GENETIC IMPROVEMENT OF CROPS

Gene manipulation using conventional and advanced approaches as well as genetic resource conservation and evaluation is an on-going activity that supports the national crop improvement programme to cope with the biotic and abiotic stresses while maintaining high level of productivity, profitability and quality.

The main focus remained on self sufficiency in wheat, maize, sugarcane; export enhancement in rice; import substitution in edible oil (sunflower & canola), & pulses and value addition in fruits (citrus, mango, apple, banana) and vegetables (potato, tomato, chilies, onion, peas, cucumber, radish, cauliflower, cabbage etc.). Among biotic stresses rusts, blight, rot, fruit fly, stem borer, hoppers and aphids were of major concern. Heat, cold, drought and salinity were the important abiotic stresses addressed.

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Wheat

- NR 268, an advance line developed by the wheat breeding program at NARC has shown encouraging results over a wide range of environments of the rainfed ecology in Pakistan. The average yield advantage over the local check was 8.3%. NR 268 is of better quality in chapati making and other desirable quality attributes (protein 12.3%; wet gluten 26%; test weight 76kg/hl and TKW 41g). It is resistant against the prevalent diseases specially the stripe and leaf rusts.

Chairman, PARC in wheat experimental area at NARC, Islamabad

Chapati from an advanced line developed at NARC, Islamabad

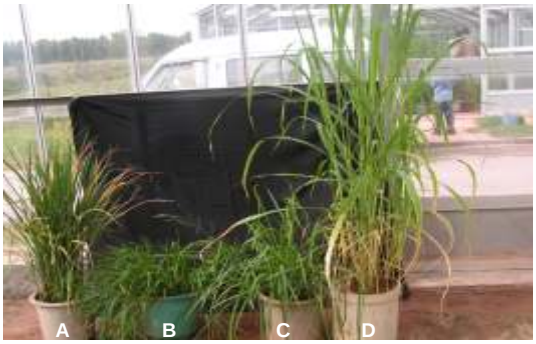
Rice

- In National Uniform Yield Trials (NUYT) tested candidate rice varieties for adaptability and higher yields. Jajai 25/A produced the highest yield (4372 kg/ha) than check variety Super Basmati (4148 kg/ha), in fine aromatic group. RD-25 (5871 kg/ha) out yielded in the coarse group. Among the cold tolerant group, rice line ILLABONG (8653 kg/ha) out yielded. Among the hybrids, Dagha-I (7223 kg/ha) out-yielded.

National Uniform Rice Yield Trial

National Uniform Rice Yield Trial

- Evaluated wild rice species for resistance against bacterial blight. *Oryza australiensis, O. grandiglumis, O. rhizomatis, O. alta, O. meridionalis, O. nivara and O. brachyantha* were highly resistant to bacterial blight.
- The new plant type (NPT) produced large panicles, maximum productive tillers, sturdy stem and longer root system. Five of the 24 NPT lines were found resistant to bacterial blight.
- Sixty four lines developed through somaclonal variation were tested for homozygosity and yield. Two lines were included in NUYT.



Reaction of bacterial leaf blight to IR-6 (A) and wild species *O. brachyantha* (B), *O. nivara* (C) and *O. alta* (D)

GENETIC IMPROVEMENT OF CROPS

NPT lines showing resistance to bacterial blight vs Jp5

Oilseeds

- Variety Evaluation Committee (VEC), PARC recommended two varieties Pakola and Canola Raya developed by Oilseeds Program, NARC.
  - **Pakola** belongs to *Brasscia napus* and was recommended for cultivation in the cooler areas (northern Punjab and NWFP). It has better quality 43.95% oil content, 1.8% erucic acid and 23.3 µmoles glucosinolates of seed meal. Average yield is 2600 kg/ha. The highest yield is in CON-I (2800 kg/ha) while in Shiralee (check) yield was 2500 kg/ha .
  - **Canola Raya** belongs to *Brasscia juncea* and locally called Raya. This variety is far superior in terms of oil quality. It has 1.6% erucic acid and 36.5 µmoles/g glucosinolates. It is best suited for cultivation the dry and warm areas of Pakistan. Its average yield (2300 kg/ha) is higher than check.

Pakola at flowering stage (NARC)

- Forty plants of canola quality mustard (glucosinolate 24.2-43.9 µmoles/g of seed) were selected from 1200 single plants of rapeseed from F_2 generations. About 40 single plants of rapeseed having glucosinolate less than 30 µmoles/g were selected from 825 plants in F_2 generation.
- In Set-I national uniform yield trial on sunflower, Helios-251 of Bolivian origin produced the maximum seed yield (2609 kg/ha.) among the 16 hybrids. Whereas, in Set-II with 18 hybrids, LG-5380 produced the maximum seed (2452 kg/ha).
- In national uniform rapeseed yield trial, entry 97-5/2-4 out-yielded and produced seed yield of 1513 kg/ha.
- In national uniform mustard yield trials, entry BBJ-30 out-yielded and produced gave seed yield of 1531 kg/ha.

Canola Raya at flowering stage (NARC)

- Out of 32 mustard lines evaluated, nine entries gave more dry pods yield (3071-5365 kg/ha) than the check (yielding 2900 kg/ha). Twelve entries matured earlier (maturity 91-95%) than check, while 23 entries indicated better 100-kernel weight (43-69 g) than check. PG1070 showed good performance with 3683 kg/ha yield.

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- Out of 118 sesame genotypes evaluated, 70 genotypes were having 107-185 pods per plant and were better than check (106 pods). Whereas total 79 accessions produced more seed yield of 427-1091 kg/ha as compared to check (424 kg/ha).
- In preliminary yield trial of sesame, four entries (SG-14, SG-36, SG-71 and SG-86) out-yielded the check (599 kg/ha) producing 707, 651, 625 and 623 kg/ha, respectively.
- 192 soyabean accessions from different sources were evaluated for different agronomic traits at six locations. Twelve cultivars were selected for preliminary yield trial.
- In preliminary yield trial (I and II) six spineless and six spiny genotypes of safflower SAF-26 out-yielded the check (670 kg/ha) whereas in case of PYT genotype SAF-19 produced more seed as compared to check. Out of ten safflower genotypes, four varieties matured early than check (TH-78). All the genotypes produced more yield as compared to the check.

Sugarcane

- In National Uniform Yield Trials, cane varieties S-97-SP-27 and CP-82-117 produced maximum yield (45.1 t/ha) in ratoon crop, while the brix contents were the maximum for varieties S-98-CSSG-676 (24.13%) followed by S-98-CSSG-668 (23.87%). In fresh planted NUYT crop, variety S-98-CSSG-567 produced maximum yield (86.7 t/ha) followed by S-96-SP-700 (83.9 t/ha). The brix contents were the highest for S-98-CSSG-668 (23.47%) followed by S-98-CSSG-567 (23.2%).
- Varieties released through Coordinated Sugar Crops Research Program of PARC were HSF-242 (early maturing, yielding 108 t/ha**;** high sugar recovery**,** 12.4 t/ha and good ratooning) and CPF-243 (early maturing, good yield of 102 t/ha and high sugar recovery 12.7 t/ha).

National Uniform Sugarcane Yield Trials

Maize, Sorghum and Millet

- A high yielding sorghum variety, “Johar” and a millet variety “Bajra Super-1” were approved by VEC. These varieties gave double yield of 2.0-2.6 t/ha as compared to local giving 1.0-1.2 t/ha.
- Soan-3 (short duration maize variety) with potential yield 5 t/ha was developed for rainfed and highland areas.
- Fulsib recombination and replicated testing were done in Pool-10, 20, 30, 40, 70 and 80. The best selected families gave 13 to 28% more grain yield than checks.

Islamabad Gold

- Two of the NARC elite hybrids (NARC-2704 and NARC-2705) performing at par to the best commercial hybrids with yield around 10 t/ha during spring, 2004 were being tested in Adaptability/NUYT Trials.

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Bajra Super-1

Johar

Soan-3

NARC-2705

Pulses

- Three kabuli gram varieties, CC94/99, NCS2001 and 90399 with relatively stable performance across the locations have been identified.
- In Desi National Uniform Yield Trial maximum average grain yield (1650kg/ha) was obtained from 97086 followed by CMC211S (1535kg/ha) and NCS9917 (1510kg/ha) .
- In Lentil National Uniform Yield Trial, the varieties 01512 and 00518 across the locations with mean seed yield of 979 and 945 kg/ha, respectively, out-performed rest of the genotypes.
- NARC-02-2 was the only genotype which was resistant to grey mold and root-rot/wilt complex diseases.
- In multi-location Lentil Adaptation testing, seven entries giving the mean seed yield ranging from 1608 to 1456 kg/ha were significantly higher yielding than rest of the genotypes.
- In Mungbean National Uniform Yield Trial, 13 promising genotypes were evaluated at 15 different locations throughout the country. The variety 2-CMG 504 produced the highest grain yield (990 kg/ha).
- In Mash National Uniform Yield Trial, comprising 8 genotypes, conducted at nine locations, the line 95019 was the highest yielder (1083 kg/ha) followed by the lines 2-CM-703 (1061 kg/ha) and 95024 (1029 kg/ha).

Fodder

- About 120 lines of oats, vetch, lathyrus, sorghum, millet and cowpeas were acquired, maintained, evaluated and distributed to various cooperating units of Fodder Research Programme in the country.
- Oats variety Scott, sorghum lines (No 1623, F-9706 & PARC SV-V) and millet lines (Acc. No. 008778, 8781, AF-pop & Synthetic-2005) are in pipeline.

Millet cultivar in pipeline for approval

Sorghum cultivar in pipeline for approval

GENETIC IMPROVEMENT OF CROPS

Agri-Biotechology

- Field trials of virus free banana plants produced through tissue culture in Thatta, Hyderabad, Nawabshah, Sanghar and Ghotki revealed that *in vitro* raised plants grew faster than conventionally propagated plants produced more suckers/plant and more fingers/bunch .

Hardening of tissue culture raised banana plants in the green house

- Virus free banana nucleus seed transplanted at field areas of Kalat (Quetta) and Chiniot gave 30% more yield as compared to conventional material. The seed were further multiplied at the same field to produce pre basic-I and pre basic-II.

- Tomato transgenic plants of cvs. Roma and Riogrande having bacterial wilt resistance genes along with a control (non-transgenic) were subjected to PCR analysis for presence of introduced gene. Two specific primer sequences for the hygromycin resistance coding region were designed to amplify hygromycin resistance gene from genomic DNA. All the samples (lanes 5 - 7) from transgenic plants gave the predicted DNA fragment band of (670 bp) of the hygromycin resistance gene.

- Transgenic rice plants of Basmati-385 for bacterial blight resistance which were confirmed by PCR analysis for Xa21 gene, were subjected to pathogenecity test with four local and exotic strains of *Xanthomonas oryzae* pv. o*ryzae*. After 14 days of inoculation, all transgenic rice (Basmati-385) plants were highly resistant to all four strains of *Xanthomonas oryzae* pv.o*ryzae*. Control plants were susceptible and died after 21-30 days of inoculation.

Transgenic rice (Basmati 385)

AZRI D.I. Khan

- From NUYT (lentil) containing 10 different entries, Entry 4 produced significantly maximum grain yield of 2440 kg/ ha followed by Entry 7 with 2297 kg/ ha.
- Of the 12 different entries of NUYT (wheat) Entry 5 gave maximum grain yield of 2174 kg/ha followed by entry 9 giving 1982 kg/ha yield.
- Grain yield of 13th Semi Arid Wheat Yield Trial (CIMMYT) under rainfed condition ranged from 1022 to 3247 kg ha^{-1}. Out of 50 entries, seven top yielded entries have been selected for further testing for yield stability.

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Citrus

- Of 19 Mandarin hybrids, NARC 05-6 and NARC 05-18 gave promising results in respect of maturity, T.S.S and juice content.

Orange

- Out of 7 Orange hybrid, NARC 04-2 was ready for harvesting during first week of December whereas in NARC 04-5, the fruit matured during 3rd week of December with juice content of 43% on fruit weight basis. The juice content in Mussambi was 32%.
- M-18 (KxS) hybrid was back crossed with Salustiana (orange) to reduce the number of seed in the hybrid. The crossed fruits were picked during December and seeds collected for growing the seedlings.

Peach

Vegetables

- Selected promising accessions/lines of peas, chilies and onions..
- Seven promising tomato lines yielding 19 - 26 t/ha. Avinash-2 selection of tomato under NUTYT gave maximum yield.

Potato

- Five different crosses developed during 2005 were evaluated in primary trials and 190 new clones were selected on performance basis and better yield.
- Sixty five clones out of 430 were selected for secondary trials at NARC.
- 15 Dutch potato varieties were tested in replicated trials.
- 75 promising clones were distributed to different research institutes/stations during 2005-2006.
- During 2006, of the 15 TPS hybrid families developed and planted for evaluation under nursery trials, 6 families showed better tuber characters and yield (500-630 tubers/m^2).
- Ten hybrid progenies were developed by NARC during 2005 were evaluated under nursery and field trials. Four were found suitable for further evaluation at farmer's field (the yield range was 25 to 30 t/ha as compared to control varieties giving 15-20 t/ha).

Virulence on Wheat Rusts

- Trap nurseries consisted of isogenic wheat lines and commercial varieties were planted at different locations in the country to evaluate the virulence of leaf and stripe rust pathogens against wheat resistant genes.

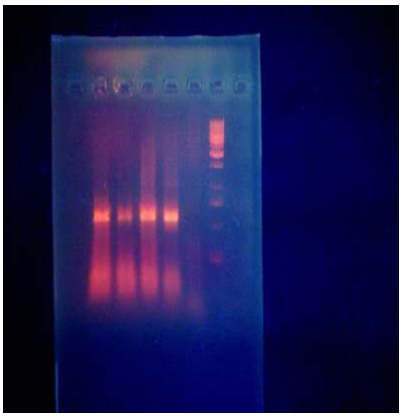
Leaf showing leafrust

Leaf showing yellow rust

GENETIC IMPROVEMENT OF CROPS

Genetics of Yellow Rust Pathogenecity

Virulence factors for Yr1, Yr2, Yr6, Yr7, Yr9, Yr17, YrA and Yr27 were present in all locations. Virulence factors for Yr8 were present in Islamabad, Fatehjang and Pirsabak in Northern Punjab and NWFP; for Yr18, Yr29 and Yr28 in 5 locations out of six Bahawalpur, Peshawar, Islamabad, Fatehjang and Pirsabak, for Yr28 Faisalabad, Peshawar, Islamabad, Fateh jang and Pirsabak; for Yr31 in Bahawalpur, Islamabad, Fateh jang and Pirsabak. Yr24 showed reactions like moderately resistant to moderately susceptible in Islamabad and Pirsabak in remaining locations it gave 0 reactions. For genes Tatatara (Yr3), Yr5, Yr10, Yr15, Yr26, Yrsp and YrCv virulence factors were not observed during test year, thus these genes can be recommended as effective genes which can be used as resistance sources for incorporation in national breeding programme. Among commercial cultivars Kohsar 95, Soorab 96(Barley), GA 2002 and Marvi 2000 were found resistant. Genes Lr28, Lr36 and Lr37 showed no virulence factors while all other genes were virulent. The genes incorporated into Chakwal 86, Sindh 81, Inqilab 91, Kirin 95, Parwaz 94, Kohistan 97, Rohtas 90, Suleman 96. Bhawalpur 2000, Fakhr-e-Sarhad, Marvi 2000, Zarlashta, GA 2002, Margalla 99, Saleem 2000, Pirsabak 2004, Punjnad 1, V-87094 showed complete resistance against leaf rust



Bdv1 gene identified through PCR

Barley Yellow Dwarf Virus

- Two primer sets Xgwm 130 and Xbarc 352 were used for the confirmation of Bdv1 gene in exotic material namely Opata 85, Superseri, Super Kauz, Tonichi 81, Parula, Pavon 76, and Anza. A band of 130 bp confirmed the presence of Bdv1 gene with Xgwm 130 primer, whereas a bank of 250 bp confirmed the Bdv1 gene with Xbarc 352 primer.
- Out of 128 synthetic hexaploid wheat lines screened under glasshouse conditions for Karnal bunt resistance, 62 were found resistant. Further 193 A genome synthetic wheat hexaploids (AAAABB) were also evaluated under field conditions, out of which 168 lines were found free of Karnal bunt infection. These lines will further be tested under glasshouse conditions to confirm their resistance.

Wheat seed infected with karnal bunt

Mungbean Yellow Mosaic Virus

- One hundred and five mungbean lines were tested for mungbean yellow mosaic virus (MYMV) resistance, 22 were found resistant and 50 were found resistant against urdbean leaf crinkle virus (ULCV). Among 68 Mash lines 28 were found resistant against MYMV while 39 were resistant against ULCV.

Mung bean field infested with MYMV

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Wheat Aphid

- Ten rainfed varieties, 6 barley, 22 NUMYT and 4 NUWYT lines were tested for resistance against aphids, one variety, V-5 was resistant from rainfed, four varieties 691C454-4, 691B531-3, 694Co78-2 and CKP-348 were resistant in NUMYT, RWM-9313 was resistant in NUWYT and none of the barley

Aphid resistance testing on wheat seeding

Components of Resistance

- Twenty lines of NUWYT tested after 24 hours for preference by aphids showed that varieties V-02192 and V-002493 were least preferred.
- Antibiosis test performed on 12 rainfed wheat varieties showed that PR-83 was least fecund.
- Four varieties NR-241, SN-128, V-5 and PR-83 out of 12 NUWYT (RF) 2004-05 were categorized as highly tolerant.
- Host plant and life cycle studies were carried out for 25 species, three new hosts were recorded for Sphingidae, 1 for Nymphalidae and 13 for Cassidinae.

KARINA, Juglote

- Among the 20 wheat entries tested at KARINA and Chilas, E-13 gave the highest yield of 4222 kg/ha while entry E-20 has the lowest yield of 2100 kg/ha. Among 20 late entries E-20 gave the highest yield of 4000 kg/ha.
- Among 12 maize varieties, E-5 was highest with yield of 3400 kg/ha. Among 34 hybrid lines E-239 and 254 were highest among all.
- Of six alfalfa varieties tested at KARINA, yield of the variety Australian T.S.T. was highest (14.8 t/ha).
- Maize variety Afgui gave highest fresh fodder (19 t/ha).
- The fruit nurseries at Chilas and Juglote consisting apricot, apple, pear, peach, plum, fig, grape, pomegranate, persimmon etc. were extended and 30000 root stocks were developed which are ready for grafting and budding.

Wheat experiment at KARINA, Juglote

Aspagol (*Plantago ovata)*

Badiyan *(Hilicium verum)*