Track 5: Crop Breeding & Genetics

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Indian Wheat Programme as backbone for national food security

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Wheat Species Grown in India

(i)	Bread Wheat *(Triticum aestivum)* 2n=42	95% area
(ii)	Durum or Macaroni Wheat *(T. durum)* 2n=28	4 % area
(iii)	Emmer or Khapli Wheat *(T. dicoccum)* 2n=28	1 % area
(iv)	Indian dwarf wheat *(T. sphaerococcum)* 2n=42	Sporadic in Gujarat

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Wheat in Early Days

- In early periods of 20th century, wheat varieties grown in India were mostly mixtures of various botanical forms usually referred to as ***'sorts'.***

- Prominent 'sorts' were-

T. aestivum	Sharbati, Dara, Safed Pissi, Chandausi, Karachi, Choice White, Hard Red Calcutta, Lal Kanak, Lal Pissi etc.
T. durum	Haura, Bansi, Kathia, Jalalia, Gangajali, Khandwa, Malwi etc.
T. dicoccum	Khapli, Popatia, samba

- The *dicoccums* are under cultivation, especially in Karnataka and South Maharashtra. *Khapli* wheat, a dicoccum widely acclaimed for quality and stem rust resistance has been widely used in the breeding programmes.

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Era of Pre Semi-dwarf Wheat Varieties (1905-62)

I-Phase (Pure line selection from local mixtures)
Muzaffar Nagar White, Buxar White, Pissi and Haura Wheat (Howard and Howard, 1909). **NP 4, NP 12, Pb8, Pb 8A, Pb 9D, Pb 11, K13, K46, AO13, AO 85, AO 90, Bansi, Motia, Gulab etc.**
II-Phase (Recombination breeding between pure lines)
Pb C 518, Pb C 591 (Ch. Ramdhan Singh in Pb) NP 52, NP 80-5, NP 120, NP 125, NP 165, Niphad 4, AO 69, AO 113, AO 115 (No emphasis on disease resistance)
III Phase (emphasis on disease resistance through hybridization with exotic genotypes)
Late Prof. K.C. Mehta and Dr. B.P. Pal
NP 700 and NP 800 series (NP 710, NP 770, NP 783, NP 824) **NP 809- a classical achievement – resistant to 3 rusts** **NP 814 – first variety developed for good management cultivation**
Other good varieties: PbC228, C 273, C 281, C 519, Hyb 11, Hyb 23, Hyb 38, RS 31-1, Kenphad 28,

Advent of Green Revolution

Introduction of the semi-dwarf Mexican wheat (*New dwarf plant type having Rht genes from Norin 10*) through the Green Revolution in 1965

Present Scenario
• *Veery* germplasm (1B/1R)
•Synthetic hexaploids
• Buitre
•Chinese sub compactoid
• Wild relatives and
•Elite germplasm gene pool

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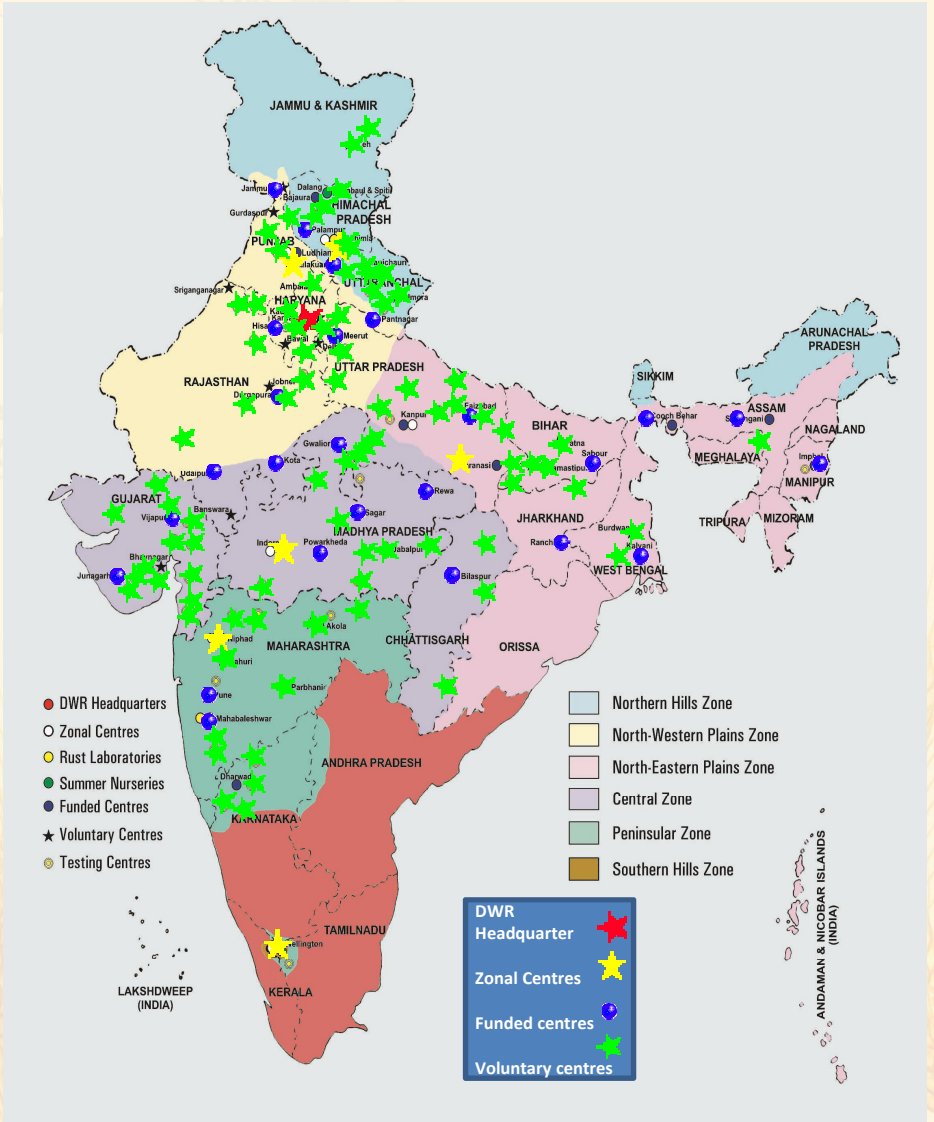
Initiation of AICW&BIP (DWR)- A Milestone…

- The Indian Council of Agricultural Research (erstwhile Imperial) in 1929
  - became the main funding agency and promoter of wheat research in India.
- Establishment of the All India Coordinated Wheat Improvement Project (AICWIP) in 1965 by the ICAR
  - *Resulted in the real breakthrough in productivity through the Green Revolution.*
- Status of Directorate of Wheat Research (DWR) in 1978 and later shifted to Karnal in 1990.
- DWR is nodal institute
  - Coordinating multidisciplinary and multilocational testing of varieties, crop management and crop protection technologies
- The coordinated research under five disciplinary themes
  - Crop Improvement, Resource Management, Crop Protection and Health, Quality and Basic Science, Statistics and Social Sciences.

ICAR - Directorate of Wheat Research
All India Coordinated Wheat & Barley Improvement Project

- Nodal centre of wheat & barley research
- All India Coordinated Wheat & Barley Improvement Project
  - 107 scientists from 31funded centres
  - 174 scientists from 119 non-funded cooperating centres



"Ensuring food security of India by enhancing the productivity and profitability of wheat and barley on an ecologically and economically sustainable basis and making India the world leader in wheat production"

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DWR regional centres…….

- *Regional Station at Flowerdale, Shimla* **(established in 1930 by Late Dr. KC Mehta) which serves as a national facility for**
  - **Monitoring wheat rust pathotypes,**
  - **Evaluating advanced generation material,**
  - **Postulating probable rust resistance genes in the test lines and**
  - **Act as a repository for maintenance of the wheat rust virulences.**

- *Off-season nursery facility at Dalang Maidan (Lahaul & Spiti),* **Himachal Pradesh (>12000 ft amsl) for**
  - **Advancing of generation,**
  - **Making crosses,**
  - **Multiplying seed,**
  - **purify stocks and**
  - **Evaluating germplasm for yellow rust resistance.**

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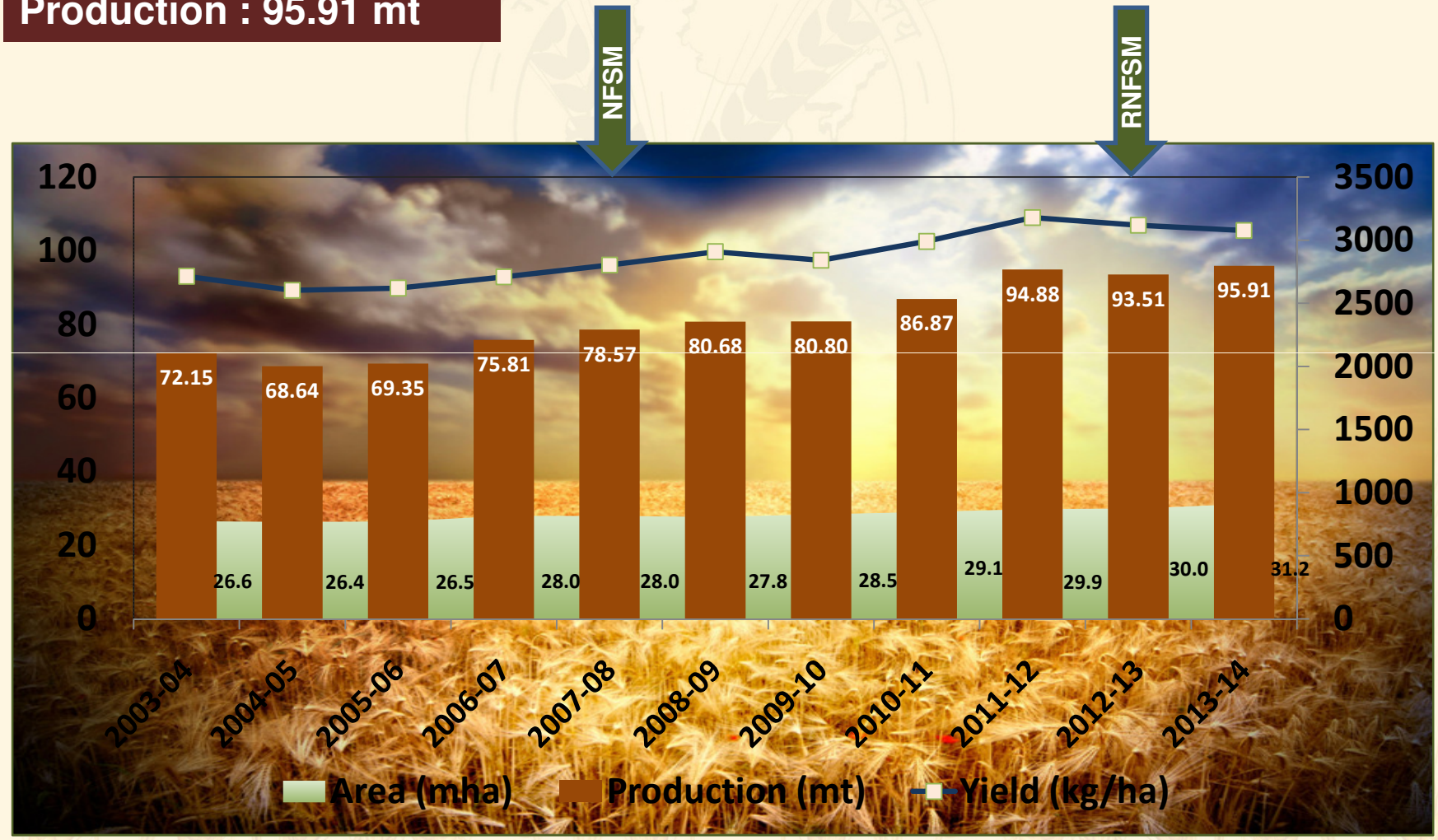
Scenario of Area, Production and Yield in Wheat

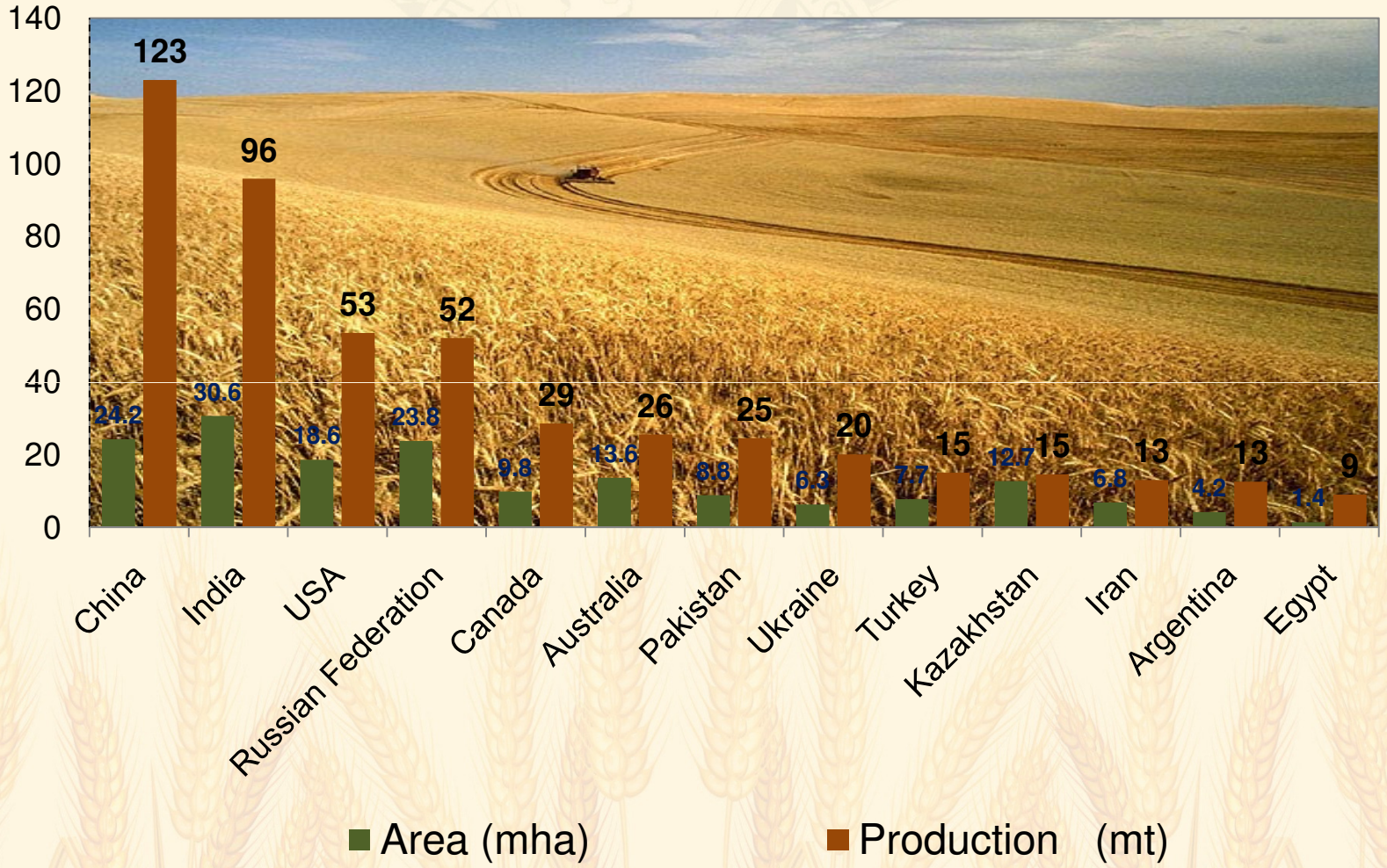
Area : 31.19 mha
Production : 95.91 mt

Yield : 3075 kg/ha

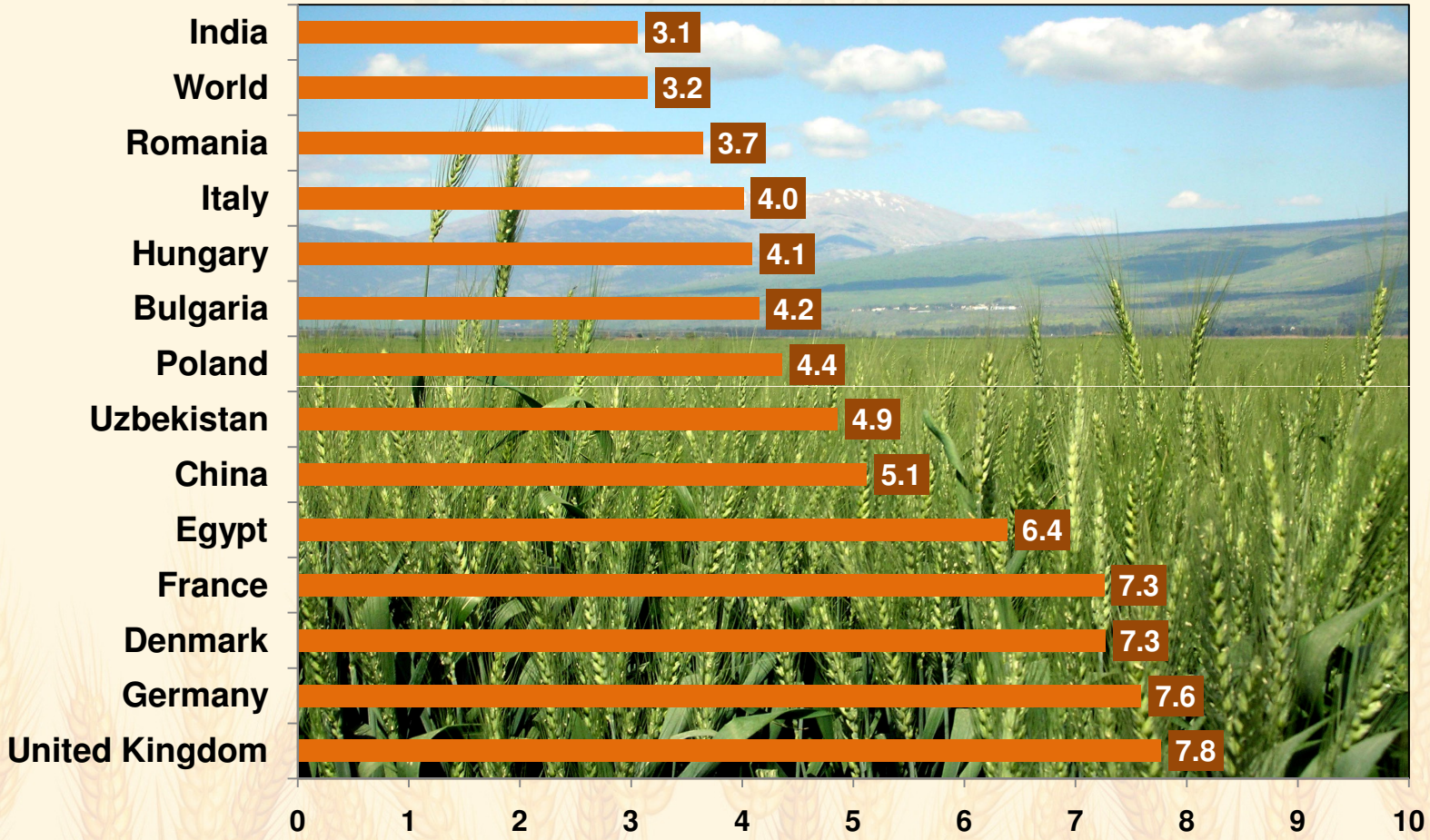


2.40 mt (2.57 %) increase in production from 2012-13

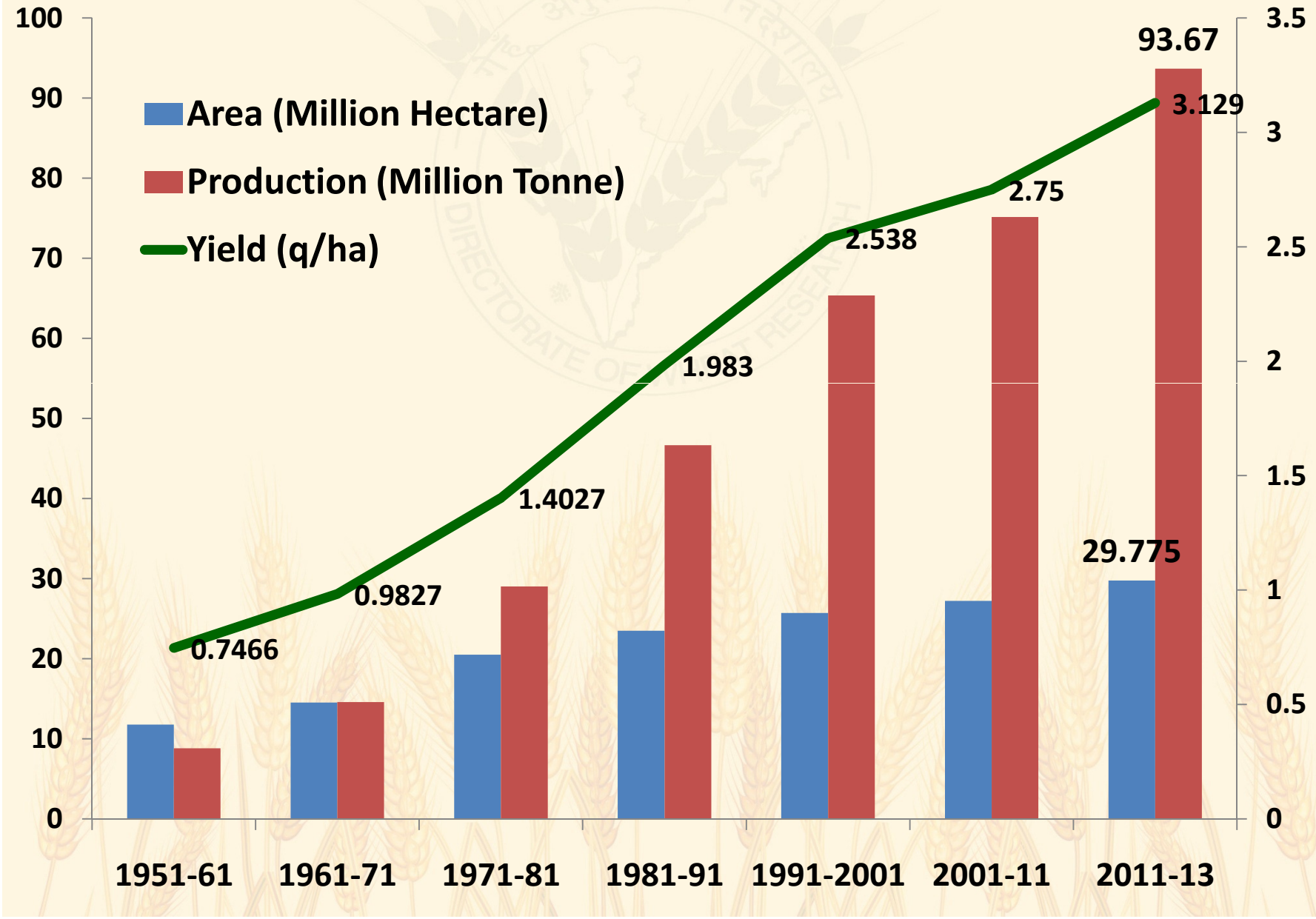
India - 2nd largest wheat producing country (2014)



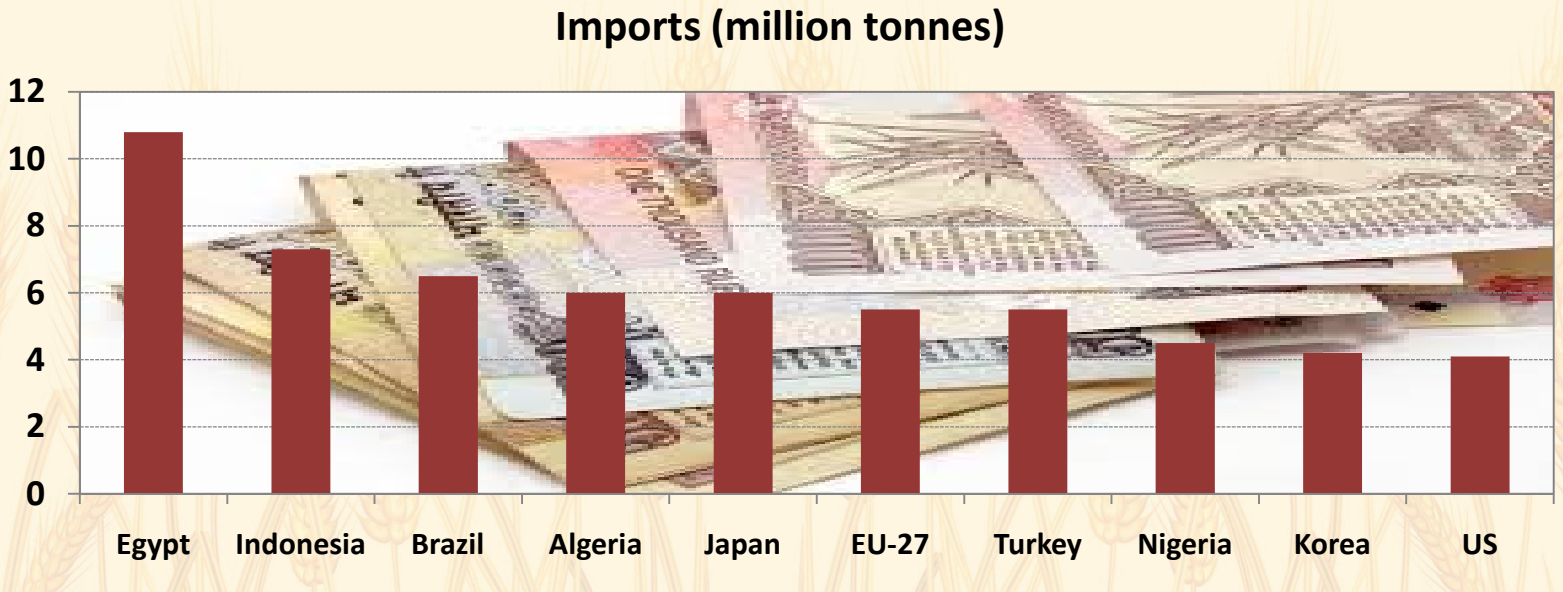
India vis-à-vis other countries in wheat yield (t/ha) - 2014



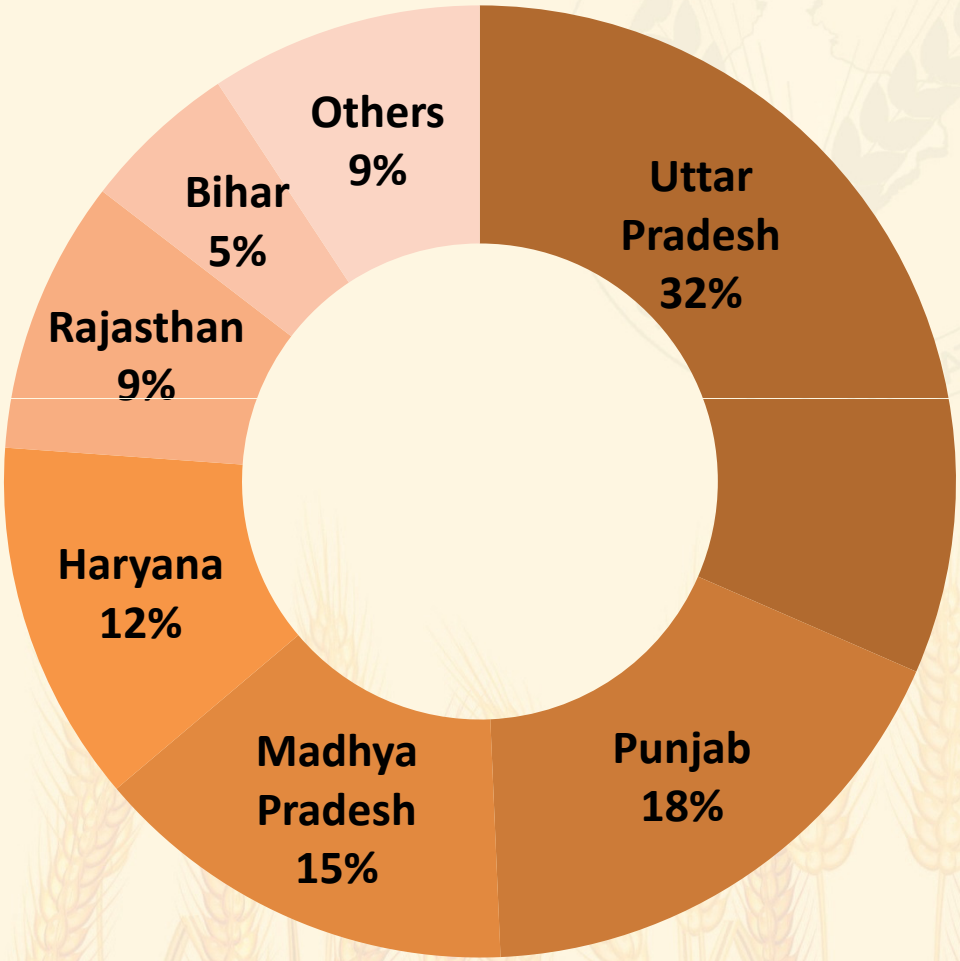
Decade wise production statistics



Top exporters & importers (2013-14)



Production in 2013-14



State	Production (mt)
Uttar Pradesh	30.25
Punjab	17.04
Madhya Pradesh	13.93
Haryana	11.80
Rajasthan	8.92
Bihar	5.08
Others	8.89
INDIA	95.91

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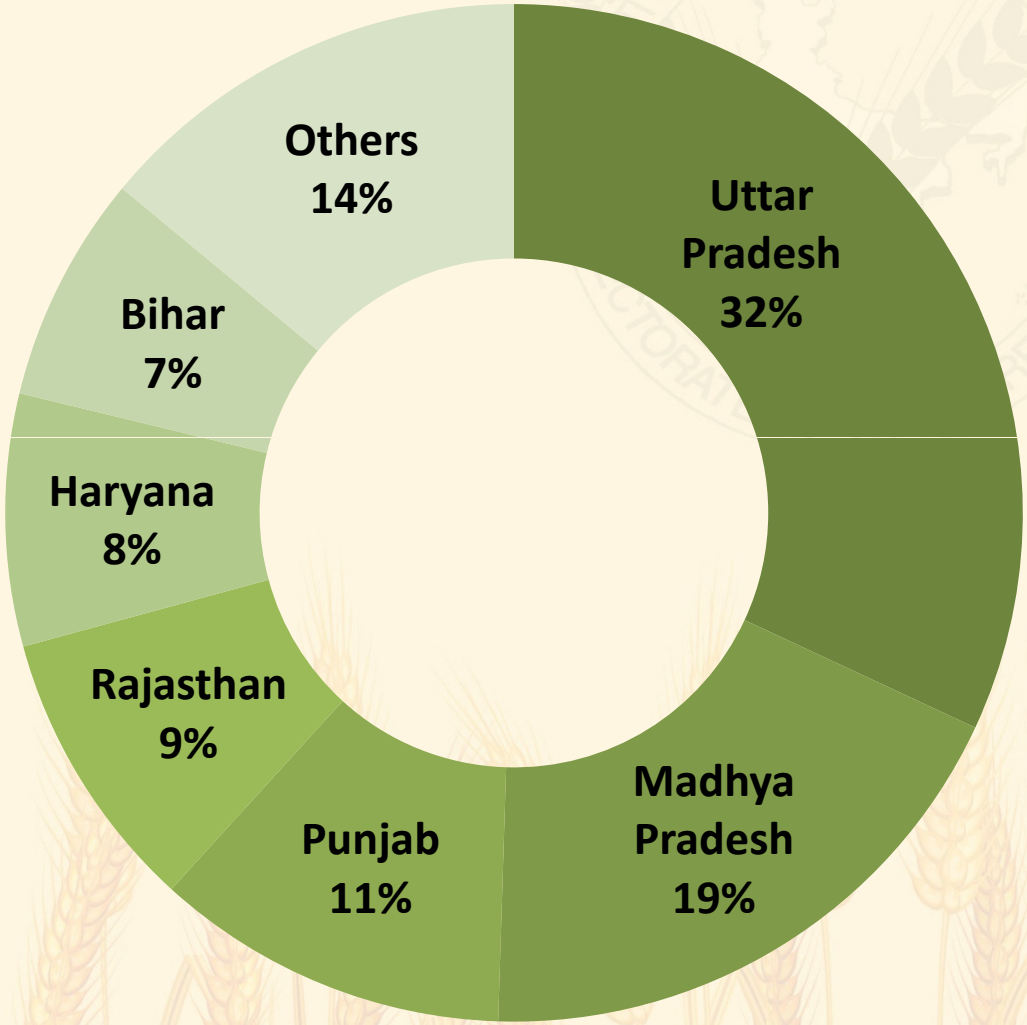
Area sown in 2013-14



State	Area (mha)
Uttar Pradesh	9.96
Madhya Pradesh	5.79
Punjab	3.51
Rajasthan	2.81
Haryana	2.50
Bihar	2.26
Others	4.36
INDIA	31.19

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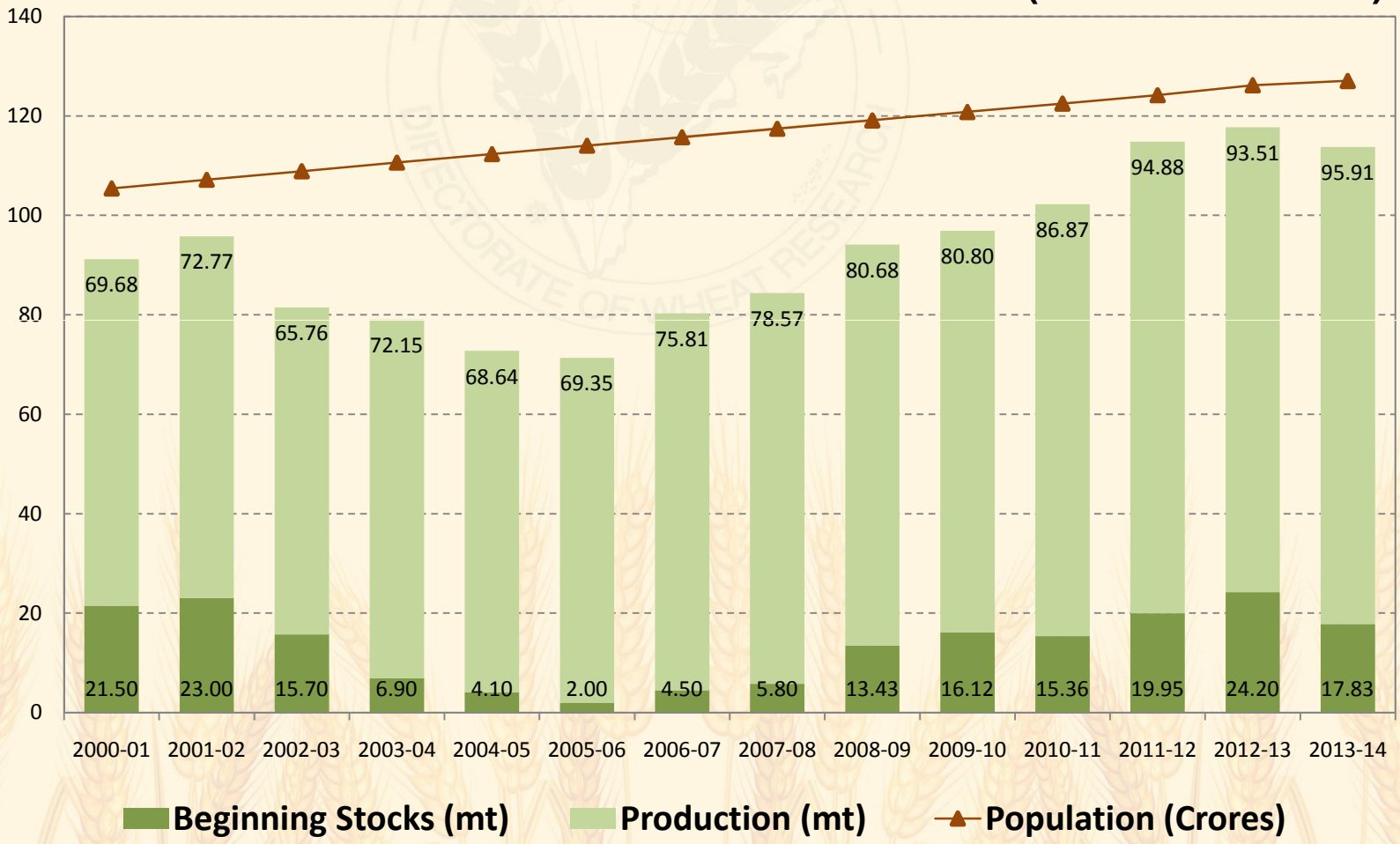
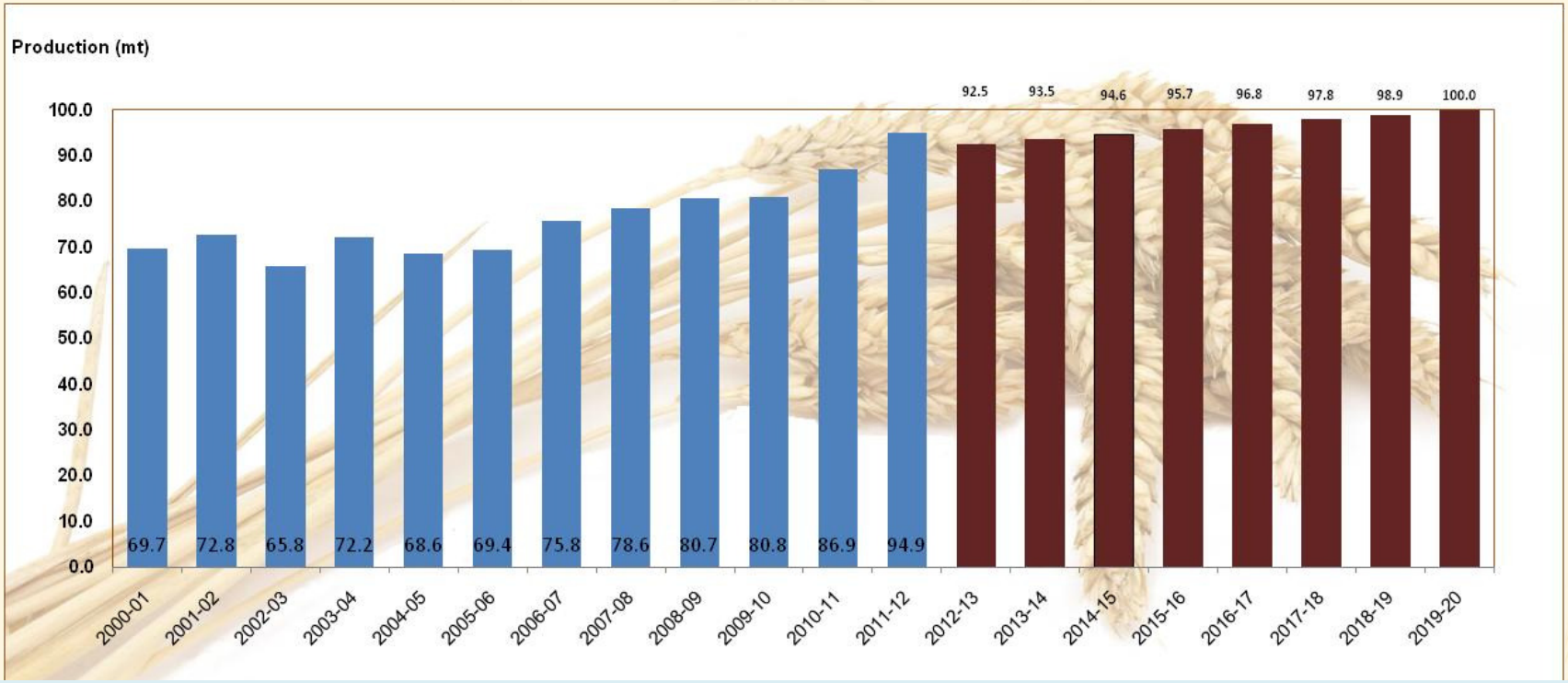
Beginning Stocks, Production & Population

Procurement: 28 mt (as on 16.07.2014)
Stocks : 38.11 mt (as on 08.08.2014)



Source: USDA and India Stat Portal's

Production target for 2020



BY 2020: Vision Food Security and Nutrition Planning Commission Report by R. Radhakrishnan and K.Venkata Reddy

108 mt :Business-As-Usual (BAU) Scenario
173 mt:Best-Case Scenario (BCS)

92 mt:Demand

140mt by 2050

Wheat growing zones of India

Northern Hills
0.9 mha

North Western Plains
11.5 mha

Central
5.0 mha

North Eastern Plains
10.5 mha

Peninsular
1.8 mha

Southern Hills
0.05 mha

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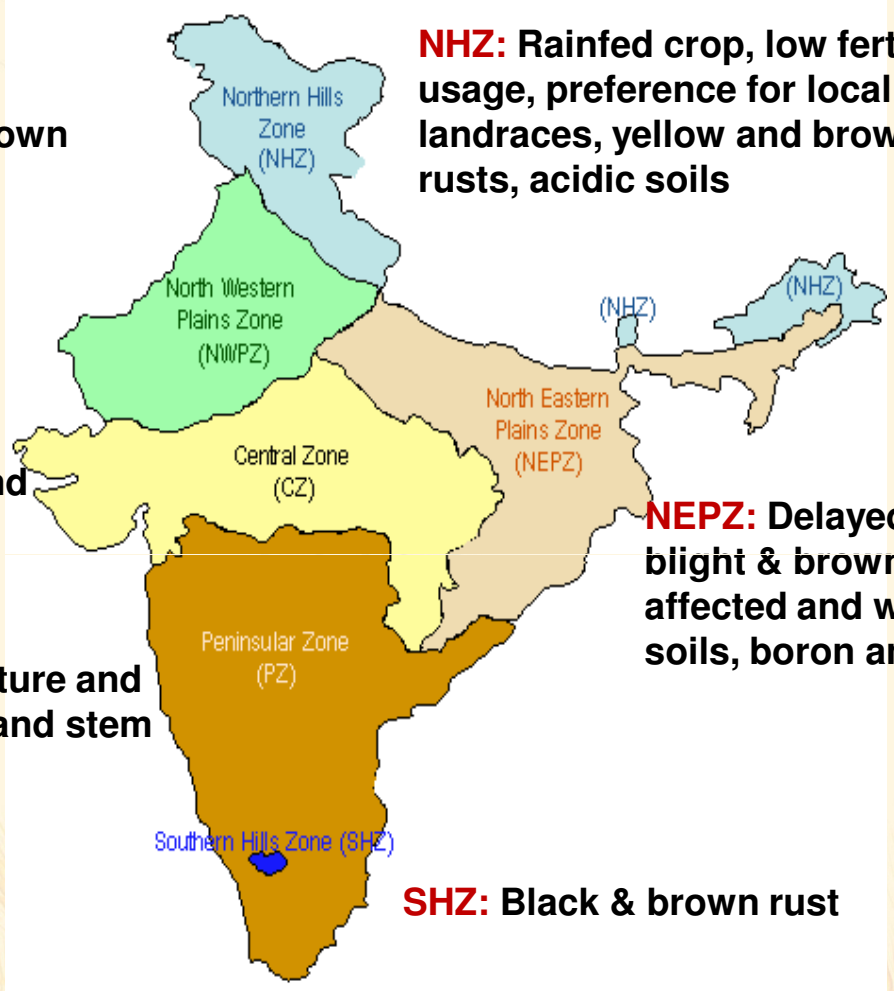
Major challenges in different zones

NWPZ: Yellow and brown rusts, Karnal bunt, Terminal heat stress, *Phalaris minor,* Zn, Fe & Cu deficiency

CZ: High temperature and water stress, leaf and stem rust

PZ: High temperature and water stress, leaf and stem rust



NHZ: Rainfed crop, low fertlizer usage, preference for local landraces, yellow and brown rusts, acidic soils

NEPZ: Delayed sowings, leaf blight & brown rust, salt affected and waterlogged soils, boron and zinc deficiency

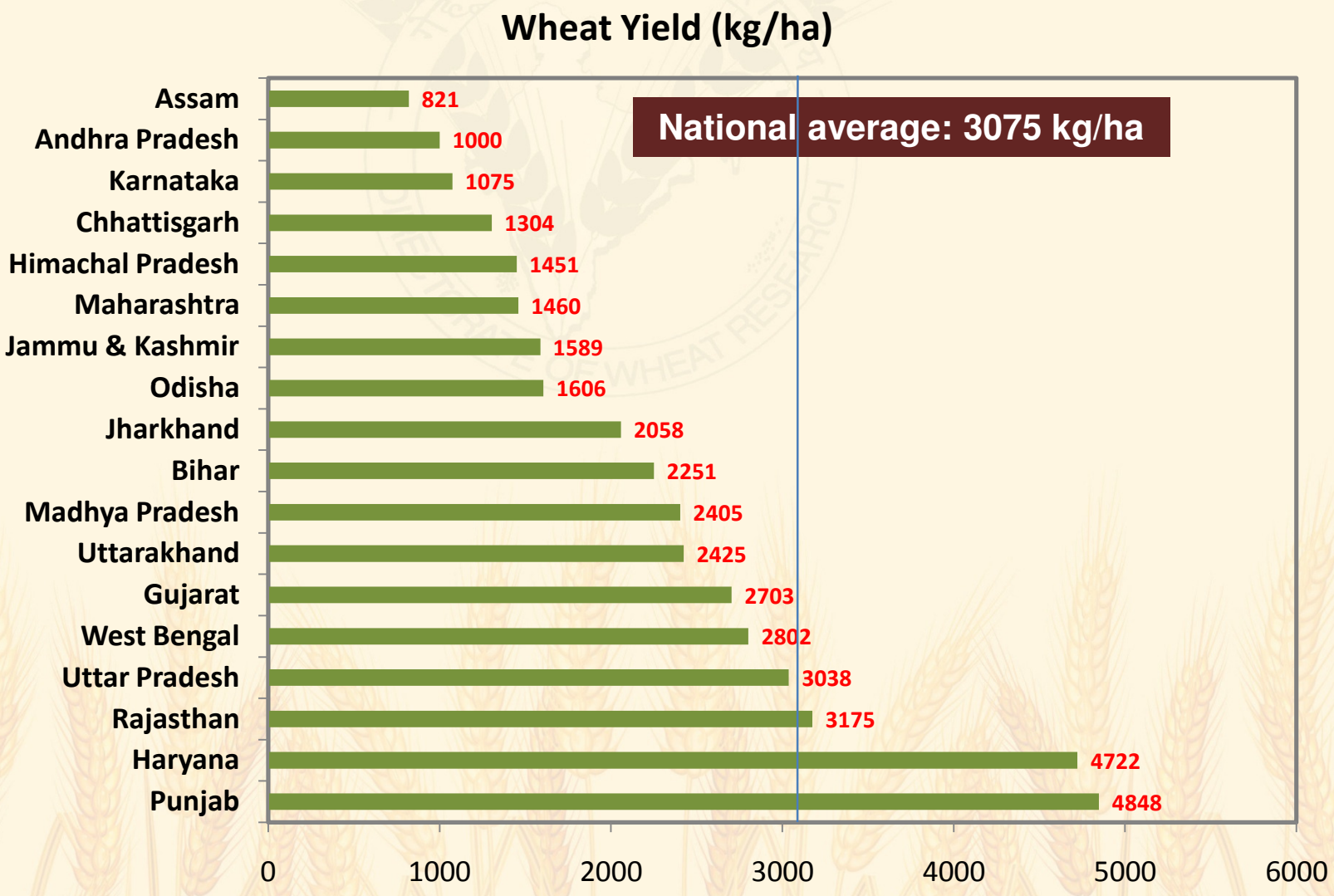
SHZ: Black & brown rust

Nutrient deficient soils

46 % Zn 17 % Bo 12 % Mo 11 % Fe 5 % Cu 38% S

Bridging Yield gaps

Yield deviation from national average (2013-14)



Harness from states having lower yield with higher area – UP, MP, Bihar and Gujarat

Research accomplishments - Wheat

- > 400 wheat varieties released through AICWIP (1965-2014)
- 160 genetic stocks registered for various traits
- Germplasm enrichment and sharing
- Surveillance & strong crop protection strategies have checked wide spread occurrence of diseases during last 4 decades
- Eco-sustainable production technologies developed
- Adequate breeder seed production to meet seed replacement requirements
- Varieties identified for various end-products (Target customers)
- Strong linkage (R4D) established with partner countries for global food security

Released wheat varieties since 1965

S.No	Type	CVRC	SVRC	TOTAL
1	Bread wheat (*T. aestivum*)	234	118	352
2	Macaroni wheat (*T. durum*)	32	23	55
3	Emmer Wheat (*T. dicoccum*)	05	01	06
4	Triticale (*X Triticosecale*)	05	01	06
	TOTAL	276	143	419

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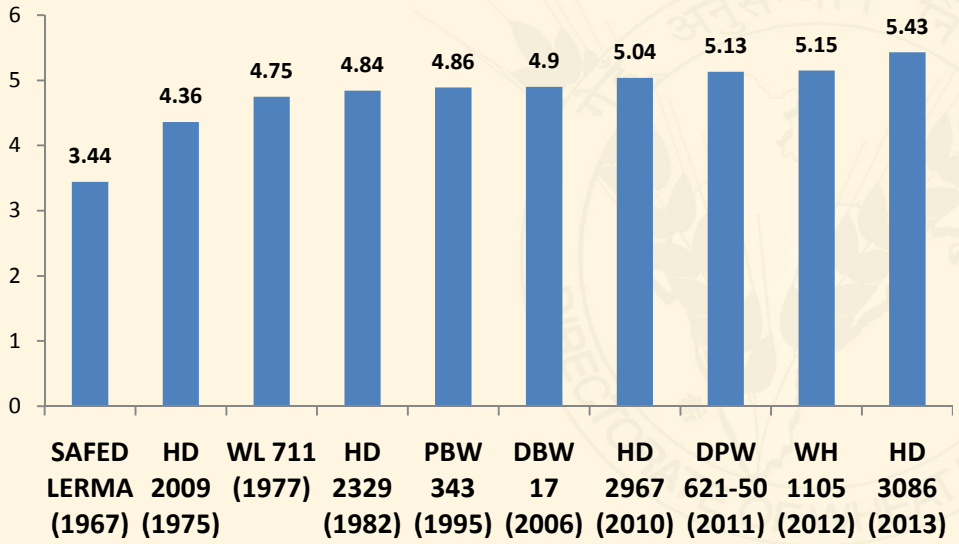
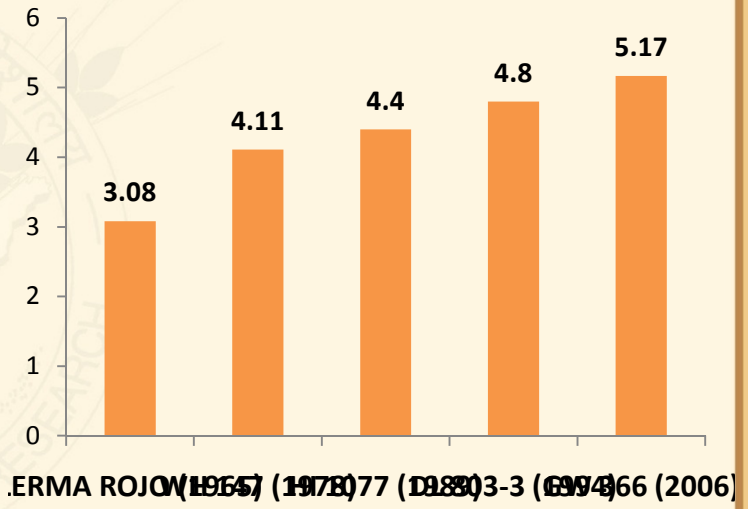
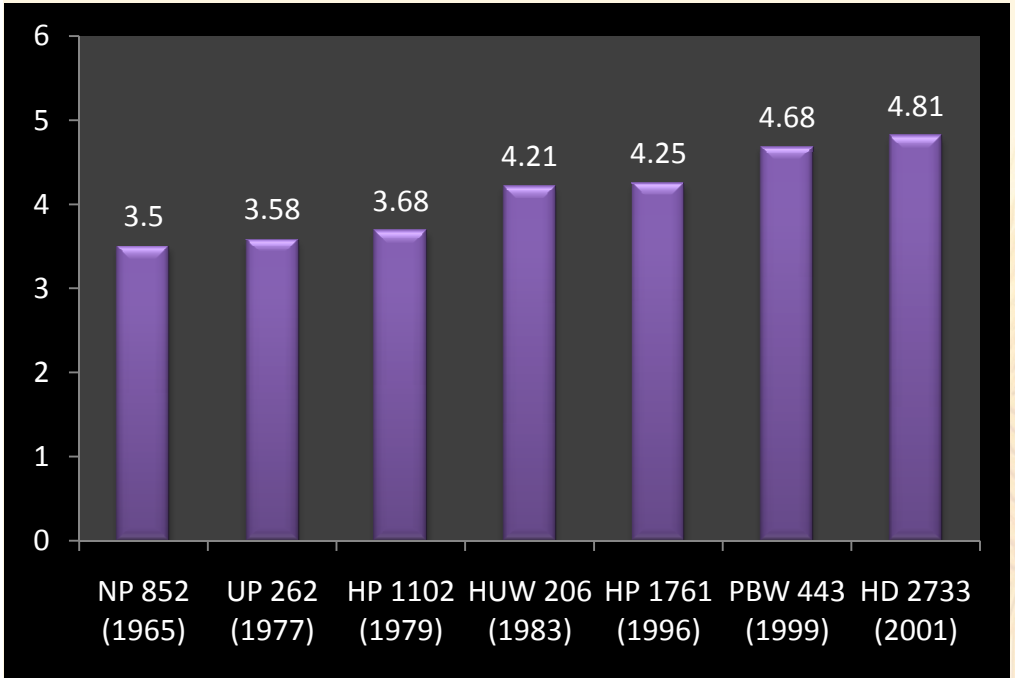
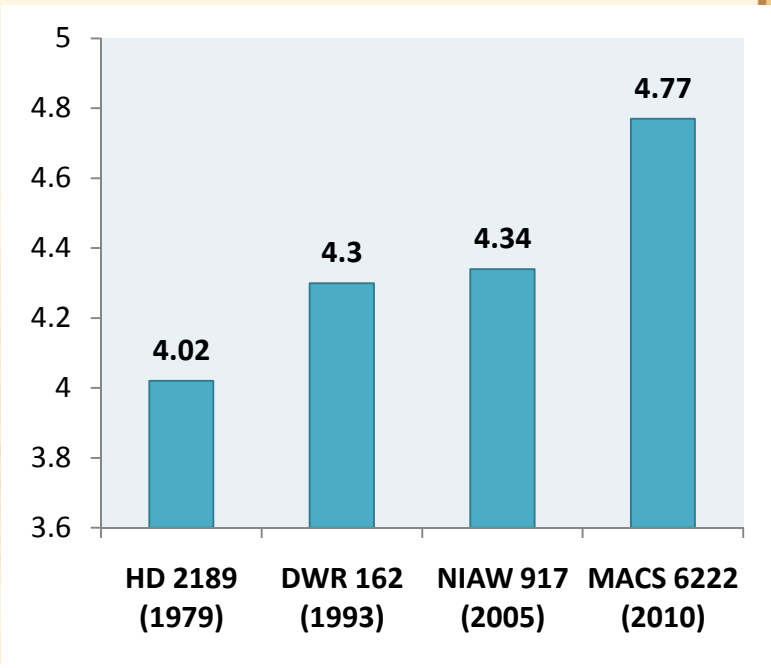
Irrigated timely sown









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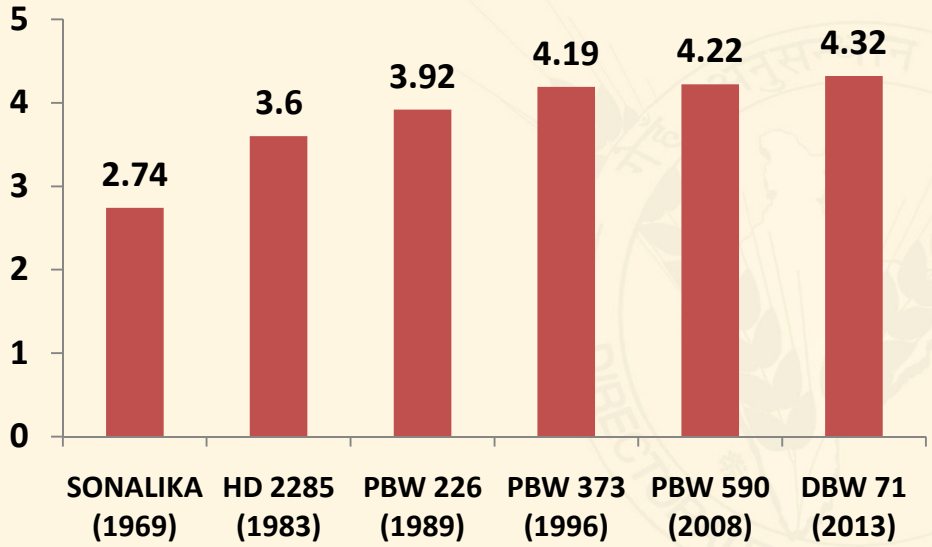
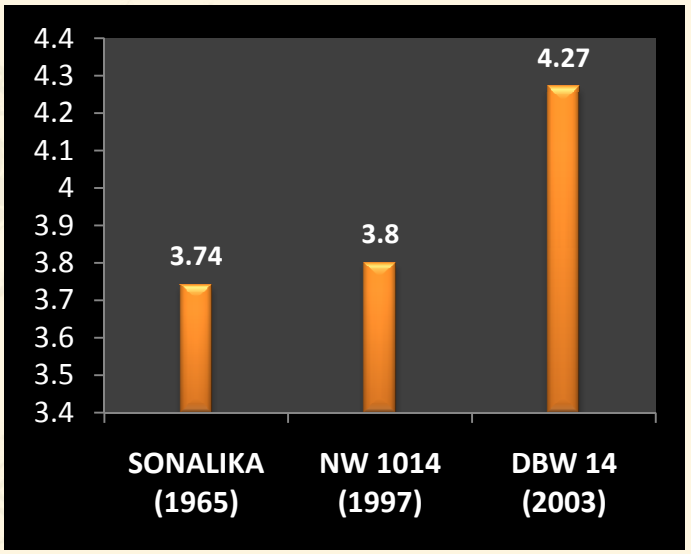
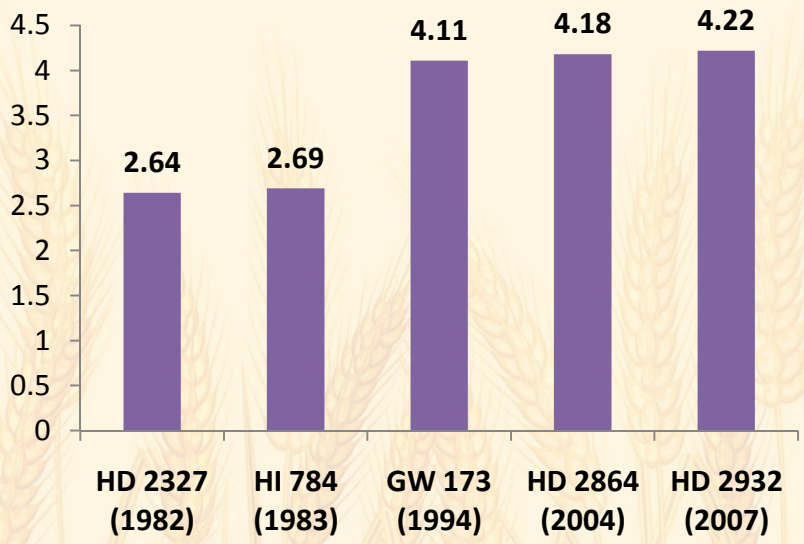
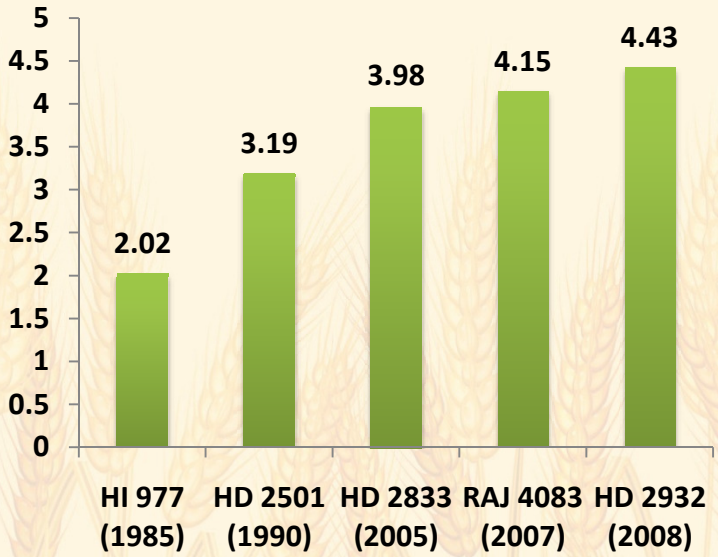
Irrigated late sown



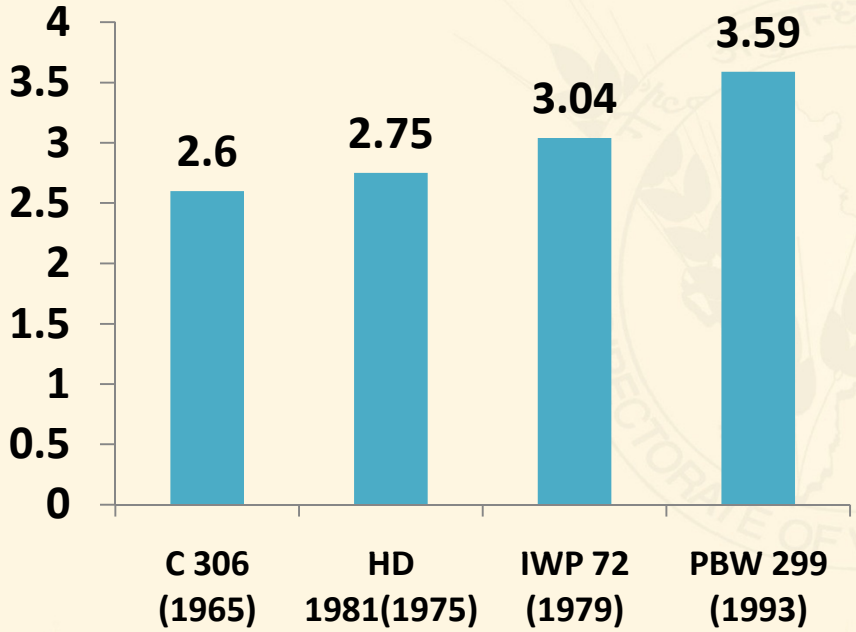


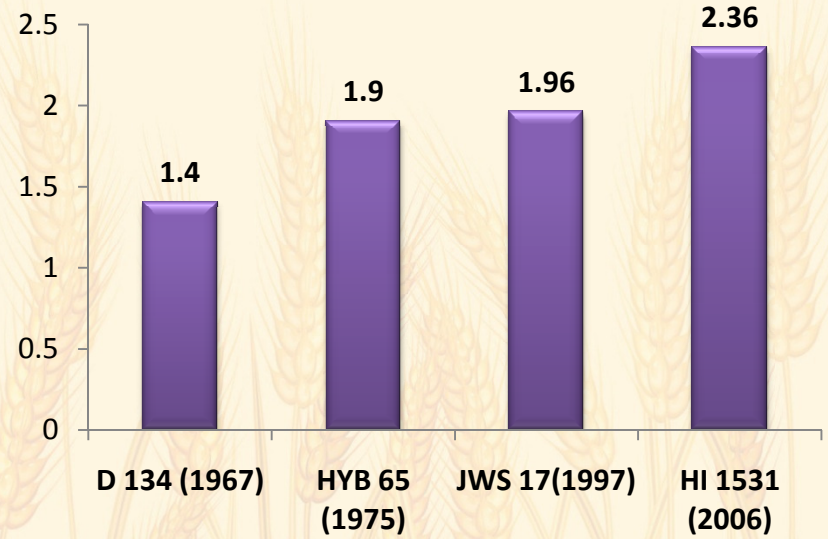


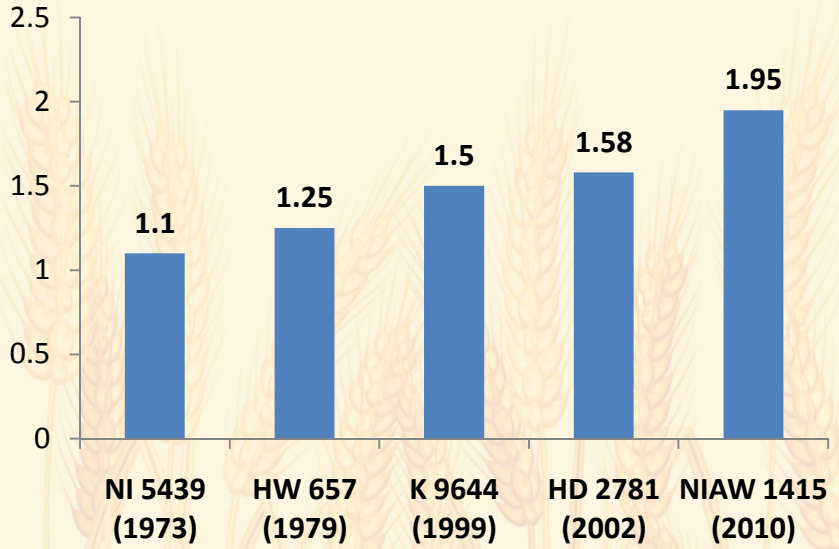


DWR

Timely sown rainfed







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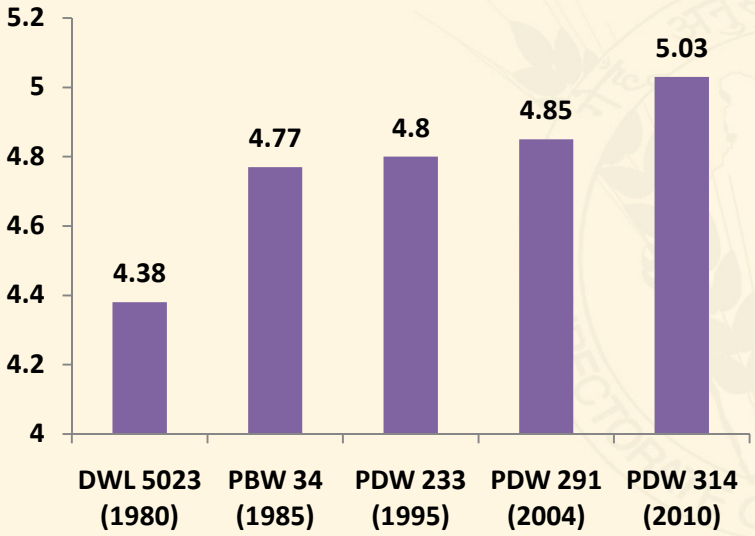
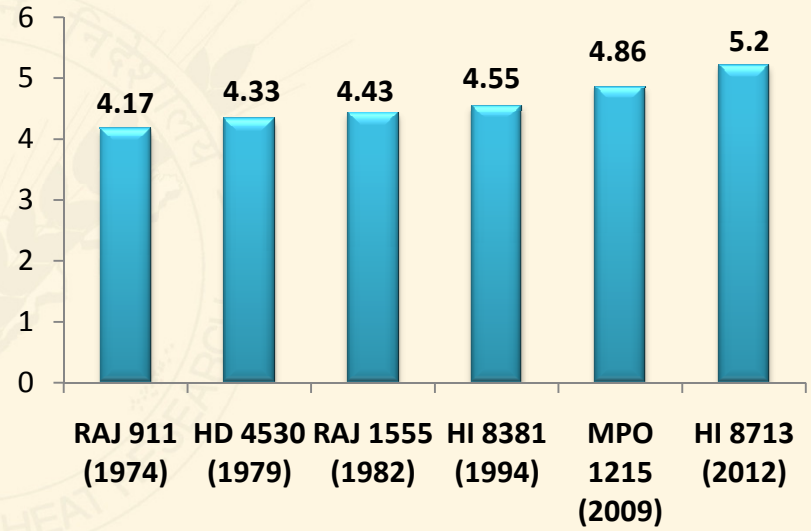
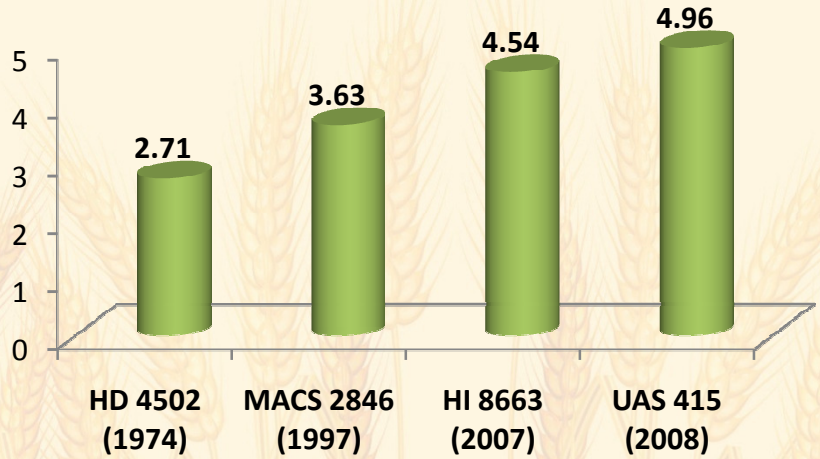
Durum wheat







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Area Coverage of Prominent Wheat Varieties

Period	Varieties #	Approx % Area	Prominent Varieties
1965-80	5	3.20	C 306 (1969), WH 147 (1978), UP 262 (1977), HD 2189 (1979), Sonalika (1965).
1981-90	11	11.80	Lok 1 (1981), HUW 234 (1983), GW 496 (1990), Raj 1482 (1982), Sujata (1984), WH 283 (1985).
1991-2000	28	29.60	PBW 343 (1996), UP 2338 (1995), PBW 443 (2000), Raj 3765 (1999), NW 1014 (1997), NW 1012 (1997)
2001-2014	70	55.40	PBW 550 (2008), GW 322 (2002), PBW 502 (2004), DBW 17 (2007), HD 2967 (2011), K 0307 (2007), WH 711 (2002), PBW 509 (2004)

Challenges ahead

- **Stagnating yield potential,**
- **Comparatively low seed replacement**
- **Climatic vulnerability**
- **Intensive and imbalance use of inputs & resources**
  - Deteriorating soil health and ground water
- **Changing pest and disease dynamics**
- **Decline in farm size & reduced profitability**
  - Reduced total factor productivity
- **Shift in consumption pattern**
- **Nutritional gaps**
- **Intellectual Property Rights**
- **Global pricing and subsidy policies**

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Constraints in wheat production

Biotic stresses

- **Rusts**
  - **Stripe**- More prevalent on north western parts and hills.
  - **Leaf** – All parts of the country
  - **Stem** – Central & Peninsular parts however infestation not observed or under control
- **Leaf Blight** - More prevalent in north eastern plains followed by peninsular, central and low in north western parts (15 mha)
- **Karnal bunt** – confined to northwestern plains
- **Powdery mildew** – Emerging problem in northwestern plains
- **Aphids and termites** - observed in pockets

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Constraints …….

Abiotic stresses

- Drought – Central, peninsular and northeastern parts – 3.5 to 4 mha
- Heat – Central, peninsular and northeastern parts
  - 3.5 mha northeastern plains
  - 3-4 mha central and peninsular parts
- Suppressive soils/Soil health
  - Salinity, alkalinity - 2.5 -3.0 mha in Northwestern plains, northeastern plains and Central parts
  - Nutrient deficient soils – 46 % Zn, 17 % B, 12 % Mo, 11 % Fe, 5 % Cu and 38% S
  - Waterlogging - 3.2mha in northwestern and northeastern plains

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Constraints …….

Weeds – broad and narrow leaved

- *Phalaris minor* and wild oats
- *Chenopodium*, *Rumex* sp., *Medicago* sp
- *Malva parviflora* –more in zero tillage

Phalaris minor is more prevalent in rice-wheat system as well as irrigated cotton wheat system occupying 9.0 mha area.

Other issues

- Timely availability of essential inputs
  - ~~Improved seed~~
  - Fertilizer availability
  - Irrigation water
  - Farm machinery
- Infrastructure improvement
  - Roads
  - Storage
  - Market

Required essentially for marketing of produce

- Extension of new technologies to farmers level
  - Improved varieties and production technologies

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Technological Innovations
&
Interventions needed

1. Breeding for Enhancing productivity

- Breaking yield barriers
  - Exploitation of heterosis for developing hybrids
  - Broadening genetic base of varieties - pre-breeding
- Breeding for Biotic & Abiotic Stress tolerance
  - Gene mining- Identification of new genes in Indian landraces and germplasm
  - Incorporating new genes for resistance against biotic and abiotic stresses
- Biotechnological interventions
  - Developing transgenics for abiotic stresses
  - Genomic selection and high throughput support for marker analysis including GBS (genotyping by sequencing) along with precision phenotyping
- Breeding for conservation agriculture
- Breeding for increased Water and nutrient efficiency
  - Enhance photosynthetic efficiency (C3-C4), root physiology
- Improving quality and nutritional aspects

Indian genotypes: Source for abiotic stress & quality

Drought and Early Heat	**Dharwar Dry** Job 66, Job 2028, RS 519, RS 628, Raj 3777, 21(S) AD, AKW 65-1, JOB 828, MP 3054, RS 488, RS 491, WT 245
Heat Tolerance	**C 306**, WJ 89, WH 730
Salinity /Alkalinity	**Kharchia local, Kharchia 65**, KRL 19, KRL 20, KRL3-4, KRL 13, KRL 22, KRL 28, KRL 32, KRL 35, KNS 57 Job 32, Job 33, Job 42, Job 43, Job 75, Job 89, Job 245, Job 666, Job 673, Job 666,K9006, K9351, K 9353, K 9507, MPJ 12, NW 1032, NW 1053, NW 1065, NW 1067, NW 1082, WR 814
Quality	**NP series of wheat varieties** **C 306** Pissi Local, Sujata K65, K68 **Nap Hal- double null trait for soft wheat- biscuits**

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2. Agronomical manipulations

Bed planting

Zero till

Surface residue

- Conventional and bed planting involves 10 to 12 tractor passes (3 harrows + 3 cultivator + 3 planking + drilling) zero tillage, rotary tillage and rotary disc drill involves single pass seeding
- Rotary disc drill is a machine which can also seed into sugarcane ratoon

Improving soil health by

- Addition of organic matter to soil through green manuring /crop residue recycling
- Balanced fertilisation
- Integrated nutrient and water management
- Diversification/ intensification of rice-wheat system by including pulses, oilseeds and vegetables crops

Need based N application using remote sensing based NDVI (Normalized difference vegetation index) for increasing NUE without yield penalty

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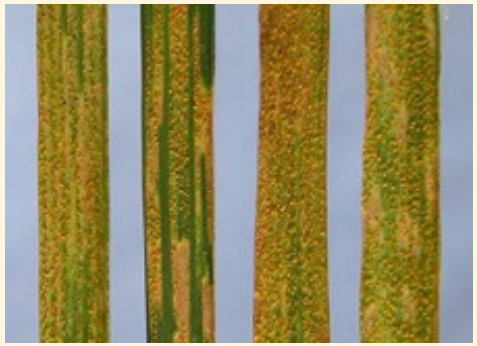
3. Disease management

- Vigilance against new virulences – crop health monitoring, forecasting, pathotype identification
- New molecules for chemical control of pathogens (rusts, foliar blight, powdery mildew, aphids, termites etc)
- Karnal bunt free wheat for export
- Creating national repository of pathotypes of different rust pathogens and integrating molecular tools for understanding variability in pathogens.
- Devise eco-friendly management of diseases and pests as well as to promote IPM.



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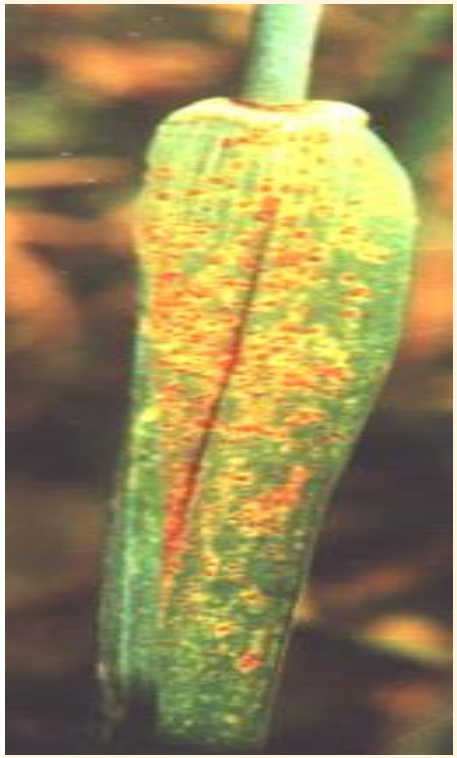

Sources for effective disease resistance genes

Leaf rust

Resistance gene	Source
Lr 24, Lr 28, Lr 32	HW series (NILs)
Lr 34	BW11, HS240
Lr 37	PBW 343 / Tc**Lr37*

Stripe rust

Resistance gene	Source
Yr 5	UP 2338/ Avocet *6 *Yr5*
Yr 10	WH542/Av *6 Moro
Yr 15	WH542/Av *6 *Yr15*
Yr 18	HS240, BW11

Powdery mildew

Gene	Source
Pm 8	WH542

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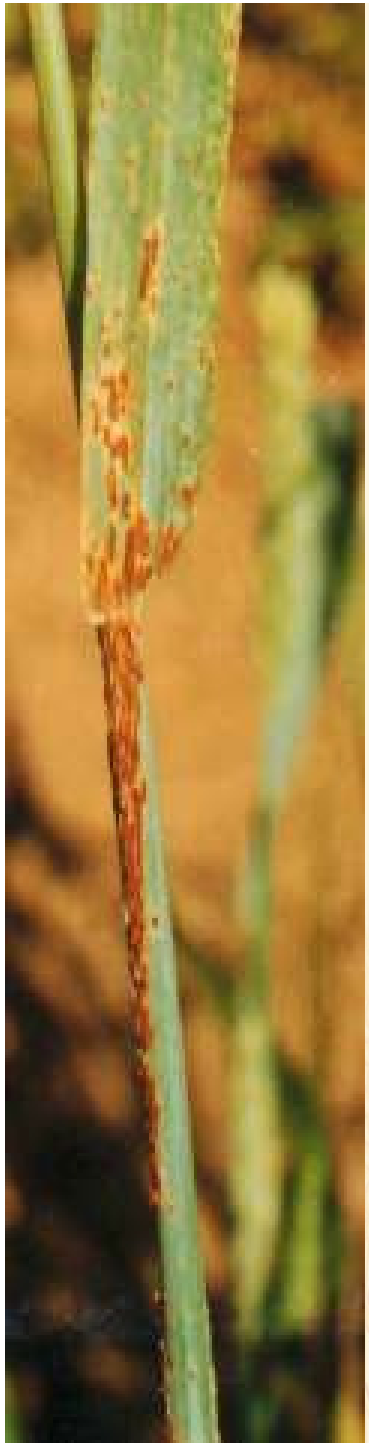

Combating stem rust resistance

- Stem rust occurs in the southern hills and the central peninsular zone, but is considered to be under control.
- More than ten Sr genes are (e.g. *Sr*2, *Sr*5, *Sr*7b, *Sr*8a, *Sr*8b, *Sr*9e, *Sr*24 and *Sr*31) available in Indian cultivars/breeding lines (AVTs)
- Though India's wheat crop is seen vulnerable to 'Ug99' **but it does not face any immediate threat from the disease.**
- Virulence on Sr31 (Ug99 type of pathotypes) were not identified anywhere in India, Bangladesh, Bhutan and Nepal i.e. **No Ug99 lineage races have been detected in India.**

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4. Quality improvement

- **Product specific varieties with enhanced nutritional quality**
  Chapati, biscuit, bread, noodles, macaroni and other pasta products
- **Understanding genetics of quality traits and their molecular basis**
  Gluten strength & noodle quality, dough & pasta colour, yellow pigment content, anti-nutritional factors & biosynthetic pathway to manipulate starch properties for improving quality and yield
- **Enhancing bio-availability of Fe & Zn and increasing antioxidant activities**

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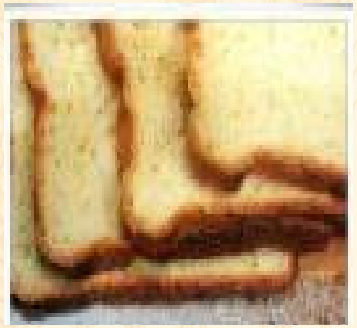
Traditional baked and pasta products from different species of wheat

Types of wheat	Products
Triticum aestivum	Chapati/Roti/Phulka, Tandori Roti, Rumali Roti, Naan, Kulcha, Bhattura, Pizza, Puri, Kachori, Samosa, Matthi, Namakpara, Papad, Parantha, Paysam, Balusai, Jalebi, Ghewar, Sattu, Noodles, Laddu etc. Bread, Biscuit, Cake, buns and pastry.
Triticum durum	Chapati, Parantha, Dhebra, Bhakri, Porridge (Salted & Sweet), Rawa Idli, Rawa Puttu, Khichidi and pasta products like macaroni, speghatti and Vermacelli.
Triticum dicoccum	Culadi Ki Laddu, Godi Huggi, Sweet Pan Cake, Madel and pasta products etc.

Promising Genotypes for Wheat Products

Product	Genotypes
Chapatti (>8.0/10.0)	GW 391, DH 2987, C 306, PBW 175, Raj 4120, K 0307, K 8027, HD 2888, Lok 1, GW 322, HI 1531, HW 2004
Bread (>575 ml loaf volume)	HD 2985, WH 1061, WH 1062, AKAW 4627, MACS 6222, MACS 6273, UAS 304, UAS 305, HP 1913, HD 2987, WH 1021, DBW 14, NW 2036, GW 173, HD 2864, HD 2932, MP 1203, NIAW 917, NIAW 34, Raj 4083, HI 977, NI 5439, HD 2781, PBW 596
Biscuit (>7.5 spread factor)	HS 502, HS 490
Pasta (>6.5/9.0)	PBW 311, PDW 314, UAS 419, DDW 12, GW 1245, PDW 233, WH 896, HD 4672.

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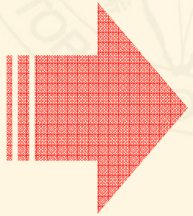
Conclusion
Green to Gene Revolution

- Adoption of modern varieties
- Improvement in yield potential – Norin genes, 1B/1R ….
- Increase in wheat area
- Improved policies
- International collaborations - CIMMYT



- Exploring new genetic variability
- Trait based breeding – gene discovery; allele mining
- Genomics & phenomics
- Hybrid wheat
- Durable disease & pest resistance
- GM wheat– abiotic & biotics stresses
- Genotype x system approach
- Conservation agriculture
- Increasing NUE, WUE and photosynthetic efficiency
- Better seed delivery
- Improving nutritional quality
- Multi-faceted collaborations

Carrying Forward Borlaug's Legacy

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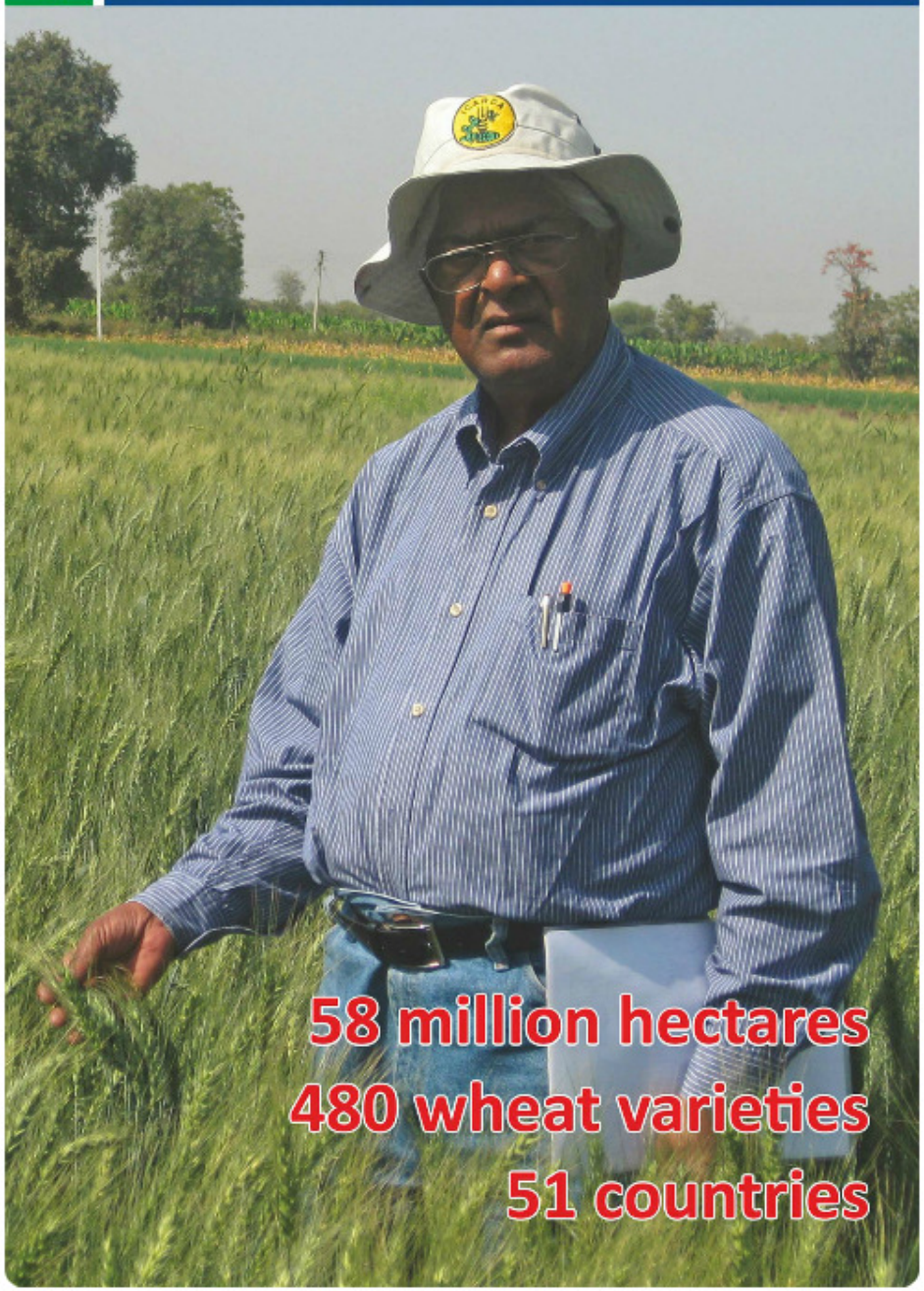
2014

The World Food Prize - Honoring Dr. Sanjaya Rajaram



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Thank You

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