow and stem rusts). NIA-Saarang variety showed highly resistant reaction to stem rust with low intensity of disease in national trials. The variety is suitable to grow under normal sowing conditions in Sindh.
Candidate wheat varieties of NIA Tando Jam:

ESW-9525: A candidate wheat variety possesses better tolerance to salinity has been developed. It has potential to grow well in salt-affected lands having high EC level (EC=12 dS/m). The candidate variety ESW-9525 was multiplied in different parts of Sindh province. The variety showed better performance. The variety is being evaluated under national trials (NUWYT) for adaptation studies.

MSH-14: A candidate mutant wheat variety MSH-14 has been evolved through radiation-induced mutations. MSH-14 is high yielding, early maturing, possesses better grain quality, resistance to leaf and yellow rust diseases. The line has completed two years of evaluation in national trials (NUWYT). It showed better performance in NUWYT. It ranked among top10 genotypes over 43 locations in the country. It possessed better grain quality (14.0% protein, 26.4% wet gluten and 9.0% dry gluten).

Seed production and multiplication: Production of pure wheat seed for the dissemination among growers, public and private seed companies is the regular activity of NIA. The pre-basic seed produced each year is being distributed among the end users viz. public, private seed companies and progressive growers of Sindh province.

The BNS seed of 9 released wheat varieties were multiplied during 2011-12 in an area of 45 acres at NIA Farm viz., Sarsabz (8 acres), Kiran-95 (11 acres), Marvi-2000 (4 acres), Bhittai (4 acres), Sassui (4 acres), Khirman (4 acres), NIA-Amber (3 acres), NIA-Sunhari (3 acres) and NIA-Sunder (4 acres). During 2011-12, the quantity of pre-basic (PBS) and basic seed of wheat varieties viz., Sarsabz (6 tons), Kiran-95 (14.5 tons), Marvi-2000 (3.6 tons), Bhittai (5 tons), Sassui (5 tons), Khirman (2.5 tons), NIA-Amber (4.5 tons), NIA-Sunhari (3.6 tons) and NIA-Sunder (2.6 tons) was produced. The seed will be distributed among growers and seed companies during 2012-13.

2. RICE

History of the project: The rice project was initiated since the establishment of NIA in 1963. The objectives of the project were to exploit mutagens (chemical and physical) for evolution of improved rice varieties to ameliorate socio-economic condition of rice farmers. Rice breeders of the institute have developed and released six improved paddy varieties. The judicious use of chemical and physical mutagens resulted in change of economic traits in paddy. The following six paddy varieties of NIA are being cultivated on a vast paddy area of Sindh and adjacent regions of Balochistan.

Achievements: Presently three rice varieties Shua-92, Sarshar and Shandar have major economic impact as these varieties are being cultivated on about 25 percent paddy area of Sindh. Apart from this, several improved stable lines have also been developed, which are being evaluated in different trials. NIA-625 and NIA-102 are the candidate varieties contesting in National Uniform Rice Yield Trials.

Shadab: Shadab was developed from widely adapted coarse variety IR6 through mutation induced by chemical mutagen EMS. It was released in 1987. The potential yield is 7000 kg/ha, possessing fine grain quality.
**Shua-92:** Shua-92 was developed from a popular coarse variety IR8 through physical mutagens (Fast neutrons). It was released in 1993. Its yield potential is 8000 kg/ha, with salient feature of salt tolerance.

**Khushboo-95:** Khushboo-95 was developed from an aromatic land race Jajai-77 through physical mutagens (Gamma rays). It was released for general cultivation in 1996. Yield potential of this variety is 4500 kg/ha, with salient feature of excellent cooking quality and taste.

**Sarshar:** Sarshar was also developed from IR8 cultivar through physical mutagens (Gamma rays). It was released in 2002. Yield potential of Sarshar is 8500 kg/ha, with salient feature of shattering resistance.

**Mehak:** Mehak was developed from Basmati-370 variety through physical mutagens (Gamma rays). Mehak was released in 2006 for general cultivation in Sindh province. Yield potential of this variety is 3500 kg/ha, with salient feature of strong aroma in environment of Sindh.

**Shandar:** Shandar was developed from IR6 through physical mutagens (Gamma rays). It was released in 2006 for general cultivation in Sindh. Yield potential of this variety is 9500 kg/ha, with salient feature of high yield having long panicles. Shandar occupy extensive rice areas in Sindh and Balochistan.

### 3. COTTON

**History of the project:** Cotton is a cash crop and Pakistan earns a huge amount of foreign exchange. It has been ranked on fourth position for area and production compared with other developed countries. The crop was cultivated on 2.835 million ha with a production of 13.95 million bales at an average yield of 815 kg/ha during the year 2011-12. The project was started in mid eighties and evolved four cotton varieties for general cultivation in Sindh province viz., Chandi-95 (1996), Sohni (2002), Sadori (2006), and NIA-Ufaq (2010). The Sadori variety is more popular among farmers.
Achievements:

**Chandi-95:** The mutant variety Chandi-95 was developed from irradiated population of NIAB-78 variety through gamma rays (300 Gy γ-rays $^{60}$Co source). It was released for general cultivation in year 1996. Its yield potential variety is 5500 kgs/ha with an average seed cotton yield 3800 kg/ha and proved superior yield by 15% to its parent/commercial variety NIAB-78. It has long staple (29.5 mm) and fine fiber quality (3.9 micron) micronaire value and fiber strength 98 tppsi. It is tolerant to Jassids and CLCuV disease. Its opening is fluffy and easy to pick and fit in crop rotation of Sindh.

**Sohni:** The Sohni variety was developed from irradiated (300 Gy gamma rays $^{60}$Co source) population of NIAB-78 variety. It has an edge over the parent variety NIAB-78 in terms of high seed cotton yield, earliness and ginning outturn percentage. Furthermore, it is 10-15 days earlier in maturity as compared to NIAB-78, needs less number of irrigations and reduced number of sprays of insecticides for insect pest control. The variety was released for general cultivation in the province of Sindh in 2002.

**Sadori:** The variety Sadori was developed through hybridization in combination with mutagenesis. The variety was released for general cultivation in 2006. This variety is characterized with high yield, early maturity, improved ginning outturn percentage, tolerant to jassid attack and CLCuV disease. Its yield potential is 5200 kg ha$^{-1}$ with an average of 3800 kg ha$^{-1}$ and proved superior in yield over NIAB-78. It bears first sympodial branch on lower 6-7th node and manifests 67% harvest in first pick at 120 days after planting and 10-15 days earlier than NIAB-78. Early maturity makes it more suitable for cotton-wheat-cotton cropping pattern in the province of Sindh. It is featured with long staple (28.3 mm), fiber uniformity ratio 49.2%, fiber maturity 82% and fiber strength 97 thousand pounds per square inch (tppsi).

**NIA-Ufaq:** Cotton variety ‘NIA-Ufaq’ was approved for general cultivation in Sindh in 2010. It was developed from the irradiated populations of DEM-84 variety through gamma rays 250Gy ($^{60}$Co source). It is early in maturity, possesses high yield potential (5000 kg/ha) and high GOT%. It exhibited 3% more lint as compared to NIAB-78. It is featured with long staple (28.5 mm), uniformity ratio 49.2%, fibre maturity 82% and fibre strength 97 tppsi. Early maturity makes it more suitable for cotton-wheat-cotton cropping pattern in Sindh. It is tolerant to sucking insect pest especially jassids and harboured least infestation of spotted, pink and American bollworms to
buds, flower and bolls. NIA-Ufaq had good seed cotton yield at high salinity level (EC=12 dS/m).

**Candidate varieties:** Two candidate varieties have been developed namely NIA-Perkh and NIA-Noori. NIA-Perkh was approved by Technical Sub-Committee and recommended for Provincial Sindh Seed Council. The candidate line NIA-80 has secured first position in National Coordinated Varietal Trial (NCVT 2011-12 and 2012-13) in Sindh province.

**NIA-Perkh:** A new cotton candidate variety NIA-Perkh was evolved through mutation breeding (γ- rays 300 Gy, (60 Co source). The proposal of NIA-Perkh was approved and recommended by Technical Sub-Committee, Government of Sindh during May 2011 to Provincial Seed Council. The variety has high yield, high GOT%, tolerant to CLCuV, harboured less insect attack (sucking complex) and fit in cropping pattern of Sindh.

**NIA-80:** NIA-80 (NIA-Noori) a candidate variety produced higher seed cotton yield (1994 kg ha⁻¹) and ranked 1st in Sindh for NCVT trials during 2011-12. NIA-80 was also tested in NCVT trials during 2012-13 for 2nd year and had higher seed cotton yield (2407 kg ha⁻¹) which ranked 1st in Sindh province.

4. **SUGARCANE**

**History of the Project:** Sugarcane occupies a distinct position as an agro-industrial crop of Pakistan, covering around an area of one million hectares. Average yield of sugarcane in Pakistan is about 55 tons per hectare. There is an increasing pressure to enhance the productivity of sugarcane in order to sustain profitable sugar industries. Plant biotechnological methods can be applied to improve varieties for specific targeted objectives.

The work on sugarcane improvement was initiated in 1976. The group was enthusiastic in developing the improved sugarcane clones by the introduction of exotic material as well as through somaclonal variation and in vitro mutagenesis. The efforts resulted in establishment of a plant tissue culture laboratory and it was first plant tissue culture laboratory in the province of Sindh. Lateron, a molecular laboratory for genetic analysis was established in 2003.

The work on evolution of improved cultivars of sugarcane (Saccharum spp. hybrid) through induced somatic mutations and in vitro culture techniques remained in progress. The main thrust is to develop high yielding varieties endowed with early maturity, wide adaptability and improved quality characters.

**Achievements:** Three sugarcane varieties viz., NIA-98, NIA-2004 and NIA-2010 have been released for general cultivation in the province of Sindh.

**NIA-98:** The variety was approved by Sindh Provincial Seed Council in 1998. The variety is erect, medium to thick cane, easy stripping, occasional splits, high cane and sugar yield, mid-maturing, tolerant to lodging, moderately resistant to insect pest and diseases and good rationing capability.
**NIA-2004:** The variety was approved by Sindh Provincial Seed Council in 2004. The clone is early maturing endowed with high yield potential. Its average yield ranged from 71-95 tons/ha and commercial cane sugar (CCS) (13.9%). This shows 12 to 25% increase in yield over commercial varieties grown in Sindh. It has an erect and fast growing characteristic. It’s cane is medium to thick, tall with long internodes and green to yellowish green in colour. Leaves are medium broad, light to dark green in colour. The variety is tolerant to lodging, insect pests and diseases. It is also a good ratooner.

**Sugarcane breeding material and upcoming lines:** Due to the environmental constraints sugarcane breeding in Pakistan relies on the introduction of exotic material in the form of fuzz. NIA Tando Jam generating new genetic material through mutation breeding and biotechnological techniques. A large number of improved clones have been developed and two of them are in the advance stages of selection viz., NIA81-0819/P5 (NIA-2011) and AEC86-328/P37 (NIA-2012). Salient features of upcoming lines are as under:

**NIA-2011:** High yielding, early maturity, less water requirement, good ratooner, average yield 56 tons/acre and 11% sugar recovery in the month of November.

**NIA-2012:** High yielding, early maturity, good ratooner, average yield 68 tons/acre and 11% recovery in month of November.

**NIA-2010:** The variety was approved by Sindh Provincial Seed Council in 2011. NIA-2010 is the first sugarcane somaclone developed at NIA Tando Jam. The clone is high yielding with an average yield of 100-110 tons/ha and commercial cane sugar (CCS%) (13.2%). This shows about 30% increase in yield over commercial varieties grown in Sindh.

**In-vitro culture studies (callus culture):** Somaclones were generated through callus culture. Four somaclones were selected out
of 435 for the field by the molecular marker studies. Significant variation in cane yield, CCS% and sugar recovery were recorded.

**In vitro mutagenesis:** Somaclones of NIA-98 were generated through *in vitro* mutagenesis. Six selected somaclones showed significantly higher cane yield, CCS% and sugar recovery than their parents.

**Direct regeneration in sugarcane:** Somaclones of NIA-2010 were generated through direct regeneration. Out of 611 somaclones, only 6 were selected for the field studies after molecular screening. Significant variation for cane yield, CCS% and sugar recovery were recorded.

**Mutation breeding:** The irradiated material of NIA-2004 were grown and multiplied to raise M<sub>1</sub>V<sub>5</sub> population. This material was selected with the help of molecular marker studies. The selected population of 33 clones i.e. 10 of 10Gy, 18 of 30Gy and 15 of 40Gy were planted in row trial for evaluation.

**Molecular Studies in sugarcane:** Mutated population of NIA-98, NIA-719 and NIA-2004 were assessed through RAPD markers for genetic diversity. Selected somaclones were assessed for low water requirement through STS markers. The sucrose content was analyzed through TRAP markers.

**5. Improvement of banana (musa spp.) through *in vitro* culture technique and induced mutation**

**History of the project:** Banana is an important fruit crop in Pakistan, but its yield per unit area is very low because of non availability of improved cultivars. Therefore, this project has been initiated with collaboration of coordinated research programme (FAO/IAEA contract No. 5426/RB) in 1976. The main objectives of this programme were to evolve new cultivars of banana with high yield and good quality of fruit.

**Achievements:** Established methodology for micro-propagation and callus culture.
- Developed liquid culture for shoot multiplication and root induction.
- Methodologies of *in-vitro* mutagenesis have been perfected.
- Protocol for regeneration of disease free banana plants through micro-propagation has been perfected and efforts are in progress to commercialize this technique.
- Three clones viz. FHIA-23, GCTCV-215 and KM5 were selected for multiplication along with local cultivar Basra.

The Banana Bunchy Top Disease (BBTD) created serious problem for the availability of virus free plants for new planting. Micro-propagation technique has immense importance to combat disease challenges. It provides new vistas to generate disease free...
plants with minimum time, space and labour.

5. BRASSICA

**History of the project:** Brassica is an important oil seed crop in Pakistan. The brassica is cultivated under an area of 0.452 million acres with a production of 0.158 million tons, and oil production of 0.051 million tons during the year 2012-13. The total requirement of edible oil in Pakistan was 2.0 million tones, of which 29 per cent is from local production, and remaining 71 percent is to be imported at the cost of US$ 800 million each year. Canola with lowererucic acid and glucosinolate contents varieties were introduced in Pakistan and the research work on brassica improvement was initiated in 1992.

Our main thrust is to develop new high yielding varieties endowed with early maturity and improved quality characters which in turn, reduce the import of edible oil and save a huge foreign exchange.

**Achievements:**

**Surhan-2012 (R00-125/14):** First canola variety named Surhan-2012 was released for general cultivation in Sindh province during the year 2013. The variety was developed through gamma irradiation (1250 Gy). Surhan 2012 has potential to produce 3.0 tons per hectare with 45% oil contents. This is an early maturing, high grain yielding variety possesses long pods with high oil content and shattering resistance. The extracted oil of this variety has also good quality characters such as high oleic acid and linolenic acid percentages and low erucic acid and glucosinolate.

**Upcoming lines of brassica:** Two advance lines, R00-100/6 (high grain yield, early maturing, short stature, and resistant to diseases), and W97-125/13 (high grain yield, early maturing, long pod with high oil content, and shattering resistant) are in pipeline.

6. LENTIL

**History of the project:** Lentil is a valuable protein source and has the potential to sustain on relatively poor soils under adverse biotic and abiotic stresses. In Pakistan, lentil is grown as a winter crop. Due to narrow genetic base of lentil, the success in genetic improvement is very limited. The work on lentil improvement was initiated in 1985-86. Our main thrust is to develop high yielding varieties endowed with early maturity, wide adaptability, improved grain quality characters and disease tolerance.

**Achievements:** NIA-Masoor-05 is the only variety of lentil released in Sindh province by NIA, Tando Jam during 2006.

7. MUNGBEAN

**History of the project:** Mungbean is a second major kharif pulse crop after chickpea, mainly grown during spring in the provinces of Sindh and Punjab. However, the average yield of mungbean in Pakistan is very low (1482 kg/ha). The work on mungbean improvement was started in 1980. The main aim of the project is to develop new high yielding varieties endowed with early maturity, resistant to shattering and...
insect pests and improved grain quality characteristics.

**Achievements:**

**AEM-96:** The variety was approved in 1998 for general cultivation in Sindh.

**Upcoming lines of Mungbean:** Three mutant lines viz., AEM-40/30, AEM-25/20 and AEM-31/37 endowed with high yielding, early maturity, dwarfness and resistance to diseases are in advanced trials for yield stability.
PLANT PROTECTION DIVISION
This division initiated its scientific activities as Entomology Division with main objective to minimize crop losses due to ravages of insect pests. In 2009, it was renamed as Plant Protection Division. The main focus of this division is to promote eco-friendly management tactics in combination with nuclear techniques to manage insect pests and diseases of major crops and fruits.

1. INTEGRATED MANAGEMENT OF FRUIT FLIES

History of the Project: Tephritid fruit flies (Diptera: Tephritidae) are among the most destructive agricultural pests in the world. Fruit flies are overall the most significant pests of Pakistani fruits and vegetables, causing an estimated annual US$ 200 million loss to farmers alone, with further losses to traders, retailers and exporters. Physical losses of fruits were estimated conservatively as 7.5% of citrus, 15% of mango, 35% of guava, 15% of apricot, 20% of pomegranate, 30% of peach, 35% of plum, 35% of melon, 7.5% of watermelon and 20-30% of gourds and cucumbers. Keeping in view the economic importance of fruit flies, research work on its management was started in 1970.

Achievements:

- Major fruit fly species (*Bactrocera zonata*, *Bactrocera cucurbitae*, *Bactrocera dorsalis*, and *Dacus ciliatus*) were identified and the protocol for their rearing was established.
- Wheat shorts based diet was found to be the best for economical rearing of fruit flies.
- Irradiation at six day old pupae @ 90 Gy found to be adequate dose for inducing 100% sterility in males and females of *B. zonata*.
- Male Annihilation Technique (MAT) was perfected and is being used profitably by the farming community. More than 1500 hectares of mango orchard each year is managed against fruit fly with MAT.
- Two fruit fly parasitoids, *Dirhinus giffardii* (Pupal parasitoid) and *Trybliographa daci* (larval cum pupal parasitoid) were identified and are being reared successfully in laboratory.
- Irradiation of host larvae and pupae enhanced its shelf life and proved more suitable for rearing of larval and pupal parasitoids.
- Integration of bio-control agents with MAT reduced fruit fly population and fruit infestation, improved field parasitism and increased fruits quality as well as production.
- Bait application technique (BAT) was introduced and is being transferred to farmers’ community.
• The research on development of female attracting system of fruit fly is in progress and three component based lure has been identified for perfection.
• Mechanical disturbance of B. zonata pupae on day 3rd and 4th after pop out caused significant damage to flight muscles showing utmost deformity. It was practiced that female fruit flies were more sensitive to it as compared to males during embryonic development.
• Different protein based baits (protein hydrolysate, Nu-lure and prima bait) were evaluated against Bactrocera cucurbitae under field conditions.

2. INTEGRATED MANAGEMENT OF SUGARCANE BORERS
History of the Project: Sugarcane (Saccharum officinarum L.) is grown all over the country as one of the important cash crop. Apart from being the main source of sugar, the crop provides essential ingredients for chipboard, paper, chemicals, plastics, paints, fibre and detergent industries. Sugarcane production is affected by the attack of many insect pests. The control of sugarcane insect pests especially sugarcane borers by insecticides has always been difficult due to concealed feeding habit of the damaging larvae. Moreover, resistance is another problem created by these chemicals. To overcome these constrains, the bio-control programme was initiated in 1989, with the objectives to develop and commercialize the improved methods of insect pest control with an emphasis on the need for bio-intensive or ecologically based pest management strategies in sugarcane crop.

Achievements:
• Established mass rearing of egg parasitoid Trichogramma chilonis on fictitious host Sitotroga cerealella (Olivier) for releases in the field to manage the sugarcane borers.
• Enhanced the production capacity of ‘Tricho cards’ up to 300000 per year.
• Established 9 bio-control laboratories in collaboration with sector at Al-Noor Sugar Mills, Moro, Habib Sugar Mills Nawabshah, Fauji Sugar Mills Khoaki, Mehran Sugar Mills Tando Allahyar, Nawazabad Farms Mirpurkhas, Matiari Sugar Mills Matiari, Tasso Seed Corporation Tando Allahyar, Ranipur Sugar Mills Khairpur Mirus and Pangrio sugar Mills Badin.
• Annually 105500 hectares of sugarcane and 1500 hectares of cotton are being treated successfully with bio-control technology in eight districts of Sindh with the help of private sector.
• Standardized the rearing of Sitotroga cerealella reared on wheat grains produced significantly higher progeny followed by maize and rice grains.
• Sugarcane borers were successfully managed with bio-control agent T. chilonis by reducing infestation from 21% to 7%. 
Radiation doses of 20 and 25 Gy proved effective to enhance the parasitic potential of the parasite, *T. chilonis* as well as decreased the age effect of host eggs.

Irradiated supplemental host proved efficient for initial survival and establishment of parasitoids to combat the sugarcane borers in the field.

Nulure (protein) and brewer’s yeast based adult artificial diet was found to be efficient for quality production of predators *Chrysoperla carnea* (Stephens).

Mass rearing of larval parasitoid, *Cotesia flavipes* was improved by reducing immunity in 4th and 5th instar larvae of *Chilo infuscatus* (Snellen) of sugarcane borers by gamma irradiation for making them suitable for parasitization.

*T. chilonis* at rate of 10000 parasitoids/acre/ month release managed the pest population below economic threshold level in the field.

The temperature plays an important role in the establishment and parasitism % of parasitoids released in the field. Maximum parasitisation was observed when parasitoid cards were placed at middle portion of the plant leaf canopy in evening time.

### 3. INTEGRATED MANAGEMENT OF COTTON INSECT PESTS

**History of the Project:** Cotton (*Gossypium hirsutum* L.) being the major cash crop of Pakistan and is the key source of foreign exchange earnings. The infestation of bollworms and sucking complex at various stages of crop growth are the major constraints contributing to qualitative and quantitative losses. The use of synthetic pesticides is the most widespread method of control for these pests which has been a chronic threat to non target species, air, water, bottom sediments and food. Most of the insect species have also developed resistance to insecticides. That is why more attention needs to be given to alternative approaches of pest control such as growing plants resistant to insect pests, using pheromones for mating disruption, releasing natural enemies of insect pests and using botanical pesticides etc. Plant Protection Division of NIA had initiated this project in 1988, and successfully developed and implemented eco-friendly management approaches for sustainable management of cotton pests.

**Achievements:**

- Determined the economic threshold level of cotton bollworms on the basis of male moth catches in pheromone bait traps.
- F1 males in 20:1 ratio released in field cages reduced larval infestation of flowers and green bolls.
- Integrated application of PB/SB-ROPE pheromones and egg parasitoids lessened
male moth population and reduced the invasion of pink and spotted bollworms.

- Secondary predators like ants and spiders disturbed the efficacy of bio-agents *T. chilonis* and *C. carnea* just after 2 hours of cards installation. It is also confirmed that minimum population of secondary predators was observed when cards were installed at upper leaf canopy of the cotton plant.

- Integration of biological control with pheromonal control reduced the populations of sucking and bollworm complex and enhanced the cotton yield.

- Minimum population of sucking complex was observed when bio-control agents were used in transgenic cotton as compared to conventional cotton. The study manifested that transgenic cotton is a bio-control friendly technology and has no negative impact on beneficial insect fauna.

- Combined application of protein hydrolysate and sugar significantly enhanced the abundance and performance of *C. carnea* and *T. chilonis* compared to all other treatments leading to minimum pest infestation. Protein hydrolysate with sugar can be effectively used for the conservation of bio-control agents.

- Pix (Mepiquat chloride) 75 g/acre alone or in combination with insecticide reduced the attack of sucking pests as well as incidence of bollworms and enhanced seed cotton yield.

- Population dynamics was studied on Bt and conventional cotton. In Bt cotton, lowest population of moth was investigated during August to mid September, however, population tended to increase during the month of October. It is important to mention that number of moths caught per trap in Bt cotton were comparatively lower than the conventional cotton.

- The impact of augmentative releases of bio-control agents, *C. carnea* and *T. chilonis* was evaluated. Fifteen cards /acre of each predator and parasitoid were proved to be effective for sucking and bollworm complexes in cotton.

- Different Bt and conventional cotton genotypes were screened out against sucking complex and bollworms. Bt cotton genotypes IR-443 and IR-2620 proved to be the most tolerant for reduced infestation of sucking and bollworm pests. Among different conventional cotton genotypes, Sadori and NIA-80 were least preferred by different insect pests, whereas the susceptible reactions were apparent on NIA-78, NIA-79, NIA-186 and AST-II (S1).

- Bioassays were carried out for monitoring resistance level in the field population of pink bollworm collected from transgenic and conventional cotton. The highest mortality percentage (100) was observed in the field population collected from the transgenic cotton by using all tested insecticides. No cross-resistance against the insecticides in the pink bollworm’s population was survived in transgenic cotton.

4. STUDIES ON THE ECOLOGY, BEHAVIOR AND CONTROL OF RICE STEM BORERS

**History of the Project:** Rice is cultivated on 2.5 million hectare that is 10.9% of the total cultivated area with production of 5.1 million tons of milled rice. In Pakistan, it is second staple food and contributes more than 2 million tons to our national food requirement. Rice crop is attacked by 70 species of insect pests in Pakistan. Of these, stem borers, white backed plant hopper, leaf folder and grasshoppers are the pests of economic importance. It has been estimated that these pests cause 25-30% losses to the
crop annually. There was a need to develop economical and environment friendly techniques to use alone or as a component of integrated pest management programme for the control of rice insect pests. The division is effectively engaged to save this staple food from insect pests by using different eco-friendly techniques since 1979.

Achievements:
- Different non-aromatic rice genotypes were screened out against rice stem borers. The Sarshar and Shadab were the most efficient for holding reduced borer infestation and enhanced paddy yield.
- The level of plant resistance/tolerance was studied in 25 aromatic rice genotypes against the rice stem borers. Minimum borer’s infestation and severity (dead hearts, white heads), and increased rice yield were recorded on Jajai-15A/97 and M.S. Line-14.
- Chilled supplemental hosts were used to check the initial survival of *T. chilonis*. The initial establishment of *T. chilonis* was superior in the treatment where bio-control agent was released along with supplemented host *S. cerealella* eggs compared to the treatment with no supplemental host.
- Cartap 4G and Monomehypo 5G applied in nursery to manage rice stem borers after transplantation in aromatic Mehak and Khushboo-95 varieties.
- Effects of different sowing dates were studied on the incidence of rice stem borers. The effect of sowing date on pest incidence was the least on early sown crop compared to medium and late sown crop.

5. ECOLOGY AND CONTROL OF CHICKPEA POD BORER

History of the Project: Chickpea (*Cicer arietinum* L.) is an important grain legume crop grown on a large scale in the districts of Shikarpur, Khairpur and Larkana (Sindh) Pakistan. Production of chickpea in Pakistan could not keep pace with demand, as evidenced by increasing import of the crop. Chickpea can be host of a wide range of insect pests. By far the most economically important insect pest of chickpea is the pod borer, *Helicoverpa armigera*. Yield loss due to pod borer is estimated at 21 percent. The pest is reported to cause about 50-60% damage to the chickpea pods. Therefore, efforts were intiated in 1982 to develop an eco-friendly management model for the control of gram pod borer.

Achievements:
- A field experiment was conducted to screen out 26 chickpea genotypes taken from NIAB against *H. armigera* in pesticide free open field. The plants reacted differentially against the pest, the minimum larval population and percentage pod damage, and highest grain yield were observed in CH-52/02, CH-28/02, CH-4/02, B-8/03 and CH-31/02, whereas, maximum damage and minimum grain yield were found in CH-63/02, CH-20/02, CH-31/99 and CM-561/03. The genotypes found tolerant against *H. armigera* due to their genetic potential may be used as donor for creating *H. armigera* resistance in chickpea breeding.
- A field experiment was conducted to evaluate the efficacy of different chemicals for controlling pod borer *H. armigera* (Hubner) infestation on chickpea genotype CH-63/02. The results revealed that Deltaphos and Karate were the most effective and statistically at par in reducing the pest population and recorded the highest chickpea grain yield as compared to the untreated control.
6. EXPLOITATION OF MUTAGENESIS AND SELECTION FOR THE GENETIC IMPROVEMENT OF OLEIFEROUS BRASSICAE

History of the Project: The oleiferous brassica crop is one of the main sources of vegetable oil in Pakistan. There are various insect pests which attack Brassica like aphids, white fly, painted bug, pea leaf miner and saw fly but aphids are very serious. Aphids multiply very rapidly under favourable conditions on leaves, stems and inflorescence from where these pests suck the sap. Due to the attack of aphids on Brassica affected pods and seeds remain stunted. The yield loss ranges 30-35% by the attack of aphids on Brassica spp. This Division initiated this project in 1993 and implemented eco-friendly management approaches for sustainable management of brassica pests.

Achievements:

- Twenty eight different canola genotypes were screened out for their resistance or susceptibility to the attack of aphids. NR-18 and NR-4 showed least infestation by the aphids and produced significantly higher yields.

- Compatibility of different concentrations of neem oil with C. carnea was studied to manage the aphids in canola. The results manifested that integration of neem oil 2% with the predator, Chrysoperla carnea proved very effective for the management of aphids in canola giving higher yields which revealed that neem oil has no negative effect on the population of natural enemies and both can be used in integrated form for the management of aphids in brassica.

- Field surveillance was conducted on synchronization in populations build up of aphid and its predator lady bird beetle. There was no proper synchronization recorded between populations of the prey and its predator that appeared late. The nominal population of the predator was recorded when the late population of the aphid was at its peak and the pest started to migrate from the mustard fields. This gap may only be filled up by the use of eco-friendly chemicals (botanicals or non-toxic) to attract predators.

- Field observations on the predatory activities of the predators C. carnea and C. septempunctata on population density of aphids in brassica were recorded. The results reflected that both predators reduced the aphid population and differed significantly in their predatory potential.

- Efficacy of newer formulations of Imidacloprid, Acetamiprid and Esfenvalerate insecticides were studied against aphid. Imidacloprid and Acetamiprid gave better control of the pest and showed low toxicity against coccinellid predators. But Esfenvalerate, besides being least effective against aphid also caused the collapse of populations of beneficial insect.

- Studies on aphid population dynamics with reference to crop phenological stages was investigated on Hyola-42. Results displayed that the population of aphid followed varying pattern throughout the crop growth periods. Peak population of aphid was generally found during pod formation or seed filling stages.

- Effects of intercropping one row of wheat and barley with two rows of canola on the incidence of pests population and related crop yield was studied. Study revealed that canola intercropped with cereals supported
smaller number of aphid per plant than monoculture.

7. MANAGEMENT OF DISEASES OF CEREALS AND FRUITS

History of the Project: Plant pathology is an important discipline in agriculture dealing with the diseases of all crops that serve as a limiting factor in crop productivity. The main focus of plant pathology is to monitor the occurrence of various diseases of the mandate crop of this institute. The preliminary work on wheat rusts, brown spot of rice and sudden death syndrome of mango trees at NIA was started in 2009. The survey was conducted to assess the incidence and severity of mango sudden death syndrome (MSDS) in mango growing areas of Sindh i.e., Hyderabad, Tando Allahyar and Mirpur Khas. The results showed that it was prevalent in all mango orchards. In order to confirm the cause of mango sudden death syndrome the present studies were conducted. The disease samples were collected from the infected orchards including the infected bark, xylem portion of infected root, soil samples and bark beetles. This study was conducted to find the seed borne nature of sudden death of mango. For this purpose the seeds of different mango varieties were collected. Certain isolation methods like Blotter paper method, deep freezing and direct plating of different parts of mango seeds on potato dextrose agar (PDA) medium were used.

Achievements:

- Among all the tested 2790 lines against leaf rust, 18 were found highly resistant, 1727 were screened as resistant, 392 moderately resistant, 385 showed MS-type reaction and 268 fell susceptible against the leaf rust and none was found infected with stripe rust.
- Urediospores of leaf, stem and other rusts were collected from infected fields, trap nurseries and experimental farms. Collected spores were air-dried and preserved for short and long term use.
- Increase in moisture %, protein %, iron and zinc contents in wheat grain leads from susceptibility to resistance, while increase of copper showed reverse response.
- Among tested 329 lines/varieties of rice, 15 were highly resistant, 129 resistant, 76 moderately resistant, 51 moderately susceptible, 32 susceptible and 26 were highly susceptible against brown spot disease of rice.
- Eight fungicides were evaluated against Helminthosporium oryzae. Among them Topas and radomil gave better results as compared to other fungicides.
- Disease incidence of sudden death varies from 10-15% in different orchards.
- Diseases severity and tree mortality varies from 5-10% depending upon the management practices carried out by the growers.
- The results showed the association of different fungal flora with different plant parts, soil and bark beetle. Among fungi Ceratocystis spp. was the dominant followed by Lasiodiplodia spp. Fusarium spp. Alternaria spp. were observed in low frequencies.
- The results showed the presence of certain saprophytic and field fungi but no growth of Ceratocystis was observed. These results suggested that sudden death is not seed borne in nature.
PLANT PHYSIOLOGY
DIVISION
The main focus of the Division is to enhance crop productivity by understanding stress tolerance physiological responses and exploring ways to cultivate suboptimal lands through applying different approaches (mass scale screening, exogenous applications of different growth regulators and mineral nutrition) for salinity and drought tolerance in crops of economic importance.

1. NUTRITIONAL PHYSIOLOGY EFFICIENCY OF PHOSPHATIC AND NITROGEN FERTILIZER

**History of the project:** Mineral nutrition of plants is a subject which has gained new importance due to the staggering increase in the world population and the urgency to provide sufficient food for the growing population. The problem of increasing the yield can be tackled by more than one method. This could be done by increasing the land under cultivation or manage the available land in a more efficient manner. The science of mineral nutrition can also play an important role in the improved management of land and increasing the productivity of our crops. Therefore this work was done during 1962-66 to determine the best mode, time and the rate of fertilizer which can give optimum yield. In these studies $^{32}\text{P}$ and $^{15}\text{N}$ labeled, as well as newly introduced slow release fertilizer and chelates with conventional fertilizer were used and compared to explore their effects on plant productivity.

**Achievements:**

- Surface placement, whether hoed in or not was superior to shallow (10 cm) or deep (20 cm) placement.
- Phosphorus can be applied to rice at any time up to two weeks before primordial initiation.
- Best uptake of nitrogenous fertilizers takes place when applied half at 3 to 4 weeks and the other half at 6 to 8 weeks after transplanting.
- Ammonium Sulphate and Urea were the best source of nitrogen for rice crop.
- Using cotton as test crop, the maximum benefit of fertilizer was obtained when it was applied at least 30 days after sowing.
- Grain yield of wheat showed better response to Potassium Nitrate and Ammonium Sulphate Nitrate when applied at sowing and first irrigation.
- Studies related to rate and source of nitrogenous fertilizers on yield and protein content of wheat have shown that 90 Kg/ha (75% of locally recommended dose) was as good or even better than 120 Kg/ha for straw and grain yield.


**History of the project:** Studies were conducted during the year 1969-75 under PL-480 research contract. The work on nutritional physiology was done using various test crops i.e cotton, jowar, wheat, soybean, sarson and raya by supplying radioisotopes of $^{45}\text{Ca}$, $^{35}\text{S}$, $^{32}\text{P}$, $^{56}\text{Fe}$, $^{54}\text{Mn}$ and $^{65}\text{Zn}$ to plants under normal and saline conditions.

**Achievements:**

- These studies revealed that increase in salt concentrations decreased seedling growth but simultaneous application of kinetin partially reversed the inhibitory effect of salt stress.
- The qualitative uptake of various elements was disturbed due to the presence of salt but
the trends generally varied with different crops.

- Chemical analysis of various plants parts revealed that concentrations of nitrogen, calcium and potassium were reduced while phosphorus and sodium were increased under saline growth conditions.

- It was concluded that cultivars M-4 and M-100 of cotton, H-68 of wheat, S-5 of sarson, R-II-1 and R-II-40 of raya may give good yields in soils containing up to 0.4% salts.

- Pretreatment of wheat seeds with GA$_3$ resulted in a better seedling performance as compared to IAA under saline condition.

3. **TECHNIQUES FOR TESTING PLANTS UNDER CONTROLLED CONDITIONS**

**STABLISHMENT OF SUITABLE MEDIUM FOR GROWING PLANTS UNDER CONTROLLED CONDITIONS**

**History of the project:** There are many methods for testing germination and seedling growths of the crops. This study was conducted during 1963-65 to select suitable growth medium for the basic studies under controlled laboratory conditions. Three medium (glass plate, agar gel and filter paper) were selected for the study.

**Achievements:**

- Anchoring of root and water availability was found better in agar gel (0.75%) medium than filter paper and glass plate methods.

4. **FEASIBILITY OF TESTING COMMERCIAL SCALE HYDROPONIC SYSTEM AND GLASS HOUSE FOR RAISING DIFFERENT CROPS IN SANDY DESERTS, BARREN LANDS AND UTILIZATION OF BRACKISH WATER.**

**History of the project:** There are large barren areas in the country where normal agriculture is not feasible due to absence of good quality soil and enough irrigation water. In such areas, hydroponic culture has proved an alternative for raising fresh vegetables etc. In this system instead of soil, gravel or sand serves as the supporting medium and due to the recycling of irrigation water there is significant saving on irrigation water. It may even be possible to use brackish water with appropriate amendments under the hydroponic system. As in due course of time our country may have to make use of the barren/stress prone areas to meet the food requirements of its growing population. Keeping in view this project was initiated in 1971. A number of crops (bajra, tomato, kakri, khira, potato and peanuts) according to season were raised in hydroponics and glasshouse in gravel and desert sand beds.

**Achievements:**

- The potato cultivation was moderately successful in both gravel and sand culture.

- The gravel culture medium was found less suitable than fine sand medium.

- Generally it was observed that bajra, tomato and cucumber (khira and kakri) performed quite well up to 3,000 ppm salinity above which the growth was adversely affected.

- This setup was also found satisfactory for mass scale screening of crops under stress conditions.

5. **HORMONAL RELATIONS AND EXOGENOUS APPLICATION OF GROWTH REGULATORS**

**HORMONAL RELATIONS UNDER SALINITY STRESS**

**History of project:** Plants are continuously exposed to environmental stresses throughout their life cycle. Seasonal fluctuations in temperature, moisture, light and salts often to the levels that are sub-optimal affect plant growth. During 1984, a number of experiments were conducted to
study their interaction on germination and seedling growth. Basic physiological studies were also conducted on various stress related hormonally regulated physiological mechanisms.

Achievements:

- The role of abscisic acid (ABA) on proline accumulation under stressful environmental conditions was studied. Proline accumulation is not a specific response to salinity/osmotic stress but also accumulates under etiolation and disease infection (rust).

- It was also demonstrated that ABA is not involved in proline accumulation under salinity stress.

- The Kinetics of $^{14}$C-IAA was studied in maize coleoptile segments treated with norflurazon (ABA inhibitor) and triadimifon (GA inhibitor). Transport of $^{14}$C-IAA intensity was enhanced in which biosynthesis of GA and ABA was interfered.

- This is perhaps the first study, which suggests that blockage of GA, or ABA biosynthesis did not decrease the auxin transport intensity.

- Nitrate reductase (NR), the first regulatory enzyme of nitrogen assimilation pathway is sensitive to environmental stress. We studied the effect of enhanced and reduced ABA levels on this enzyme and observed that salinity affects its activity indirectly, i.e. by reducing the substrate (NO$_3$) flux.

- Cytokinin (CK) and abscisic acid (ABA) levels are known to differentially influence the senescence process. Their effects on chlorophyll contents of salinity stressed wheat seedlings were studied. Chlorophyll degradation was reduced by CK (benzyle amino purine) but not by other treatments.

6. TECHNIQUE DEVELOPED THROUGH USING GROWTH REGULATORS

History of project: Plant growth regulators may be considered as a new generation of agrochemicals after fertilizer, pesticides and herbicides. Dropping of fruits (mango), vegetables (tomato and chilies) and boll dropping in cotton is a natural phenomenon, sometimes it becomes more extensive. To overcome this problem work was started during 1977, to study the effect of chemicals on premature flowers, fruits and boll drop in various crops.

Achievements:

- Different concentrations of chemicals and growth regulators were sprayed on fruiting of mangoes, tomatoes, chilies and cotton. Applications of growth regulators naphthalene acetic acid (NAA), silver nitrate (AgNO$_3$), cobalt nitrate (CoNO$_3$), salicylic acid (SA), acetyl salicylic acid (ASA) and plenofix enhanced fruit retention in mango, tomatoes, chilies and also minimized boll dropping in cotton.

- Application of acetyl salicylic acid (later named frotofix in the year 1998) gave comparatively better results for
enhancement of harvestable fruits/crop yield.

- After standardizing the technology, it has been introduced to many mango and cotton growers at different locations of Sindh.
- Increased production of 20-25% was obtained in the crops where it was applied.
- Considering the cost, easy availability and convenience of preparing solution, this technology is well appreciated and gaining popularity among growers.

7. **USE OF PHYTOHORMONES TO ALLEVIATE THE EFFECT OF SALINITY IN CROPS**

**History of project:** This research programme was initiated in 2001 with an objective to evaluate different phytohormones for their potential to promote germination and to improve yield under saline conditions.

**Achievements:**

- Studies of germination and growth responses at seedling stage under different salinity levels alone and with different combination of phytohormones (GA \(10^{-6}\)M, IBA \(10^{-5}\)M, NAA \(10^{-5}\) M) using wheat genotypes revealed that germination and growth was inhibited by salinity (0.5-1% NaCl).
- Pre-treatment of wheat seed with different growth hormones was found very effective in improving the rate of germination under salt stress.
- Significant increase (>25%) in germination was observed with GA\(10^{-6}\)+NAA\(10^{-5}\) at highest salinity level (1% NaCl) similarly this combination of hormones was also found effective in seedling growth and biomass production under saline conditions.
- Experiments were conducted up to maturity presoaked seeds of different wheat varieties with different growth hormones (GA \(10^{-6}\), IBA \(10^{-5}\), NAA \(10^{-5}\)) were planted. A general reduction of 50-60% was observed in wheat varieties at the higher level of salinity (12 dS/m).
- Comparisons of different growth hormones at (12 dS/m) have shown that GA was found effective in promoting germination by 35%, while NAA and IBA also enhanced germination (30-35%) in comparison to untreated control.
- These phytohormones were also evaluated alone or in combinations under natural saline field conditions. The most effective combination for enhancing germination of wheat cultivars was GA \(10^{-6}\)+NAA \(10^{-5}\) (>35%) under saline field conditions (13-15 dS/m).
- Beneficial effects were observed on growth with the presoaking of growth regulators by increasing physiological activities under saline conditions. Increased leaf area (27%) and spad chlorophyll (16%) was observed in the treated plants under saline conditions.
- Presoaking treatment maintained osmotic potential and accumulated more proline, decreased Na accumulation and improved K/Na ratio of wheat cultivars.
- Higher concentration of Ca in the shoot was recorded in the presence of salinity with GA\(10^{-6}\)+NAA\(10^{-5}\).

8. **SALT TOLERANCE STUDIES GROWTH PHYSIOLOGY OF SOYBEAN AND ASSOCIATED CHANGES IN THE NITROGEN ECONOMY OF SOIL AS AFFECTED BY SUBSTRATE SALINITY**

**History of the project:** Studies were conducted during the year 1986-1989 under FAO/IAEA research contract No. 4101/RB.

**Achievements:**

- These studies have indicated that all soybean cultivars/ accession were found sensitive above 25mM NaCl. The nitrogen fixing bacteria (*Rhizobium japonicum*) isolated from the soybean roots were similarly
sensitive whereas rhizobial strains form NIFTAL were tolerant up to 50mM NaCl.

- Nodulation reduced due to salinity but this reduction was dependent on salt tolerance of host plant and bacteria responsible for nitrogen fixation.
- Physiological studies on different aspects revealed that tolerance of soybean could be correlated with certain parameters like RGR, WUE, Na and K uptake and their fluxes.

9. SALT TOLERANCE STUDIES IN PLANTS

**History of the Project:** This project was started from 1988 with the collaboration of British O.D.A. for screening different crops of importance.

**Achievements:**
- These studies successfully identified a number of tolerant and sensitive cultivars of cotton, mustard, maize, sorghum, millets, and some other grasses.
- The response was generally dependent on ion accumulation in shoot, their proportions, fluxes, selectivity’s.

10. MULTIPURPOSE TREE SPECIES FOR SMALL FARMS IN THE ARID AND SEMI-ARID TROPICS (WINROCK, F/FRED)

**History of the Project:** To meet the needs of fuel, food and fodder and to improve the management of land and forest recourses in Asia for small scale farmers a project was started with the collaboration of PAEC and Winrock F/FRED in 1988-90 to identify the appropriate germplasm for profitable utilization of arid lands.

**Achievements:**
- Four tree species were selected (*A. nilotica, P. cineraria, P. pallida and P. acculiata*).
- Pruning treatment resulted in taller plants then control (non-pruned) and provided material which could be utilized as fuel wood/fodder.
- Basal diameter (D-10) and diameter at breast height (DBH) were better in non-pruned pruned.
- *A. nilotica* had the best overall growth and possessed nice long stems, suitable as timber/poles/posts.

11. AUSTRALIAN WOODY SPECIES FOR SALINE SITES IN ASIA

**History of the Project:** The performance of a number of native and exotic tree species were evaluated with different aspects (tree establishment and species evaluation trails, provenance trails, water use efficiency and inoculation of nitrogen fixing bacteria) under joint project of PAEC, Islamabad and ACIAR No # 8633, Australia, from 1988-98.
Achievements:

- The evaluation studies under saline field conditions (where salinity ranges from 1.0 to 2.5%) showed that Australian species i.e. *Acacia ampliceps* is more salt tolerant followed by *Acacia stenophylla*, *Acacia mechanochiena*, *Casurina glauca*, *Prosopis juliflora*, *Prosopis alba* and *Prosopis glandulosa*.

- Nitrogen, potassium, and phosphorus were higher in newly expanded and low in older leaves.

- Nitrogen content in *A. nilotica* was higher than *A. ampliceps*.

- Phosphorus (P) mobility was more in *A. nilotica* than *A. ampliceps*.

- Potassium (K) contents remain parallel throughout the year in both genotypes except May-August and November-December.

- Calcium (Ca) is an immovable element hence its concentration was high in older tissues than in new ones.

- Calcium contents in *A. nilotica* leaves ranged from 0.4-3.77% (new) 1.46-4.09 in (old). Whereas in *A. ampliceps*, 3.90-5.9% (new) and 4.6-6.86% (old).

- In *A. ampliceps*, sodium concentration in newly expanding leaves was higher than the older ones.

- In *A. nilotica*, sodium content in new and old expanded leaves were more or less similar, ranging from (0.125-0.159%) and (0.112-0.185%) respectively.

12. EXPLOITATIONS OF GENETIC VARIABILITY/ HIGH YIELD POTENTIAL IN SUNFLOWER FOR DEGRADED LANDS

**History of the project:** Genotypic variability/high yield potential in 33 sunflower genotypes were investigated underfunded programme of PSF (2001-2003).

**Achievements:**

- High degree of salt sensitivity was observed in this crop, as more than 50% reduction was observed in all growth parameters at seedling stage.

- Wide range of variability has been observed among these genotypes. However the genotypes SC-84, Euroflore, Sputnik, Predovic, Amiata and Ho-I have shown comparatively better tolerance at seedling and maturity stage (good germination, large floral diameter and more productive in grain yield above 40g grain wt./plant) under both saline (EC 10-15dS/m) as well as non-saline field conditions.

13. NUCLEAR TECHNIQUES ASSISTED MANAGEMENT OF SALT AFFECTED LANDS AND BRACKISH WATERS IN PAKISTAN

**History of the Project:** The project was initiated from 2002-06 with the collaboration of PARC and PAEC to observed the effect of brackish water on tree species and selection of wheat genotypes.
Achievements

- Effect of brackish water (4000ppm) on five trees species were observed, it was concluded that *A. nilotica* species performed better in their survival and growth as compared to other four species.

- Analysis of macro and micro nutrients also showed that the native acacia has maximum N, Cu, Zn, and Fe contents in foliage and hence can play an important role to improve soil fertility and thus grower can have good economical returns from these marginal lands.

- Out of sixty one wheat genotypes, seven showed tolerance at 12 dS/m salinity at early seedling stage.

- In glass house study three genotypes showed better productivity at 12 dS/m salinity.

- Carbon isotopes study showed strong correlation for tolerant genotypes.

- Eight tree species were planted in the saline field (EC 1:5) 2.28-10.58, out of which three species survived well.

14. INDUCED MUTATION TO IMPROVE SALT TOLERANCE IN NON-AROMATIC RICE VARIETIES (IAEA PROJECT NO. PAK/5/042 2004 – 2005)

**History of the Project:** Induce mutation studies were conducted in 2004 to improve salt tolerance traits in some non aromatic rice varieties.

**Achievements:**

- Effects of different doses of radiation on physiological responses of rice plants have shown that comparatively more chlorophyll quantities were found at 150Gy at both levels of salinity (EC 6dS/m and 9dS/m NaCl). There was a negative relationship between sodium uptake and chlorophyll contents under salinity.

- 150Gy was found effective in maintaining low shoot sodium concentration. This reduced Na concentration in shoot may be positively linked with better growth under salinity in 150Gy plants.

- The dose to 150Gy was found effective in maintaining low shoot sodium and yield enhancement in Shua-92 and IR-8 in comparison to non irradiated ones.

15. BIORESTORATION OF SALINE WASTELAND AND DEVELOPMENT OF SALT TOLERANT PLANTS

**History of the Project:** This Collaborated Project was funded by Ministry of Science and Technology, Chinese Academy of Agricultural Sciences and PAEC, from 2004-06.

**Achievements:**

- Forty one wheat genotypes were tested at 12 dS/m salinity in glass house out of which, three genotypes performed well on the basis of less than 50% reduction in different variables.

- Fourteen barassica species were tested at 12 dS/m salinity on the basis of less than 50% reduction in different variables four genotypes showed tolerance.

16. SCREENING FOR SALT TOLERANCE IN WHEAT

**History of the Project:** This is an on-going programme for salt tolerance studies started in 2000, with objectives to screen exotic and locally developed wheat germplasm and to understand the physiological mechanism in wheat.

**Achievements:**

- Plants were grown hydroponically in saline solution. Germination percentage, shoot root lengths, fresh and dry weights were determined. The genotypes Pak-81, LU-26s and C-228 performed better on the basis of
< 50% reduction at 200 mM NaCl under laboratory conditions.

- Twenty four genotypes were tested under laboratory, glass house and at natural saline and non-saline field conditions.

- Out of twenty four wheat genotypes Sarsabz, V-8001, Lu-26s, KTDH, KTDH-22, Bhittai, DS-17 were found tolerant at Early seedling stage (exhibited <50% reduction).

- The genotypes (Sarsabz, Lu-26s, V-8001, KTDH, KTDH-22, Bhittai, ESW-9525, V-8319, C-228, Zardana, Chakwal, and V-7004) were found tolerant under Glass House conditions.

- The genotypes (Sarsabz, Lu-26s, KTDH22, Bhittai, DS-17, V-8319, Chakwal - 86, V-7004, Inquilab, V-7003, Zardana, RWM-9313, Marvi-2000, Abadgar, ESW-9525) were found tolerant under field studies (exhibited <40% reduction in yield).

- On the basis of these three methods Sarsabz, Lu-26s, KTDH-22 and Bhittai were found tolerant whereas V-7012, Bakhtawar, Khirman were found sensitive.

- Physiochemical studies showed that better performance of Sarsabz, Lu-26s, KTDH-22 and Bhittai appeared due to their higher adjustment of osmotic potential by proline, betaine and total sugars; more accumulation of potassium over sodium in the tissue; increased leaf area, less degradation of chlorophyll contents and enzymatic activities (NRA, NiRA), high delta Δ values \(^{12}\text{C}/^{13}\text{C} \) discrimination under salinity stress.

17. SELECTION OF WHEAT GENOTYPES USING NUCLEAR ASSISTED TECHNIQUES IN SALINITY / DROUGHT PRONE AREAS OF PAKISTAN

**History of the Project:** This Collaborative Project between PAEC and IAEA, during the period of 2010-13 with the objective to select wheat genotypes using nuclear assisted techniques in salinity/drought prone areas of Pakistan.

**Achievements:**

- Studies were carried out at early seedling stage. Out of twenty four wheat genotypes six were found tolerant at 12dS/m salinity.
- In gravel culture studies seven genotypes performed well at 12 dS/m salinity.
- In the field three genotypes were found tolerant at 16 dS/m salinity.
- These twenty four wheat genotypes were tested for drought tolerance. On the basis of 30% reduction at 0.75 MPa drought stress in different growth parameters at seedling stage. It was found that DH-1, DH-2, DH-5, DH-6, DH-8, DH-10, DH-12, DH-14, DH-15, DH-18, DH-19 and DH-20.
- In pot-house experiments on the basis of less than 20 % decrease in different agronomical parameters, the genotypes V-1DH, V-2DH, V-5DH, V-6DH, V-8DH, V-10DH, V-12DH, V-14DH, V-15DH, V-17DH, V-18DH, V-19DH and V-20DH had the potential to perform under low water regimes.
- In the field on the basis of less than 30% reduction in different variables, 9 genotypes viz. V-2DH, V-5DH, V-6DH, V-8DH, V-10-DH, V-12-DH, V-17DH, V-18DH, and V-20DH along with checks Chakwal-86 and Khirman were categorized as tolerant.
- On the basis of two year results the genotypes DH-13, LU26s were found salt tolerant
- Whereas DH-18, DH-20 and chakwal-86 and were found drought tolerant.
- The genotypes DH-18 and DH-13 also have the potential to perform quite satisfactorily under low water regimes. Therefore it is well recommended for drought prone areas of Pakistan.
On the basis of physiochemical studies better response of DH-13 under salinity might be due to its less accumulation of Na in plant, resulting comparatively less reduction in K/Na ratio.

Under water stress conditions the genotype DH-18 performed better.

Better response in DH-13 and LU-26s under salinity and DH-20 under drought is encouraging for their recommendation to cultivate in salt and drought prone areas of Pakistan especially in Sindh province.

Nitrogen use efficiency in DH-13 and LU-26s under salinity and DH-20 under drought is encouraging for their recommendation in salt and drought prone areas of Pakistan especially in Sindh province.

18. MASS SCALE SCREENING FOR SALINITY AND WATER STRESS TOLERANCE IN RICE (ORYZA SATIVA L.).

History of the project: This is an ongoing programme on mass scale screening of diversified indigenous and exotic rice germplasm for the identification of stress tolerant promising genotypes, which can be directly cultivated under stress environment or for using in a breeding programme to combat the challenges of salinity and increasing scarcity of water. This project was initiated in 1981. In the decade of eighty some preliminary work was done on some old land races and IRRI lines. Later on the work was reinitiated in1998 and up till now five hundred rice lines/genotypes of diversified origin have been tested for their responses to salinity/water stress. Furthermore efforts were also taken to acquire in depth knowledge about the diversity in the mechanism of salt tolerance which render differential tolerance / sensitivity in rice genotypes and for the identification of physiological traits contributing in stress tolerance.

Achievements:

- This work has been successful in identifying some promising lines of rice (7 lines), which possess tolerance against salinity and produces satisfactory yield under saline conditions.
- The cultivars IR-6-93, IR-36, IET-4094, Khara ganga, K x Thore, NIAB-6 and Jajai-LG was found medium tolerant.
- The cultivars, IR-6, Shadab, IR-8, Shua-92, IR-2053 Pokkali, Nona Bokra and Ganja white, Ganja red and KS-282 was found tolerant (9 dS/m NaCl salinity).
- Comparison of physiological characters among tolerant and sensitive lines under salinity have shown that less Na uptake, and efficient K regulation in shoot, higher K/Na ratio, high quantity of proline and sugar, less reduction in Chl a. were found some contributory characters in adaptation of plants under saline conditions.
- A sodium distribution pattern study in rice leaves have revealed that leaf no.2 and 3 may be used as a good indicator for studying ionic relations under salinity.
• These studies may prove helpful in identifying the specific physiological traits as selection criteria for transferring desirable gene traits in breeding programme for salt tolerance.

• Comparative studies among lowland and upland types of rice revealed that generally lowland types have yielded comparatively more grain weight than upland types under saline conditions (6dS/m NaCl). Upland types have yielded comparatively more under water stress (aerobic conditions).

• Three rice genotypes under salinity and four under water stress exhibited comparatively better tolerance than their specific internationally known checks.

• Comparative osmoregulatory responses of UPL and LOL rice types have revealed that LOL type have better selectivity for sodium and osmoregulation through K accumulation.

• UPL types raised their osmotic potential through accumulating total soluble sugars and more proline.

• Isoosmotic concentrations of PEG-6000 and NaCl were used to differentiate between osmotic and ionic effects at early seedling stage. It was observed that osmotic stress was found more severe for growth at early seedling stage in comparison to ionic stress.

19. DROUGHT TOLERANCE STUDIES SCREENING FOR DROUGHT TOLERANCE IN WHEAT (TRITICUM AESTIVUM L.) GENOTYPES

History of Project: This programme was initiated during the year 2000, with the objective to evaluate wheat genotypes for drought tolerance through different screening techniques.

Achievements:

Germination Stage

• A series of laboratory experiments were conducted to screen out 260 wheat genotypes collected from different organizations of the country and those developed at NIA, Tandojam (Plant Breeding and Genetics Division). In all wheat genotypes the germination percentage decreased with increase in osmotic stress. It was observed that 91 genotypes showed more than 60% germination at -0.5 and -0.75MPa.

• But the genotypes MASR-01, MASR-03, MASR-06, MASR-07, MASR-08, MASR-09, C-591, CM-28/87, QM-4531, QM-4934, RG-24, 8ARC-1, V-8319, M-172, DH-20, DH-17, DH-18, DH-19, SMR-4, SMR-5, SMR-6, SMR-9, SMR-10, SMR-16, M-28, M-29, M-37, Chakwal-86 and khirman performed well even at -1.0 MPa, demonstrating high genetic makeup for drought resistance during germination (70%) when compared with control.

Seedling Stage

• Twenty four wheat genotypes have been studied at seedling stage under osmotic stress for various biochemicals parameters like NRA, proline contents glycine-betaine, total sugar and K+ contents.

• Twelve wheat genotypes viz Marvi, H-68, CM-24/87, Khirman, C-591, Chakwal-86, C-228, AGA, Bues, RG-24, M-172 and HT-37 were found tolerant at -0.75 MPa osmotic stresses. These genotypes maintain their osmotic potential under water stress conditions.

Pot-House Studies (Controlled Conditions)

• The performance of 142 wheat genotypes was tested under controlled conditions in the wire-netted pot-house in cemented tanks with two treatments, control (normal irrigation), terminal drought (soaking dose). On the basis of comparison of yield data, 43 genotypes performed better.

Field Studies

• The experiment was conducted at NIA experimental farm with the same 142 wheat genotypes, with two treatments irrigated (four irrigation) non-irrigated (soaking
dose). The 43 wheat genotypes exhibited relatively less reduction (< 20%) over control in yield and yield contributing components under terminal drought.

Physiological Studies

- The physiological behavior of wheat genotypes were studied with an objective to understand the mechanism of adaptation to drought conditions through studying parameters included proline, glycine-betaine, total sugar, potassium (K\(^+\)) contents, total chlorophyll, nitrate reductase activity (NRA) and osmotic potential. Proline contents >16 fold and glycine-betaine > 2 fold increased in tolerant genotypes.
- The maximum concentration of potassium (3.42-3.35%), less reduction in total chlorophyll, nitrate reductase and lower osmotic potential was observed in tolerant genotypes under drought conditions. This programme is of continuous nature as the productivity of wheat could be enhanced by studying the nature of adaptation of wheat to drought and to find out physiological traits for evolving the best adapted and high yielding wheat varieties for droughted areas of Sindh in particular and Pakistan in general.

20. SCREENING FOR DROUGHT TOLERANCE IN CANOLA TYPE BARASSICA SPECIES

History of Project: Keeping in view the great economic importance of canola for farmers and the shortage of water (drought) in the country, experiments were conducted for the evaluation of drought tolerant/low water requiring canola genotypes. This project was in progress from 2004 to 2008.

Achievements:

- The genotype Con-III and mutant Rainbow-2 (R-100/6) were found relatively tolerant to drought stress.
- Relative water contents (RWC), Osmotic potential (OP) and potassium contents were generally decreased whereas, total greenness (Spad value) and proline contents increased under various water regimes as compared to control.

21. GENOTYPIC VARIATION FOR POTASSIUM UPTAKE AND UTILIZATION EFFICIENCY IN WHEAT

History of Project: Due to rapid depletion of soil potassium (K) and increasing cost of K-fertilizer in Pakistan, the K efficient genotypes have become very important for agricultural sustainability. Keeping this important aspect in view, a project was initiated for the evaluation of wheat genotypes for potassium uptake and use efficiency from 2009 to-date.

Achievements:

- Biomass production was significantly affected by K levels, genotypes and their interaction.
- Khirman was the most badly suffered genotypes due to K deficiency stress in terms of shoot and root dry weight with 47% and 56% of KSF (Potassium stress factor) respectively.
- On the basis of K-use efficiency, three genotypes (NIA-MB-1, SD-4047, and Khirman) were ranked as efficient and responsive.
- Two genotypes NIA-Sarang, NIA-Sundar ranked as efficient and non-responsive.
- Four genotypes MSH-14, 22-03, SD-502 and Chakwal-86 ranked as non-efficient and responsive.
SOIL SCIENCE DIVISION
THE MAIN THRUST OF SOIL SCIENCE DIVISION IS THE MAXIMIZATION OF CROP PRODUCTIVITY THROUGH INNOVATIVE TECHNIQUES, INTENSIVE CROPPING, BETTER MANAGEMENT PRACTICES AND BALANCED FERTILIZATION.

1. STANDARDIZATION OF METHOD FOR AVAILABLE PHOSPHORUS IN SOIL

**History of the project:** This project was initiated in 1965 to standardize a chemical method for determining available soil phosphorus (P) under the agro-climatic conditions of this region. The following four methods (extractants) were used in three types of soils with light, medium and heavy texture for determination of available P in soil.

1. Olsen’s method (0.5 M NaHCO₃)
2. Truog’s method (0.002 N H₂SO₄)
3. Bray and Kurtz No. 2 method (0.03 M NH₄F+0.1 N HCl)
4. Rhode’s method (0.025 N Boric acid)

**Achievements:** The Olsen’s method was found better for extraction of available soil P for the calcareous soils.

2. APPLICATION OF RADIATION TECHNIQUES TO WATER-USE-EFFICIENCY STUDIES BY MAIZE

**History of the project:** This project was initiated in 1965 under IAEA research contact No. 379/RB to study the water use efficiency of maize. The objective was to obtain the evapotranspiration data in order to formulate appropriate irrigation practices for maize. The experiment consisted of two treatments, i) dry and ii) wet. The dry treatment received 0.5 to 0.6 times the evapotranspired water and the wet treatment received twice the amount of dry treatment.

**Achievements:** The results revealed that the evapotranspiration (Et) values obtained by the hydraulic weighing were quite close to those obtained from the neutron moisture meter. Maize appeared to be tolerant to water stress except during the fruiting period. Imposing a water stress during this period reduced the maize yield drastically. These studies indicated that a higher yield of maize grain was possible by application of higher amounts of irrigation water without increasing any other input on the farm.

3. STUDIES ON TRANSFORMATION AND AVAILABILITY OF FERTILIZER AND SOIL PHOSPHATE

**History of the project:** This study was initiated in 1967 with the objective to understand the superphosphate transformations in different soils and to estimate availability of various soil phosphate fractions.

**Achievements:** The superphosphate transformations in calcareous soils indicated that in 6 weeks time less than 10% superphosphate was taken up by wheat plant, 12–19% remained water soluble, 23% was converted to aluminum and iron phosphate, and 47% was converted to less soluble or insoluble forms of calcium phosphate.

4. USE OF ISOTOPES AND RADIATION IN WHEAT FERTILIZATION STUDIES
History of the project: This project was initiated in 1968 under IAEA research contact No. 369/RB with the objective to compare sodium nitrate and ammonium sulphate as source of N for wheat.

Achievements: The result showed that the percent utilization of fertilizer N from sodium nitrate was 20-100% higher than that from ammonium sulphate. By using $^{15}$N fertilizers, ammonium sulphate was found to be a better source of N for wheat. The results also revealed that the labelled fertilizers applied to wheat at tillering led to the highest grain yield and the highest utilization efficiency of fertilizer N, followed by the fertilizer applied at sowing and by the fertilizer applied at booting stage. In conclusion, the application of N at seeding is essential for establishing good crop stand. Thereafter, the period from tillering to pre-flowering stage is critical for split application of fertilizer. The fertilizer applied after this stage usually contributes little to the grain yield.

5. EFFECT OF SODIUM AND CALCIUM SALTS ON SUPERPHOSPHATE TRANSFORMATIONS, PLANT GROWTH AND P UPTAKE

History of the project: This project was initiated in 1968 with the objective to see the effect of sodium and calcium on fixation and transformations of superphosphates. The effect of six concentrations of sodium (0.1, 0.3, 0.5, 0.75, 1.0 and 1.5%) and same concentrations of calcium salts was investigated on wheat crop.

Achievements: The soluble phosphate increased from 6 to 167 ppm with the application of 1.5% sodium salt. However, plant growth was adversely affected by high concentrations of both salts. The plants failed to grow at 0.75% and higher levels of sodium concentrations.

6. SUPPRESSION OF PHOSPHATE FIXATION BY FARM YARD MANURE

History of the project: This experiment was initiated in 1970 with the objective to study the possibility of suppressing phosphate fixation and thereby increasing its availability.

Achievements: The fixation of superphosphate was reduced when it was thoroughly mixed with farm yard manure. The uptake of superphosphate by wheat was increased (or phosphate fixation deceased) by 21 and 35% at the end of 35 and 105 days harvest, respectively.

7. AGRICULTURAL NITROGEN RESIDUES WITH PARTICULAR REFERENCE TO THEIR CONSERVATION AS FERTILIZER AND BEHAVIOUR AS POTENTIAL POLLUTANTS

History of the project: This project was initiated in 1976 under IAEA research contact No. 1673/GS to study the residual effect of applied nitrogen, and the possibilities of ground water pollution from wheat fertilization under normal irrigation practices in lower Sindh.

Achievements: The studies revealed that continuous application of fertilizer nitrogen to crops like wheat for longer periods do not pose any threat to ground water pollution since the leaching of NO$_3$-N was restricted within one meter soil profile as monitored by Neutron probe moisture meter.

8. ZINC STATUS OF RICE SOILS OF UPPER SINDH
**History of the project:** This project was started in 1977 with the objective to find the zinc status of rice growing areas of Sukkur, Shikarpur, Larkana, Dadu and Dokri.

**Achievements:** About 50% of the soil samples were adequate and 50% in the marginal range of DTPA-extractable zinc in the upper surface (0-15 cm) soil layer. Shikarpur and Larkana samples were more deficient in Zn compared to other locations.

9. **RESPONSE OF COTTON CROP TO PHOSPHORUS IN DIFFERENT SOIL SERIES**

**History of the project:** This project was initiated in 1980 with the aim to provide information on the methods of application and the conditions under which cotton crop response to P in various soil series.

**Achievements:** The availability of P was increased by 20-30% and yield was increased by 5-10% when superphosphate was thoroughly mixed with farm yard manure before application to soil. Lalian soil series produced significantly higher seed cotton yield compared to Shahdara. The Pacca series was least suited for cotton cultivation because it was difficult to manage and bring to the proper tilth for sowing of cotton. This caused poor seed germination and plant establishment.

10. **RESPONSE OF COTTON TO PREVIOUSLY SOIL APPLIED PHOSPHORUS**

**History of the project:** This project was started in 1981 with the objective to study the response of cotton to residual as well as cumulative phosphatic fertilizer in soil.

**Achievements:** The residual P increased the seed cotton yield from 16-43%. The maximum seed cotton yield was recorded, when P was applied at sowing and minimum, where P was applied with farm yard manure.

11. **EVALUATION OF CROPPING SEQUENCES AND THEIR IRRIGATION AND FERTILIZER REQUIREMENTS FOR ENHANCEMENT OF SOIL PRODUCTIVITY WITH MINIMAL INPUTS**

**History of the project:** This project was initiated in 1983 under Technical Assistance project No. Pak/5/017/RB to evaluate the cropping sequence with respect to fertilizer inputs, amount of N fixed, transfer of fixed N to non-legumes and residual effect of applied fertilizer nitrogen.

**Achievements:** The studies showed that the banding of fertilizer N near the non-legume row (cotton) produced 24% higher yield compared to the conventional broadcast application. It was also observed that the productivity of land was increased by 21% by planting soybean into cotton.

12. **SULPHUR (SO$_4$-S) STATUS IN SOILS OF SINDH**

**History of the project:** This project was initiated in 1983 to determine the sulphur (SO$_4$-S) status of rice soils of lower Sindh.

**Achievements:** Maximum SO$_4$-S was recorded in Tando Muhammad Khan area followed by Thatta and Bulri Shah Karim soils with 430, 393 and 333 ppm, respectively. Sijawal and Matli areas have been found deficient in SO$_4$-S.

13. **POLIAR FERTILIZATION OF NITROGEN IN WHEAT**

**History of the project:** This project was started in 1984 with the objective to evaluate
the response of wheat to foliar spray of different nitrogenous fertilizers.

Achievements: Among different nitrogenous fertilizers, urea performed effectively up to 6% however, 3-4% urea solution at tillering, booting and milky stages economized N input by 20-30%. Ammonium sulphate and ammonium nitrate being highly acidic in nature produced severe leaf burning which resulted into lower crop harvests. Foliar fertilization technique is most effective under salinity and drought conditions.

14. POTASSIUM STATUS OF RICE SOILS OF LOWER SINDH

History of the project: This project was initiated in 1986 with the objective to determine the potassium (K) status of the soils of experimental farm of NIA and rice growing areas of lower Sindh.

Achievements: The available K (NH₄OAc extractable) ranged between 170 to 286 ppm in experimental farm of NIA. The available K in the rice growing areas of lower Sindh ranged between 130 to 300 ppm.

15. RESPONSE OF PHOSPHOBACTERIAL AND MYCORRHIZAL INOCULATION IN DIFFERENT CROPS

History of the project: The project was initiated in 1987 to evaluate the response of phosphobacterial and mycorrhizal inoculation in different crops.

Achievements: The protocol for isolation and preparation of phosphobacterial (Bacillus megatherium var. phosphaticum) and mycorrhizal species (Glomus, gigaspora) inocula has been perfected. The field studies with different crops indicated that phosphobacterial and mycorrhizal inoculation have the capability to solubilize the native soil P up to 50 kg ha⁻¹.

16. INTERCROPPING AND THEIR FERTILIZER REQUIREMENTS

History of the project: These long term studies were initiated in 1990 on cotton-legume intercropping systems with a view of evolving methodologies which could help to increase crop productivity per unit area without affecting the yield of dominant component of intercropping systems.

Achievements: Comprehensive research studies on various aspects of such systems indicated that simultaneous cropping of cotton and mungbean in rows arranged according to 2:1 ratio may increase the yield by 20–30% without additional inputs provided that the fertilizer N is applied alongside cotton and fertilizer P alongside mungbean rows. Intercropping of wheat or Brassica with sugarcane enhanced the crop production by 33–37%.
History of the project: This project was initiated in 1993 on a fixed layout for ten years to compare the relative efficacy of muriate of potash (MOP) versus sulphate of potash (SOP) in long term cropping systems on wheat–cotton–wheat. These efforts were sponsored by Canadian International Development Agency (CIDA) and implemented jointly by Potash and Phosphate Institute of Canada (PPIC) Pakistan programme and Pakistan Agriculture Research Council (PARC).

Achievements: Cumulative application of MOP increased the soil test chloride level by 50% within the root zone, which adversely affected the soil health and reduced the crop productivity by 10–20%, hence MOP was not recommended to be applied as a K source to different crops.

18. EVALUATION OF FERTIGATION TECHNIQUE FOR APPLYING PHOSPHATIC FERTILIZERS TO DIFFERENT CROPS

History of the project: Fertigation is a latest technique and an innovative approach where nutrients in the form of solution are applied along with irrigation water at post emergence level of the crop plants. These long-term studies were started in 1998 as a part of PAEC coordinated project to evaluate the performance of this technique for economizing fertilizer usage and enhancing crop production under agro-climatic conditions of Tando Jam, Sindh by using wheat, berseem and mungbean as test crops.

Achievements: Fertigation technique was perfected after conducting large-scale studies on different aspects. It proved cost effective, easy in management, increased crop harvests by 10–20% and economized fertilizer inputs by 30–40%.
19. NUTRITIONAL REQUIREMENTS OF NEWLY EVOLVED CROP VARIETIES EVOLVED AT NIA, TANDO JAM

History of the project: These studies were started in 2002 with the objective to work out the nutritional requirements of different crop varieties evolved at NIA, which is one of the pre-requisite of the package of improved farm technology required for the approval of varieties and techniques from Technical Sub-Committee.

Achievements: The nutritional requirements of wheat and rice genotypes evolved at NIA are presented as follows:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Wheat genotypes</th>
<th>N (kg ha(^{-1}))</th>
<th>P (kg ha(^{-1}))</th>
<th>N:P ratio</th>
<th>Grain yield (tons ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Khirman</td>
<td>120</td>
<td>90</td>
<td>4:3</td>
<td>4.93</td>
</tr>
<tr>
<td>2.</td>
<td>NIA-8/7</td>
<td>150</td>
<td>110</td>
<td>4:3</td>
<td>5.40</td>
</tr>
<tr>
<td>3.</td>
<td>ESW-9525</td>
<td>150</td>
<td>110</td>
<td>4:3</td>
<td>5.29</td>
</tr>
<tr>
<td>4.</td>
<td>SD-05</td>
<td>150</td>
<td>75</td>
<td>4:2</td>
<td>6.40</td>
</tr>
<tr>
<td>5.</td>
<td>MSH-03</td>
<td>150</td>
<td>75</td>
<td>4:2</td>
<td>7.33</td>
</tr>
<tr>
<td>6.</td>
<td>NIA-MN-08</td>
<td>90</td>
<td>70</td>
<td>4:3</td>
<td>5.13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Rice genotypes</th>
<th>N (kg ha(^{-1}))</th>
<th>P (kg ha(^{-1}))</th>
<th>Zn (kg ha(^{-1}))</th>
<th>Paddy yield (tons ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IRRI-6-25A</td>
<td>120</td>
<td>90</td>
<td>12</td>
<td>7.38</td>
</tr>
<tr>
<td>2.</td>
<td>Bas-15-1</td>
<td>90</td>
<td>45</td>
<td>7</td>
<td>3.38</td>
</tr>
<tr>
<td>3.</td>
<td>Jajai-25/A</td>
<td>90</td>
<td>60</td>
<td>7</td>
<td>4.21</td>
</tr>
<tr>
<td>4.</td>
<td>IR-6-15/A</td>
<td>120</td>
<td>90</td>
<td>12</td>
<td>10.11</td>
</tr>
<tr>
<td>5.</td>
<td>NIA-625</td>
<td>90</td>
<td>45</td>
<td>12</td>
<td>8.80</td>
</tr>
</tbody>
</table>
21. ZINC REQUIREMENTS OF DIFFERENT CROP GENOTYPES EVOLVED AT NIA, TANDO JAM

**History of the project:** This project was started in 2007 with the objective to work out the zinc nutrition requirement of different crop genotypes evolved at NIA, Tando Jam.

**Achievements:** The zinc nutrition of wheat and rice genotypes evolved at NIA is presented as follows:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Wheat genotypes</th>
<th>Zn (kg ha(^{-1}))</th>
<th>Grain yield (tons ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>RWM-9313</td>
<td>5</td>
<td>6.40</td>
</tr>
<tr>
<td>2.</td>
<td>Bhittai</td>
<td>5</td>
<td>4.40</td>
</tr>
<tr>
<td>3.</td>
<td>Saarang</td>
<td>5</td>
<td>5.61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S. No</th>
<th>Rice genotypes</th>
<th>Zn (kg ha(^{-1}))</th>
<th>Paddy yield (tons ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sarshar</td>
<td>9</td>
<td>7.57</td>
</tr>
<tr>
<td>2.</td>
<td>Mehak</td>
<td>9</td>
<td>4.02</td>
</tr>
<tr>
<td>3.</td>
<td>IR-6-15/A</td>
<td>9</td>
<td>8.50</td>
</tr>
</tbody>
</table>

22. STUDIES ON BORON SUPPLYING CAPACITIES OF DIFFERENT SOILS OF SINDH PROVINCE

**History of the project:** The studies were initiated in 2009 to formulate the recommendations for boron (B) use in rice crop, and to study the B use efficiency in rice genotypes.

**Achievements:**
- About 68 composite soil samples were collected from six rice growing districts (Shikarpur, Jacobabad, Larkana, Dadu, Thatta and Badin) of Sindh and rice experimental field of NIA Tando Jam and were analyzed for boron. Boron contents varied between 0.01 to 1.27 ppm in the soils. About 78% of soil samples were low, 18% marginal and only 4% were adequate in B contents.
- Field studies proved that B requirement of rice variety Sarshar is more than the Shandar. Hydroponic studies conducted with 14 rice genotypes revealed that application of 0.5 ppm B significantly enhanced fresh root and shoot weight. The highest fresh root (14.9 g) and shoot (14.51) weight were recorded in rice variety shua-92.
- Shandar produced the highest grain (5.5 tons ha\(^{-1}\)) at 1.0 kg B ha\(^{-1}\), while Sarshar (5.2 tons ha\(^{-1}\)) at 1.5 kg B ha\(^{-1}\).

23. INTEGRATED PLANT NUTRITION MANAGEMENT SYSTEM FOR SUSTAINING SOIL HEALTH AND ENHANCING CROP PRODUCTIVITY

**History of the project:** These long-term studies were initiated in 2010 to evaluate the efficacy of various organic amendments for sustaining soil health, economizing fertilizer usage and enhancing crop productivity when applied with mineral fertilizers on a fixed layout according to split design with organic interventions forming the main plots and fertilizer treatments, the sub plots. The green manuring crops such as sesbania (Sesbania aculeate) and cluster beans (Cyamopsis tetragonoloba) were sown in situ and incorporated into the soil at flowering stage. The farm yard manure (FYM) was added and mixed thoroughly into the soil at the rate of 6 tons ha\(^{-1}\).
Achievements: The studies proved that farm yard manure when applied in conjunction with mineral fertilizers elevated the wheat and cotton harvest by 13% and 8%, respectively and ploughed down sesbania and cluster bean increased the wheat harvest by 3%. Application of FYM and sesbania reduced the soil bulk density and enhanced the organic matter and porosity of soil.

Achievements:
- The seed of 23 wheat genotypes were tested for physical and chemical analysis. Grain moisture was up to the international standard (<12.5%). Test weight of 5 genotypes was <74 kg/hL whereas, 18 genotypes had >74 kg/hL. Genotype MNS-3 showed maximum test weight of 82 kg/hL. Physical damage (3 grains/300 grains), insect damage (1%), and protein content (10.5%) were also up to the International Standards in all the genotypes. Maximum protein (15.4%) was recorded in genotype V-4403. The highest ash (2.2%) and Fe contents (82.5 mg kg\(^{-1}\)) were recorded in MB-3. Out of 23 genotypes, 10 were adequate, 11 medium and 02 poor in Fe content whereas, 2 genotypes were adequate, 04 medium and 17 poor in Zn content according to Harvest Plus Standards (50-60 mg kg\(^{-1}\)).

All genotypes showed high phytic acid (>15:1) except one genotype which was medium in phytic acid (Phytic acid: Zinc ratio 5:1 -15:1).
## ANNEXURE-II
### List of Research Contracts

**PLANT BREEDING & GENETICS**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Title and Number of Project</th>
<th>Duration</th>
<th>Allocation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The evolution of new varieties of rice with respect to increased yield per acre, resistance to disease and better quality through the use of induced mutations (IAEA Contract No. 290/RB).</td>
<td>1965-1968</td>
<td>US$ 9,000</td>
<td>Completed</td>
</tr>
<tr>
<td>2</td>
<td>Mutation breeding of rice (IAEA Contract No. 1272/RB).</td>
<td>1971-74</td>
<td>US$ 9,000</td>
<td>Completed</td>
</tr>
<tr>
<td>3</td>
<td>Improvement of major crops by use of induced mutations (UNDP Contract No. PAK/70/014).</td>
<td>1974-77</td>
<td>Rs. 6,15,000</td>
<td>Completed</td>
</tr>
<tr>
<td>4</td>
<td>Evolution of insect pest and disease resistant high yielding and improved quality varieties of cotton by the use of ionizing radiation (IAEA Contract No. 1525/R1/SD).</td>
<td>1974-77</td>
<td>US $ 5,000</td>
<td>Completed</td>
</tr>
<tr>
<td>5</td>
<td>Utilizations of aneuploids and amphiploids for the improvement of protein content and quality for bread wheat (IAEA Contract No. 1713/RB).</td>
<td>1975-79</td>
<td>US $ 9,000</td>
<td>Completed</td>
</tr>
<tr>
<td>6</td>
<td>Gamma irradiation studies on callus and tissue culture to evolve improved sugarcane clones (<em>Saccharum</em> sp.) through induced somatic mutation (IAEA Contract No. 1891/R1/RB).</td>
<td>1976-80</td>
<td>US $ 9,000</td>
<td>Completed</td>
</tr>
<tr>
<td>7</td>
<td>Mutation breeding of soybean for high yield and oil content (IAEA Contract No. 2673/RB).</td>
<td>1980-86</td>
<td>US $ 9,000</td>
<td>Completed</td>
</tr>
<tr>
<td>8</td>
<td>Semi-dwarf mutants for rice improvement in Asia and Pacific (IAEA Contract No. 3119/RB).</td>
<td>1982-87</td>
<td>US $ 20,000</td>
<td>Completed</td>
</tr>
<tr>
<td>9</td>
<td>Mutation breeding of food legumes (IAEA-TC project, RAS/5/015).</td>
<td>1985-87</td>
<td>US$ 4310</td>
<td>Completed</td>
</tr>
<tr>
<td>10</td>
<td>Evaluation of improved varieties of sugarcane (<em>saccharum</em> sp. hybrid) through induced somatic mutations by gamma irradiation of vegetative cuttings and cell/tissue techniques. (IAEA Contract No.3584/RB).</td>
<td>1983-87</td>
<td>US$ 10500</td>
<td>Completed</td>
</tr>
<tr>
<td>11</td>
<td>Mutation breeding for improving yield, fibre quality and insect resistance characteristics in cotton (IAEA Contract No. 3600/R2/RB).</td>
<td>1984-87</td>
<td>US $ 14,473</td>
<td>Completed</td>
</tr>
<tr>
<td>12</td>
<td>Improvement of banana (<em>Musa</em> sp.) through <em>in vitro</em> Culture and induced mutations (IAEA Research Contract No.5426/RB).</td>
<td>1988-92</td>
<td>US$ 6,000</td>
<td>Completed</td>
</tr>
<tr>
<td>13</td>
<td>Genetic improvement of <em>Sesamum indicum</em> L. through induced mutation breeding (IAEA Res. Contract No. 6210/RB)</td>
<td>1990-92</td>
<td>US$ 4000</td>
<td>Completed</td>
</tr>
<tr>
<td>14</td>
<td>Genetic improvement of agronomically important characters through induced mutations in <em>Sesamum indicum</em> L. IAEA Res. Contract No. 7761/RB)</td>
<td>1993-98</td>
<td>US$ 20,000</td>
<td>Completed</td>
</tr>
<tr>
<td>15</td>
<td>Improvement of cotton quality through induced mutation (IAEA Technical Cooperation Project No. PAK/5/05)</td>
<td>1993-96</td>
<td>US$ 84,606</td>
<td>Completed</td>
</tr>
<tr>
<td>16</td>
<td>Mutation breeding of sugarcane (IAEA, TC Project No.PAK/5/025)</td>
<td>1990-91</td>
<td>US$ 16,184</td>
<td>Completed</td>
</tr>
<tr>
<td>17</td>
<td>Identification of causes of wheat sterility in Sub-tropical Asia. ACIAR project.</td>
<td>1994-96</td>
<td>US$ 14,600</td>
<td>Completed</td>
</tr>
<tr>
<td>18</td>
<td>Utilization of intraspecific and alien genetic variation for inducing salt tolerance in bread wheat. PSF Research project No. S-AEARC/AGR (131).</td>
<td>1993-95</td>
<td>Rs. 341920</td>
<td>Completed</td>
</tr>
</tbody>
</table>
### Exploitation of mutagenesis and selection for the genetic improvement of oleiferous brassica. (PSF Research project No. S-AEARC/AGR (171)).
- **Duration:** 1995-98
- **Allocation:** Rs.0.30 million
- **Status:** Completed

### Improvement of heat tolerant semi-dwarf bread wheat through radiation-induced mutations. (IAEA, TC Project PAK5/040).
- **Duration:** 2001-04
- **Allocation:** US $ 156,880
- **Status:** Completed

### Genetic improvement for salt tolerance in non-aromatic rice (Oryza sativa L.) varieties through induced mutations. (IAEA, TC Project PAK5/042).
- **Duration:** 2003-06
- **Allocation:** US$ 157340
- **Status:** Completed

### Mutation breeding for high yield, improved grain quality and earliness in non-aromatic rice (Oryza sativa L.). (PARC Alp Project)
- **Duration:** 2003-05
- **Allocation:** Rs. 1.20 million
- **Status:** Completed

### Etiology and management of cotton leaf reddening malaise in Sindh. (MINFAL, Pak.)
- **Duration:** 2003-06
- **Allocation:** Rs. 6.706 million
- **Status:** Completed

### Evaluation of wheat varieties for low water requirements using conventional and mutation breeding techniques. (PARC ALP Project)
- **Duration:** 2004-07
- **Allocation:** Rs. 1.944 million
- **Status:** Completed

### Wheat, Barley and Triticale cooperative programme PARC, Islamabad.
- **Duration:** 2004-06
- **Allocation:** Rs. 0.04 Million
- **Status:** Completed

### Exploitation of biotechnological techniques for genetic improvement and mass production of banana. Ministry of Science and Technology
- **Duration:** 2003-05
- **Allocation:** Rs. 13.653 Million
- **Status:** Completed

### Use of induced somatic mutation and biotechnological techniques for the genetic improvement of sugarcane (Saccharum spp. Hybrid). Pakistan Science Foundation Islamabad
- **Duration:** 2007-10
- **Allocation:** Rs. 0.79 Million
- **Status:** Completed

### Improvement of crop quality and stress tolerance for sustainable crop production using mutation techniques and biotechnology. IAEA/RCA project.
- **Duration:** 2007-12
- **Allocation:** ---
- **Status:** Completed

### Development of new bread wheat varieties and genetic stock resistant to new stem rust race Ug99. Government of Sindh.
- **Duration:** 2010-12
- **Allocation:** Rs. 1.999 Million
- **Status:** Completed

### Responding to the trans-boundary threat of wheat black stem rust Ug99. IAEA/RAS
- **Duration:** 2009-15
- **Allocation:** ---
- **Status:** Ongoing

### Wheat Productivity Enhancement Programme (WPEP)-NIA. USDA-CIMMYT/PARC
- **Duration:** 2011-14
- **Allocation:** ---
- **Status:** Ongoing

### Supporting mutation breeding approaches to develop new crop varieties adaptable to climate change. IAEA/RCA
- **Duration:** 2013-14
- **Allocation:** ---
- **Status:** Ongoing

## PLANT PROTECTION

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Title and Number of Project</th>
<th>Duration</th>
<th>Allocation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Eradication of fruit flies Dacus spp. through the application of sterile male technique. (IAEA CRP No. 269/RB.)</td>
<td>1964-67</td>
<td>US $ 12,000</td>
<td>Completed</td>
</tr>
<tr>
<td>2</td>
<td>Radiation effect studies on rice stem borers (IAEA CRP No. 666/RB)</td>
<td>1986-71</td>
<td>US $ 14,000</td>
<td>Completed</td>
</tr>
<tr>
<td>3</td>
<td>Evaluation of sterile male technique for the control of fruit flies, Dacus spp. Project No. A-17-ENT-23 Grant No. FG-Pa-148.)</td>
<td>1969-74</td>
<td>Rs. 200,832</td>
<td>Completed</td>
</tr>
<tr>
<td>4</td>
<td>Studies on the ecology and behavior of rice stem borers by using radioisotopes with particular reference to pest management system (IAEA CRP No. 2978/RB)</td>
<td>1981-84</td>
<td>US $ 6,000</td>
<td>Completed</td>
</tr>
<tr>
<td>5</td>
<td>Integrated management of fruit flies, Dacus spp. (IAEA TCP No. PAK/5/018)</td>
<td>1985</td>
<td>US $ 165,125</td>
<td>Completed</td>
</tr>
<tr>
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<td>Project Description</td>
<td>Start Date</td>
<td>Budget/Amount</td>
<td>Status</td>
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<tr>
<td>6.</td>
<td>Feasibility studies on F₁ sterility for the control of pink bollworm, <em>Pectinophora gossypiella</em> (Saunders) (IAEA CRP No. 5006/RB)</td>
<td>1988-93</td>
<td>US $ 20,000</td>
<td>Completed</td>
</tr>
<tr>
<td>7.</td>
<td>Integrated control of sugarcane borers (Sugar Mills)</td>
<td>1989 to date</td>
<td>Rs. 0.3 million</td>
<td>In Progress</td>
</tr>
<tr>
<td>8.</td>
<td>Integrated control of fruit fly, Bactrocera zonata (Saunders). IAEA TC Project.</td>
<td>1993-94</td>
<td>US $ 62,600</td>
<td>Completed</td>
</tr>
<tr>
<td>10.</td>
<td>Control of pink bollworm to improve cotton production (IAEA TC project)</td>
<td>1995-96</td>
<td>US $ 167,500</td>
<td>Completed</td>
</tr>
<tr>
<td>11.</td>
<td>Host plant resistance of bio-regulator treated cotton to bollworms and sucking complex and its impact on yield and yield components (PSF No. S-AEARC (AGR(141)</td>
<td>1995-97</td>
<td>Rs. 331,908</td>
<td>Completed</td>
</tr>
<tr>
<td>12.</td>
<td>Use of nuclear techniques for colonization and production of egg and larval parasitoids of sugarcane borers. (IAEA CRP PAK/10779/RB)</td>
<td>2000-05</td>
<td>US $ 30,000</td>
<td>Completed</td>
</tr>
<tr>
<td>14.</td>
<td>Integrated management of fruit flies in Pakistan. PARC-ALP No. 01010103</td>
<td>2001-05</td>
<td>Rs. 2,012 million</td>
<td>Completed</td>
</tr>
<tr>
<td>16.</td>
<td>Use of Gamma Irradiation for Quality Production of Beneficial Insects and Their Integration with Eco-friendly Tactics to Manage the Cotton Pests (IAEA CRP No. PAK-13434/RB)</td>
<td>2005-09</td>
<td>Euro 10,000</td>
<td>Completed</td>
</tr>
<tr>
<td>17.</td>
<td>Exploitation of Nuclear Techniques for the Development of Biological Control to Manage the Fruit Flies, Bactrocera spp. (IAEA CRP No. PAK-13913)</td>
<td>2006-10</td>
<td>Euro 5000</td>
<td>Completed</td>
</tr>
<tr>
<td>18.</td>
<td>Augmentation of Parasitoids for Area-wide Management of Sugarcane Borers Using Nuclear Techniques (IAEA CRP No. PAK-13940)</td>
<td>2006-11</td>
<td>Euro 5000</td>
<td>Completed</td>
</tr>
<tr>
<td>19.</td>
<td>Sharing Regional Knowledge on the Use of the Sterile Insect Technique within Integrated Area-Wide Fruit Fly Pest Management Programme (IAEA RAS/5/049)</td>
<td>2007-09</td>
<td>US $ 175,580</td>
<td>Completed</td>
</tr>
<tr>
<td>20.</td>
<td>Sharing Regional Knowledge on the Use of the Sterile Insect Technique within Integrated Area-Wide Fruit Fly Pest Management Programme (IAEA RAS/5/052)</td>
<td>2009-11</td>
<td>---</td>
<td>Completed</td>
</tr>
<tr>
<td>21.</td>
<td>Management of Insect pest of Bt cotton through the use of Bio-control technology. Awarded by Sindh Govt.</td>
<td>2010-12</td>
<td>Rs.2.0 million</td>
<td>Completed</td>
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<tr>
<td>Sr. No</td>
<td>Title and Number of Project</td>
<td>Duration</td>
<td>Allocation</td>
<td>Remarks</td>
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</tr>
<tr>
<td>1</td>
<td>Coordinated programme on the application of isotopes and radiation to rice cultivation (IAEA Contract No. 148/RB).</td>
<td>1962-66</td>
<td>US $ 15,000</td>
<td>Completed</td>
</tr>
<tr>
<td>2</td>
<td>Effect of salinity on the nutritional and developmental physiology of crops and exploration of ameliorative measures (PL-480 Project No. A-17SWC-2, FG-Pa-147).</td>
<td>1969-75</td>
<td>Rs. 197,100</td>
<td>Completed</td>
</tr>
<tr>
<td>3</td>
<td>Effect of naphthenates on growth, yield, fibre quality and physiology of cotton (PL-480 Project No. PK-ARS-18, FG-Pa-210)</td>
<td>1974-78</td>
<td>Rs. 218,808</td>
<td>Completed</td>
</tr>
<tr>
<td>4</td>
<td>Studies of the efficiency of nitrogen placement methods and slow release of nitrogen fertilizer for rice and wheat using N 1 S labeled fertilizer (IAEA Contract No. 1808).</td>
<td>1976-78</td>
<td>US $ 8,000</td>
<td>Completed</td>
</tr>
<tr>
<td>5</td>
<td>Growth physiology of soybean and associated changes in the nitrogen economy of soil as affected by substrate salinity (IAEA No. 4101/R2/RB).</td>
<td>1985-89</td>
<td>US $ 12,000</td>
<td>Completed</td>
</tr>
<tr>
<td>7</td>
<td>Australian woody species for saline sites in Asia (ACIAR No. 8633).</td>
<td>1988</td>
<td>---</td>
<td>Completed</td>
</tr>
<tr>
<td>8</td>
<td>Multipurpose tree species for small farms in the arid and semi-arid tropics (Winrock, F/FRED).</td>
<td>1988</td>
<td>---</td>
<td>Completed</td>
</tr>
<tr>
<td>9</td>
<td>Salt tolerance studies in plants (British O.D.A).</td>
<td>1988</td>
<td>---</td>
<td>Completed</td>
</tr>
<tr>
<td>10</td>
<td>Network trial on multipurpose tree species for arid zone (Winrock-USAID No. 5347/5124).</td>
<td>1988-90</td>
<td>US $ 8400</td>
<td>Completed</td>
</tr>
<tr>
<td>11</td>
<td>Australian woody species for saline lands of South Asia (ACIAR 8633/9316).</td>
<td>1990-96</td>
<td>Aus $ 15,000</td>
<td>Completed</td>
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<tr>
<td>12</td>
<td>Enhancing the productivity of rice crop in saline soils of Pakistan (IAEA/RCA Project No RAS/5/039).</td>
<td>---</td>
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<td>Completed</td>
</tr>
<tr>
<td>13</td>
<td>Improving productivity of salt affected lands through continuous cropping (PSF/S-AEARC/Agr(148).</td>
<td>1995-98</td>
<td>Rs. 102,590</td>
<td>Completed</td>
</tr>
<tr>
<td>14</td>
<td>To develop drought resistant wheat (<em>Triticum aestivum</em> L.) genotypes under water stress conditions (ALP-PARC Project).</td>
<td>2002-05</td>
<td>1.070 million</td>
<td>Completed</td>
</tr>
<tr>
<td>15</td>
<td>Nuclear techniques assisted management of salt affected lands and brackish waters in Pakistan (Collaborated with NIAB, NARC, AZRI, Funded by PARC).</td>
<td>2002-06</td>
<td>1.02 million</td>
<td>Completed</td>
</tr>
<tr>
<td>16</td>
<td>Saline agriculture farmers participatory project, Pakistan (Collaborated with NIAB, NARC, AZRI) (Ministry of Food, Agriculture and Live Stock).</td>
<td>2002-08</td>
<td>Pak Rs. 61.31 million</td>
<td>Completed</td>
</tr>
<tr>
<td>17</td>
<td>Biorestauration of saline wasteland and development of salt tolerant plants (Collaborated Project funded by Ministry of Science and Technology/ Institute for Application of Atomic Energy, Chinese Academy of Agricultural Sciences)</td>
<td>2004-06</td>
<td>4.6 million</td>
<td>Completed</td>
</tr>
</tbody>
</table>
### SOIL SCIENCE

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Title and Number of Project</th>
<th>Duration</th>
<th>Allocation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Agricultural nitrogen residues with particular reference to their conservation as fertilizer and behaviour as potential pollutant (IAEA Contract No. 1673/GS).</td>
<td>1976-1980</td>
<td>US$ 10322</td>
<td>Completed</td>
</tr>
<tr>
<td>4</td>
<td>Evaluation of cropping sequences and their irrigation and fertilizer requirements for enhancement of soil productivity with minimal inputs (Technical Assistance project No. Pak/5/017/RB).</td>
<td>1983-1987</td>
<td>US$ 15000</td>
<td>Completed</td>
</tr>
<tr>
<td>5</td>
<td>Use of MOP versus SOP in long-term cropping systems (Sponsored by CIDA and implemented through PPIC and PARC).</td>
<td>1993-1998</td>
<td>Rs. 0.25 million</td>
<td>Completed</td>
</tr>
<tr>
<td>6</td>
<td>Selection of zinc efficient wheat genotypes for balanced human nutrition (ALP, PARC)</td>
<td>2005-2007</td>
<td>Rs. 1.705 million</td>
<td>Completed</td>
</tr>
<tr>
<td>7</td>
<td>Exploitation of integrated plant nutrition management system for sustaining soil health and enhancing crop productivity (Govt. of Sindh).</td>
<td>2010-2012</td>
<td>Rs. 1.5 million</td>
<td>Completed</td>
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</table>