

# **GENETIC DIVERSITY OF RICE IN PAKISTAN**

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# Region of Basmati Rice In South Asia

Growing Area of Basmati rice



# Pakistan & Rice: National Perspective

- **2<sup>nd</sup> after wheat**
- **Consumption**                      **16Kg annual per capita**
- **Cultivation**                        **10% of total cultivated area**
- **Area**                                    **2.963 m.ha**
- **Production**                         **6.952 million tones in 2008-09.**
- **Value addition**                    **5.5% in agriculture**
- **Share in Pakistan GDP**        **1.6%**

## Rice Production - Constraints

- **Biotic factors**                      **BBL, Sheath blight**
- **Abiotic factors**                    **Drought, Salinity**
- **Salt effected soils**                **40-70%**

# Threatened – Genetic Diversity

- **Land races are generally low yielding, but have**
  - high yield stability
  - Resistance against many biotic and abiotic stresses.
- **Locally grown landraces began to disappear**  
(available only in gene banks)
- **Wide adaptability of high yielding semi dwarf varieties**

# Rice: National Germplasm Explorations

## Expeditions Organized for Rice Germplasm Collection in Pakistan

<b>Expd.</b>	<b>Period</b>	<b>Institute/Sponsor</b>	<b>Area</b>	<b>Collections</b>
<b>1</b>	<b>1921-23</b>	<b>Great Britain</b>	<b>Local landraces from all over subcontinent/Kalar tract</b>	<b>555</b>
<b>2</b>	<b>1972-77</b>	<b>USAID/PARC</b>	<b>All over country</b>	<b>900</b>
<b>3</b>	<b>1985</b>	<b>IBPGR</b>	<b>Balochistan</b>	<b>201</b>
<b>4</b>	<b>1987</b>	<b>IBPGR</b>	<b>Sind</b>	<b>196</b>
<b>5</b>	<b>1989</b>	<b>NIAR-Japan/PARC</b>	<b>Except Sindh</b>	<b>58</b>
<b>6</b>	<b>1991</b>	<b>NIAR-Japan/PARC</b>	<b>NWFP</b>	<b>191</b>

## Rice: Varieties Development – Time Line (1926)

- Rice Research Institute - Kala Shah kaku (1926).
- Initially purification of local landraces.
- Classification – sixteen commercial groups

Classification of local rice lines into agricultural commercial groups on the basis of morphological traits.

Sr#	Group	Accessions	Sr#	Group	Accessions
1	Bara/Hansraj	9	9	Mushkan	50
2	Basmati	51	10	Palman	17
3	Begmi	9	11	Ratria	22
4	Dhan	27	12	Red Rice	21
5	Jhona Kasarwala	54	13	Santhi	13
6	Jhona	96	14	Sathra	24
7	Jhoni	17	15	Sone	42
8	Kharsu	13	16	Kangra Valley Rice	90
<b>Total =555 accessions</b>					

## Rice: Varieties Development – Time Line (1947)

- Development of different varieties by pure line selection
- Basmati-370 – high quality rice (long grain, strong aroma, soft texture )
- **Jhona-349 – salt tolerant and short duration.**
- Lack of rice germplasm – limitations for the breeders

### Varieties developed by pure line selection from sixteen commercial groups

Sr #	Variety	Year	Parentage	Varietal group
1	Basmati 370	1933	Pure line selection	Aromatic
2	Mushkan-7	1933	Pure line selection	Aromatic
3	Mushkan-41	1933	Pure line selection	Aromatic
4	Jhona 349	1933	Pure line selection	Non-aromatic
5	Sathra-278	1934	Pure line selection	Non-aromatic
6	Mahlar-346	1939	Pure line selection	Non-aromatic
7	Palman-246	1939	Pure line selection	Non-aromatic

# Rice: Varieties Development – Time Line (1948-04)

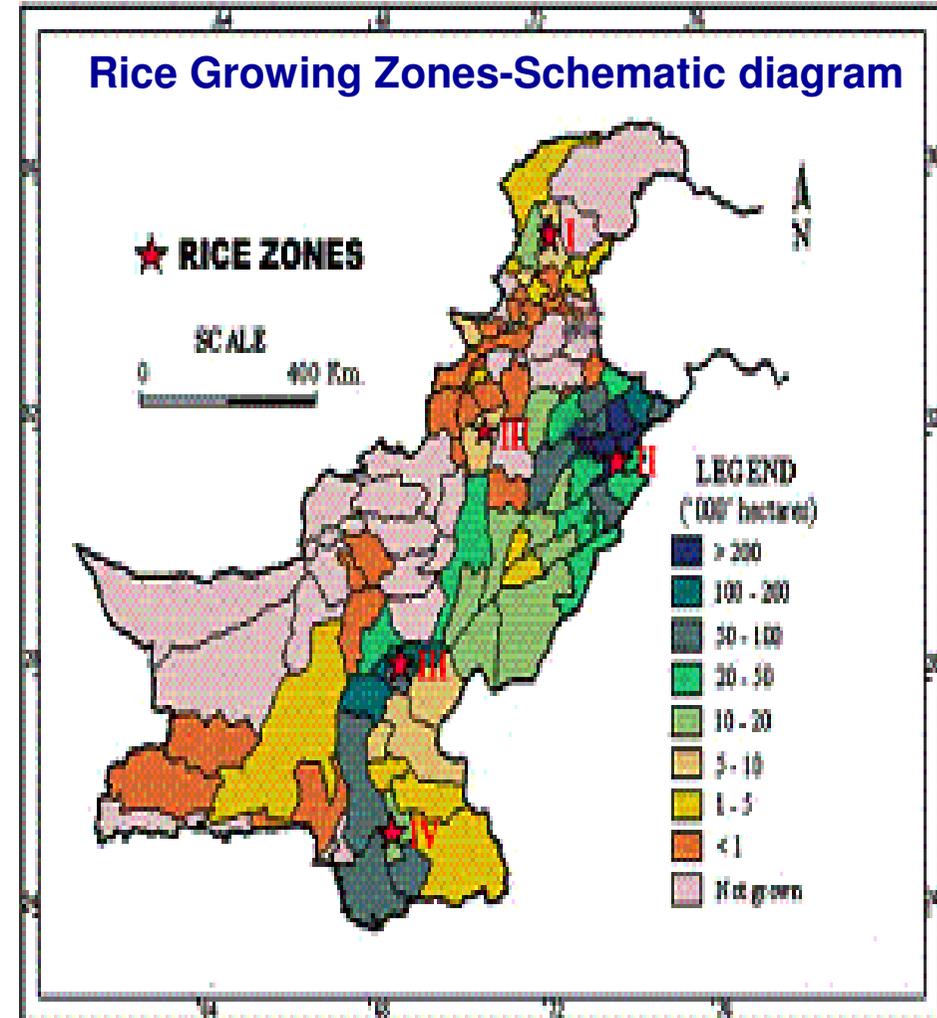
## Green revolution in 1960

- Introduction of semi dwarf high yielding varieties from IRRI
- IR-8 – Approved as IRRI-Pak (High yielding, poor cooking qualities)
- Approval of IR-6 for cultivation (1971).
- Hybrid varieties development (crossing indigenous pure lines with others)

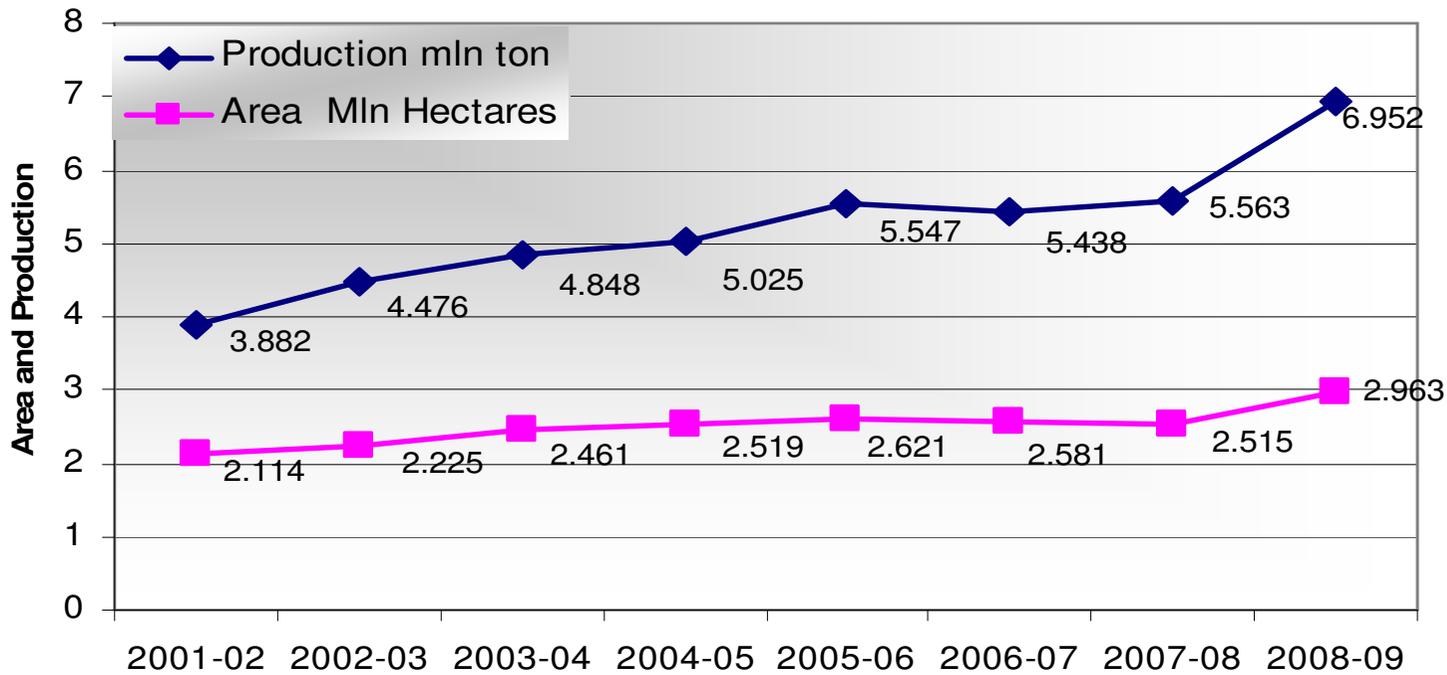
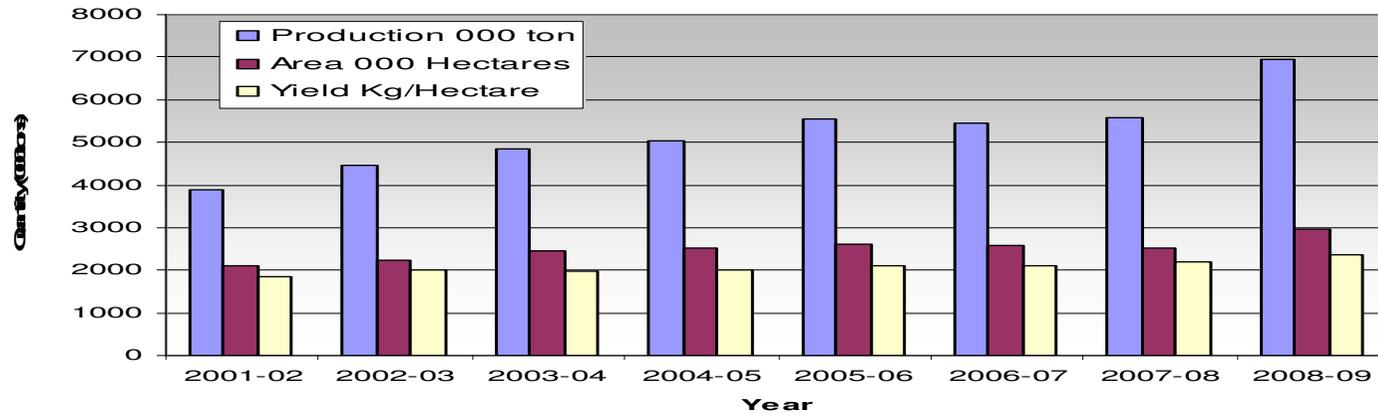
Variety	Year	Parentage
C-622	1964	Basmati 370xMushkan7
Basmati Pak	1968	Pure Line (Kernal Basmati)
IRRI Pak	1969	Introduction from IRRI (Peta x DGWG)
IR-6	1971	Introduction from IRRI (Saim29xDGWG)
Basmati 198	1972	Basmati 370 <sup>3</sup> x TN1
Pak177	1977	Basmati 370xIR760
KS282	1983	Basmati 370xIR95
Basmati 385	1988	Basmati 370 <sup>4</sup> x TN1
Super Basmati	1996	Basmati 320x10486
Basmati 2000	2001	Basmati 385x4048-3

# Rice Growing Zones In Pakistan

Zone	Characteristics
Zone I	Northern high mountainous areas (Swat and Khaghan) with sub-humid climate, average rainfall of 750-1000mm
Zone II	Lies between Ravi and Chenab, Sub-humid, sub-tropical climate with average rainfall of 400-700mm. Basmati - highly aromatic grain, long and elegantly thin mainly grown in this zone along the Kallar Tract consisting of Sialkot, Sheikhupura, Narowal, Gujranwala, and Hafizabad and Lahore Districts.
Zone III	West bank of Indus river. Larkana, Jacobabad, Nasirabad and Jaffarabad . High temperature and sub-tropical climate with average rainfall of 100mm make it best suited for medium long rices.
Zone IV	Spill flats and basins of Indus delta (Badin and Thatta Districts). Its climate is arid tropical and is suited for coarse varieties.

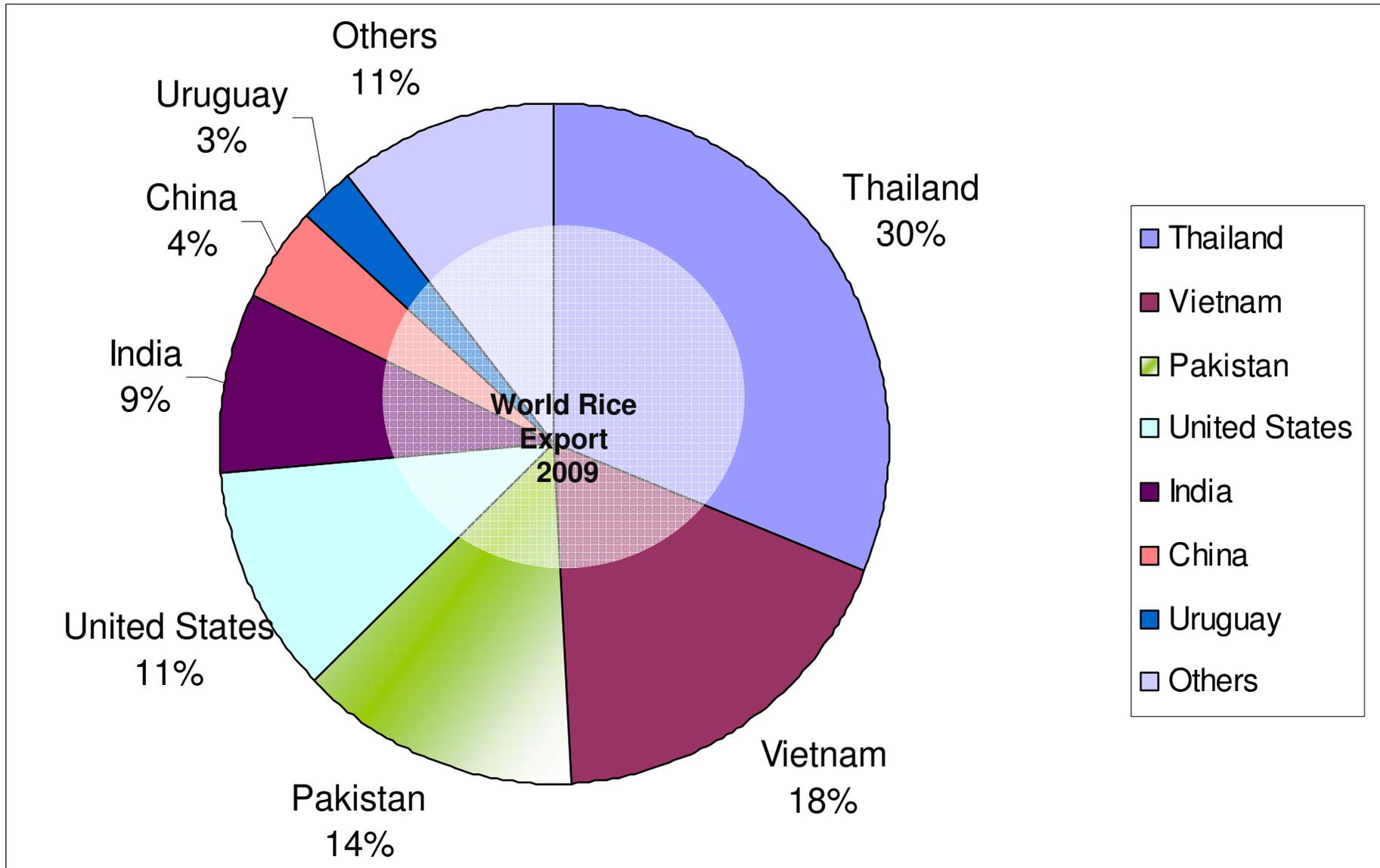


# Pakistan Rice-Production and Area



# Share in World Rice Export

- Pakistan shares 14% of world trade



# World Rice Trade- 2008

- **Total Production** **667.7 m tones**  
**(paddy)**
- **Rice Global Trade** **30.2 m tones (7% of milled rice)**  
**(milled rice)**
- **Basmati Rice trade** **2.45 m tones (8.3% of all rice trade)**
  - India** **1.183 m tones**
  - Pakistan** **1.271 m tones**

# Basmati Rice Trade

Basmati Export						
Quantity 1000 tones	2003	2004	2005	2006	2007	2008
India	708.8	771.5	1163.0	1166.6	1045.7	1183.4
Pakistan	716.7	816.3	814.9	839.0	907.9	1271.4
Value million USD						
India	415.8	433.7	628.5	687.3	616.7	1079.1
Pakistan	267.7	308.4	439.2	479.6	556.3	1068.9

# Basmati Rice: Source of Revenue

Year 2008

**Total:** **\$2.044 billion**

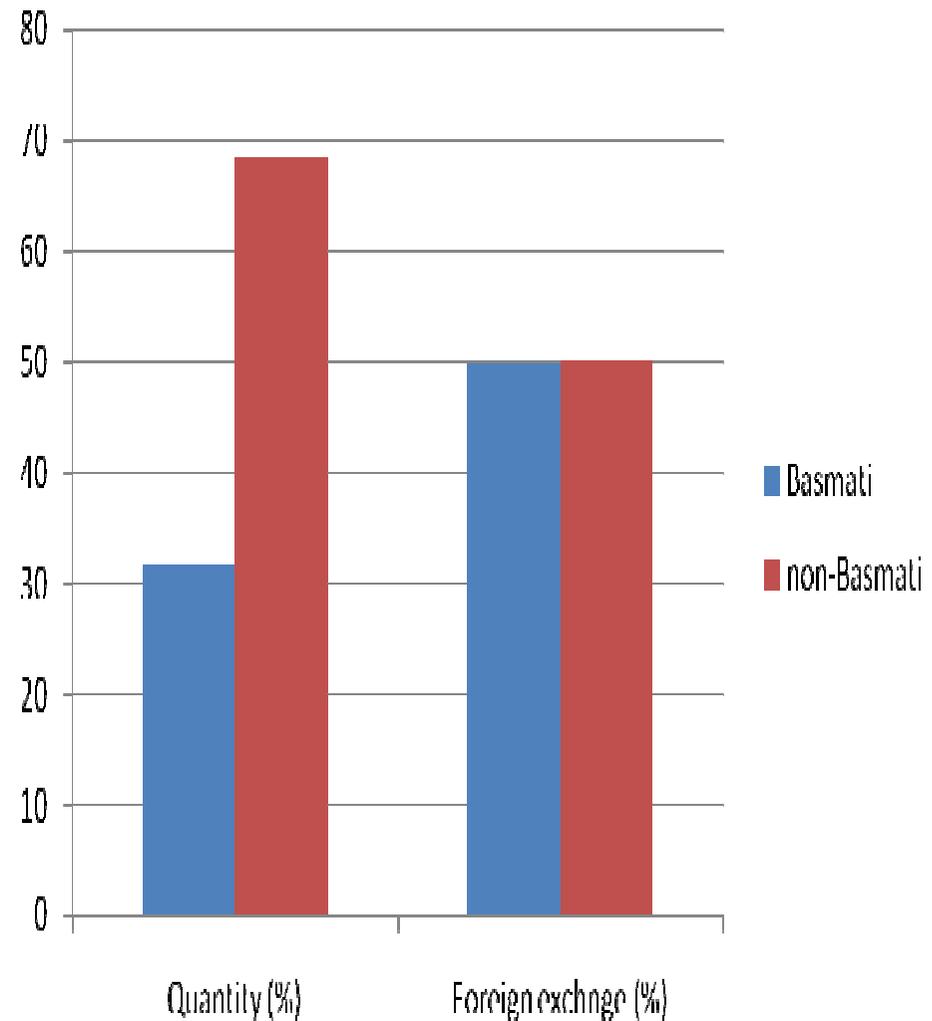
**2.930 m tons**

**Basmati Rice:** **0.924 m tons**

**(\$1.018 billion)**

**Non-Basmati:** **2.005 m tons**

**(\$1.025 billion)**



**Share of Basmati and non-Basmati rice and the foreign exchange earned by each type**

# Rice Trade-Pakistan

## Private Sector Role

### Rice Exporter's Association (REAP)

([www.reap.com.pk](http://www.reap.com.pk))

**Formed:** 1988 (after denationalization )

**Members:** 1000(mainly exporters/millers)

**Export:** 2.5 billion

### Pakistan Rice standard (PSI)

**Framed:** 1992

Abatement price 250 Euro/ton

**QRC**

# **Rice Trade- Government Interventions**

- **Minimum Export Price (MEP)**
- **Procurement price /indicator price**  
**MinFA**
- **Buy Surplus Rice- TDAP**
- **Rice research**
  - public sector**      **6 centers**
  - private sector**      **seed/hybrid rice research**
- **Regulations**  
**various ministries**

# 6 Rice Centers/Institutes in Pakistan



# Variety wise certified seed of paddy supplied by public and private sector for 2006 crop

Province/ variety	Seed Availability (Public Sector) tonnes	Seed Availability (Private Sector) tonnes	total	Area Sown (m hect.)	Seed Requirement (tones)	Area covered by certified seed(%)
<b>Punjab</b>	2840	10632	13472	1719	23891	56.4
<b>i) Basmati</b>	<b>1641</b>	<b>6150</b>	<b>7791</b>	<b>1468</b>	<b>17616</b>	<b>44.2</b>
ii) IRRI &others	1199	4482	5681	251	6275	90.5
<b>Sindh</b> “IRRI”	389	1355	1744	598	14950	11.7
<b>NWFP</b> “others”	42	10	52	61	1525	-
<b>Balochistan</b> “IRRI”	N.A	N.A	N.A	194	4850	-
<b>All Pakistan</b>						
<b>i) Basmati</b>	<b>1641</b>	<b>6150</b>	<b>7791</b>	<b>1468</b>	<b>17616</b>	<b>44.2</b>
ii)IRRI+other	1630	5847	7477	1104	27600	33.8
<b>Total</b>	<b>3271</b>	<b>11997</b>	<b>15268</b>	<b>2572</b>	<b>45216</b>	<b>33.8</b>

Source: **FSC&RD and API**

## **Exports of Pakistani Rice by Region** **(2004-05 and 2005-06)**

Region	2004-05				2005-06			
	Basmati Rice		Coarse Rice		Basmati Rice		Coarse Rice	
	Quantity (000 tone)	Value (m \$ US)						
<b>Asia</b>	651.05	346.25	694.74	184.40	678.14	380.6	910.43	245.06
<b>Oceania</b>	12.32	6.65	0.27	0.08	15.49	9.02	0.99	0.35
<b>Europe</b>	92.82	52.17	49.51	12.16	82.93	50.66	141.50	34.54
<b>Africa</b>	28.58	15.73	1200.57	279.38	34.68	19.33	1696.26	374.20
<b>America</b>	28.48	17.50	30.26	7.11	25.65	18.06	32.38	6.86
<b>CIS</b>	1.62	0.94	39.31	10.16	2.11	1.30	68.18	17.19
<b>Total</b>	<b>814.86</b>	<b>439.24</b>	<b>2014.66</b>	<b>493.31</b>	<b>839.0</b>	<b>479.62</b>	<b>2849.74</b>	<b>678.20</b>

Source: Federal Bureau of statistics, Pakistan

\* CIS stands for Central Independent State

# Rice: National Germplasm Explorations

**1972-77 :** 900 accessions were collected mostly from Punjab and Sind by Govt. of Pakistan in Coordination with USAID.

**1985 and 1987 – Total of 397 collections were made from Balochistan and Sindh (sponsored IBPGR)**  
- 201 collections from Balochistan and  
- 196 from Sind province.

**1989 and 1991 -NIAR-Japan and PARC-Pakistan with funds from IBPGR**  
Collaborative explorations in northern areas of Pakistan(249 rice accessions)

# Rice: Germplasm Preservation

## Plant Genetic Resource Programme -92-93

- a project: “**Genetic Resource Preservation and Research Laboratories**” at NARC, Islamabad Pakistan (as a gift from Govt. of Japan)

## Gene bank

Plant Genetic Resource Programme was established: having capacity to store 60,000 sample of 500gm each.

## Rice Collections

- Maintains and preserve **2092** rice collection with possible duplications – both local (**1661** samples) and exotic origin from 37 countries.
- Accessions representative to all **24** *Oryza* species are preserved – **1897** collections belongs to *O. sativa*



# Rice: Germplasm Preservation

## Collection of Rice Germplasm at PGRL

Sr #	Species	Accessions	Sr #	Species	Accessions
1	<i>Oryza alta</i>	5	13	<i>Oryza meridionalis</i>	8
2	<i>Oryza australiensis</i>	10	14	<i>Oryza meyeriana</i>	5
3	<i>Oryza barthii</i>	7	15	<i>Oryza minuta</i>	9
4	<i>Oryza brachyantha</i>	8	16	<i>Oryza nivara</i>	9
5	<i>Oryza echingeri</i>	19	17	<i>Oryza officinaRussi</i>	2
6	<i>Oryza glaberrima</i>	1	18	<i>Oryza officinaus</i>	9
7	<i>Oryza glumaepatula</i>	8	19	<i>Oryza phizomiatis</i>	4
8	<i>Oryza grandiglumis</i>	9	20	<i>Oryza punctata</i>	11
9	<i>Oryza granulata</i>	7	21	<i>Oryza ridleyi</i>	10
10	<i>Oryza latifolia</i>	8	22	<i>Oryza ruh pogon</i>	6
11	<i>Oryza longiglumis</i>	6	23	<i>Oryza sativa</i>	1897
12	<i>Oryza longistaminata</i>	5	24	<i>Oryza spontnea</i>	2

# **Germplasm from various countries preserved in Genebank at PGRL-PARC**

<b>Sr#</b>	<b>Origin</b>	<b>Accessions</b>	<b>Sr#</b>	<b>Origin</b>	<b>Accessions</b>	<b>Sr#</b>	<b>Origin</b>	<b>Accessions</b>
1	Pakistan	1661	14	Mali	1	26	Suri Nam	6
2	Australia	16	15	Mayanmar	9	27	Taiwan	3
3	Bangladesh	1	16	Nepal	1	28	Tanzania	1
4	Brazil	15	17	North Korea	103	29	Thailand	13
5	Cameroon	6	18	Papua New Guinea	3	30	Uganda	7
6	Chad	5	19	Philippines	129	31	USA	1
7	China	8	20	Phillipines	2	32	Viet Nam	2
8	Costa Rica	5	21	Senegal	1	33	Zambia	4
9	Egypt	6	22	Sierra Leone	4	34	India	31
10	Ghana	2	23	Sri Lanka	19	35	Indonesia	8
11	Guate Mala	2	24	Kenya	2	36	Japan	3
12	Guinea	4	25	Laos	1	37	Malaysia	5
13	Guyana	1						

# Preservation of rice Germplasm of Pakistani origin at various national and international genebanks

Sr #	Institution	Country	Accessions	Source
1	PGRP-NARC <sup>a</sup>	Pakistan	1661	PGRP-NARC ( <a href="http://www.parc.gov.pk">http://www.parc.gov.pk</a> )
2	IRRI <sup>b</sup>	Philippine	7573	( <a href="http://beta.irri.org/seeds/">http://beta.irri.org/seeds/</a> )
3	NGRP <sup>c</sup>	USA	857	<a href="http://www.ars-grin.gov/cgi-bin/npgs/html/tax_stat.pl?taxno=26077&amp;country=Pakistan&amp;unavail=">http://www.ars-grin.gov/cgi-bin/npgs/html/tax_stat.pl?taxno=26077&amp;country=Pakistan&amp;unavail=</a>
4	NIAS <sup>d</sup>	Japan	421	<a href="http://www.gene.affrc.go.jp/databases_en.php">http://www.gene.affrc.go.jp/databases_en.php</a>
5	Global Seed Vault	Norway	567	<a href="http://www.nordgen.org/sgsv/index.php?app=data_unit&amp;inc=search_form&amp;unit=sgsv_template&amp;institute_code=PAK001&amp;institute_code=PAK001&amp;full_scientific_name=Oryza+sativa&amp;PHPSESSID=3b1td0arodcnhufcvf6p5mv8h7">http://www.nordgen.org/sgsv/index.php?app=da ta_unit&amp;inc=search_form&amp;unit=sgsv_template&amp;institute_code=PAK001&amp; institute_code=PAK001&amp;full_scientific_name =Oryza+sativa&amp;PHPSESSID= 3b1td0arodcnhufcvf6p5mv8h7</a>

a) Plant Genetic Resource Programme, National Agriculture Research Center Pakistan.

b): International Rice Research Institute, Philippines.

c): National Genetic Resources Program, USA.

d): National Institute of Agrobiological Sciences, Japan.

# Areas rich in Diversity

- **NWFP – 70%**

(of total cultivated rice comprise traditional varieties)

- **Baluchistan – 43%.**

Surrounded by rice growing countries like China, the Soviet Union, Afghanistan, and Iran – these two provinces possess abundance of diversity.

# Rice Characterization: Morphological and Biochemical parameters

Total accessions characterized: 475

Indigenous : 375

Exotic 100

## Grain Quality parameters

Sr.	Parameter	Variation
1	Grain Length	6.0~10.66 mm
2	grain width	1.6~3.7mm
3	breadth	1.14~ 2.36mm
4	length to width ratio	2.04~5.24
5	grain weight	0.66~3.02g.
6	Hull/Pericarp Color	minimum in Pakistani rice land races (Yellow, yellowish brownish and purple)

# Characterization : Biochemical Parameters

Sr. No	Parameter	Variation
1-	Globulin	no variation Pakistani Landraces
2-	Prolamine	no variation Pakistani Landraces
3-	Albumin	Minor/slight variation
4-	Wx (waxy)-gene product	Present among most of the local rice races
5-	Glutamine	showed significant variation for the character
6-	Esterase 3 isozyme	correlated to rice varietal group Fast band appeared in indica and slow band in japonica.
7-	Amylose Contents	17.7(JP5) to 35.7 (Nali land races)

## Progress and status of GM rice development in various institutions of Pakistan

Institute	Problem	gene	stage/level	Reference
<b>CEMB*</b>	Resistance to yellow stem borer and rice leaf folder	<i>Cry1Ac</i>	Field evaluation	Bashir et al., 2005
		<i>Cry2A</i>	Lab. and field evaluation	Bashir et al., 2005 & Riaz et al., 2006
		<i>Cr1Ac+Cry2A</i>	Lab. and field evaluation	Husnain et al., 2002,
		<i>Cry1Ab</i>		
<b>NARC**</b>	Bacterial leaf blight	<i>Xa21</i>	Lab. and green house study	Khan et al., 2007 & Amina et al., 2006,
<b>NIBGE***</b> <b>CEMB</b>	Drought and salinity	<i>Dreb1A</i> & <i>OsDreb1b</i>	Lab. analysis	Husnain et al., 2004

\* National Center of Excellence in Molecular Biology(CEMB), Lahore, Pakistan.

\*\* National Agriculture Research Center, (NARC) Islamabad, Pakistan

\*\*\* National Institute for Biotechnology and Genetic Engineering (NIBGE),Faisalabad, Pakistan

### References

- Bashir et al., 2005, Crop protection,870-879
- Riaz et al., 2006, Afri. J. Bot.217-223
- Khan et al.,2007,Pak.J.Bot.1285-1292
- Amina et al.,2006, Pak.J.Bot.193-203
- Husnain et al.,2002 Euphytica 127-128

# RICE DNA Purity Tests/Authenticity

- **GM Screening**

No GM rice variety registered and/or developed so far

- **DNA purity testing (Basmati/non Basmati)**

for research and commercial purposes (NIBGE and NIGAB Pakistan )

- **Grain quality testing (ISO certified)**

GQTL working at Islamabad/ Karachi

- **Aflatoxins**

test being conducted at NARC, Pakistan

## DNA purity and adulteration test conducted at NIBGE

Year	No. of samples
2004-05	280
2005-06	230
2006-07	762
2007-08	343
2008-09	240

## Characterization - Molecular Markers (SSR/RAPD)

- **Evaluation of genetic polymorphism (Rabbani *et al.*, 2008)**
  - among 10 traditional, 28 improved and two Japanese cultivars ('Kinmaze' and 'Nipponbare' )using RAPDs.
- **Lowest level of diversity was observed among aromatic**  
Aromatic cultivars – relatively lower in genetic diversity indicates basic similarity among Basmati varieties – due to common ancestors
- **Five varieties have Basmati-370 as one of the parents.**
- **Kinmaze' and 'Nipponbare' (Japonicas)– distant relation with Indica cultivars.**
- Cultivars – 'Jhona-349', 'Lateefy' and 'Swat-1' distinct from all other non-aromatic cultivars.
- **Unique banding patterns – 'Jhona-349', 'Lateefy', not produced in any other cultivar.**
- **IRRI cultivars – IR-6 & IR-36 shared RAPD profiles with local cultivars. Also having unique fragments.**

**Ref:** Rabbani et al, 2008, Electronic J.Biotech(11)3

# Molecular Characterization – SSR

- Investigated SSR based genetic diversity among 16 aromatic, 22 non-aromatic and 2 japonica varieties.
- Traditional varieties – closer to japonica type.
- Aromatic cultivars – dissimilar from non-aromatic.
- Non-aromatic – more diverse from aromatic.
- Cluster analysis grouped most of the basmati cultivars from Punjab - '**Basmati-370**', '**Basmati-Pak**', '**Basmati-385**', '**Basmati-2000**' and '**Super-Basmati**' together, indicating common ancestors.
- **Basmati-370**' as one of the parents in their pedigree.
- based of geographic distribution – long slender and medium slender aromatic rice are largely grown in Zone - clustered into group I.
- short to long bold – grown mostly in Sind, southern parts of NWFP and northern cooler areas of Pakistan – clustered into group II.
- **Group I – possesses cultivars with desirable grain characteristics and cooking qualities.**
- Group II – have aroma of varying strength but lack desirable Basmati traits.
- Suggest probability – basmati varieties have evolved by natural mutation in indigenous non-Basmati types.

**Ref:** Rabbani et al, 2008, Electronic J.Biotech(11)3

# Issues of Plant Authenticity

1- **Reliability of data of land races**

2- **Common heritage –GI issues: PGI/PDO**

3- **Ownership**

(Kernal /Super Basmati/1121)

4- **Lineage of Basmati (Hybridization/Introgression)**

Lineage from pure line to basmati hybrids (70%,50%,10%,5%,or 1%?)

Identity of parents

5- **DNA purity test**

single test not possible except in GMOs or one variety

6- **Product Origin/type**

Mandatory?

7- **The origin and evolution of fragrance-**

Kovach et al.2009. PNAS:(106)14444-14449

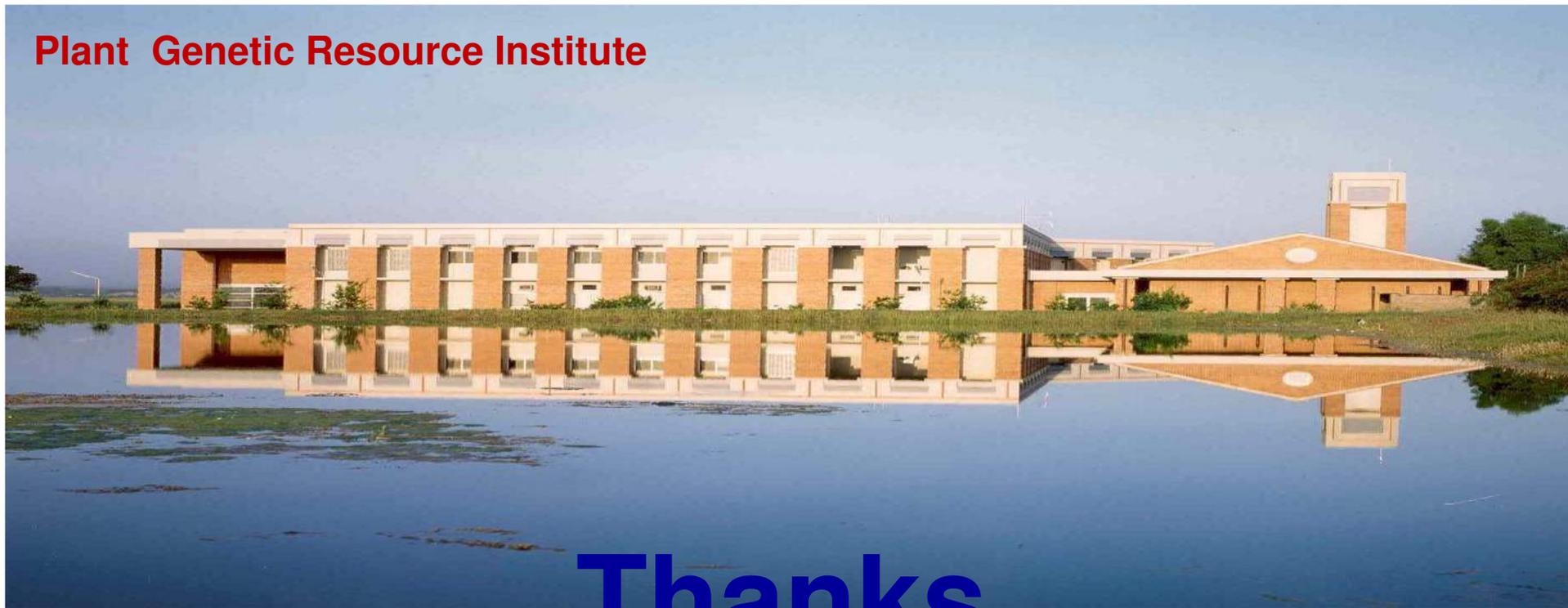
# Way Forward...

- **Evaluation/Characterization of land races: A joint venture with Europe : a future prospect??**
- **Breeding programme initiated by RRI,KSK with land races of Basmati**
- **Production of hybrid seeds in Basmati**  
to compete the spread of Chinese hybrid seed with higher yield
- **Strengthening of infra structure for genomic studies of Basmati rice**  
03 National labs have initiated work
- **A strict quality control regime at every level of production**
- **Awareness campaign among various stake holders**

# Acknowledgements

- ✓ Director RRI, KSK, Lahore
- ✓ Sr. Director IABPGR,NARC,
- ✓ Dr. Ashiq Rabbani ,PGRI
- ✓ Dr. M. Arif, Principal Scientist NIBGE
- ✓ Dr. Zafar Qureshi, ABRI, Faisalabad
- ✓ Ms. Zahida Perveez, Ph.D Student QAU
- ✓ Mr. M Farooq, Research Associate, NIGAB
- ✓ Ms. Farhat Nazir, Senior Scientist, NIGAB

**Plant Genetic Resource Institute**



**Thanks**



**Sun drying of paddy rice**