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Tracking of Sorghum Improved Cultivars Adoption in India

By

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Outline of presentation

- **TRIVSA project progress at ICRISAT**
- **Specific case of Sorghum**
  - *Introduction*
  - *Objectives of the study*
  - *Area and Production growth in India*
  - *Results from tracking of sorghum improved cultivars*
  - *Conclusions and future implications*

Project coverage

- Broadly covering six crops in five South Asian Countries

- Crops covered : Rice (by IRRI)

  Sorghum, Pearlmillet, Groundnut, Pigeonpea and Chickpea (by ICRISAT)

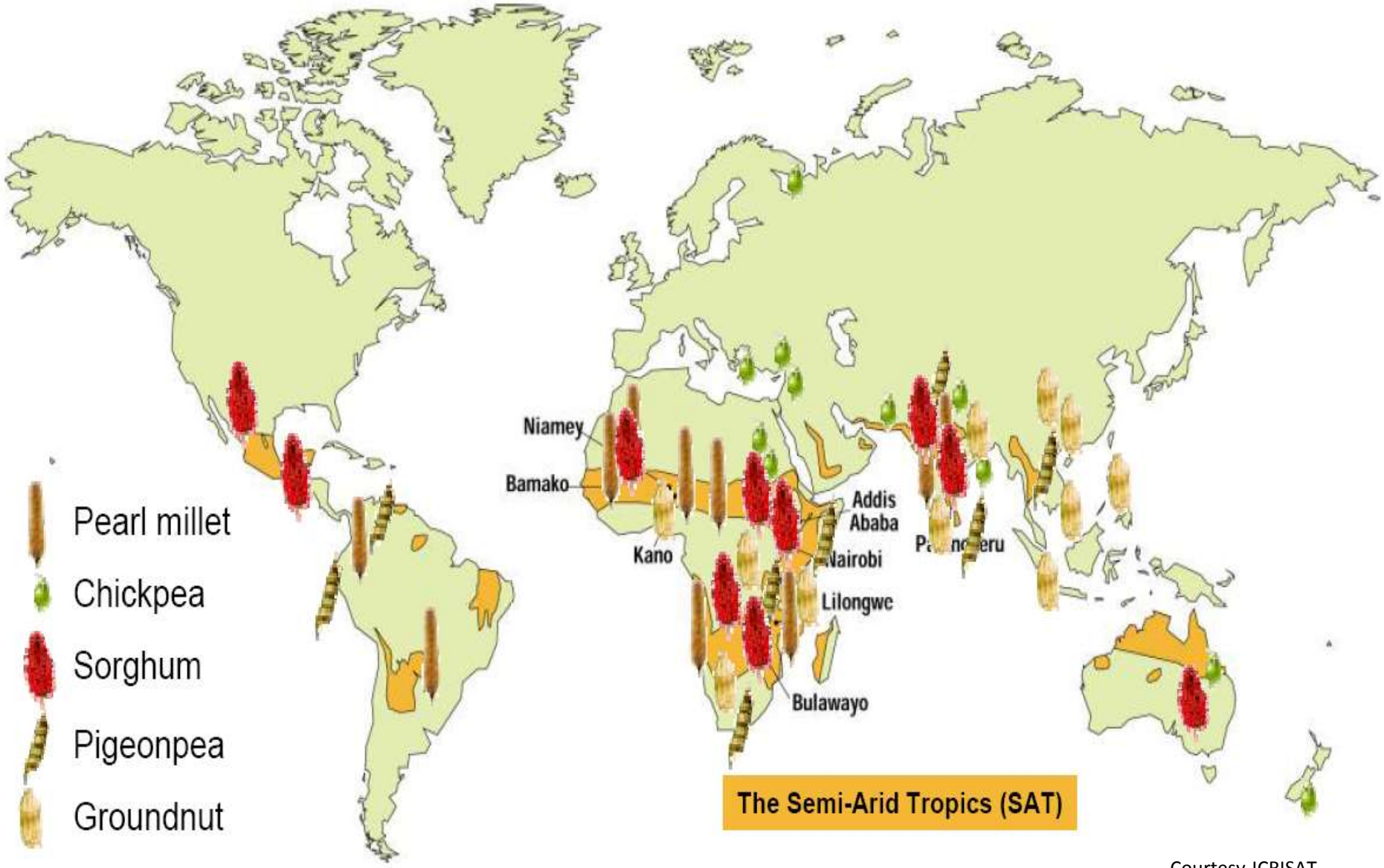
- Geographical coverage: India **(Top five major states per crop)**

  Bangladesh, Bhutan,

  Nepal and SriLanka







Courtesy-ICRISAT

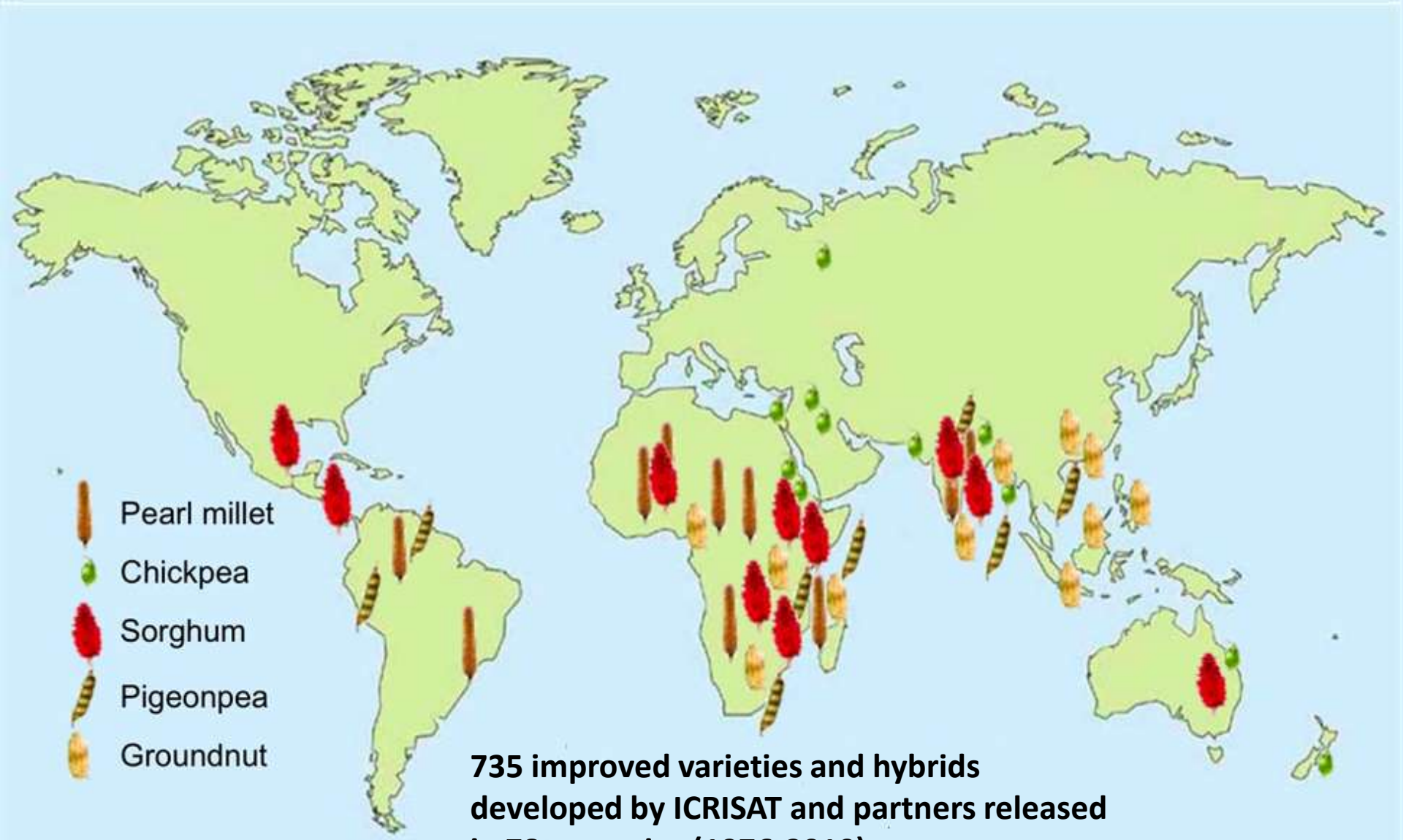
Project objectives

1. To attain a wider understanding of key aspects of the performance of food-crop genetic improvement in five ICRISAT mandate crops

Key activities :

- Documentation of modern varietal output - varietal database, materials transferred to NARS and private sectors
- Documentation of scientific strength of crop improvement – scientific strength database from personal records (IARC, public and private), scientific and human capital expenditures on crop improvement program
- Document the perceived adoption rate – Elicitation of experts opinion on adoption perceptions through a strategy and improved methods

ICRISAT's improved cultivars/hybrids



735 improved varieties and hybrids developed by ICRISAT and partners released in 78 countries (1976-2010)

Project objectives

2. To gain deeper understanding about the adoption and diffusion of new varieties for ICRISAT mandate crops

Key activities :

- A well representative household survey (including focus group meetings) will be designed to cover all five mandate crops in Maharashtra State

Primary survey intends to capture reliable estimates for adoption levels, data of first use and source of new variety, a paired trait comparison between new and replaced variety, perceived strengths and weaknesses, varietal demand and feed back to breeding process, seed supply constraints, institutional constraints, household characteristics and geo-referencing of locations etc.

Project progress at ICRISAT

- ICRISAT joined the project in Dec, 2010 (delay by six months)
- Finalized the work plans during Jan, 2011
- Recruited the support staff by March, 2011
- However, initiated the project work on fast-track by collaborating with NARS (ICAR and crop-specific AICRPs)
- ICRISAT using cost-effective and innovative methods in collecting data and delivering its best in the project
- Since ICRISAT is dealing with five mandate crops, the coverage of states and work load is high
- Nevertheless, ICRISAT is fairly at the end of objective-1 and initiated the objective-2 (primary survey) work in Maharashtra state

Summary of progress under Obj-1

Item	Sorghum	Pearlmillet	P.Pea	Chickpea	G.Nut
Cultivar database	√	√	√	√	√
NRS strength	√	√	√	√	√
R & D Expenditure	√	√	√	√	×
Elicitation -1	√	√	√	√	×
Elicitation-2	×	×	×	×	×
Obj-1 Report	√	√	√	×	×
Over all status	90%	90%	80%	70%	50%

G.nut scientist meet is scheduled during first week of November, 2011. So, the lagging part will be covered very soon. In case other crops, the second part of elicitations will be completed in Oct and Nov, 2011

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Tracking of Sorghum Improved Cultivars Adoption in India - Initial results

Introduction

- Sorghum is the major staple crop for the world's poorest and most food-insecure people across SAT
- It is fifth most important cereal crop in the world, where as in India, it is third cereal crop after rice and wheat
- It is often recommended option for farmers operating in harsh environment where other crops do poorly (400 to 500 mm rainfall)
- It is grown for a variety of uses (food, feed, fuel, alcohol and poultry etc.) in India as well as in the world
- NARS (1960s), ICRISAT (1972) and Private (late 1980s) seed companies are the major stakeholders in the crop improvement

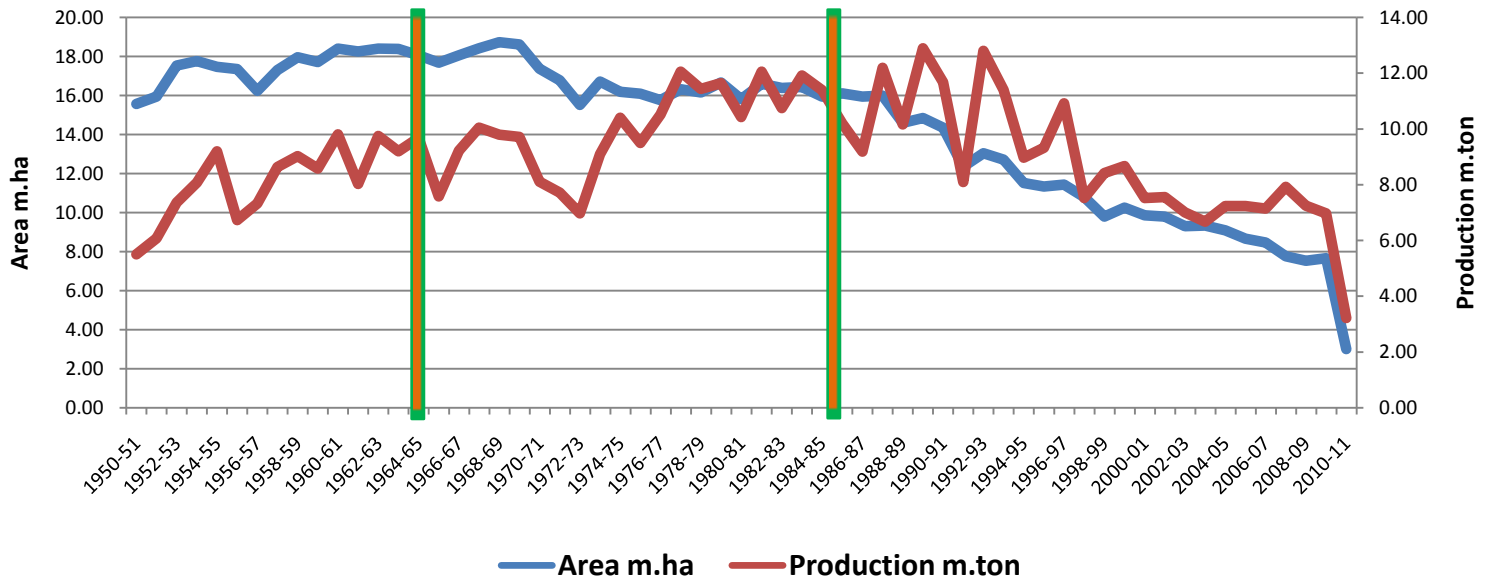
Objectives of the study

Realizing the importance of the crop, the paper made an attempt to understand the following issues :

- *History of crop sorghum improvement, 1960-2010*
- *Strategies adopted by different stakeholders*
- *Development of sorghum improved cultivars*
- *Patterns of diffusion in different states/districts*
- *Scanty or lack of reliable information on crop varietal adoption*
- *Very little statistically valid information is available on the extent of adoption at national and sub-national levels*

Production and growth in India

- The total area is declining, but post-independence period witnessed increase in production due to increase in yields
- Since 1986, the production trend was reversed
- The area has declined from 16 m.ha (in 1950) to 7.67 m.ha by 2010 (5 % of India's GCA)
- It is further complicated by a major shift in production, from the rainy season (kharif) to the post-rainy (rabi) season (peculiar in India)

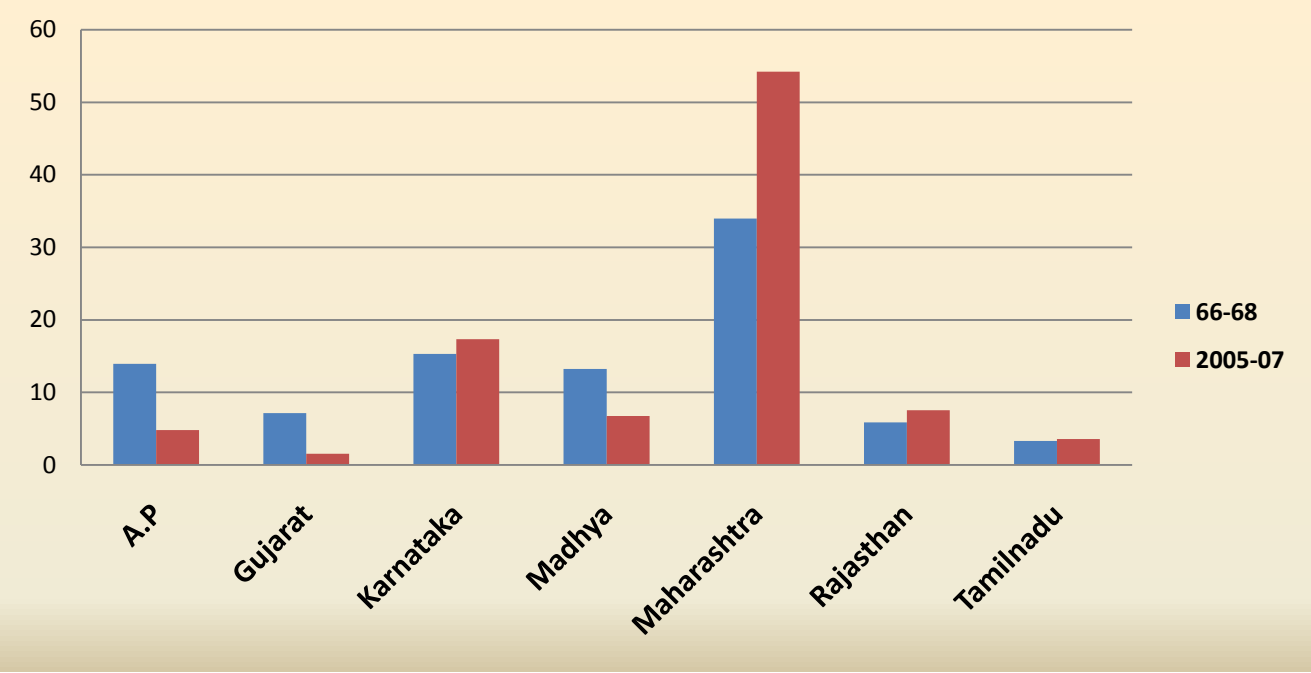


Area and production growth trends

Period	Kharif area	Kharif production	Rabi area	Rabi production	Total area	Total production
1980-85	-1.72	0.52	3.09	4.42	0.06	1.67
1985-90	-2.52	5.80	-2.42	6.07	-2.48	5.88
1990-95	-7.99	-4.44	1.27	3.92	-4.05	-1.84
1995-00	-4.49	-5.85	-2.52	-1.23	-3.48	-3.96
2000-05	-3.38	-1.04	-0.89	-4.34	-2.08	-1.98
2005-09	-8.12	-7.34	-1.68	6.10	-4.33	0.54
1980-2009	-4.44	-3.22	-1.14	0.13	-2.89	-1.95

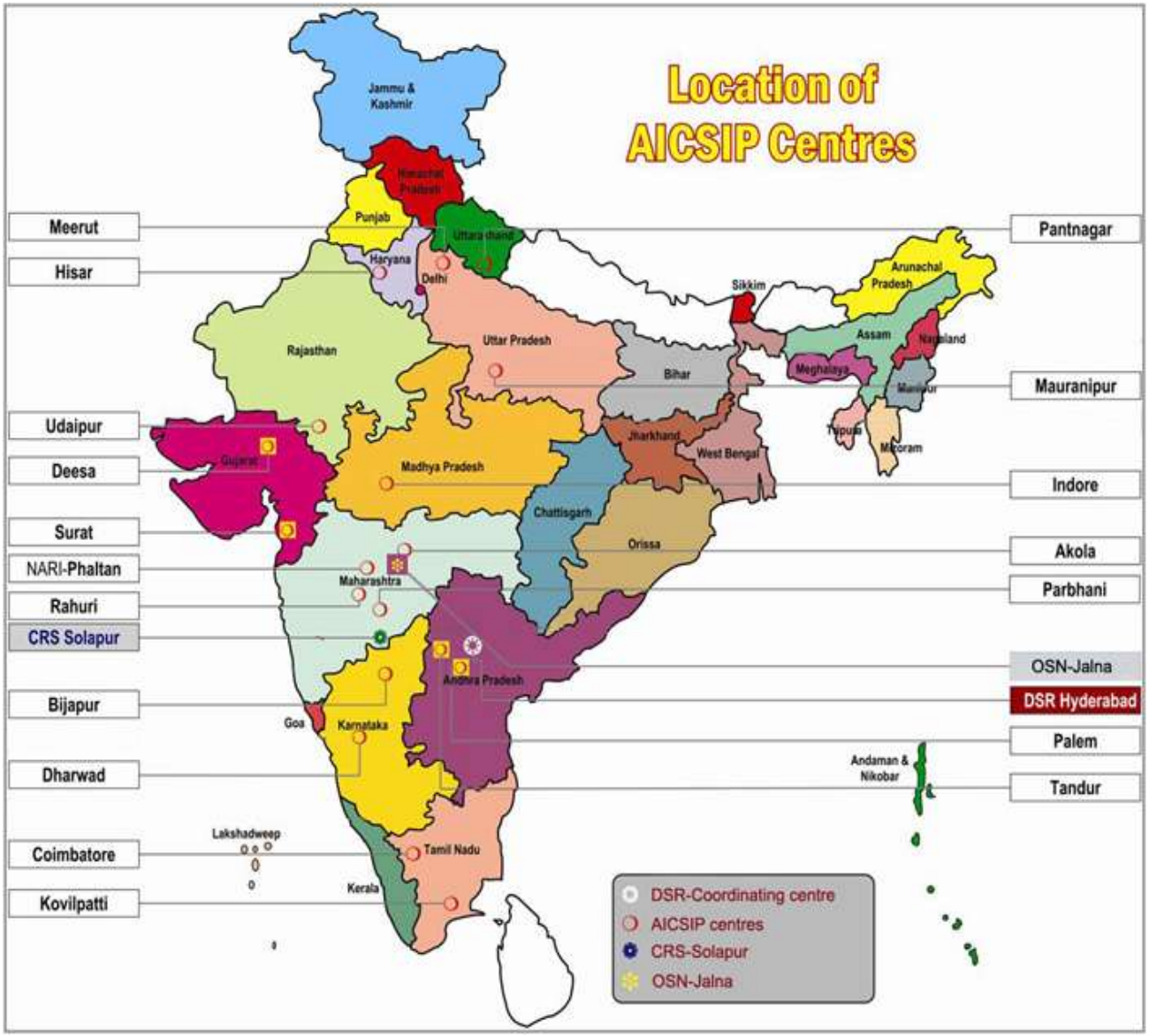
- Changing consumer preferences towards wheat and rice from coarse grains reduced the demand (especially rainy season)
- Diversification due to availability of irrigation, improved cultivars in other crops, fetching attractive and remunerative prices compared to sorghum
- Poor grain quality due to rains in rainy season crop
- Rainy season production has decreased despite successful crop improvement efforts

Sorghum performance across states



- Sorghum area has increased significantly in Maharashtra (59%) followed by Karnataka (14%)
- The highest productivity was observed in A.P followed by Gujarat, Madhya Pradesh and Karnataka

Organization of NARS research



Centre-wise research thrust

State	Center	SAU Name	Major constraint dealt with	Major product types
Tamil Nadu	Coimbatore	TNAU	Diseases, drought	Dual purpose and forage
	Kovilpatti	TNAU	Insects, esp. of panicle	Dual purpose and sweet & forage
Karnataka	Dharwad	UAS	Insects, foliar diseases, mold	Hybrids and varieties, dual purpose
	Bijapur	UAS	Shoot fly, charcoal rot, drought	Rabi hybrids and varieties
Andhra Pradesh	Palem	ANGRAU	Insects, mold	Dual purpose, forage
	Tandur	ANGRAU	Rabi adaptation	Varieties
	Warangal	DSR	Borer, storage pests	Forage
Maharashtra	Parbhani	MAU	Mold, shoot fly, borer, shoot bug	Hybrid and verities, sweet stalk
	Rahuri	MPKV	Shoot fly, char-coal rot, Food quality	Hybrid, variety, sweet sorghum, forage
	Akola	PDKV	Shoot fly, borer, mold	Hybrids and varieties
Gujarat	Surat	NAU	Shoot fly, borer, panicle pests and mold	Dual purpose and forages
	Deesa	SDAU	Shoot fly, borer, foliar diseases	Forages single- and multicut
Madhya Pradesh	Indore	JNKVV	Shoot fly, borer, leaf diseases	Hybrids and varieties
Rajasthan	Udaipur	MPUAT	Shoot fly, borer, leaf diseases	Dual-purpose varieties, single-cut forage
Uttar Pradesh	Mauranipur	CAUAT	Shoot fly, borer, leaf diseases	Dual purpose varieties, single-cut forage
Haryana	Hisar	CCSHAU	Stem borer	Forage, single-and multi-cut
Uttarakhand	Pantnagar	GBPUAT	Borer, leaf diseases	Forage, single- and multi-cut

NARS crop improvement strategies

Characteristics	Zones	Purpose	Major states covered
Kharif sorghum			
	Zone I	Mainly dual purpose	Coimbatore (TN), Kovilpatti (TN) Palem (AP)
	Zone II	Mainly hybrids	Dharwad (KAR), Parbhani (MAH), Akola (MAH), Indore (MP), Surat (GUJ)
	Zone III	Forage/dual purpose	Udaipur (RJ), Deesa (GUJ), Hisar (HR), Pantnagar (UK),Meerut (UP), Mauranipur (UP)
Rabi sorghum	-	Grain type	Tandur (AP), Bijapur (KAR), Rahuri (MAH)
Sweet sorghum	-	High sugar hybrids	Rahuri, Parbhani, Akola, Coimbatore and Phaltan
Forage sorghum	-	Forage/dual purpose	North zone (mainly fodder purpose) South zone (mainly grain and dual purpose)

- Recently NARS have developed a new scheme of national zonation research focus for crop improvement
- So far, hybrid breeding targeted to rainy season only (till late 1990s), unsuccessful in developing post-rainy season hybrids
- Area under improved cultivars was much higher in rainy season but in post-rainy season it was low

ICRISAT strategies

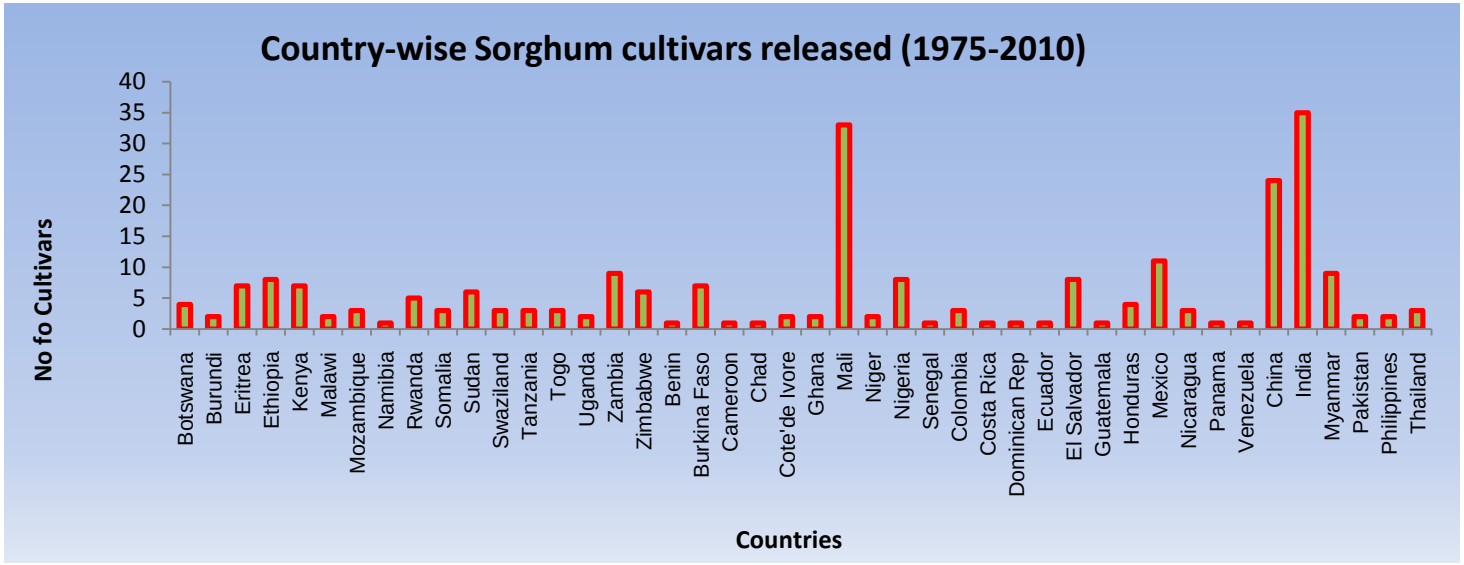
ICRISAT involves both in pre-breeding (mainly through germplasm conservation) and breeding strategies :

- **Phase 1:** Breeding for wide adaptability and higher grain yield (1972-75)
- **Phase 2:** Breeding for wide adaptability and screening techniques (1976-79)
- **Phase 3:** Regional adaptations and resistance breeding (1980-1984)
- **Phase 4:** Specific adaptation and resistance breeding (1985-1989)
- **Phase 5:** Trait-based breeding and sustainable productivity (1990-1994)
- **Phase 6:** Intermediate products and upstream research(1995 to present)

HPRC (2000) is an initiative with increasing scope of accessibility to better hybrids by poor farmers through effective public-private partnerships. Nearly 35 seed companies including MNCs are members in the program. Around 70 hybrids which are in field today, 54 are produced from ICRISAT based parental lines or their derivatives.

ICRISAT sorghum releases globally

Years	Africa	America	Asia	Total	India	Other Asia
1975-80	9	4	3	16	1	2
1981-85	5	7	10	22	1	9
1986-90	31	11	6	48	5	1
1991-95	28	9	19	56	9	10
1996-2000	24	4	14	42	7	7
2001-05	21	0	11	32	3	8
2006-10	14	0	12	26	9	3
Total	132	35	75	242	35	40

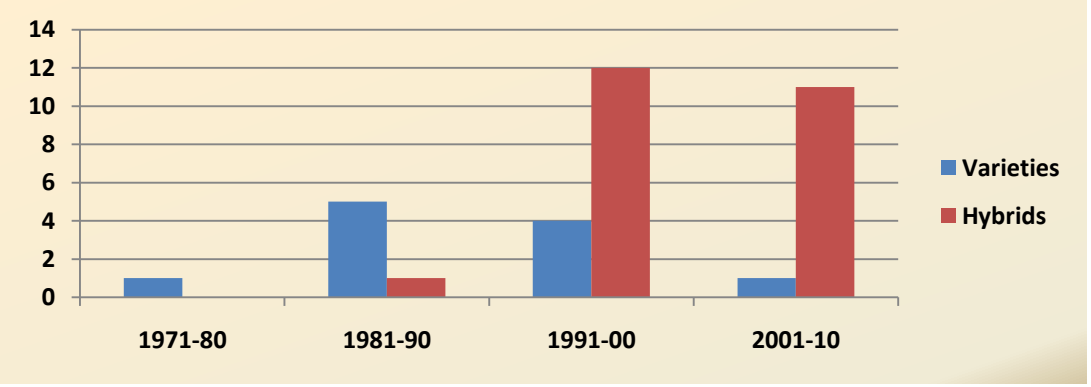


Development of improved cultivars

Released period	ICRISAT (1975-2010)	NARS releases (1964-2010)		
		ICAR*	Other notified varieties**	Total
1961-70	Nr	5	7	12
1971-80	1	12	48	60
1981-90	6	10	49	59
1991-00	16	12	64	76
2001-05	3	7	22	29
2006-10	9	4	18	22
Total	35	50	208	258

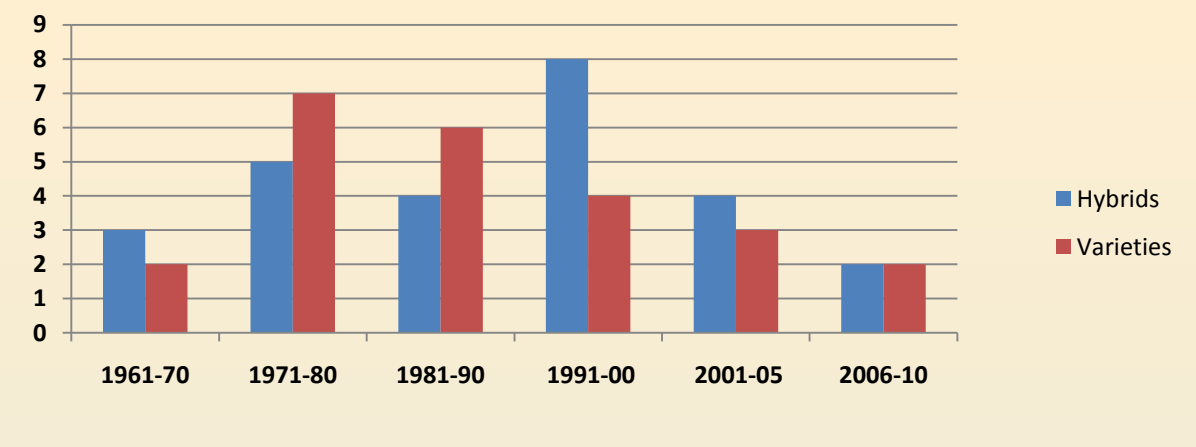
*only hybrids and varieties ** Includes state releases and SAU's

ICRISAT releases in India from 1975-2010

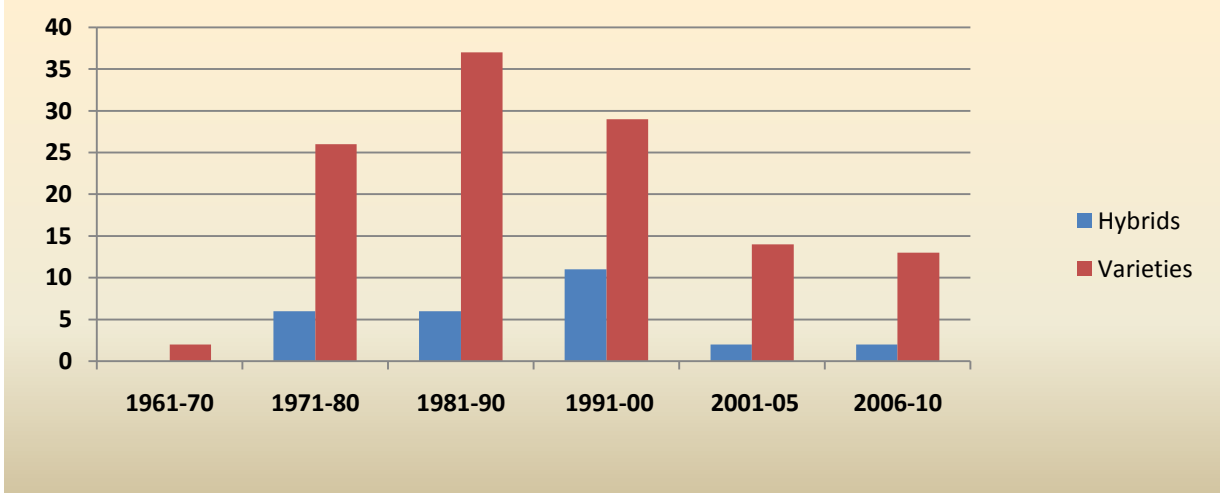


Pattern of NARS releases

Pattern of ICAR National releases in India, 1964-2010



Pattern of state releases including SAUs, 1964-2010



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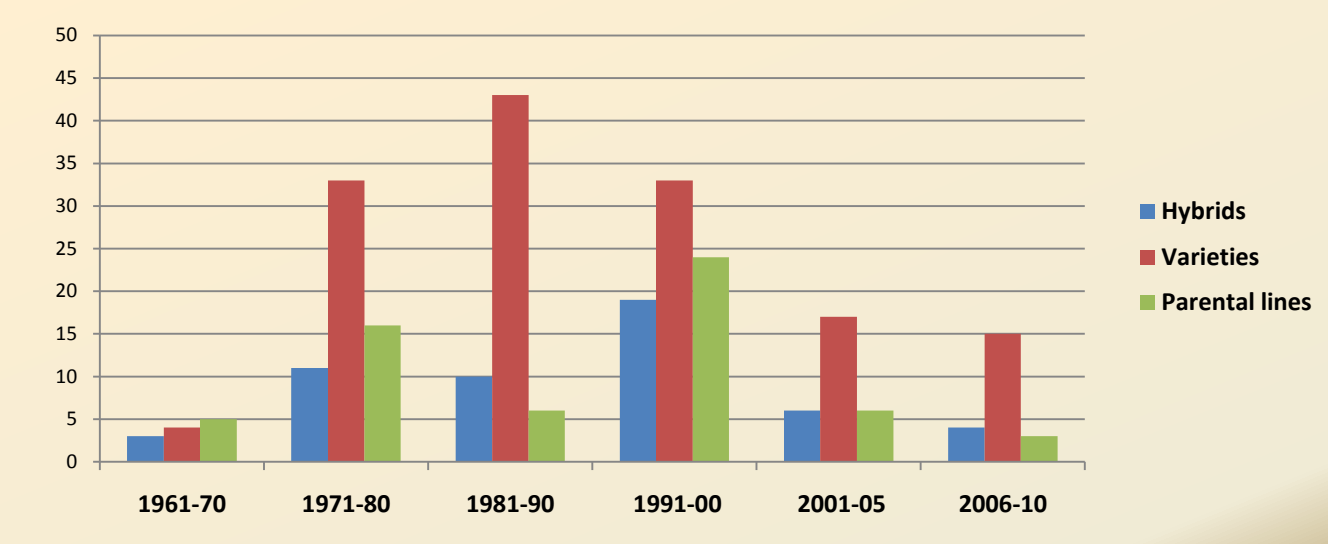
Contd.,

Decadal-wise total notified cultivars, 1964-2010



Variability in crop releases

Variability in annual varietal releases of sorghum in India, 1964-2010

Institutions	Mean annual release rate	Years with zero releases	Standard deviation of releases	Coefficient of variation
ICRISAT (1975-2010)	1.00	20	1.89	189
ICAR* (1964-2010)	1.09	19	1.36	125
Other notified **(1964-2010)	3.22	6	2.54	79
NARS (1964-2010)	4.30	2	2.80	65
India (1964-2010)#	5.07	2	3.76	74

*** includes Hybrids and varieties ** includes state releases and SAU's**
 # NARS and ICRISAT releases together

NARS strength (FTE) on crop improvement

Discipline	Actual staff			FTE
	DSR**	AICSIP	Total	
Agronomist	8	24	32	26.24
Plant breeder	22	52	74	60.68
Entomologist	10	19	29	23.78
Pathologist	7	18	25	20.50
Physiologist	4	10	14	11.48
Genetic resource specialist	4	4	8	6.56
Social scientist	4	0	4	3.28
Bio chemistry	3	2	5	4.10
Post harvest/ food technology	1	2	3	2.46
Molecular biology	1	1	2	1.64
Seed technology	3	2	5	4.10
Soil science	1	2	3	2.46
Genetics / cytogenetics	5	2	7	5.74
Eco botany	1	0	1	0.82
Computer application	1	0	1	0.82
Bio technology	4	2	6	4.92
Total	79	140	219	179.58

NARS R&D expenditures

Full time equivalent scientific staff by educational degree, 2010

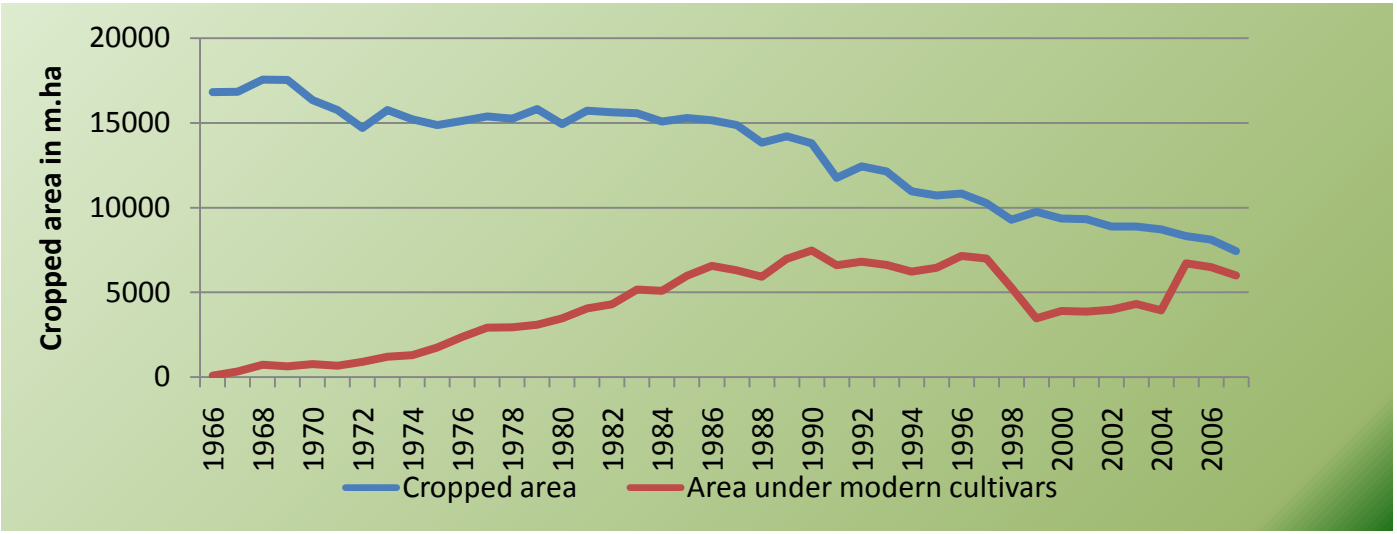
Institution	PhD	MSc	BSc	Total
AICSIP	46.7	4.9	63.1	114.8
DSR	30.3	2.5	32.0	64.8
Total NARS	77.08	7.38	95.12	179.58

Research expenditure over the last four years (Rs lakhs)

Year	DSR	AICSIP	Total	Allocation per scientist FTE*	Sorghum Production (lakh tons)	Research cost per ton (Rs)
2007-08	689.00	416.85	1105.85	13.8	79.0	14.0
2008-09	1103.10	755.29	1858.39	23.1	72.0	25.7
2009-10	1683.00	633.55	2316.55	28.8	69.8	33.2
2010-11	1374.00	659.89	2033.89	25.3	N.A	N.A

* Considered scientist FTE

Diffusion of improved cultivars



Diffusion of improved cultivars in major states (per cent area)

State	1966-68	1976-78	1986-88	1996-98(P1)	2006-08(P2)	P2 over P1 %
Maharashtra	2	22	59	87	94	8.0
Karnataka	1	24	24	31	75	141.9
Andhra Pradesh	1	11	35	68	31	-54.4
Madhya Pradesh	1	18	48	71	85	19.7
Rajasthan	0	1	4	10	29	190.0
Gujarat	0	3	25	33	47	42.4
Tamil Nadu	2	13	40	63	82	30.1
All India	1	18	43	67	80	19.4

District-wise adoption patterns, 1977-07

States	Per cent total sorghum area under improved cultivars			
	< = 25 %	26-50 %	51-75 %	76-100 %
	1977-79			
Andhra Pradesh (18)	17	1	0	0
Gujarat (16)	14	2	0	0
Karnataka (13)	5	4	4	0
Madhya Pradesh (34)	24	8	2	0
Maharashtra (21)	8	9	3	1
Rajasthan (22)	22	0	0	0
Tamil Nadu (8)	5	2	1	0
All India (132)	95	26	10	1
	1991-93			
Andhra Pradesh (18)	0	8	6	4
Gujarat (16)	6	7	2	1
Karnataka (13)	2	5	5	1
Madhya Pradesh (34)	12	3	12	7
Maharashtra (21)	1	2	4	14
Rajasthan (22)	20	1	0	1
Tamil Nadu (8)	0	3	3	2
All India (132)	41	29	32	30
	2005-2007			
Andhra Pradesh (18)	5	5	6	2
Gujarat (16)	5	6	3	2
Karnataka (13)	2	2	3	6
Madhya Pradesh (34)	12	5	5	12
Maharashtra (21)	0	0	0	21
Rajasthan (22)	15	1	2	4
Tamil Nadu (8)	0	0	0	8
All India (132)	39	19	19	55

EC and cultivar specific adoption estimates

- Two rounds of expert elicitations (EC) were planned under each crop
- Based on the knowledge and skills, information was collected either at regional or state level
- **EC advantages**: rapid, low-cost, less-time consuming and reliable provided the group has good knowledge
- **EC disadvantages**: lack of good comprehension about the farm-level adoption, insufficient information about cultivars, biasness in the judgments and poor knowledge about seed chains etc.
- In general, results obtained from expert elicitations are comparable with secondary sources of information

Conclusions

- ✓ The cropped area has declined appreciably (48%) from 1960s to date
- ✓ NARS, ICRISAT and Private seed companies are major players in crop improvement in the last fifty years
- ✓ Around 293 cultivars were notified and made available to farmers
- ✓ The analysis has concluded that nearly 80 per cent of cropped area is under improved cultivars
- ✓ Adoption of improved cultivars increased the productivity levels up to 71 per cent between 1960 and 2010
- ✓ The findings aptly justify the role of improved cultivars in sustaining the higher yields and reducing yield variability

Implications for future research

- In addition to the biotic and abiotic challenges, presumed climate change also affects sorghum area and its importance globally
- Climate change will modify length of growing period and increases the predicted temperatures across different regions
- More thrust is needed on development of drought resistant and heat tolerant varieties using modern bio-technology tools
- Emphasis should also given on development of post-rainy season cultivars and its adoption
- Development of high yielding sweet stalks and increasing the density of grain micro-nutrient traits are other emerging areas of interest

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