Advances in Crop Improvement of small millets

AICSMIP

All India Coordinated Small Millets Improvement Project
Project Coordinating Unit
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Finger millet

Foxtail millet

Kodo millet

Little millet

Barnyard millet

Proso millet

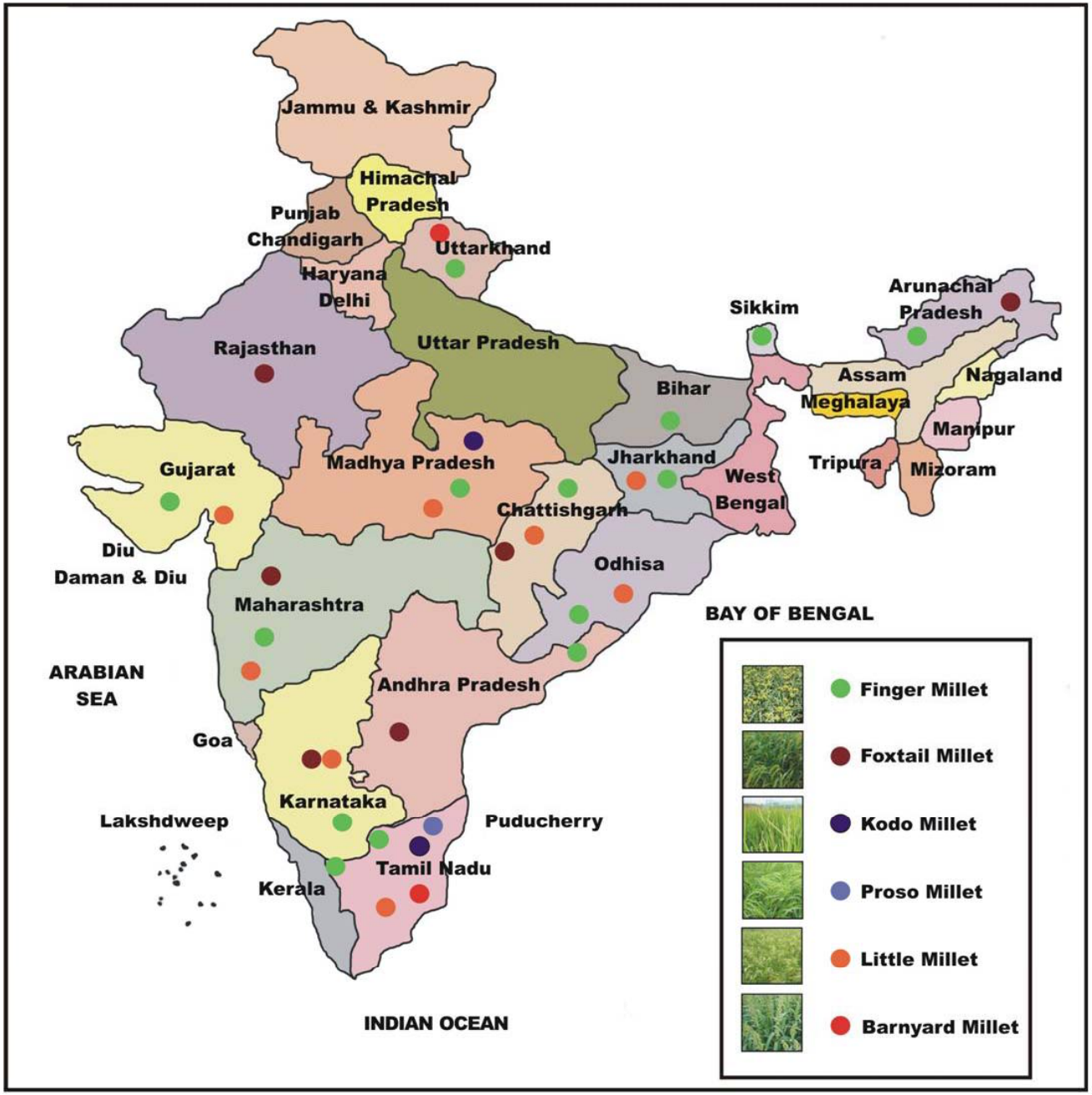
SMALL MILLETS

- Crops of antiquity-traditional cropping systems,
- Ethnic foods & diversity,
- Suitable for dry lands & important in hill and tribal agriculture,
- Food & Fodder security of disadvantaged regions,
- Require less water, mature early and cultivated in scarcity conditions,
- Highly Resilient in adapting to different ecological conditions,
- Ideal crops for climate change and contingency plantings,
- Unique nutritional properties –
  - high fiber,
  - quality protein &
  - mineral composition
- Nutritional security of disadvantaged groups.

SMALL MILLETS

Sl.No.	Common name	Vernacular names	Scientific name	Chromo. no.	Place of domestication
1.	Finger millet	Ragi, mandua, Nagli, Kapai, Madua	Eleusine coracana L. Gaertn.	2n=36 (4x)	Ethiopia, African high lands
2.	Foxtail millet	Kangni, Korra, Navane, Tenai, Rala	Setaria italica L. P. Beauv.	2n=18 (2x)	Central Asia, India
3.	Kodo millet	Kodo, Varagu, Haraka, Arikalu	Paspalum scrobiculatum L.	2n=40 (4x)	India
4.	Little millet	Kutki, Samai, Same, Samalu, Vari, Gundli.	Panicum sumatrense Roth.	2n=36 (4x)	India
5.	Proso millet	Cheena, Panivaragu, Variga, Baragu	Panicum miliaceum L.	2n=36 (4x)	Central Asia, India
6.	Indian Barnyard millet	Madira, Sawan, Kuduraivali, Oodalu, Ooda	Echinochloa frumentacea Link.	2n=54 (6x)	India
7.	Japanese Barnyard millet	Madira, Sawan, Kuduraivali, Oodalu, Ooda	Echinochloa utilis ohwi et yabuno.	2n=54 (6x)	East Asia
8.	Korne	Korle	Brachiaria ramosa (L.). Stapf		India

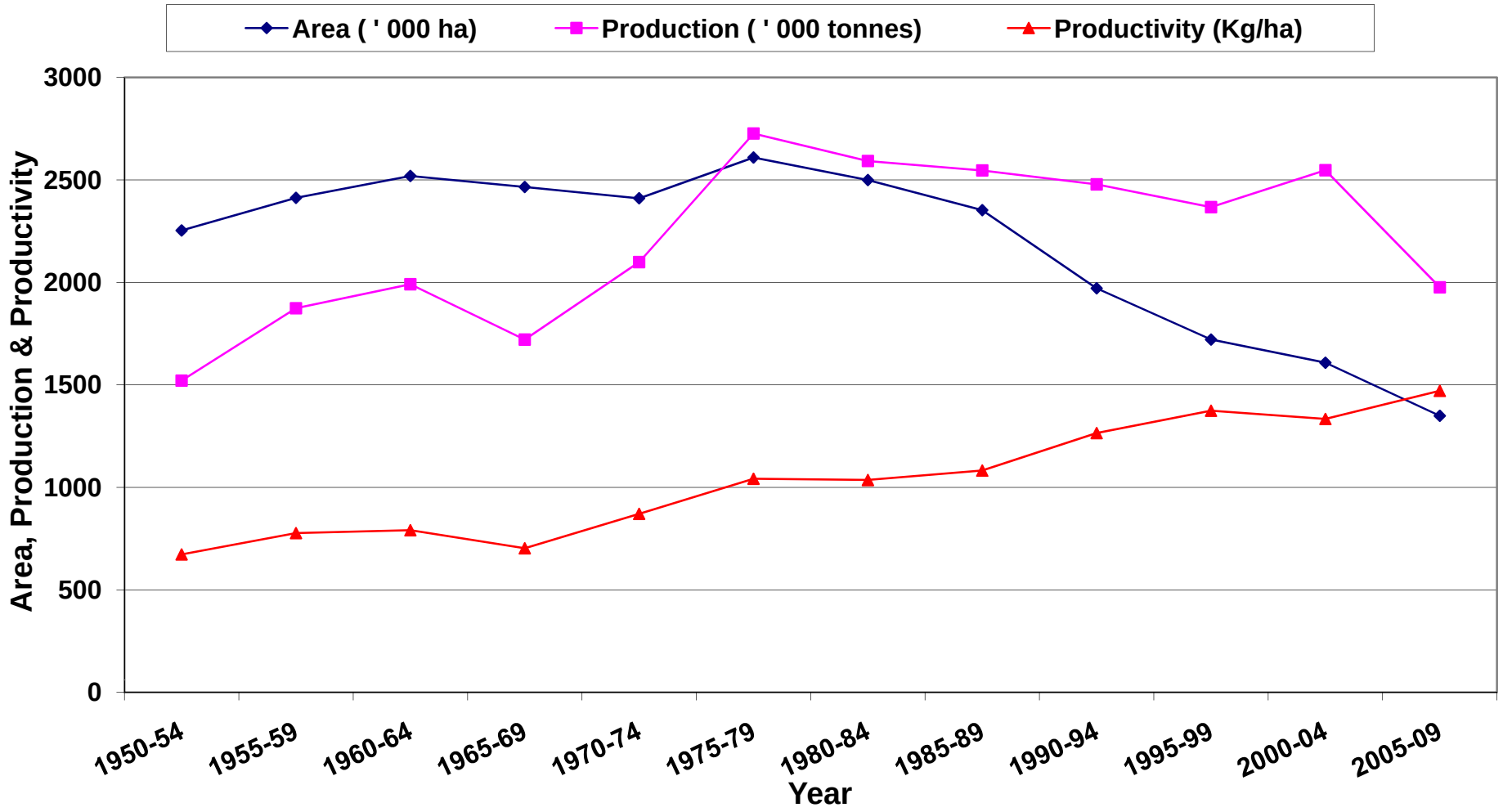
Distribution of small millets in India



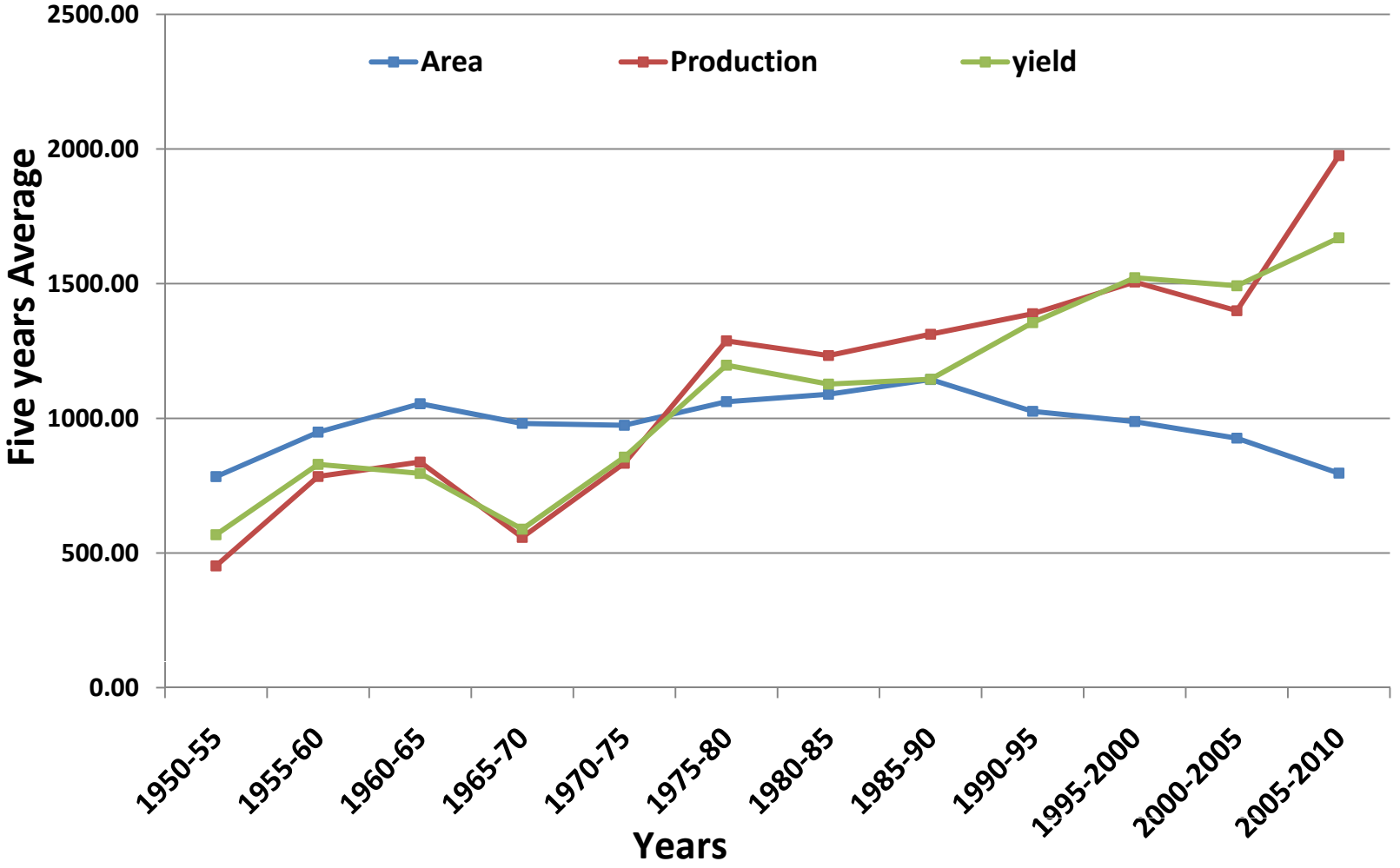
Area, production and productivity of small millets in India

Year	Finger millet			Small millets		
	Area ('000 ha)	Production ('000 t)	Productivity (kg ha^{-1})	Area ('000 ha)	Production ('000 t)	Productivity (kg ha^{-1})
1951-55	2274	1605	704	5290	2177	410
1956-60	2454	1873	764	5022	1955	389
1961-65	2555	1888	743	4677	1889	404
1966-70	2420	1887	779	4741	1784	376
1971-75	2442	2227	909	4489	1745	388
1976-80	2588	2650	1021	4326	1743	402
1981-85	2474	2612	1054	3459	1391	401
1986-90	2306	2510	1088	2754	1198	437
1991-95	1891	2511	1331	1950	851	439
1996-00	1718	2413	1402	1492	738	435
2001-05	1563	2088	1331	1173	510	435
2006-10	1350	1976	1471	970	467	480

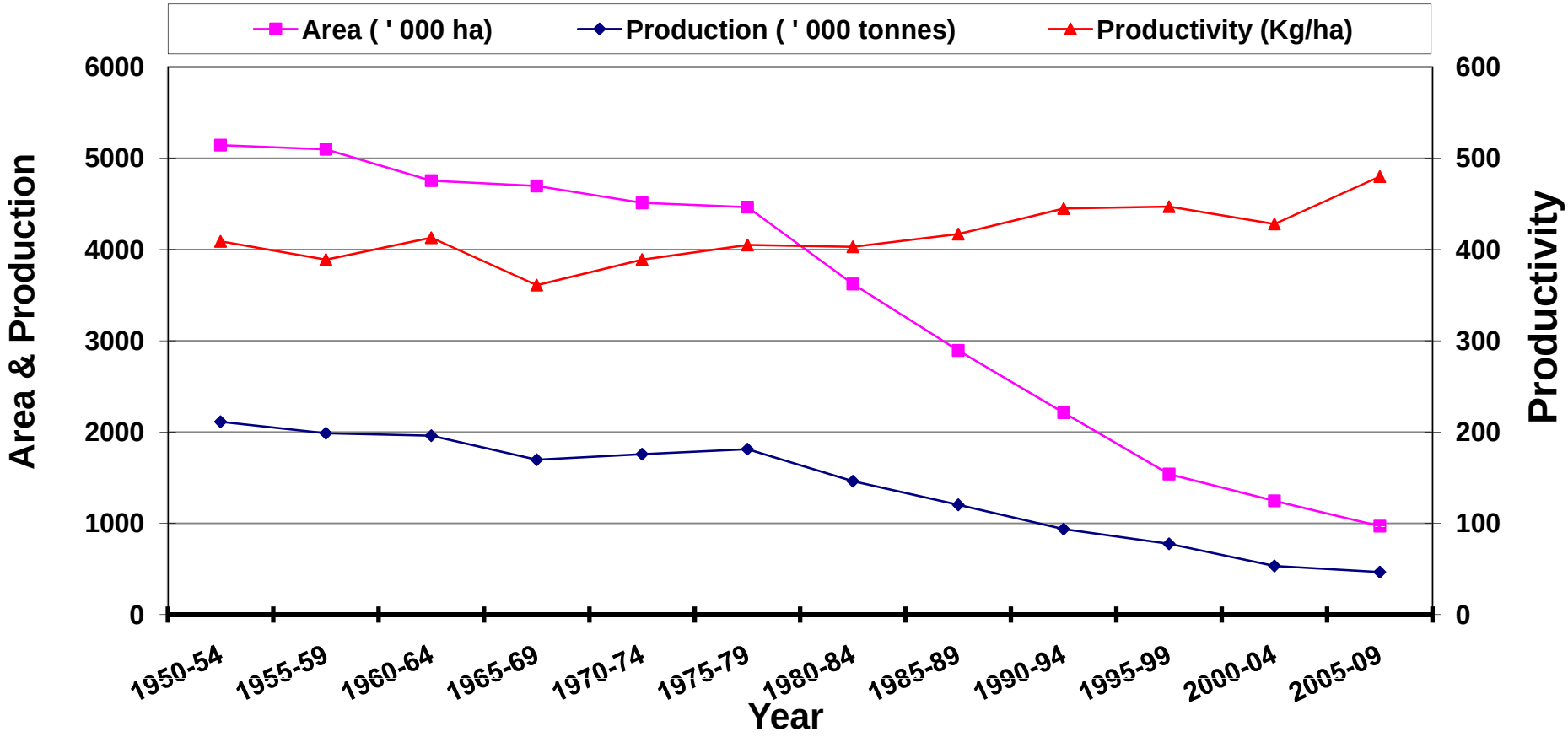
AVERAGE AREA , PRODUCTION & PRODUCTIVITY OF FINGER MILLET IN INDIA (1950-51 TO 2009-10)

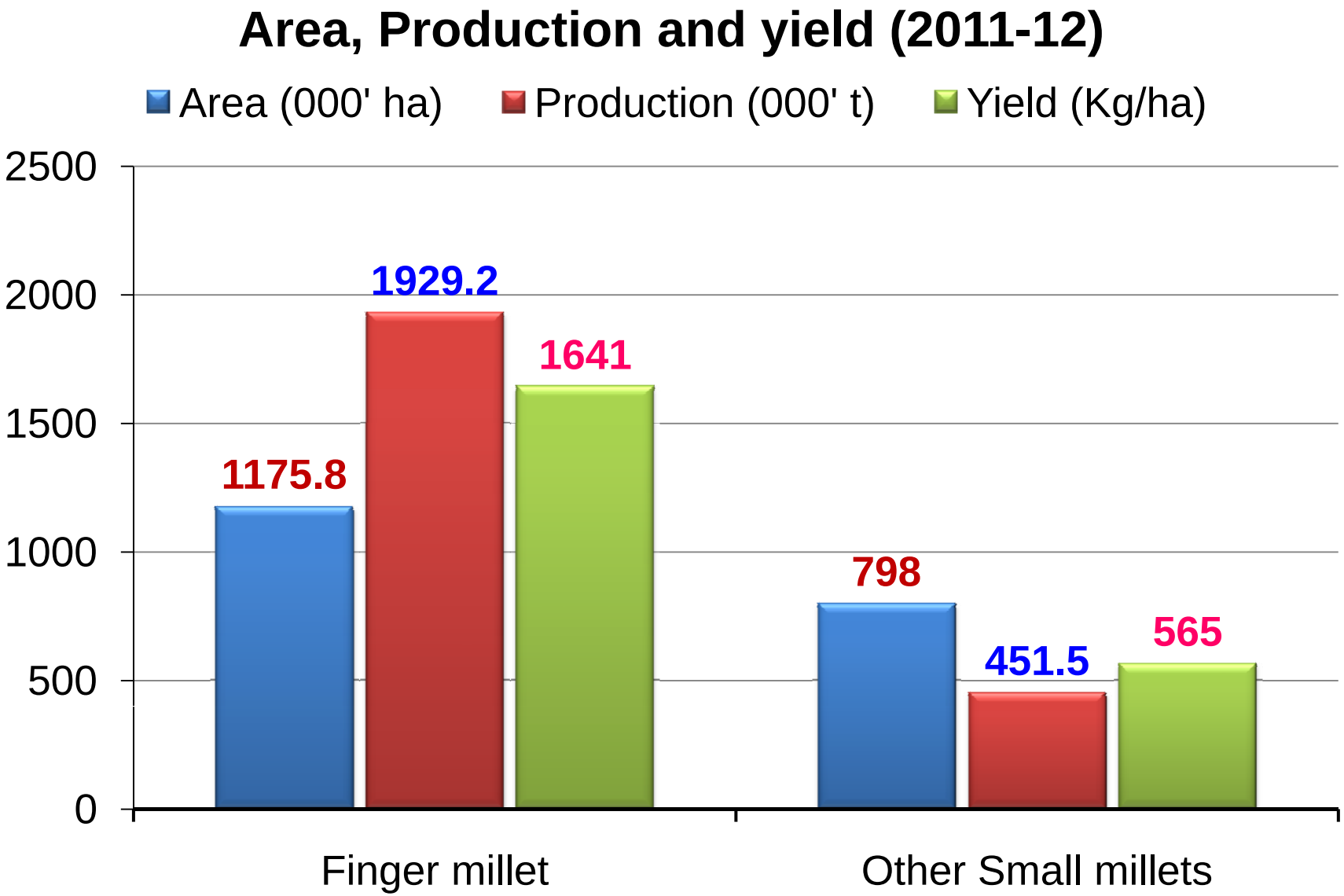


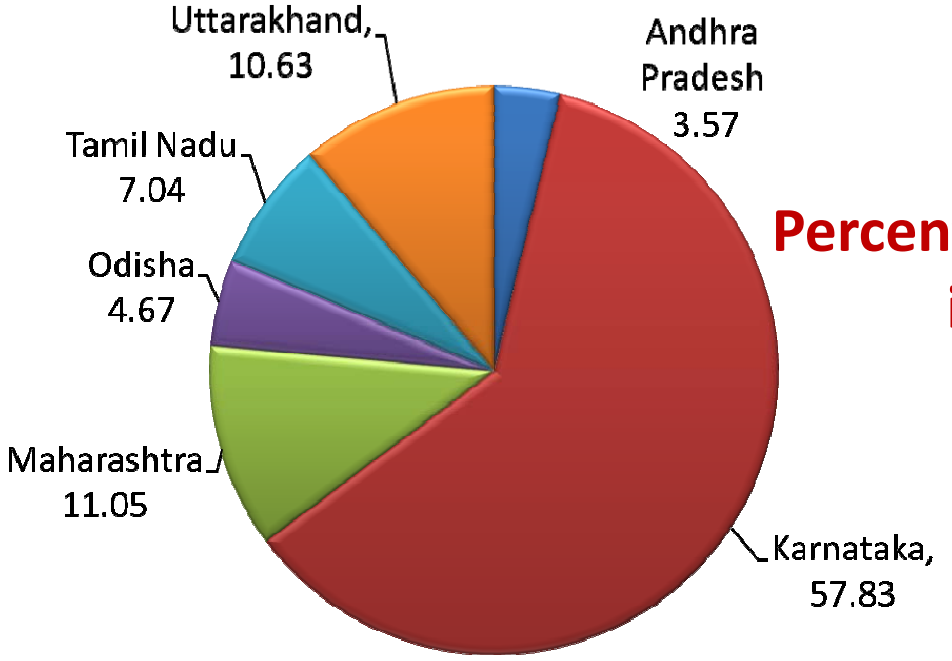
Five-year Average of Finger Millet Area, Production & Yield from 1950-2010 in Karnataka



AVERAGE AREA, PRODUCTION & PRODUCTIVITY OF OTHER SMALL MILLETS IN INDIA
(1950-51 TO 2009-10)

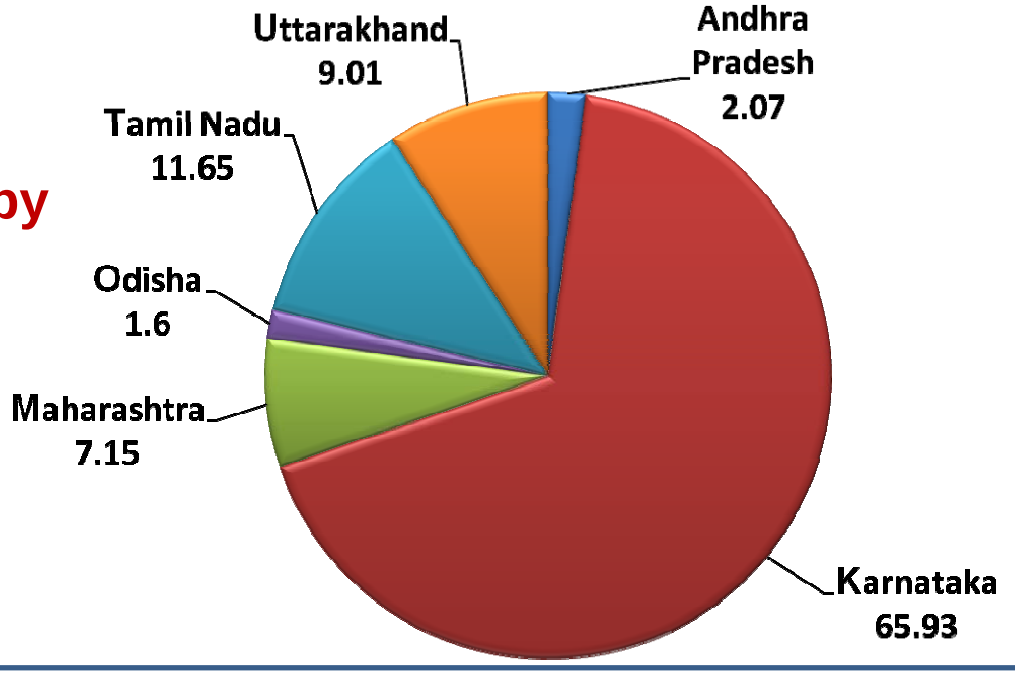


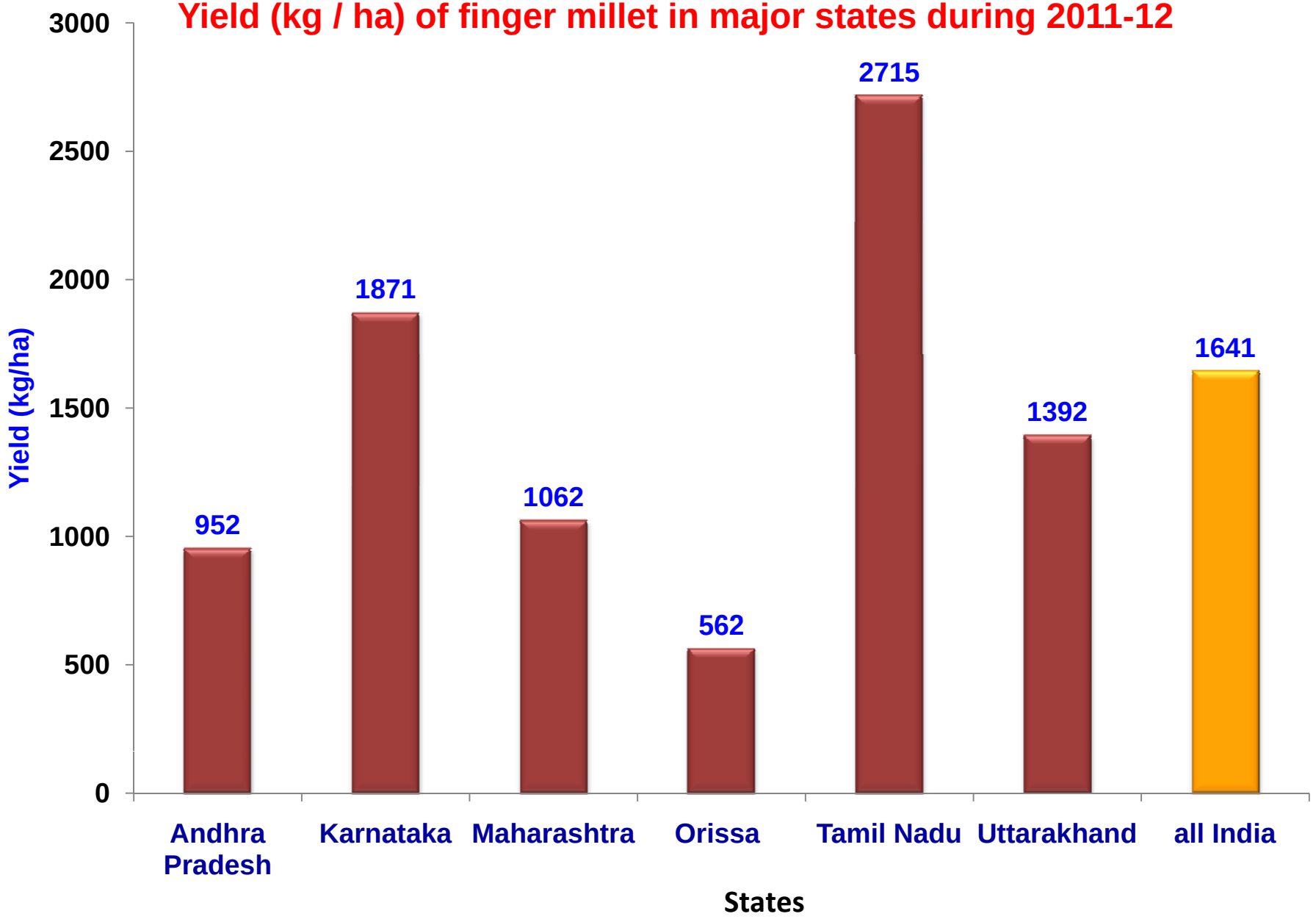

Area, Production and yield (2011-12)
Area (000' ha)
Production (000' t)
Yield (Kg/ha)
2500
2000
1500
1000
500
0
1175.8
1929.2
1641
798
451.5
565
Finger millet
Other Small millets

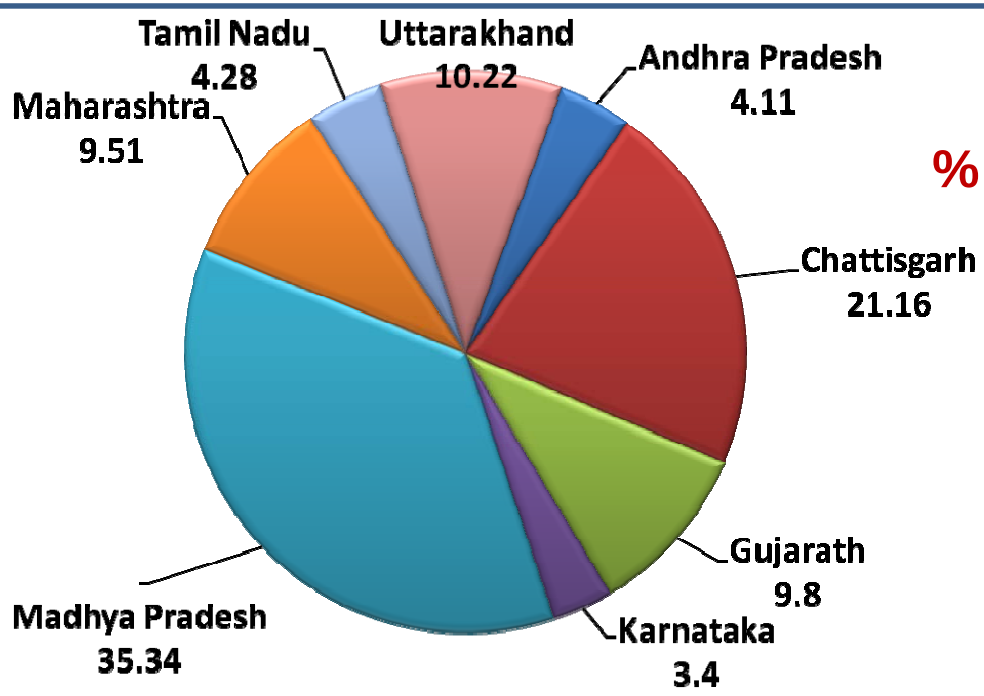


Percent area occupied by Finger millet in major states (2011-12)

Finger millet: % production by major states (2011-12)

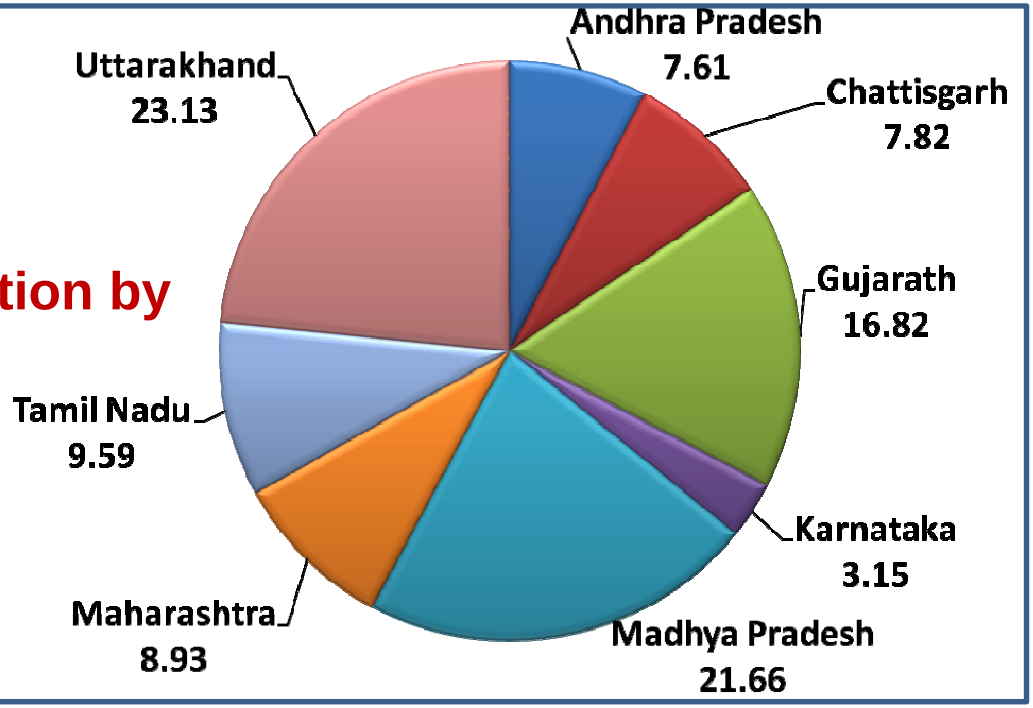



Yield (kg / ha) of finger millet in major states during 2011-12
Yield (kg/ha)
3000
2500
2000
1500
1000
500
0
952
1871
1062
562
2715
1392
1641
Andhra Pradesh
Karnataka
Maharashtra
Orissa
Tamil Nadu
Uttarakhand
all India
States

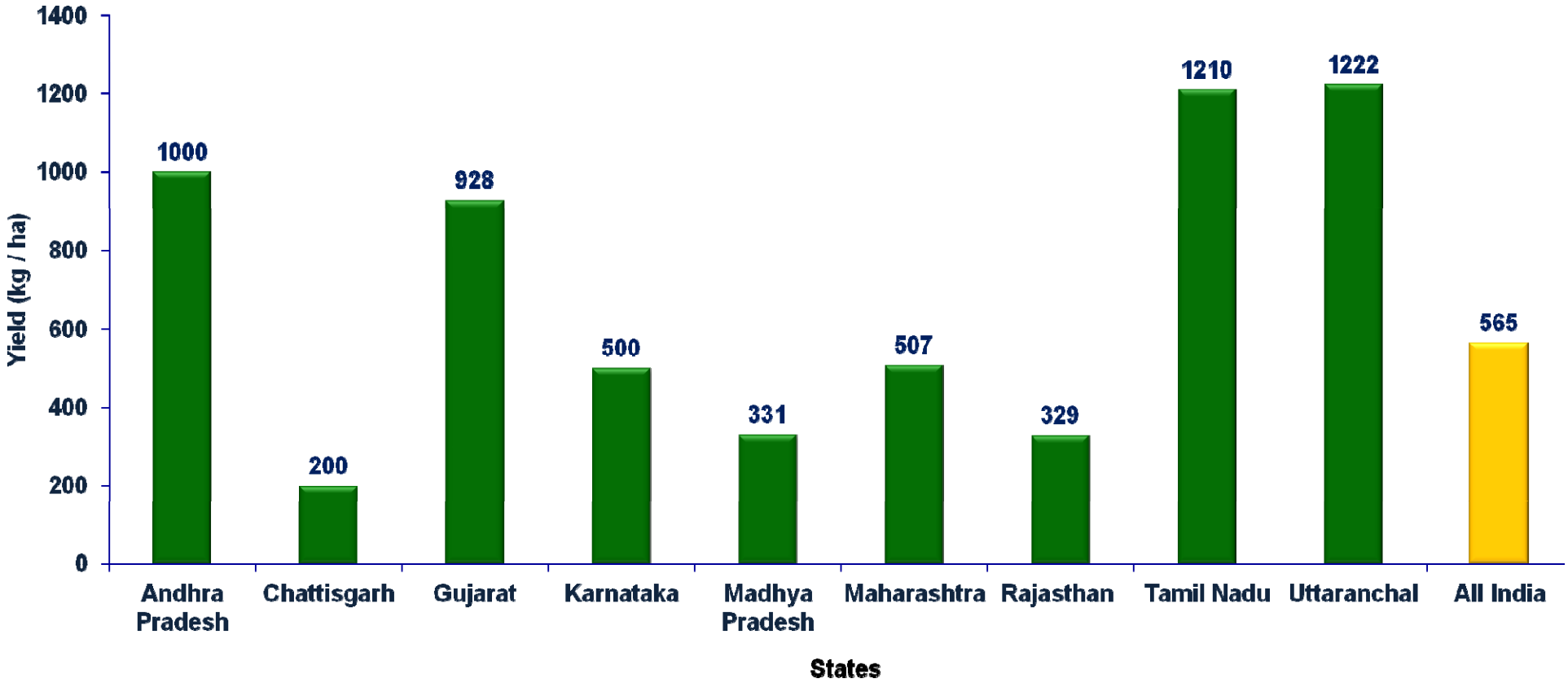


Other small millets: % Area occupied in major states (2011-12)

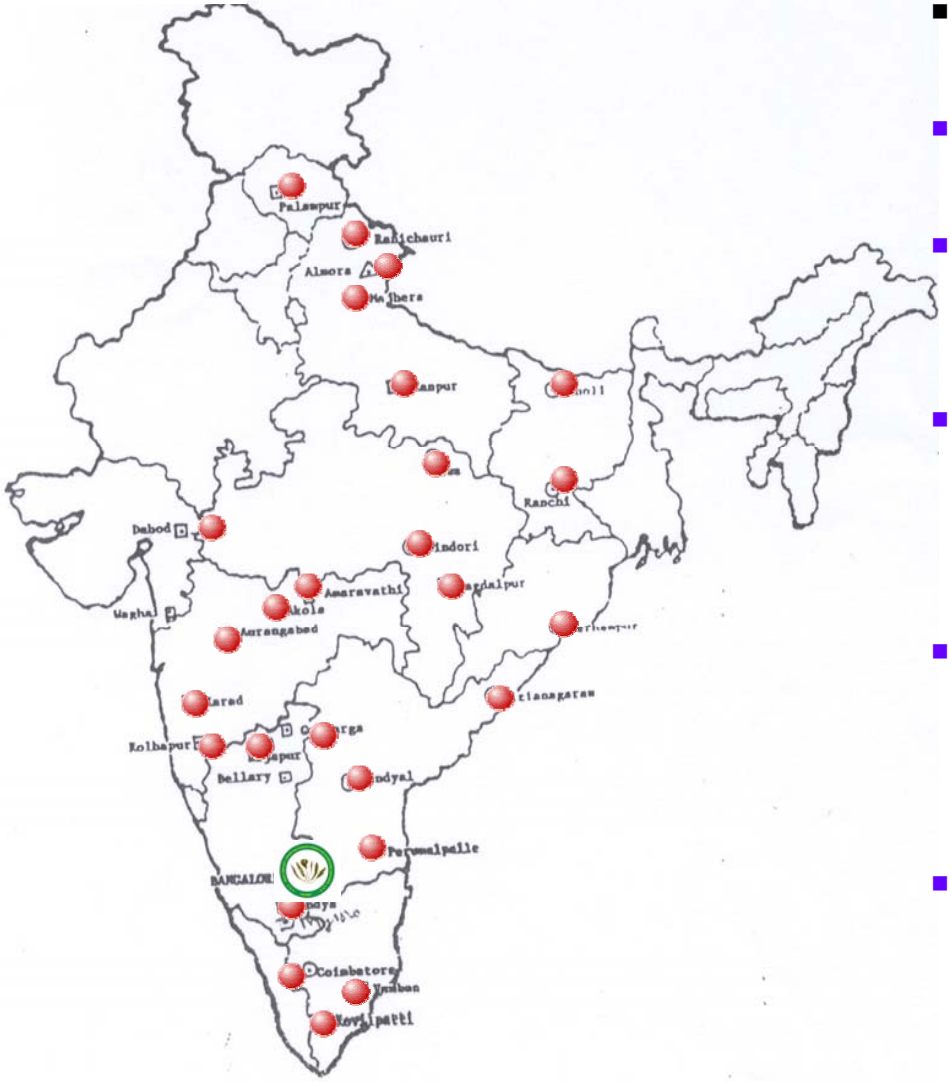
Other small millets: % production by major states (2011-12)



Yield (kg / ha) of other Small millets in major states during 2011-12



ALL INDIA COORDINATED SMALL MILLETS IMPROVEMENT PROJECT



- Established in 1986
- Head Quarters at UAS, Bangalore
- 14 AICRP centres and 16 voluntary centres located all over India.
- Target crops - Finger millet, Foxtail millet, Barnyard millet, Proso millet, Little millet and Kodo millet
- Focussed on developing appropriate production technologies to meet regional needs.
- Work is multidisciplinary and applied in nature

AICSMIP-PROJECT APPROACH & MANDATES

- ✓ To organize research relevant to regional needs through applied and multidisciplinary approach
- ✓ Coordinating and monitoring research in different centres
- ✓ Evolving improved varieties and refining production and protection technologies
- ✓ Conserve, evaluate and document genetic resources and promote their utilization
- ✓ Research on value addition and grain processing to expand utility
- ✓ Transfer of Technology through Front Line Demonstrations

Genetic resources

- NAGS for small millets
- Core, mini core, reference sets formed
- Evaluated for agro-morphological traits, biotic & abiotic stresses
- Utilized in crop improvement - High yield, blast resistance

Agrobiodiversity-NAG site

Finger Millet one of the important crop for detailed eavluation for biotic and abiotic stresses

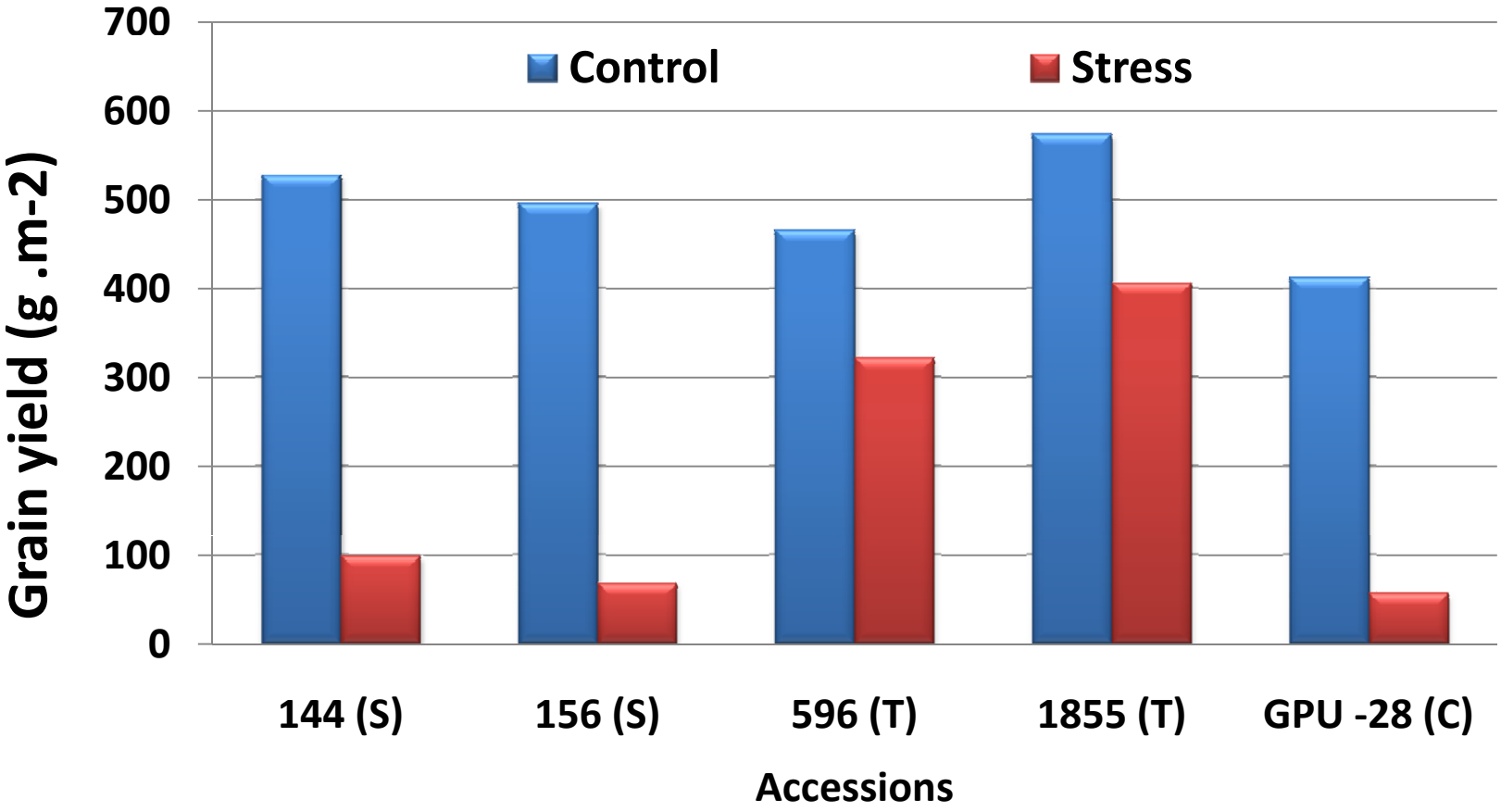
STATUS OF GERMPLASM

Crops	No. of Accessions	Details of collections
Finger millet	7070	Landraces and cultivars from 14 states in India, Kenya, SriLanka, Uganda, Malawi, Ethiopia, Tanzania, Zimbabwe, Zambia and Japan
Foxtail millet	2421	Landraces and cultivars from 13 states in India, Afghanistan, USA, USSR, Turkey, Taiwan and African countries
Kodo millet	1491	Landraces from 8 Indian states and USA
Barnyard millet	1196	Landraces from 5 Indian states and Japan
Proso millet	926	Landraces from 7 Indian states, Afghanistan, Bangladesh, Japan, Rumania and USSR
Little millet	1889	Landraces from 9 Indian states and Rumania
Total	14993	

Finger millet accessions identified for drought tolerance (45-75 DAS)

Type	Grain yield ($g\ m^{-2}$) (C)	Percent redn.	Duration (days)	Accessions
Tolerant	> 400	< 37.0	108	GE-208, GE-496, GE-596, GE-1855, GE-4434, GE-4730, GE-4976
Susceptible	>400	> 72.0	108	GE-144, GE-156, GE-834 , GE-2262, GE-4790, GE-4962
Check	> 400	65	108	GPU-28

Performance of Selected accessions for drought tolerance in finger millet

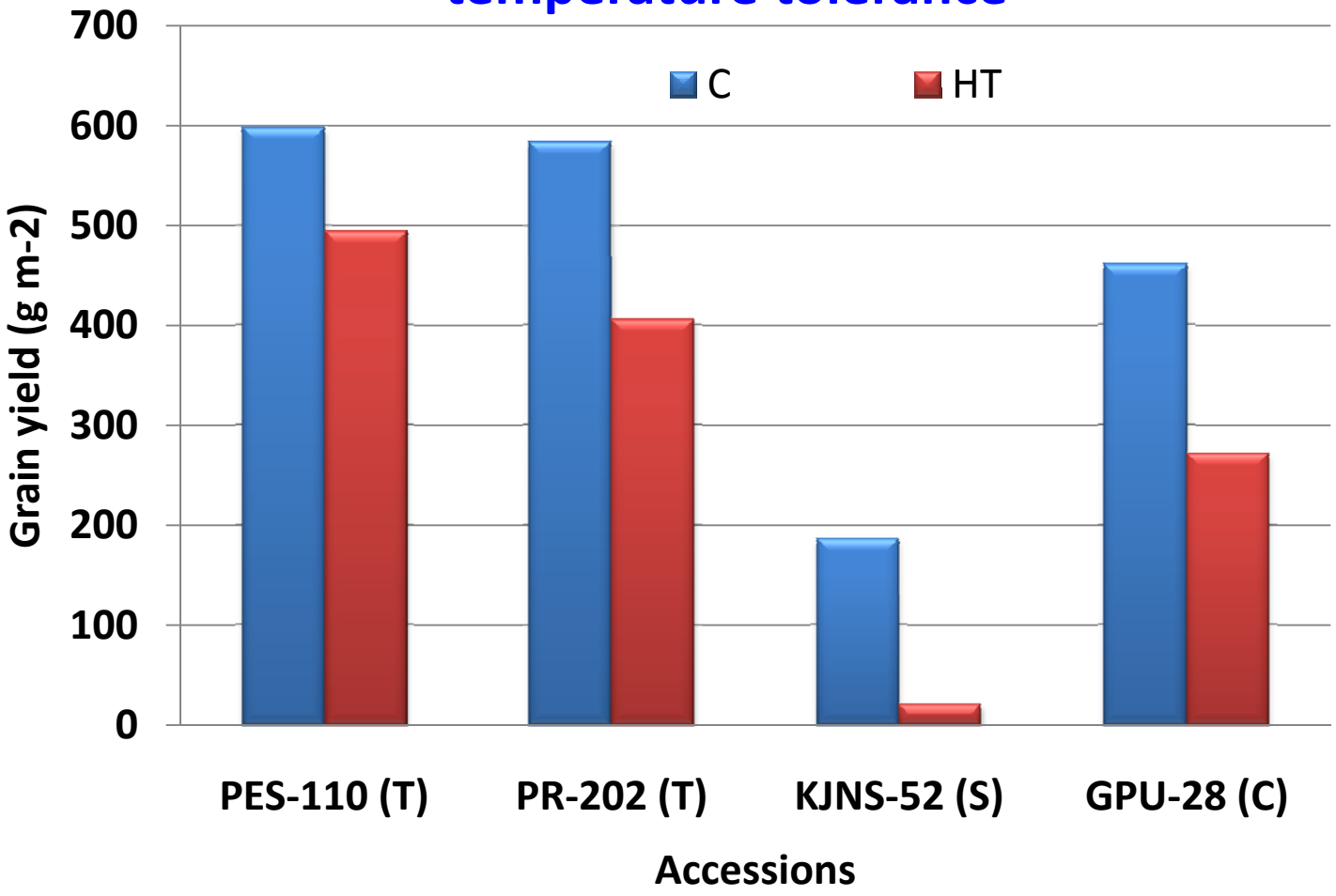


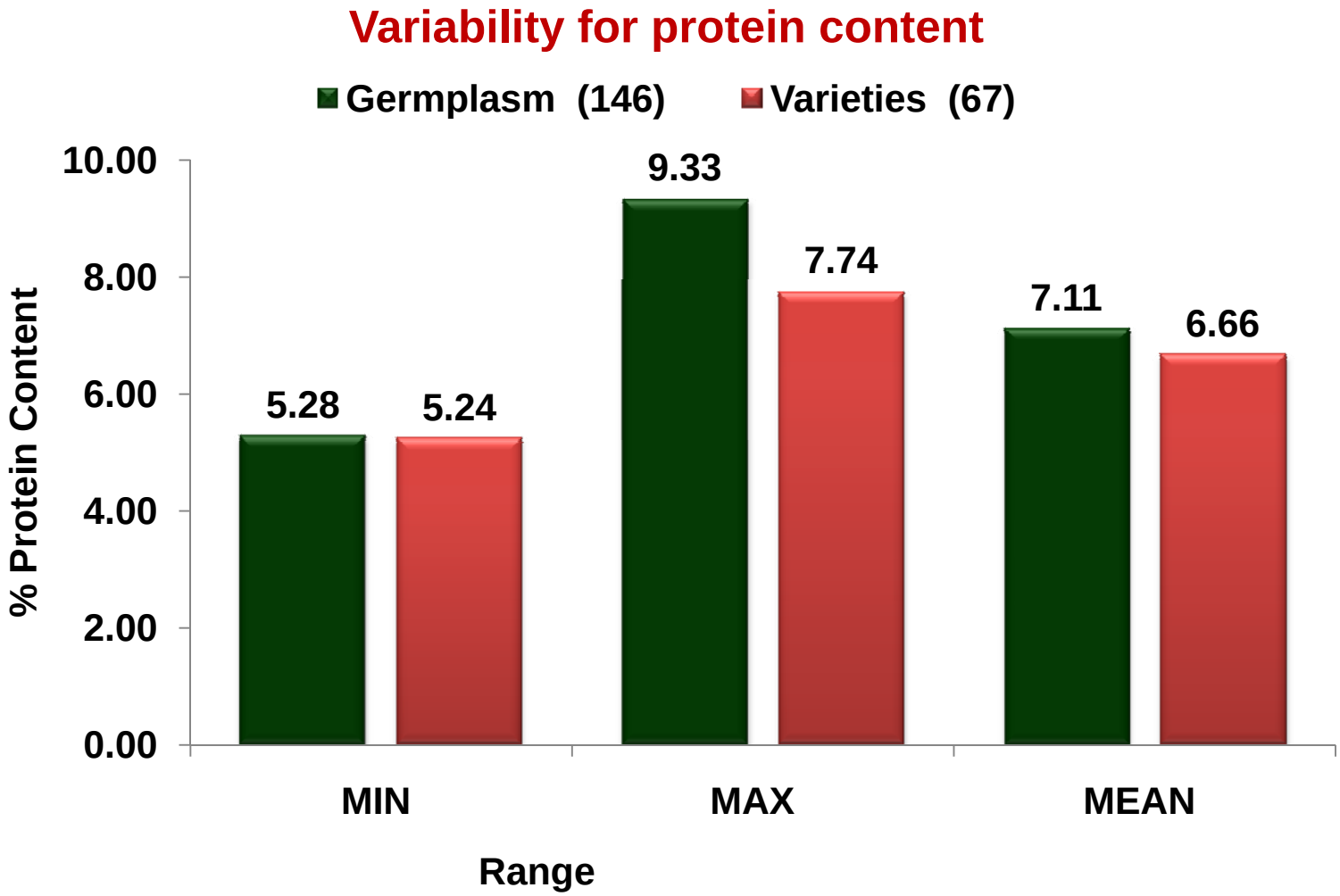
Finger millet accessions identified for high temperature tolerance (2.5°C above normal temp. during reproductive phase)

Type	Grain yield ($g\ m^{-2}$) (C)	Grain yield ($g\ m^{-2}$) (HT)	Range (% Redn.)	Accessions
Tolerant	> 400	>400	4.10 - 19.50	GE- 4, 99, 128, 145, 909, 1013, 1028, 1274, 1815, 2370, 2911, 3303, 3265, 3266, 3885, GPU-26, L-5, PES-110, Chilika, KMR-301, Poorna
Sensitive	>400	< 20	96 -100	GE- 2858, 2672, 2963, 3521, 4683, 4798, 4842, 4898
Check	➢400	348	24.70	GPU-28

To mitigate the challenges of climate change and ensure food security

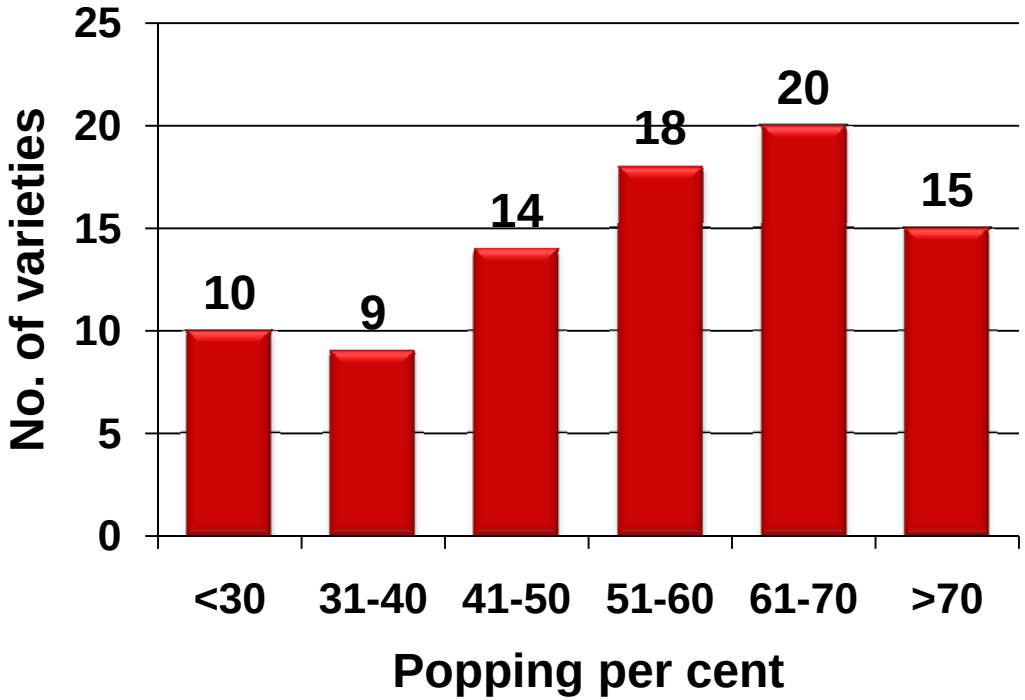
Performance of Selected accessions for high temperature tolerance




Variability for protein content
Germplasm (146)
Varieties (67)
10.00
8.00
6.00
4.00
2.00
0.00
% Protein Content
5.28
5.24
9.33
7.74
7.11
6.66
MIN
MAX
MEAN
Range

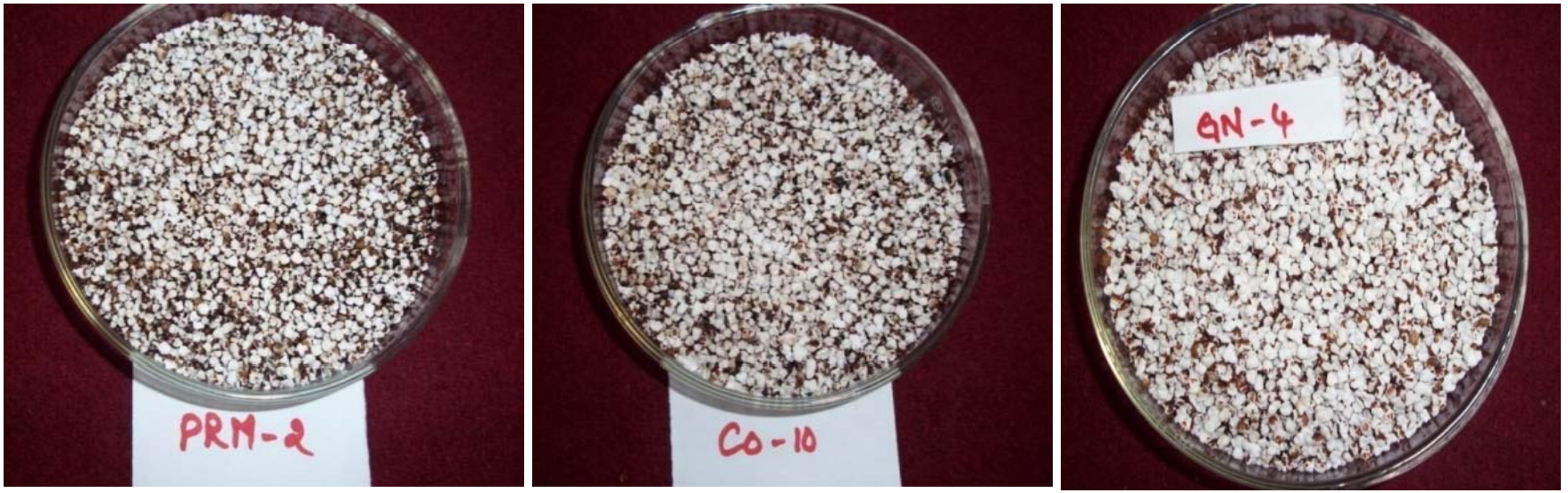
Popping in finger millet

Evaluation of Eighty six released varieties of finger millet



Variety	Total Popping (%)
High popping varieties	
Co-10	88.2
Indaf-3	85.9
Kari kaddi ragi	81.1
PR-202	78.8
GPU 66	72.4
GN-4	77.2
Low popping varieties	
Jenu Bonda ragi	20.5
PRM-802	18.8
Pichakaddi ragi	18.6

Popping in finger millet



High popping varieties

Low popping varieties

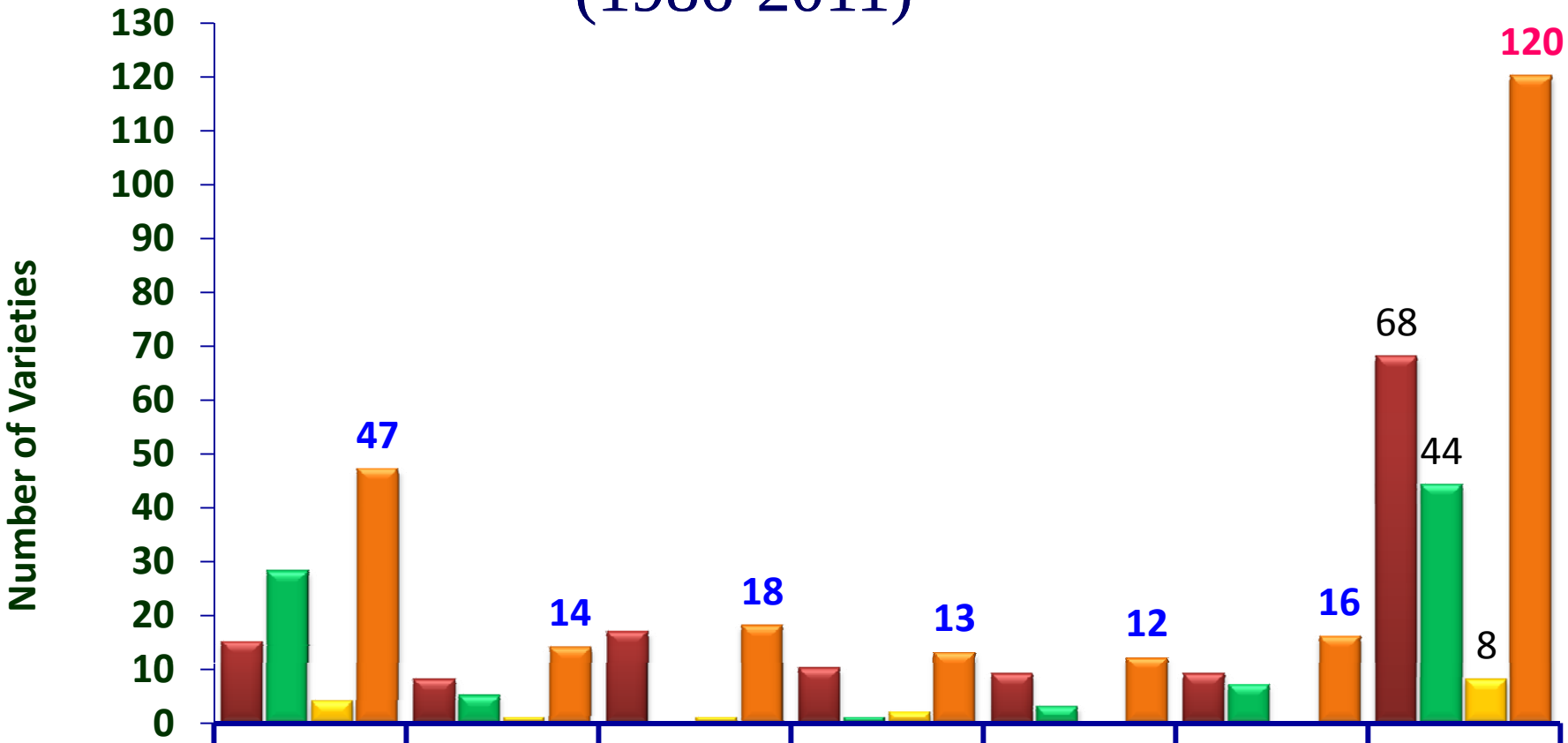
Initiatives for germplasm utilization

- **Evaluation of core sets for biotic & abiotic stresses as well as quality traits**
- **Identification of trait specific germplasm for utilization in crop improvement (Specifically for disease and pest resistance which is a major treat in small millet cultivation)**
  - ✓ **Finger millet- blast disease,**
  - ✓ **Foxtail millet-Blast, downey mildew, rust & shoot fly,**
  - ✓ **Kodo millet- Head smut & sheath blight**
  - ✓ **Little millet- Grain smut, sheath blight & shoot fly**
  - ✓ **Barnyard millet- Grain smut, sheath blight & shoot fly**
  - ✓ **Proso millet- Sheath blight and shoot fly.**
- **Identification of elite germplasm and varieties with superior nutrition traits and bio fortification of elite lines in different small millets**

Crop Improvement

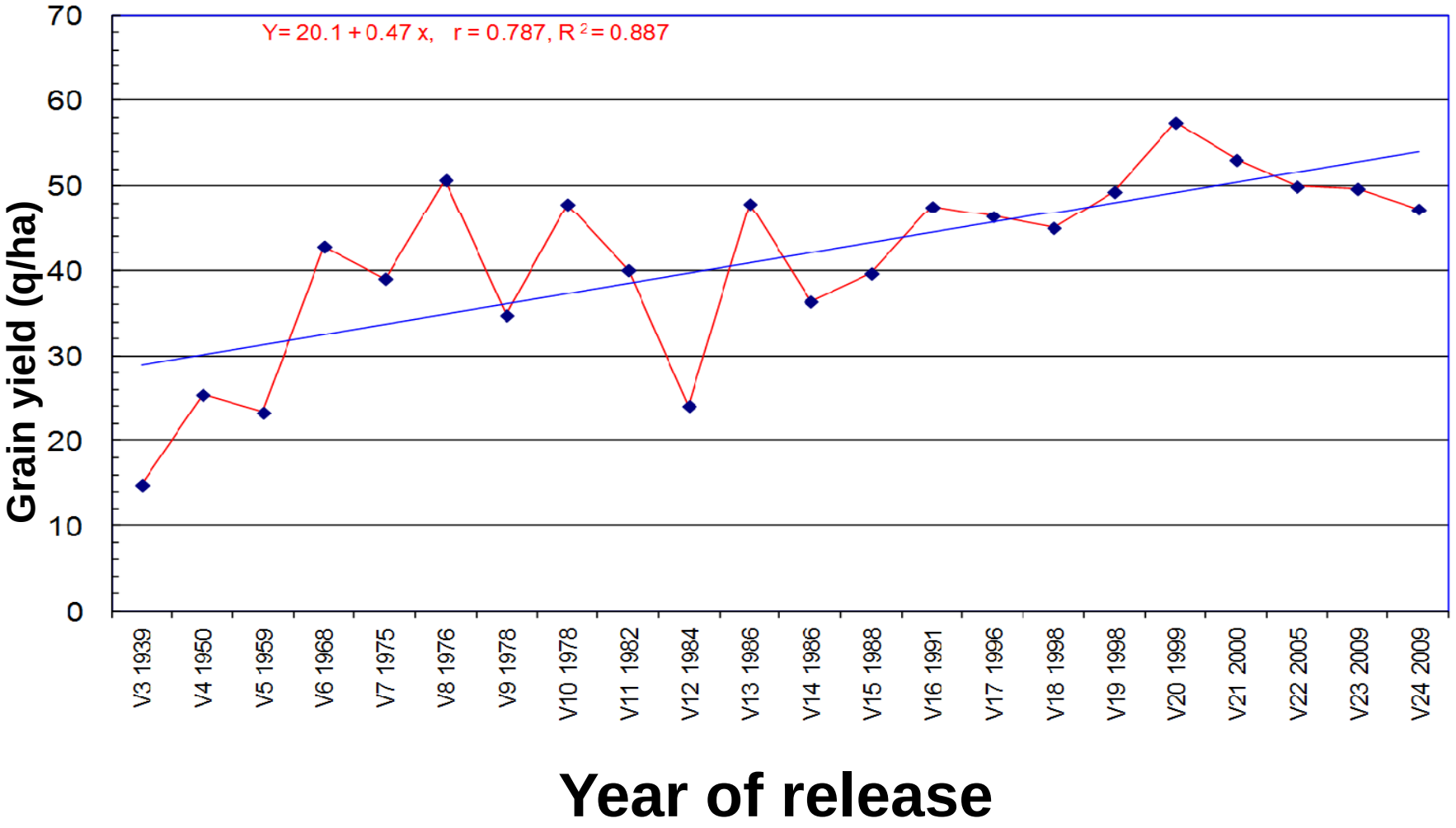
- **Break through** in productivity by Indo-African crosses
- **Blast Resistant varieties** stabilized the productivity
- Varieties for different **agro-climatic regions**
  Hills, coast, plains
- Varieties of different duration to suit different sowing dates
- New initiatives
  - Molecular Breeding
  - Genetic dissection of blast resistance

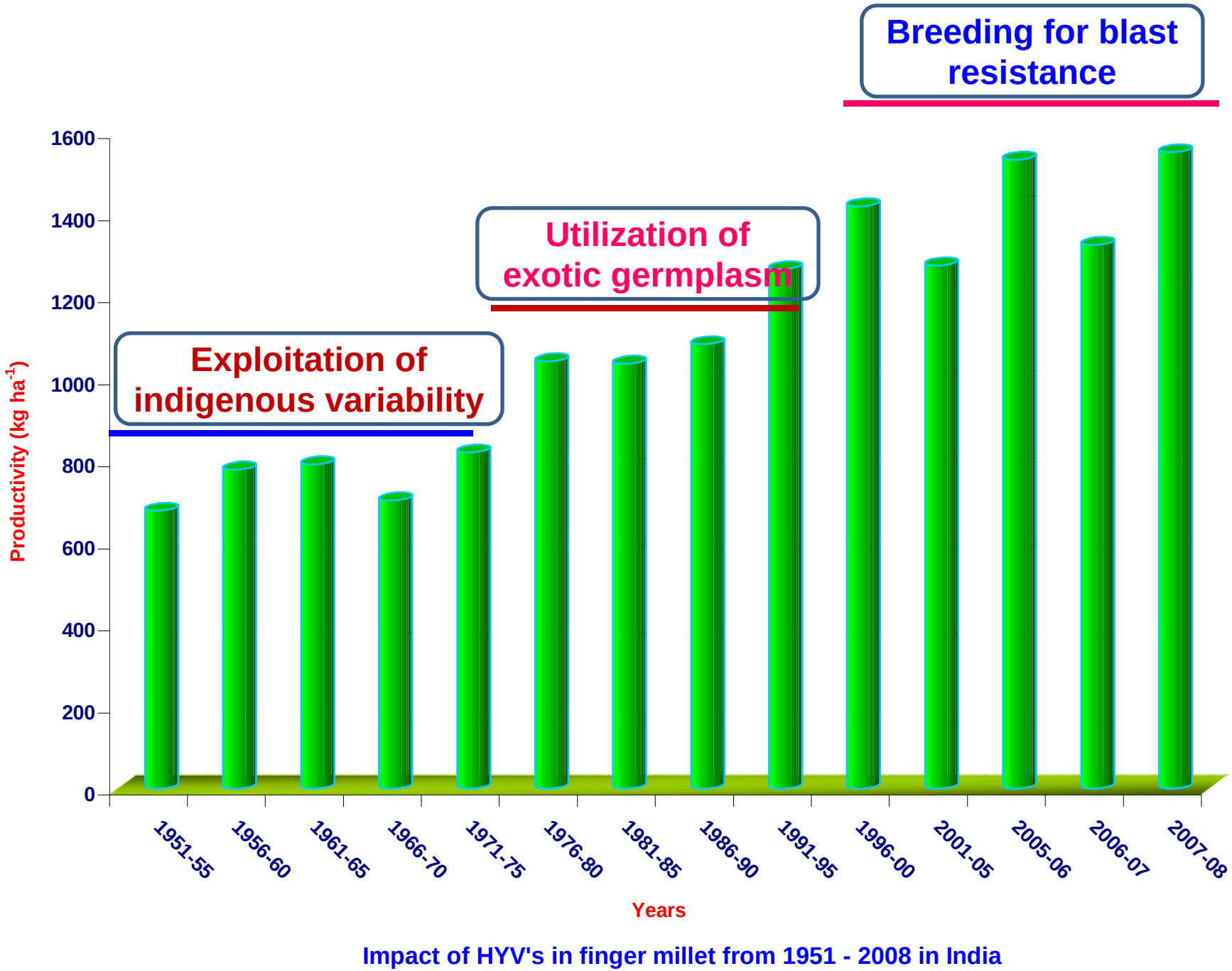
Method wise and Crop wise Varietal Development (1986-2011)



	Finger millet	Foxtail millet	Kodo millet	Little millet	Barnyard millet	Proso millet	Total
Selection	15	8	17	10	9	9	68
Hybridization	28	5	0	1	3	7	44
Mutation	4	1	1	2	0	0	8
Total	47	14	18	13	12	16	120

Finger millet yield improvement over the years





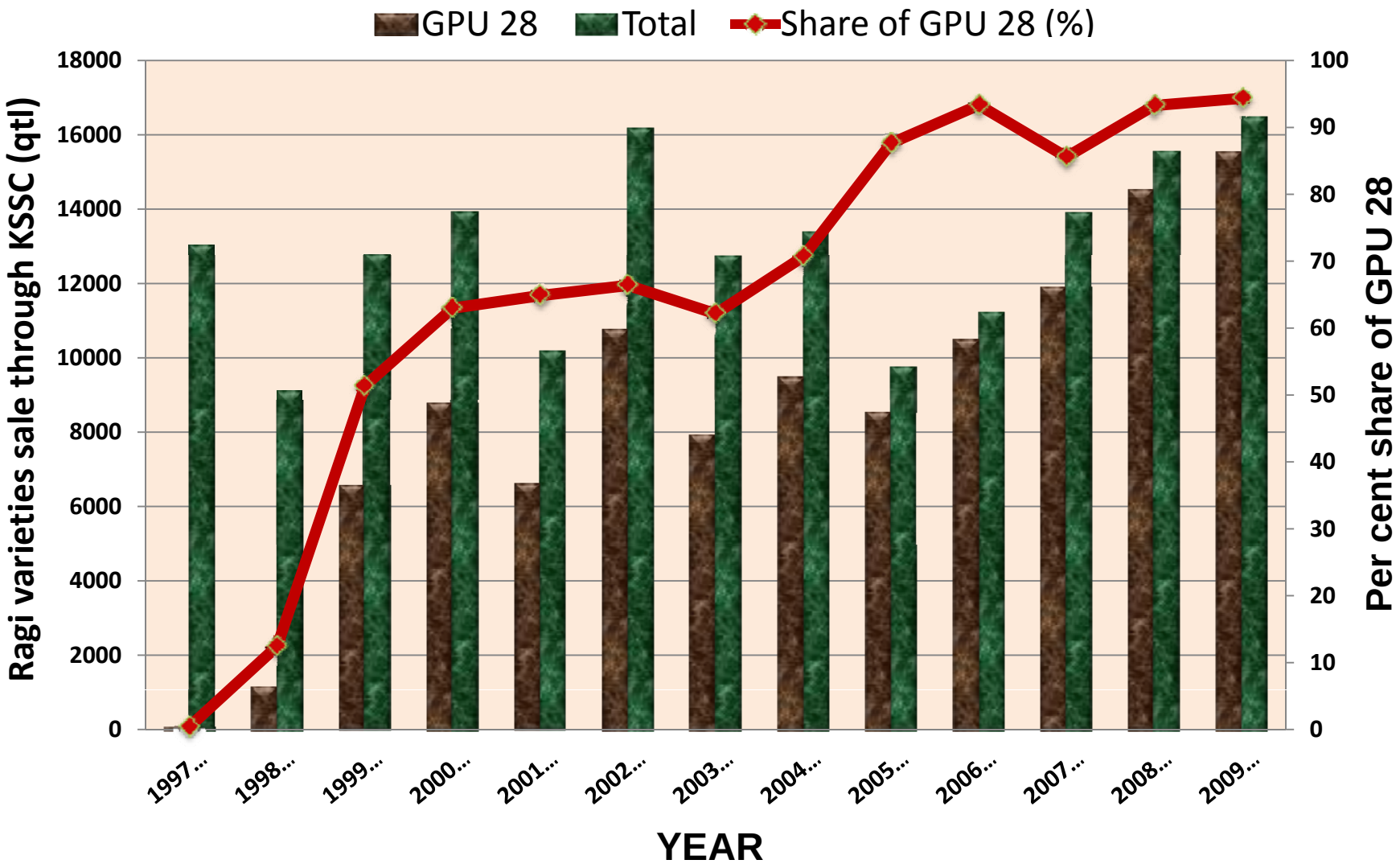
Impact of HYV's in finger millet from 1951 - 2008 in India

GPU 28

- Medium duration (110-115 days)
- Suitable for delayed sowing and performing well under terminal drought situation
- Highly resistant to neck and finger blast which is a major threat in finger millet production
- More than 70% area is under GPU 28 in Karnataka
- High yielding and average productivity has increased from 10 Q to 20 Q by the introduction of this variety
- Potential grain yield of 35-45 Q/ha

Source : KSSC limited Bangalore

Impact of GPU 28



GPU 28* has maintained its resistance without a breakdown

Very much important to dissect the mechanism of resistance

Impact of new Varieties in Foxtail millet

- New short duration varieties SiA 3085 and SiA 3088 are becoming popular
- Instead of fallow and Chickpea, Foxtail-Chickpea has increased income significantly in Karnool.
- In paddy fallows, short duration foxtail is becoming popular in Karnool, AP. - in view of limited water supply.
- Increased demand from cities like Bangalore and Hyderabad area is increasing in recent years.
- New Varieties have a yield potential of 20-25 Q/Ha.
- There is an increase in area under foxtail millet because of the new opportunities and new varieties

VARIETY IDENTIFIED AT STATE LEVEL

Selection from IEC 542

- **Short duration (73-105 days)**
- **Potential grain yield of 22-25 Q/ha**
- **Selection from a germplasm accessions from ICRISAT**
- **Completely resistant to grain smut and highly resistant to brown leaf spot**
- **Good fodder yield**
- **Very popular in hilly areas**
- **Fit for cropping systems**

PS – 1
(GPU 28 – MS)

- **EMS** induced mutant - a new **genetic resource** for **finger millet** improvement
- Genetic background of **GPU 28,** resistant to finger and neck blast
  - **Single Recessive Gene**
  - Easy maintenance (Covering with paper bags)
  - **High recovery of hybrids >70 %**
  - Superior genetic background of (GPU 28) and high yielding
  - High level of resistance to neck and finger blast
  - **Recombination breeding for crop improvement has been initiated**
  - **Technology for hybrid production is in progress**

Virescence a Morphological marker for introgression and identification of recombinants

Early stage

Normal plants

Virescence plants

Later stage

Normal plants

Virescence plants

Normal plants

Initiatives towards Crop Improvement

- Identification of varieties suitable for mechanical harvesting in all small millets adapted to different agro-climatic situations
- Development of high yielding varieties with stable blast resistance suitable to different finger millet growing regions.
- Development of varieties combining resistance to smut with high grain yield.
- DUS characterization of small millet varieties
- Development of hybrid technology in finger millet

Breeder seed and Quality seed prodution

- **Strenthening of institutional arrangement for the production and supply of quality seeds**
  - **The centres should be encouraged to produce seeds of improved varieties**
  - **Local seed supply systems involving Civil Society organizations needs to be supported**

Breeder Seed Production of finger millet (2012-13) Central sector indent

Sl. No.	Name of variety	Name of the producing centre/State	DAC Indent	Actual allotment (q)	Quantity produced (q)	Surplus(+)/Deficit(-) over BSP-I target
Finger millet						
1	Godavari	Peddapuram, AP	0.6	1.2	1.5	0.3
2	PR-202		0.25	0.5	2.5	2
3	VL Mandua 315	Almora, Uttarakhand	0.15	0.3	0.6	0.3
4	VL 149		0.15	0.3	0.6	0.3
5	VL 324		0	0	0.6	0.6
6	PRM -1	Ranichauri, Uttarakhand	0.1	0.2	0.2	0
7	MR-6 (Divya)	Mandya, Karnataka	0.5	1	10	9
8	MR-1		0.6	1.2	10	8.8
9	Indaf-9		0.1	0.2	2	1.8
10	Indaf-7		0.1	0.2	2	1.8
11	GPU-67	PC Unit, Karnataka	0.75	1.5	5	3.5
12	ML-365		0.25	0.5	10	9.5
13	GPU-48		0.2	0.4	1	0.6
14	GPU-45		5	10	10	0
15	GPU-28		3.98	8	10	2
16	Indaf-5		0	0	5	5
17	VR-708	Vizianagaram, AP	0.6	1.2	1.2	0
18	Birasa, Marua -2	Ranchi, Jarkhand	0.13	0.26	0.5	0.24
19	RAU-8	Dholi, MP	3	6	3	0
20	Bhairabi (BM-9-1)	Berhampur, Odissa	0.6	1.2	2.5	1.3
21	SUVRA (OUAT-2)		0.6	1.2	2	0.8
22	Chilika (OEB-10)		0.6	1.2	2	0.8
23	CO-13	Coimbatore (TN)	0	0	0.6	0.06
24	CO-14		0	0	0.1	0.1
25	Phule nachani	Akola, Maharastra	0	0	3.6	3.6
	Total		18.26	36.56	86.5	46.9

Quality Seed Production for Finger Millet from different centres (2012-13)

Center	Variety	Seed production (q)
Mandya	MR 1	180.00
	MR 6	405.00
	KMR 301	150.00
	KMR 204	66.00
	Indaf 5	310.00
	Indaf 7	481.00
	ML 365	15.00
	GPU 66	10.00
Almora	VL- 315	0.85
	VL- 324	1.45
	VL- 149	1.15
Coimbatore	Co (Ra)14	1.86
Kolhapur	PR 202	5.16
	Phule Nachini	1.00
Viziyanagaram	Bharathi (VR 762)	15.00
	Sri chaithanya (VR 847)	15.00
	Hima [VR(W) 936]	20.00

Quality seed production and supply of finger millet by KSSC during 2012 –13

Sl. No.	Name of variety	Quantity in quintals	
		Target	Sale
1	Indaf 9	190	2054
2	Indaf 7	210	225
3	MR 1	690	494
4	MR 6	800	734
5	ML 365	30	23
6	PR 202	720	709
7	GPU 48	160	111
8	GPU 28	12890	12986
	TOTAL	15690	15487

Breeder Seed Production in Other Small millets (2012-13)

Sl No.	Variety	DAC Indent	Production	Production Surplus (+)/Deficit(-) over BSP-I target (q)
Foxtail millet				
1	Srilakshmi	-	1.00	(+) 1.00
2	SiA 3085	-	1.00	(+) 1.00
3	PS 4	-	1.00	(+) 1.00
4	HMT 100 -1	-	3.00	(+) 3.00
	Total		6.00	(+) 6.00
Barnyard millet				
1	Co 2	-	0.20	(+) 0.20
2	RAU 11	-	1.50	(+) 1.50
3	VL 207	-	0.60	(+) 0.60
	Total		2.30	(+) 2.30
Kodo millet				
1	Co 3	-	0.14	(+) 0.14
2	JK 439	-	2.39	(+) 2.39
3	JK 48	-	1.62	(+) 1.62
4	JK 155	-	1.02	(+) 1.02
5	JK 439	-	0.51	(+) 0.51
6	JK 13	-	0.53	(+) 0.53
7	JK 98	-	0.35	(+) 0.35
	Total		6.56	(+) 6.56
Little millet				
1	OLM 203	-	1.30	(+) 1.30
2	Co 4	-	0.61	(+) 0.61
3	JK 8	-	4.38	(+) 4.38
4	TNAU 63 (Sukshema)	-	4.00	(+) 4.00
5	GV 2	-	2.60	(+) 2.60
	Total		12.89	(+) 12.89
Proso millet				
	GPUP 21	-	0.50	(+) 0.50
	Total		0.50	(+) 0.50

Quality Seed Production for Small Millets (2012-13)

Crop	Center	Variety	Seed production (q)
Barnayard millet	Almora	VL 207	0.85
	Coimbatore	Co(KV)2	1.08
Little millet	Coimbatore	Co(Samai)4	137.30
Kodo millet	Coimbatore	Co 3	1.19
Foxtail millet	Coimbatore	Co (Te) 7	0.83
Proso millet	Coimbatore	Co (PV)	1.37

Approaches to strengthening seed chain

Organized seed supply systems are virtually absent in Small Millets & weak in finger millet in several states

- State Departments should compulsorily undertake seed production & distribution
- Extending subsidized seed supply
- Involvement of genuine and capable NGOs in seed production
- Strengthening local seed supply systems like seed cooperatives on the lines of successfully run seed banks

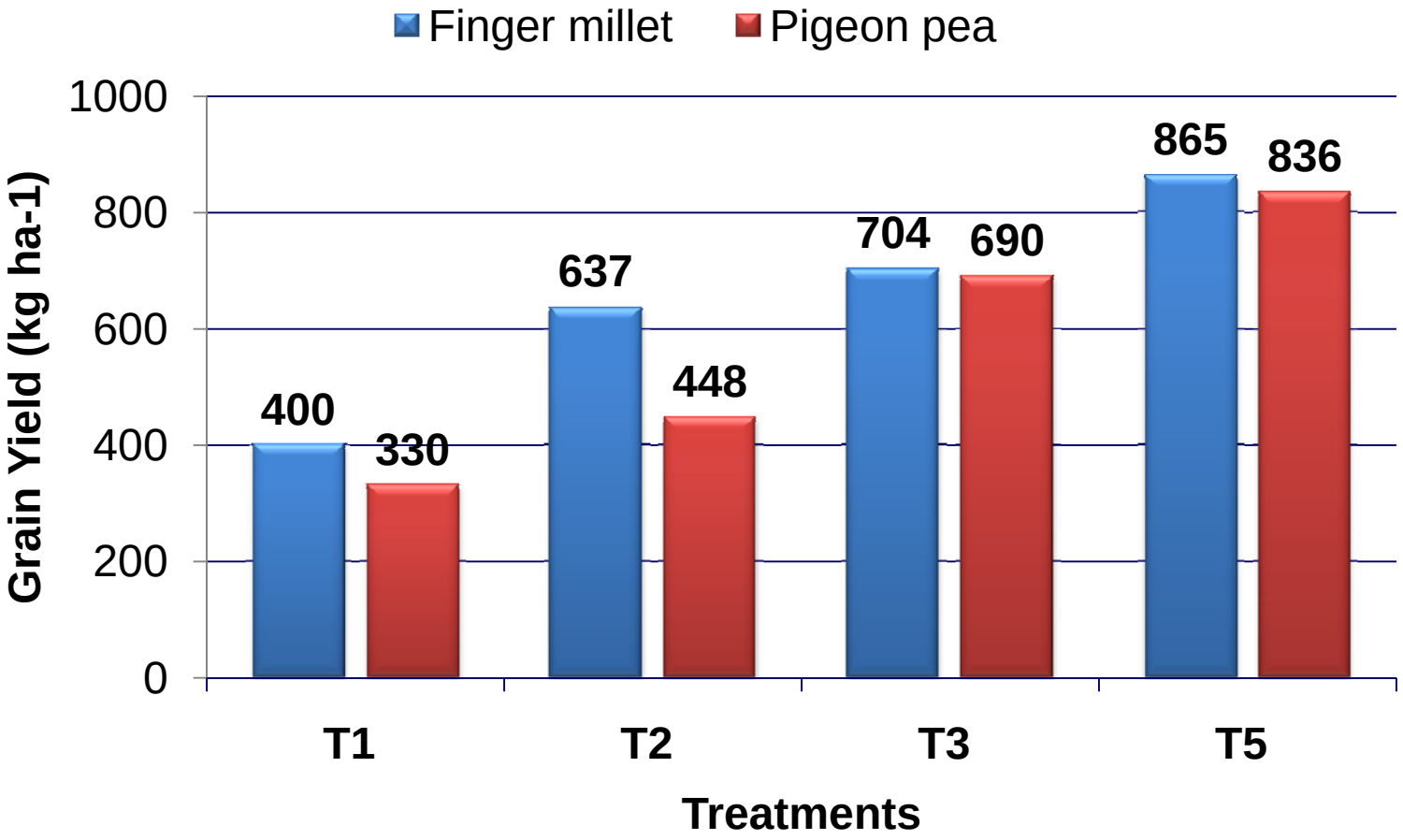
Crop Production Technologies

- **Small millets are mainly rainfed and facing severe competition from other crops**
  - **Crop management efforts should be aimed at reducing cost of production and raising productivity**
    - **Innovative water and moisture conservation practices**
    - **Better crop establishment, efficient nutrient management & soil health practices**
    - **Selective mechanization of key operations**

BEST INTERCROPPING SYSTEMS IN SMALL MILLETS

Small millets	Inter crop	Ratio of planting	States
Finger millet	+ PigeonPea	8:2	Karnataka, Andhra Pradesh and Tamil Nadu
Foxtail millet	+ PigeonPea	5:1	Karnataka and Andhra Pradesh
Kodo millet	+ PigeonPea	2:1	Madhya Pradesh and Chattisgarh
Little millet	+ PigeonPea	2:1 or 4:1	Madhya Pradesh, Odhisa, Jharkand and Chattisgarh

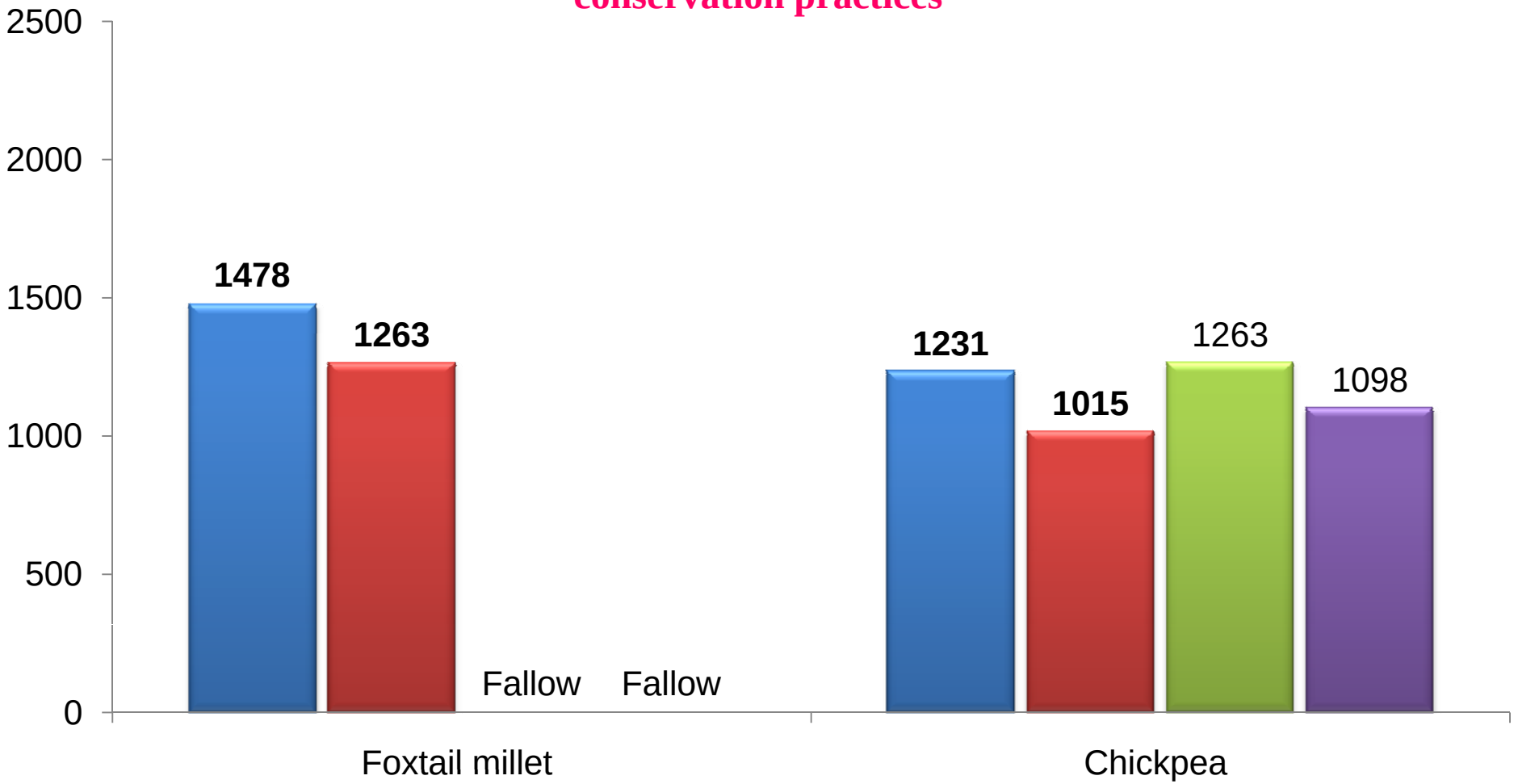
Enhancing productivity of improved intercropping system of under rainfed conditions at Jagdalpur (4 years)



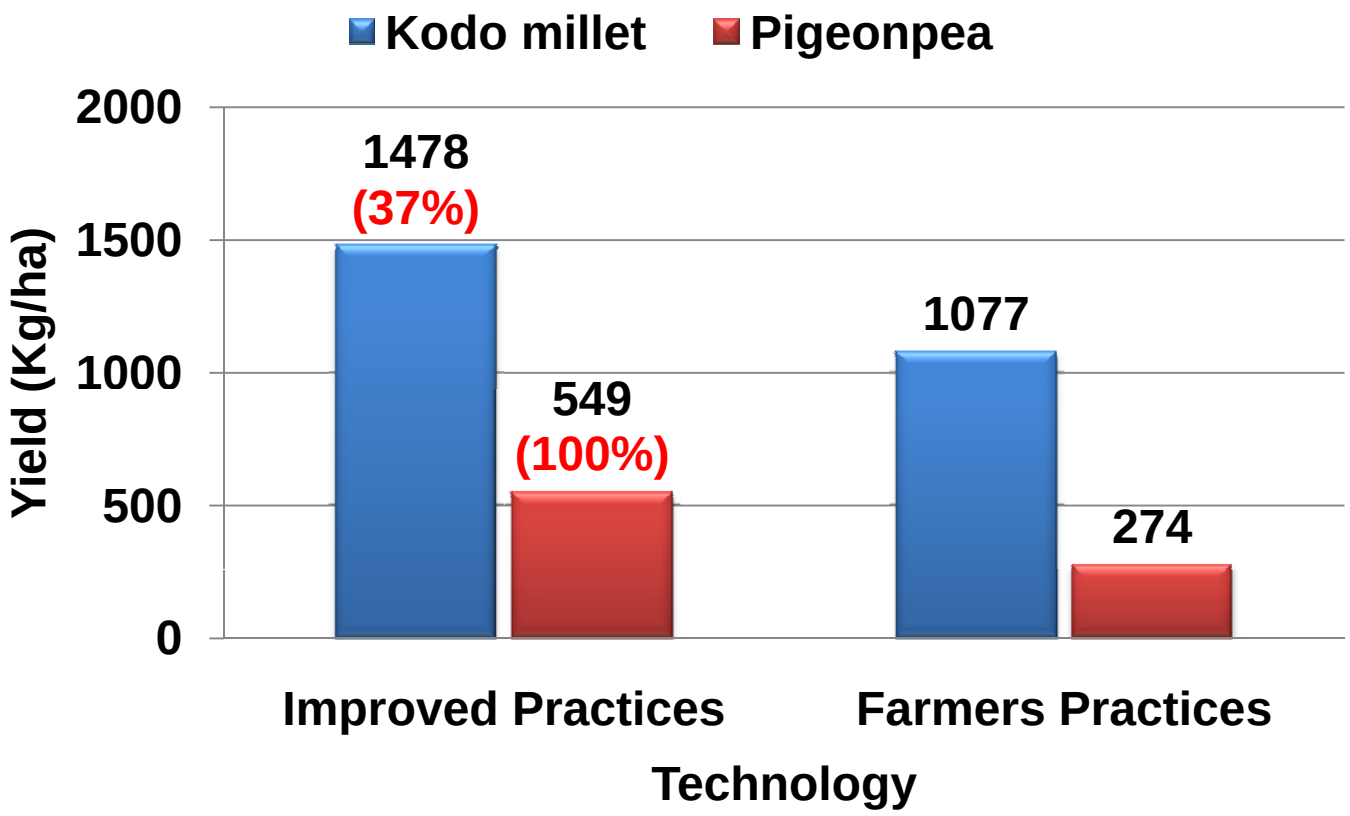
T_1: Farmer's practice (*Akadi*)
T_2: FM + PP (8 : 2) drill sowing
T_3: FM + PP (8 : 2) transplanting 40-45 DOS
T_5: T_3 + Sodium molybdate seed treatment @ 4 g kg^{-1} seeds to PP

Note: FM: Finger millet, PP: Pigeon pea, DOS: Day old seedlings

Foxtail millet and chickpea grain yield (kg/ha) as influenced by *in-situ* soil moisture conservation practices



Kodo millet based intercropping system on farmer's field under participatory mode comparing it with farmer's practice (OFAR) at Dindori & Jagdalpur

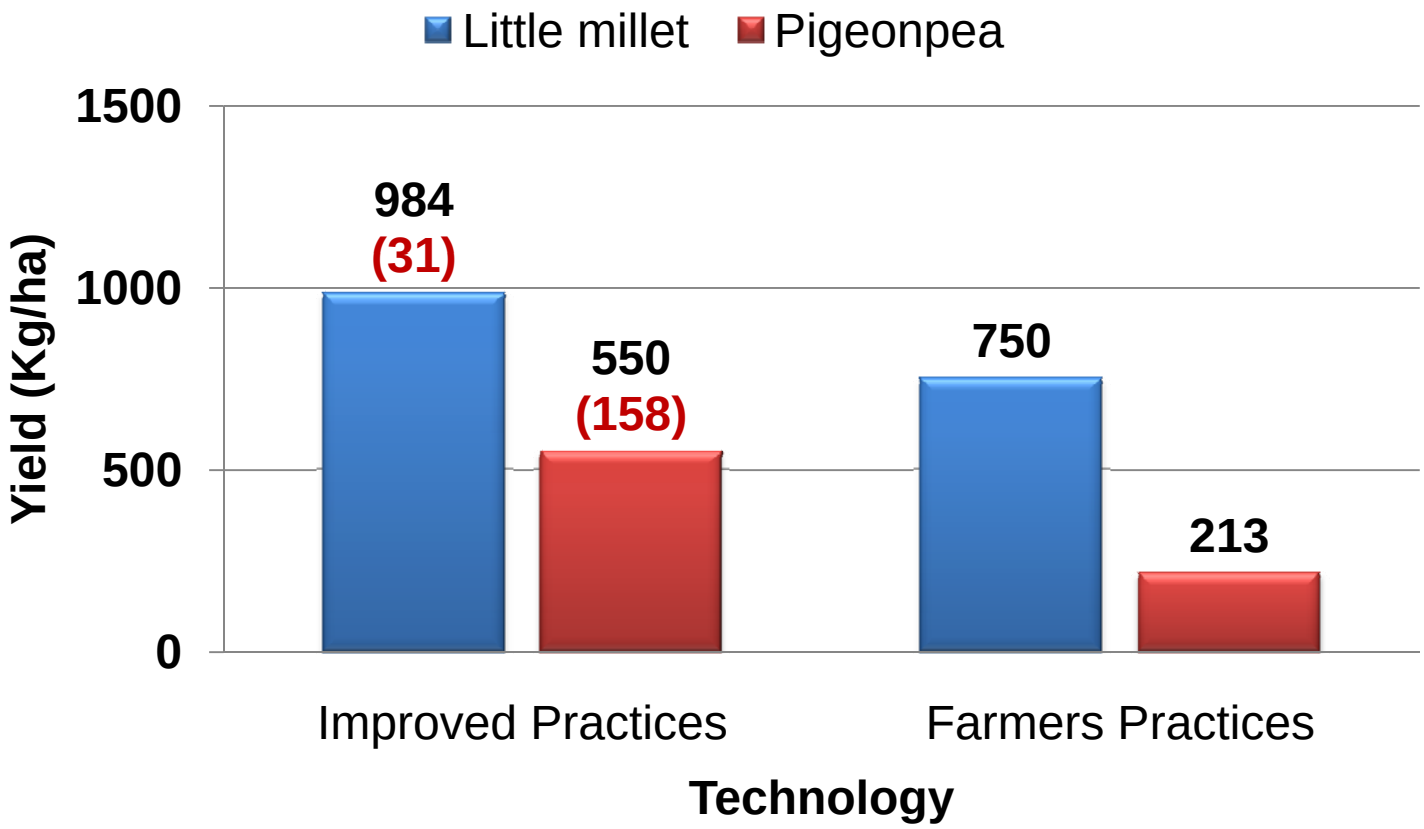


Improved practice: Kodo millet + Pigeon pea (PP) inter cropping (2:1)

Total of 6 OFAR trials conducted

Note: Data in parenthesis indicates % increase in yield as compared to Farmers practice

Little millet based intercropping system on farmer's field under participatory mode comparing it with farmer's practice (OFAR) at Dindori & Jagdalpur



Improved Practice: Little millet + Pigeon pea (PP) inter cropping (4:1)

Total of 6 OFAR trials conducted

Note: Data in parenthesis indicates % increase in yield as compared to Farmers practice

Lodging genotypes

MECHANISATION NEED OF THE HOUR

Labour shortage

Non-lodging genotypes

GPU 67

- Non-lodging
- Suitable for mechanized harvesting
- Wider adaptability across the country
- Moderately resistant to neck and finger blast

Grain smut of Barnyard Millet

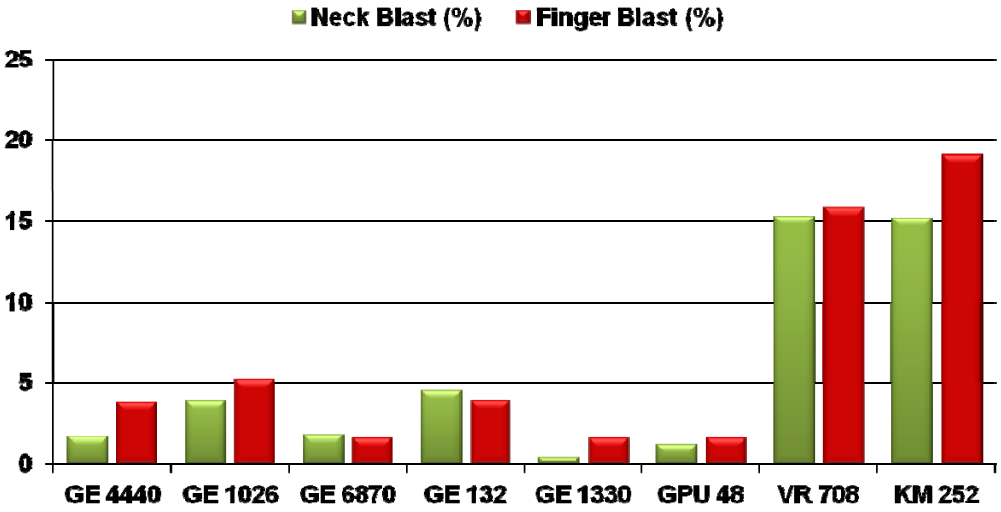
Grain smut of Little millet

Resistance Sources

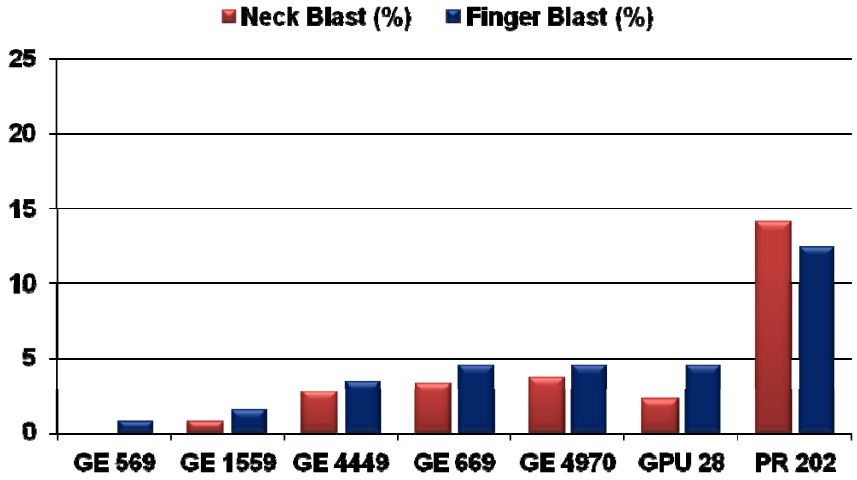
NEED OF THE HOUR

Head smut of kodo millet

Early duration Germplasm resistant to neck and finger blast screened over location (2012)



Germplasm resistant to neck and finger blast screened over location (2012)



Pedigree and origin of resistance sources identified

Sl. No	Entry no	Alternate name	Native
Germplasm Accessions			
1	GE 1559	IE 990	-
2	GE 569	IE339	India (TN)
3	GE 1330	P228	Africa
4	GE 4440	-	India (Orissa)
5	GE 4449	-	India (Orissa)
6	GE 669	IE1012	Africa (Zambia)
7	GE 1356	P282	Africa
8	GE1026	HR23-8-9	India (Karnataka)
9	GE 5192	IE3655	-
10	GE 132	IE329	India (MP)
11	GE 145	IE293	India (Kerala)
Varieties			
1	GPU 28	Indaf 5 x (Indaf 9 x IE 1012)	India (Karnataka)
2	GPU 48	GPU 26 x L 5	India (Karnataka)
3	GPU 66	PR 202× GPU 28	India (Karnataka)
4	GPU 26	Indaf 5 x (Indaf 9 x IE 1012)	India (Karnataka)
5	GPU 45	GPU 26 x L 5	India (Karnataka)

Promising small millet germplasm

Crop	Entry/Accession	Against
Kodo	KOPKM 1, 10 and RPS 973	Head smut
Little millet	IPMR 841 and 1061	Grain smut
Foxtail millet	RFM 29, 84, GS 162, 1204, SiA 1827, 2566, 2667, 2863 and ISc 1488 <10% Sh. Bl.	Sheath blight
Barnyard millet	GP 70A, 90A, 110, 117 and PRJ 1	Grain smut

Initiatives in disease and pest management

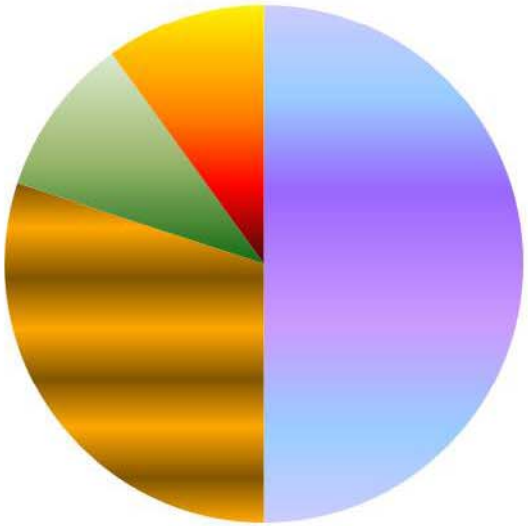
- Basic research on the finger millet blast fungus (Pyricularia grisea) for better understanding of races prevailing in the country
- Identification of stable sources of resistance to shoot fly in different small millets
- Evolving IPM module for effective management of shoot fly

Biscuits based on finger millet

Millet based soup

Processing and Value Addition

Preparation of millet based snack food



- Millets
- Coarse cereals
- Soy
- Other ingredeints

TECHNOLOGIES FOR VALUE ADDITION

- ✓ Prototype mill for de-husking of other small millets
- ✓ Decortication process for finger millet
- ✓ Parboiling process for other small millets for easy milling without endosperm breakage
- ✓ Formulation of Health foods / beverages / malt / bakery products

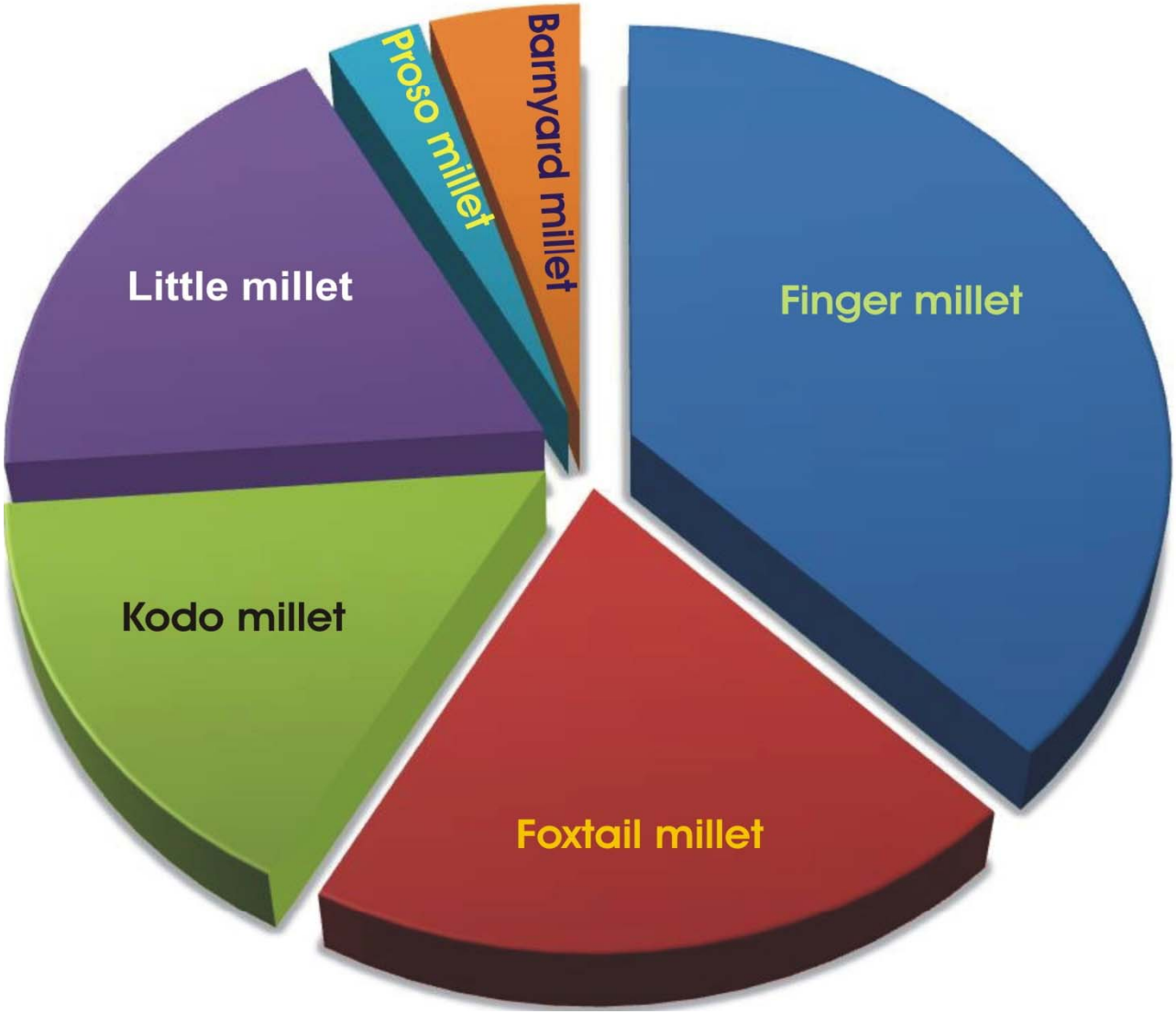
Challenges and priority in value addition

- **Storability of processed small millets (millet rice) is one of the often asked questions and there is a need for systematic analysis to develop proper storage systems**
- **The non availability of proper prototype of millet mill has emerged as a big hindrance in the utilization of small millets for food use**
- **Involvement of various stake holders (Institutions and private manufacturers) is emphasized for addressing this issue on priority basis**

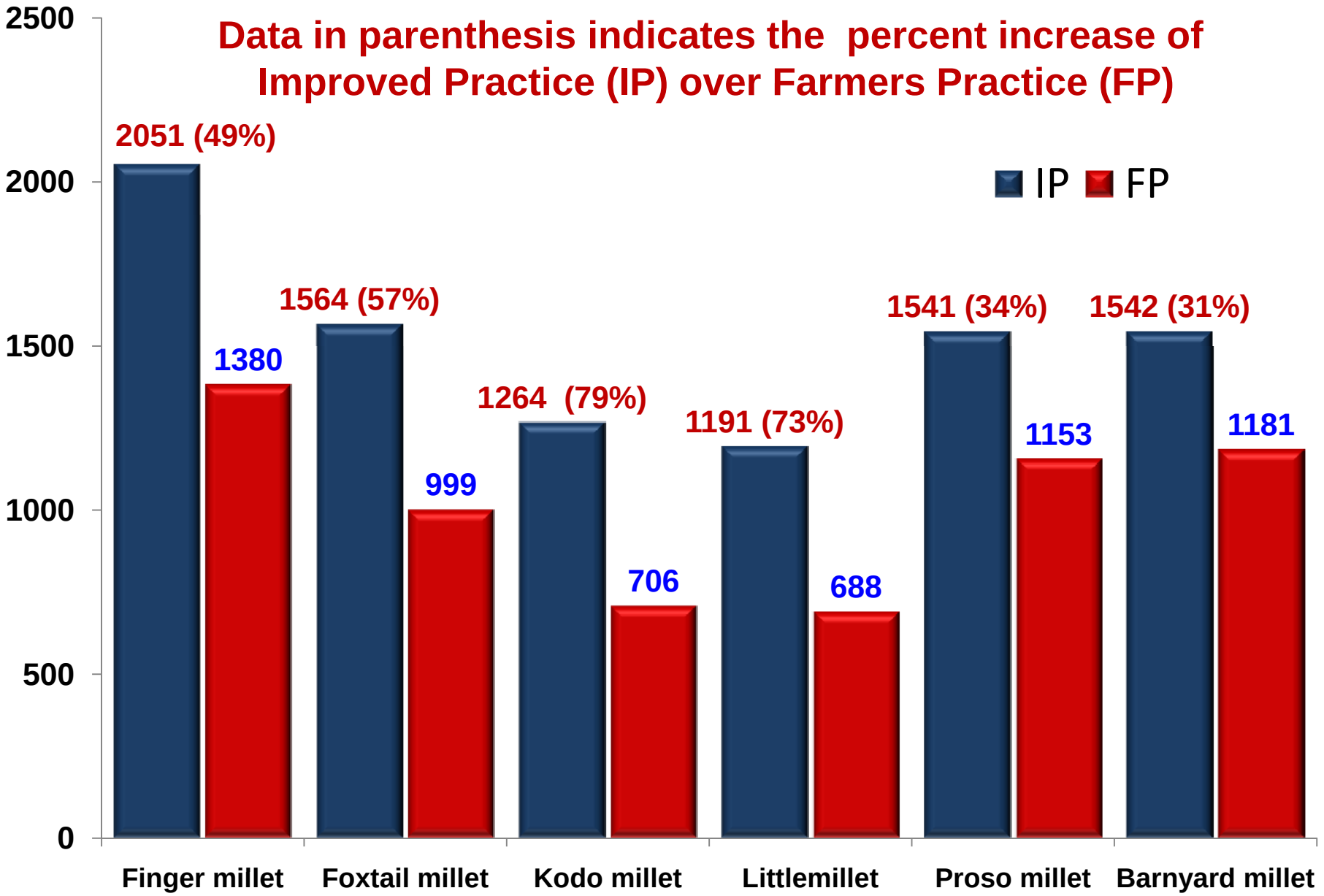
Transfer of technology Through Frontline Demonstrations

Crop wise area and no. of farmers involved in Front Line Demonstrations

During 2011-12 and 2012-13 (2 years)



Crop	Area (ha)	No. of farmers
Finger millet	366.52	1268
Foxtail millet	200.69	306
Kodo millet	154.4	321
Little millet	180.25	435
Proso millet	29.29	49
Barnyard millet	46.60	369
Total	977.75	2748



Grain yield of different small millets in front line demonstrations during 2011-12 and 2012-13 (2 years)

Recent status of varieties released in Small millets

Crop	Varieties released during 2008-2011
Finger millet	GPU 66, GPU 67, VR 847, KMR 301, KOPN 235
Foxtail millet	SiA 3085 and SiA 3088
Kodo millet	JK 106, JK 65, JK 98 and DPS 9-1
Little millet	OLM 208, OLM 217 and JK 36
Proso millet	TNAU 151, TNAU 164 and TNAU 202
Barnyard millet	Co 2

Crop	Varieties proposed for release during 2012-13
Finger millet	VL 352
Foxtail millet	SiA 3156
Kodo millet	TNAU 86 and RK 390-25

Initiatives in basic and strategic research on small millets

- Improvement of yield potential in finger millet
  - Hybrid technology
  - Improve biomass production and harvest index
- Development of genomic resources
  - Employ tools of comparative genomics
- Improvement of nutritional quality (Grain and Fodder) and bio-fortification
  - Exploit with in species variability for nutrients
  - Improve bio-availability
- Crop improvement for resistance to biotic and abiotic stresses
  - Blast disease in finger millet
  - Shoot fly in little, proso and foxtail millets
  - Tolerance to drought, temperature and salinity

Future thrust

- Development of genomic resources and its application in breeding
- Assessment of nutritional & nutraceutical properties in the millet germplasm
  - Biofortification for micronutrients
  - Breeding varieties for specific end uses such as popping & malting
- Design & development of low cost cottage scale machinery
  - for milling
  - preparation of semolina & flours, flakes, noodles, pasta
  - Malting & popping
- R & D on Phytochemicals with nutraceutical characteristics
- Development of functional foods for diabetic and obese populations by exploiting nutritional & nutraceutical features

- Multi-disciplinary, multi-institutional & PPP approaches is the key

Thank you.....