

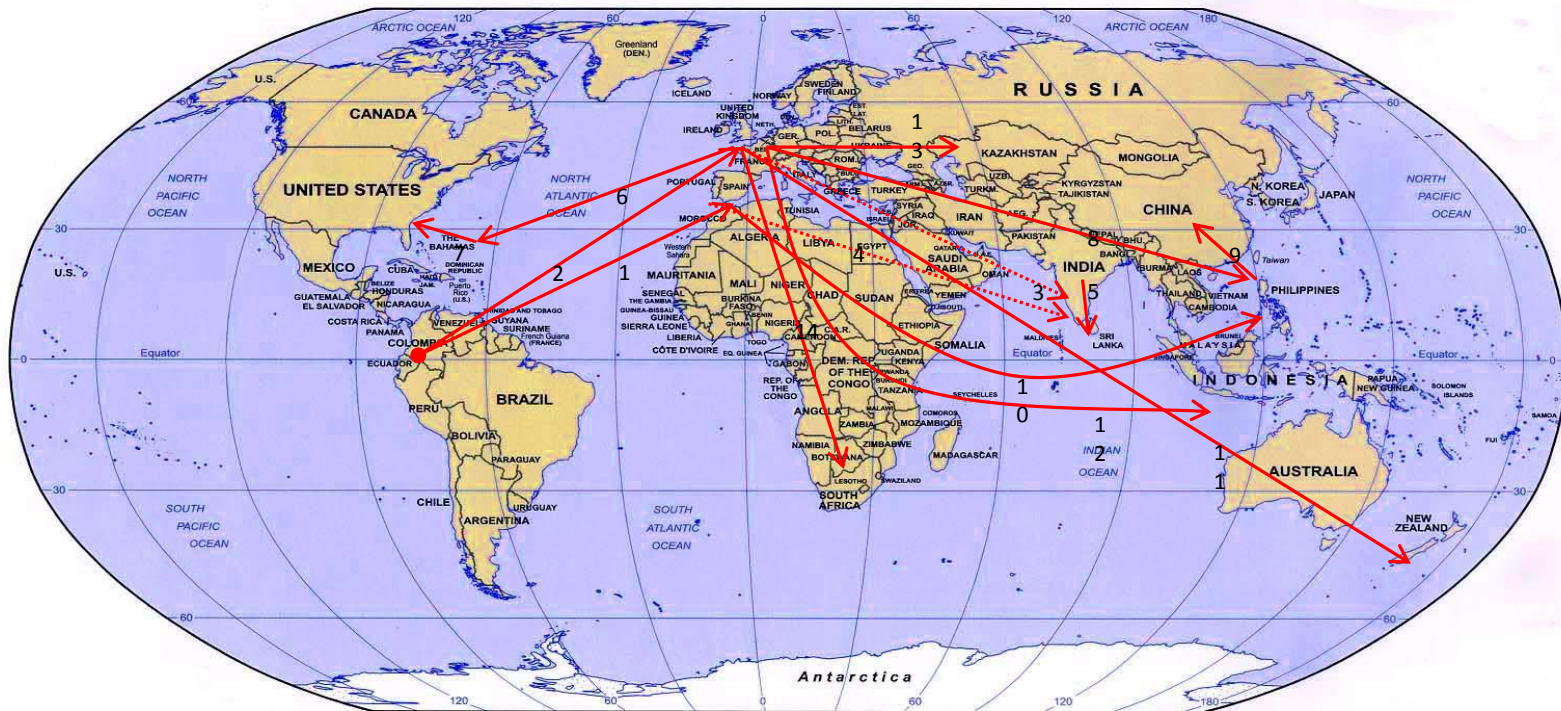


# Potato varieties for table and processing

Vinod Kumar, Pr. Scientist  
CPRI, Shimla



# Journey of Potato



- Potato originated in high Andean region of South America
- Till 16<sup>th</sup> century it was unknown to rest of the world.
- Potato moved from South America to Spain (1570) and UK (1590).
- Potato's global voyage began in the 17<sup>th</sup> century from Europe.
- In India & Sri Lanka, potatoes were introduced in early 17<sup>th</sup> century.
- Potatoes, became one of the most important world crops in a span of 300 years





# Potato adaptation



- In Andes of South America, potato was adapted to short days, tropical highlands (2,000 and 4,000 m).
- Its equatorial origin makes potato essentially short-day dependent for tuberization
- In Europe, tuber formation was inhibited under long photoperiod (long days).
- Long-day acclimation for tuberization to achieve higher tuber yields in Europe.
- Breeding over more than 150 years led to plants tolerating long day condition.
- The mutations in tuber formation regulator allow potatoes to escape the original short day regulation mechanism suited to the Andes, so potatoes can be grown in Europe & other northern latitudes of world
- Mutations in the tuber formation regulator gene which occur in different combinations in modern potato cultivars, giving rise to early, medium and late varieties, depending on the combination of the gene variants present in the tetraploid crop (Kloosterman et al. 2013).



# Potato Breeding

- Cultivated potato is auto-tetraploid and highly heterozygous.
- Heterosis is observed on crossing diverse parents.
- Breeding of potato involves hybridization between identified parents and selection of superior clones from the progeny.
- The genetic constitution of the genotype obtained following hybridization is fixed in seedling stage.
- Due to vegetative propagation the genetic constitution of potato genotype with all its intra- and inter-locus interactions responsible for its phenotypic expression are maintained in the clonal generations.
- Hence, a clone if perceived desirable can be multiplied for commercial cultivation even though initially it may be present as a single plant.
- More than 50 traits should be combined in a modern potato variety (Ross, 1986).
- An ideal potato variety affects not only yield and quality but also production cost, environmental issues, post harvest and yield of future crops (Struik and Wiersema, 1999, Collard and Mackill, 2008).
- It can take 10 to 15 years to release a variety.

# Potato varieties developed in the world



Potato breeding has resulted in the release of over 4000 cultivars in more than 100 countries.

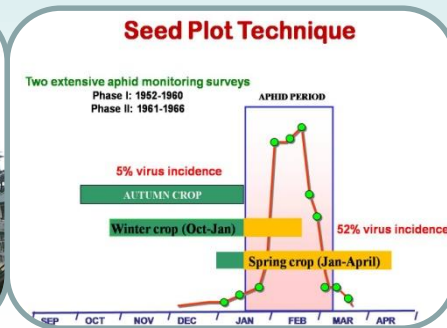
# Need of potato Breeding in India

Parameters	India	Europe/America
Growing season	Winter	Summer
Temperature during planting & harvesting	High	Low
	Planting: 25-32°C	Planting: (15-25°C)
	Harvesting: 10-20°C	Harvesting: Less than 20°C
Day & night temp. during crop season	Day : 25-32 °C	Day : 20-25 °C
	Night : 3-15 °C	Night : 5-20 °C
Crop duration (d)	Short (60-100)	Long (150-180)
Photoperiod	10 hrs/day	14 hrs/day
Frosting	Common	Absent
Post harvest handling	Difficult (high temps.)	Easy (low temps.)
Result	Low yields, less dry matter, and more reducing sugars	High yields, high dry matter & low reducing sugars

- European varieties were long-day adapted
- Progressive accumulation of degenerative viral diseases
- Physiological limitations on storage & utilization in hot/humid summers
- Varieties: Craig's Defiance, Great Scot, Up-to-Date and Magnum Bonum

# Potato breeding in India

- 1935: Potato breeding programme at Potato Breeding Station, Shimla.
- 1949: CPRI at Patna (Bihar)-Regular breeding programme .
- 1956: CPRI at Shimla (HP) to facilitate hybridization & seed health .
- 1963: Seed Plot Technique.
- Potato breeding system developed.
- This approach yielded for potato improvement and potato seed production.
- CPRI varieties prefixed with ‘KUFRI’ as a memento to place of crossing.



# Germplasm collection and evaluation

- ❖ Collection
- ❖ Field/Glass house maintenance
- ❖ Evaluation

## Selection for

- ❖ Vigorous plant type
- ❖ Short duration
- ❖ Desirable tuber attributes
- ❖ Early bulking
- ❖ High tuber yield, tuber number, average tuber weight
- ❖ High dry matter
- ❖ Good keeping quality
- ❖ Processing attributes
- ❖ Late blight resistance
- ❖ Water stress
- ❖ Heat stress
- ❖ Nutrient use efficiency
- ❖ Nutrition quality





Total: ~ 4375 (40 countries)



Indian varieties and parental lines

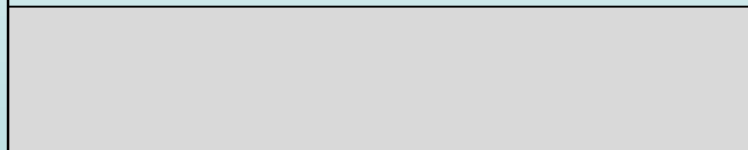


305



Exotic

Tuberosum



2218

(30C, 241CC)

Andigena



770 (5C, 77 CC)

Wild spp.



1082 (5C, 118 spp.)

Nearly 14,000 accessions in CIP gene bank

Nearly 6000 accessions in US potato gene bank

Nearly 1500 accessions in Commonwealth potato collection



# Sources of resistance to various diseases in potato

<b>Diseases</b>	<b>Sources</b>
Viruses - PVX	<i>S. acaule, S. berthaultii, S. tuberosum</i> subsp. <i>andigena</i>
PVY	<i>S. phureja, S. demissum, S. stoloniferum</i>
PLRV	<i>S. acaule, S. demissum, S. tuberosum</i> subsp. <i>andigena</i>
Late blight Vertical	<i>S. demissum, S. verrucosum, S. stoloniferum</i>
Horizontal	<i>S. berthaultii, S. chacoense, S. microdontum, S. vernei</i>
Wart	<i>S. acaule, S. berthaultii.</i>
Common scab	<i>S. chacoense, S. tuberosum</i> ssp. <i>andigena</i>
Bacterial wilt	<i>S. Chacoense, S. microdontum,</i>
Cyst nematodes	<i>S. tuberosum</i> subsp. <i>andigena, S. berthaultii. S. vernei</i>
Root knot nematode	<i>S. spegazzinii</i>
Aphids	<i>S. berthaultii.</i>
Frost	<i>S. acaule, S. ajanhuiri</i>
Heat tolerance	<i>S. chacoense, S. commersonii</i>
High protein content	<i>S. phureja</i>

Most commonly used are: *S. berthaultii, S. bulbocastanum, S. chacoense, S. microdontum, S. multidissectum, S. phureja, S. sparsipilum, S. stenotomum, S. tarigense, S. vernei, S. demissum*



# Breeding Programmes in India

## Breeding for table potatoes (Indo-gangetic plains)

- North-western plains
- West-central plains
- North-eastern plains

## Breeding for late blight (hills)

- North-western hills
- North-eastern hills
- Southern hills
- Darjeeling & Sikkim hills

## Special breeding programmes

- Breeding for processing attributes
- Breeding for heat tolerance
- Breeding of drought tolerance
- Breeding for nutritional quality
- Breeding for Kharif potatoes
- Breeding for nutrient efficient varieties
- Breeding of PCN resistance

# Potato breeding methodology

## Parental preference

- i) *S. tuberosum* ssp. *tuberosum* (commercial varieties, breeding lines, stocks in on-going programmes, old land races)
- ii) *S. tuberosum* ssp. *andigena*
- iii) Primitive cultivated species
- iv) Wild tuber bearing species
- v) Wild non-tuber bearing species

## Selection of parents

## Selection parameters

Phenotypic performance, adaptation, genetic divergence, combining ability, heterosis, progeny tests

## Hybridization

- 1) Establishing parents
- 2.) Pollen fertility estimation (2% Aceto-carmin)
- 3) Emasculation
- 4) Pollen collection & pollination
- 5) Berry, TPS extraction, storage

## Assessment of segregating population

**Seedling stage:** Good vigour, desirable tuber colour, shape, eye depth, no-cracking, irregularity

## Evaluation of clones ( $F_1C_1$ - $F_1C_7$ )

Weightage Score ↑

Initial evaluations ( $F_1C_1$ - $F_1C_3$ ) : Un-replicated trials    Advanced evaluations ( $F_1C_4$ - $F_1C_7$ ) : Replicated trials

DUS, DNA fingerprinting

## Multi-location & on-farm trials under AICRP (P)

AICRP (P):25 (18+7)

Multi-location trials : 2 years

On-farm trials : 1-2 years

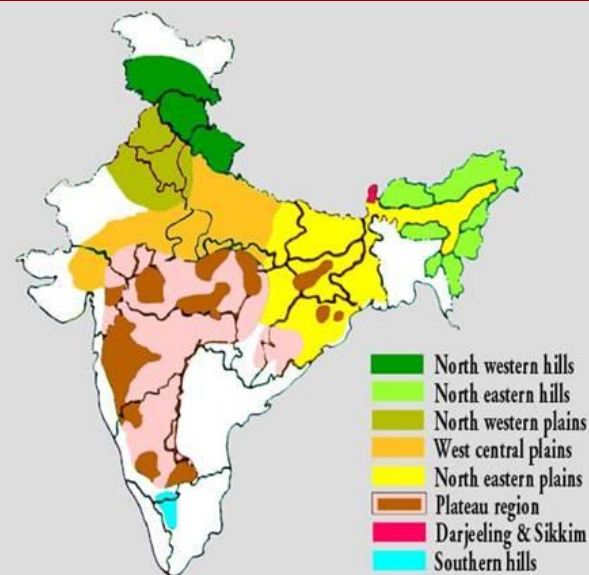
## Release & notification of variety

10-15 years of concerted



# Potato breeding strategy

## Potato growing regions



Area	Season	Traits
North Indian hills	<b>Summer</b> (April-Sep.), Spring (Jan/Feb-May/June) & Autumn (Aug-Nov/ Dec).	<b>Long-day adapted, resistant to late blight,</b>
North Indian plains	Spring (Jan./-April-May) and <b>Autumn</b> (Oct.-Jan./ Feb. or Nov.-March)	<b>Short-day adapted, early bulking, moderately resistant to late blight &amp; frost, good keeping quality</b>
Plateau region	<b>Kharif</b> (July-September), Rabi (Nov.-Feb.)	Early bulking, <b>ability to tuberize under high temperatures</b> , resistant to bacterial wilt, tuber moth and mites, slow rate of degeneration
South Indian hills	Summer (April-Aug.), Autumn (Sep.-Dec.), Spring (Jan.-May)	Early bulking, <b>resistant to late blight and cyst nematodes</b>
North Bengal hills & Sikkim	<b>Autumn</b> (Sep.-Dec.)	Medium maturing, <b>resistant to late blight, immune to wart, red skinned tubers</b>



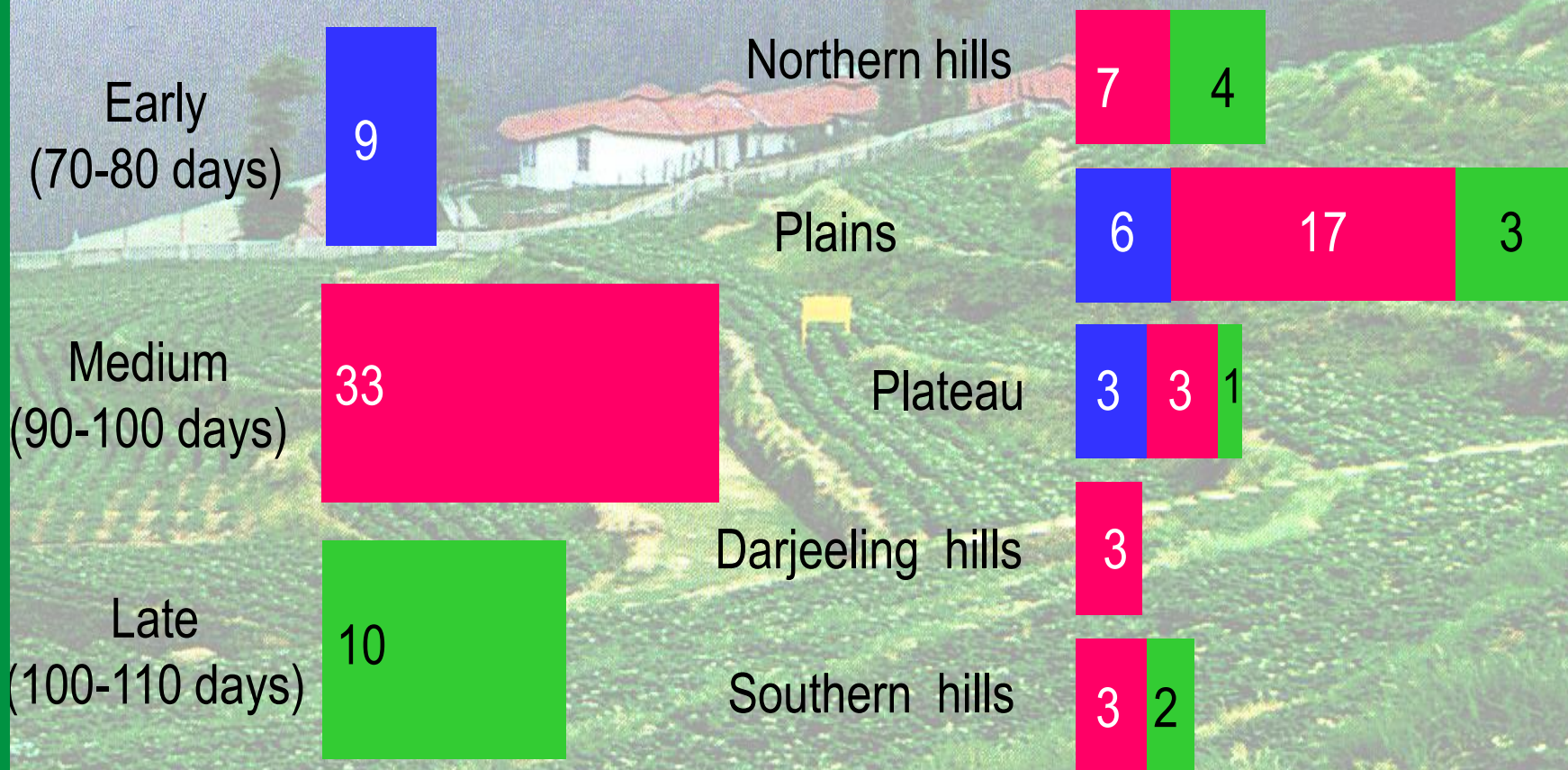
# Potato varieties released by CPRI (52)

Year	Varieties
1958	Kufri Kisan, Kufri Kuber, Kufri Kumar, Kufri Kundan, <b>Kufri Red</b> , <b>Kufri Safed</b>
1963	Kufri Neela
<b>1967</b>	<b>Kufri Sindhuri</b>
1968	Kufri Alankar, Kufri Chamatkar, Kufri Chandramukhi, Kufri Jeevan, Kufri Jyoti, Kufri Khasigaro, Kufri Naveen, Kufri Neelamani, Kufri Sheetman
1971	Kufri Muthu
1972	Kufri Lauvkar
1973	Kufri Dewa
1979	Kufri Badshah
1980	Kufri Bahar
1982	<b>Kufri Lalima</b> <span style="float: right;">2(CS)-21(IxI)-21(IxE)-8 (ExE)=85</span>
1983	Kufri Sherpa <span style="float: right;">Adina, Craigs Defiance, Ekishiraju, Katahdin, Up-to-Date</span>
1985	Kufri Swarna
1989	Kufri Megha
1996	Kufri Jawahar, Kufri Sutlej, Kufri Ashoka
1998	Kufri Pukhraj, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Giriraj
1999	Kufri Anand, <b>Kufri Kanchan</b>
2005	<b>Kufri Arun</b> , Kufri Pushkar, Kufri Shailja
2006	Kufri Surya, Kufri Chipsona-3, Kufri Himalini
2008	Kufri Himsona, Kufri Sadabahar, Kufri Girdhari, Kufri Khyati
2009	Kufri Frysona
2010	Kufri Chipsona-4, Kufri Neelma
2012	Kufri Gaurav, Kufri Garima
2013	<b>Kufri Lalit</b> , <b>2015 (Kufri Mohan)</b>



# Developed 52 improved varieties

## Number of varieties





# Breeding for Indo-Gangetic Plains

(Jalandhar, Modipuram & Patna)

## Requirements:

65-85 days early maturing varieties

To fit into Rice – Potato – Wheat

Late blight resistance - not required essentially

## Procedure:

### Hybridization at Kufri

Parents – Tuberosum, Improved Andigena

- **Seedlings/Early generations** ( $F_1C_1 - F_1C_3$ ) :- Tuber characters
- **Advance Generations** ( $F_1C_4 - F_1C_6$ ) :- a. Yield trials  
b. Keeping quality  
c. Cooking quality
- **Multilocation Trials:-** (2 years – Replicated  
(under AICRP) 2 years – on farm)
- **Release and Notification**





# Breeding for Northern hills

(CPRI, Shimla; CPRS, Shillong)

## Requirements:

- 100-110 days medium maturing varieties
- High level of Late blight resistance required

## Procedure:

- **Hybridization at Kufri & Shillong**  
Parents – Tuberosum, Improved Andigena, wild species
- **Seedlings:** :- Late blight in lab
- **Early generations** ( $F_1C_1 - F_1C_3$ ) :- Tuber characters & LB
- **Advance Generations** ( $F_1C_4 - F_1C_6$ ) :-
  - a. Yield trials (Plains & hills)
  - b. Keeping quality (Plains)
  - c. Cooking quality
- **Multilocation Trials:-** (2 years – Replicated  
(under AICRP) 2 years – on farm)
- **Release and Notification**



# Breeding for Southern hills

## (CPRS, Ootacamund)

### Requirements:

- 100-110 days medium maturing varieties
- High level of Late blight resistance required
- Resistance to cyst nematodes essential

### Procedure:

- **Hybridization at Ootacamund & Kufri**  
Parents – Tuberosum, Improved Andigena, Vernei clones
- **Seedlings:** :- Late blight
- **Early generations** ( $F_1C_1 - F_1C_3$ ) :- Tuber characters, LB, CN
- **Advance Generations** ( $F_1C_4 - F_1C_6$ ) :-
  - a. Yield trials
  - b. Keeping quality  
(Dormancy)
  - c. Cooking quality
- **Regional Multilocation Trials:-** (2 years – Replicated  
2 years – on farm)

**Regional Release and Notification**

# Breeding for Heat Tolerance

## Requirements:

- 75-90 days early/medium maturing varieties
- Suitable for early planting in west-central plains
- Suitable for non-traditional potato growing areas
- Some level of late blight resistance – desirable

## Procedure:

- **Hybridization at Kufri**  
Parents – Tuberosum, Improved heat tolerant lines
- **Seedlings:** :-Under normal conditions at Modipuram
- **Early generations** :- Early planted crop Modipuram
- **Advance Generations**
  - a. Yield trials- Modipuram and plateau
  - b. Keeping quality
  - c. Cooking quality
- **Multilocation Trials:-** (2 years – Replicated  
(under AICRP) 2 years – on farm)
- **Regional Release and Notification**



# Breeding for Processing

## Requirements:

- 90-100 days medium maturing varieties
- High dry matter, Low reducing sugars
- Tuber characters - Suitable for chips & French Fry
- Late blight resistance – required

## Procedure:

- **Hybridization at Kufri**  
Parents – Tuberosum, Improved Andigena
- **Seedlings:** :-Tuber characters
- **Early generations** :- Quality and tuber characters
- **Advance Generations**
  - a. Yield and quality trials
  - b. Quality tests at factory
  - c. Keeping quality

**Multilocation Trials:-** (2 years – Replicated)  
(Under AICRP) (2 years – On farm)

**Release and Notification**

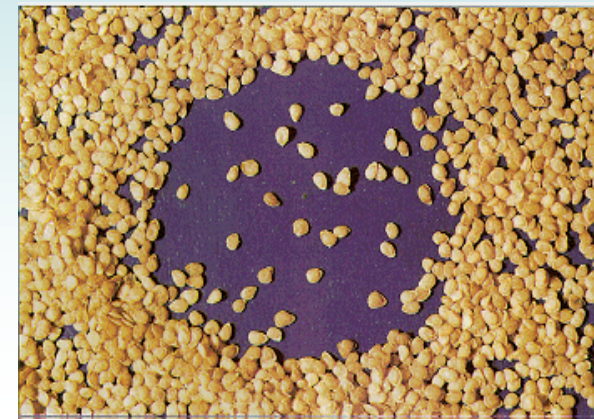
# Breeding for TPS populations

## Requirements

- 90-100 days early/medium maturing populations
- Uniformity in tuber characters and early bulking
- Late blight resistance required
- Good seedling survival as transplant

## Procedure

- Hybridization at Kufri/Modipuram/Patna
- Seedling evaluation for transplant crop - Shillong
- Seedling evaluation for seedling tuber production - Modipuram/Patna/Shillong
- Multilocation testing in North-eastern region
- Multilocation trials under AICRP
- Recommendation/Release



# Some Popular Indian Potato Varieties



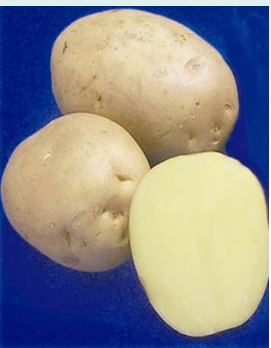
## **Kufri Jyoti:**

wide adaptability, early bulker, slow rate of degeneration, immune to wart, moderately resistant to late blight and early blight



## **Kufri Bahar:**

For North Indian plains, early bulker, immune to wart, Resistant to Gemini virus (PALCD)



## **Kufri Pukhraj:**

For North Indian plains and plateau, Suitable for low input, early bulker, immune to wart, moderately resistant to late blight and early blight



### **Kufri Ashoka:**

For Indo-gangetic plains,  
early maturity



### **Kufri Chandramukhi:**

For North Indian plains and plateau  
early maturity



### **Kufri Badshah:**

For North Indian plains and plateau,  
medium maturity,  
moderately resistant to late blight and  
early blight, resistant to PVX



### **Kufri Sindhuri:**

For North Indian plains,  
late maturity,  
moderately resistant to early blight, tolerant to PLRV



### **Kufri Kanchan:**

For North-Bengal hills and Sikkim,  
medium maturity, immune to wart  
moderately resistant to late blight,  
slow rate of degeneration



### **Kufri Swarna:**

For southern hills, medium maturity,  
resistant to cyst nematodes, immune to wart  
resistant to late blight and early blight



### **Kufri Lauvkar:**

For plateau, early maturity,  
heat tolerant



### **Kufri Surya:**

For plateau, early maturity,  
heat tolerant





## **Kufri Chipsona-1:**

For North Indian plains, medium maturity  
high dry matter, low reducing sugars, low phenols  
resistant to late blight



## **Kufri Chipsona-3:**

For North Indian plains, medium maturity  
high dry matter, low reducing sugars, low phenols  
resistant to late blight, immune to wart

## **Some latest releases**

1. **Kufri Pushkar**
2. **Kufri Khyati**
3. **Kufri Sadabahar**
4. **Kufri Himalini**
5. **Kufri Himsona**
6. **Kufri Girdhari**
7. **Kufri Gaurav**
8. **Kufri Garima**
9. **Kufri Mohan**



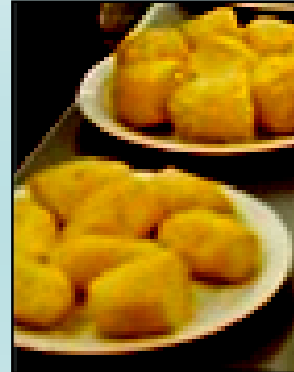
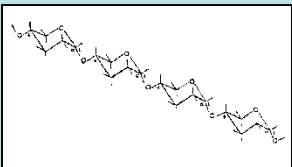
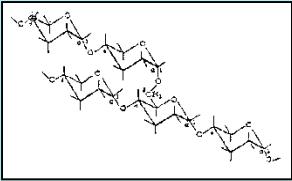
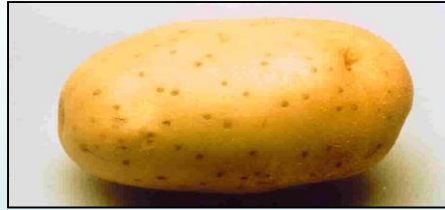


# Recent releases from CPRI



S. N.	Variety	Selection number	Year of release	Parentage
36	Kufri Arun	MS/92-2105	2005	Kufri Lalima x MS/82-797
37	Kufri Pushkar	JW 160	2005	QB/A 9-120 x Spatz
38	Kufri Shailja	SM/87-185	2005	Kufri Jyoti x EX/A 680-16
39	Kufri Surya	HT/92-621	2006	Kufri Lauvkar x LT-1
40	Kufri Chipsona-3	MP/97-583	2006	MP/91-86 x Kufri Chipsona-2
41	Kufri Himalini	SM/91-1515	2006	I-1062 x Bulk pollen (CP2132-Tollocan)
42	Kufri Himsona	MP/97-644	2008	MP/92-35 x Kufri Chipsona-2
43	Kufri Sadabahar	MS/93-1344	2008	MS/81-145 x PH/F-1545
44	Kufri Girdhari	SM/93-237	2008	Kufri Megha x Bulk Pollen (10 genotypes)
45	Kufri Khyati	J/93-86	2008	MS/82-639 x Kufri Pukhraj
46	Kufri Frysona	MP/98-71	2009	MP/92-30 x MP/90-94
47	Kufri Neelima	OS/93-D-204	2010	E/79-15 x E/79-42
48	Kufri Chipsona-4	MP/01-916	2010	Atlantic x MP/92-35
49	Kufri Gaurav	JX576	2010	JE 812 x K. Jyoti
50	Kufri Garima	MS/99-1871	2011	PH/F 1045 x MS/82-638
51	Kufri Mohan	MS/5-1543	2015	MS/92-1090 x CP 1704 (Claudia)
51	TPS Population	83-P-47 (I) x D- 152 (II)	2007	

# Potato: Many uses



**Starch**

**Par-fried**

**Snacks & extruded products**

**Cooked**

**Dried (Granules, flakes etc.)**



# Need for breeding processing varieties

- All the 29 varieties bred by CPRI till 1998 were mainly for table consumption
- Processing was at a low ebb till 1998
- With the entry of MNC's in potato processing sector in 1998, a need was felt for suitable processing varieties having high dry matter and low reducing sugars
- In the absence of Indian processing varieties, an American variety Atlantic was introduced in India, which gave lower yields under short day conditions and was susceptible to late blight

Cont.....



# Need for breeding processing varieties

- A challenge was thrown to the CPRI for developing indigenous processing variety
- After 8 years of dedicated efforts, India's first processing varieties namely, Kufri Chipsona-1 and Kufri Chipsona-2, were released
- Another improved processing variety, Kufri Chipsona-3, producing higher proportion of processing grade tubers with no tuber defects was developed in 2005
- An exclusive chipping variety, Kufri Himsona, was released for hilly regions of India in 2007



# Quality requirements of potatoes for different forms of processed products

Characteristics	Products			
	Dehydrated	French fries	Chips	Canned
Tuber shape	Round to oval	Oblong	Round to oval	Round to oval
Tuber size, mm	30	>75	45-80	20-35
Eyes	Shallow	Shallow	Shallow	Shallow
Specific gravity	1.080	1.080	> 1.080	< 1.070
Dry matter, %	>20	>20	>20	<18
Reducing sugar (% fresh wt)	0.15	0.15	< 0.1	0.5
After cooking discoloration	Slight	Slight	-	Nil
Texture	Fairly firm to mealy	Fairly firm	Fairly firm to mealy	Waxy

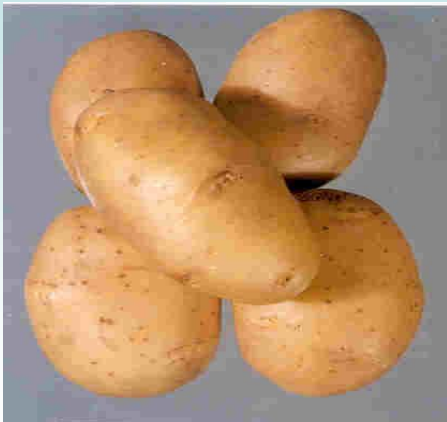
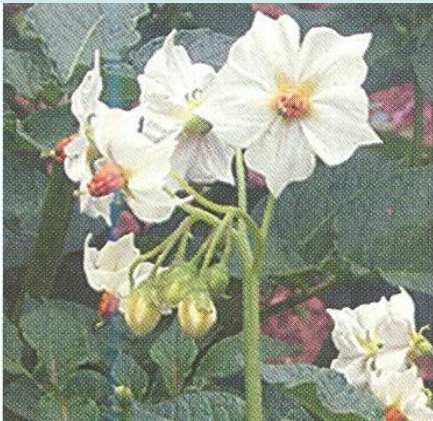
# Desirable biochemical attributes for breeding processing varieties

*Parents selected for breeding varieties should have following traits*

- The dry matter should be  $>20\%$  and reducing sugar content should be  $<0.1\%$  on Fresh wt basis
- No enzymatic browning
- The glycoalkaloid content should be  $<20$  mg/100 g Fresh wt

# Salient features of Indian processing varieties

## Kufri Chipsona-1



- Selection from the progeny of the cross CP 2416 x MS/78-79 made in 1990
- The plant has medium compact canopy with white flowers and the tubers are white cream, ovoid with shallow eyes and white flesh
- The variety is well adapted to north-Indian plains and has a maturity period of 90-110 days
- It has resistance to late blight and gives an average yield of 300-350 q/ha and possess very good storability



# Salient features of Indian processing varieties

## Kufri Chipsona-2



- Selection from the progeny of the cross CP 2346 (F-6 from Peru) x QB/B 92-4 made in 1991
- The plant has medium compact canopy with white flowers and the tubers are white cream, round with shallow eyes and creamy flesh
- The variety is well adapted to north-Indian plains and has a maturity period of 100-110 days. It is resistant to late blight and gives an average yield of 300-325 q/ha

# Salient features of Indian processing varieties

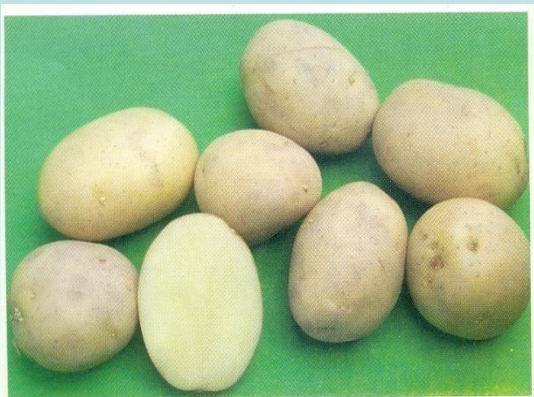
## Kufri Chipsona-3



- Selection from the progeny of the cross Kufri Chipsona-2 x MP/91-86 made in 1996
- The plant has medium compact canopy with white flowers and the tubers are yellow, ovoid with medium-deep eyes and creamy flesh
- The variety is well adapted to north-Indian plains and has a maturity period of 90-110 days. It is resistant to late blight and gives an average yield of 350-400 q/ha

# Salient features of Indian processing varieties

## Kufri Himsona



- Selection from the progeny of the cross MP/92-35 x Kufri Chipsona-2

- The plant has medium canopy with purple flowers and the tubers are white to creamy, round-oval with shallow eyes and cream pale yellow flesh

- The variety is adapted to hilly regions of the country and has a maturity period of 120-140 days

- It has field resistance to late blight and gives an average yield of 250 q/ha.

# Features of French fry variety Kufri Frysona (MP/98-71)



**Total yield: 38.3 t/ha**

**French fry grade yield: 19.8 t/ha**

**Dry matter: 23.0%**

**Excellent fry colour**

**Very good storability at 10-12 °C  
with CIPC**

# Features of promising early maturing hybrid MP/01-916 (Kufri Chipsona-4)



- Higher total and processing grade yield
- Excellent chip colour
- High specific gravity (1.083) and dry matter (24.3%)
- Low level of reducing sugars (0.03%)
- Moderately resistant to late blight in comparison to popular variety Kufri Jyoti and exotic Atlantic

# Biochemical traits and suitability of Indian processing varieties

Varieties	Dry matter (%)	Reducing sugars (mg/100 g FW)	Suitability for Products
Kufri Chipsona-1	21-24	45-100	Chips, French fries, flakes, flour, dehydrated products
Kufri Chipsona-2	21-25	45-95	Chips, flakes, flour, dehydrated products
Kufri Chipsona-3	21-24	50-70	Chips, flakes, flour, dehydrated products
Kufri Himsona	22-26	45-65	Chips, flakes, flour, dehydrated products
Kufri Frysona	21-23	80-100	French Fries

# Impact of Indian processing varieties

- The long pending demand of the industries was met as Indian processing varieties contained  $>21\%$  dry matter and low reducing sugars ( $<0.1\%$  on fresh wt)
- All these varieties are suitable for chips and dehydrated products
- Kufri Chipsona-1 due to its oval to oblong tuber shape is utilized both by the chipping and French fry industries
- These varieties have brought revolution in the Indian processing scenario within a span of 10 years

# Future thrust

- Development of French fry varieties
- Development of cold chipping variety
- Development of early maturing chipping variety



**Thanks**

