RECENT TRENDS IN ONION BREEDING AND GENETICS FOR VARIETAL IMPROVEMENTS

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Global / National scenario of onion & Garlic

ONION	India	Rank	Other top contributors	World	India's share (%)
Area (million ha.)*	1.48	1	1.35 (China) (2nd Rank)	5.1	29
Production (million t) *	24.2	1	24.0 (China) (2nd Rank)	106.3	23
Productivity t/ha*	16.4	90	85.4 (Republic of Korea)	20	-
Export quantity (Million MT)#	1.53	2	1.03 (Netherlands)	6.7	22.83
Export value (Billion USD)#	0.41	-	0.52 (Netherlands)	5.14	8

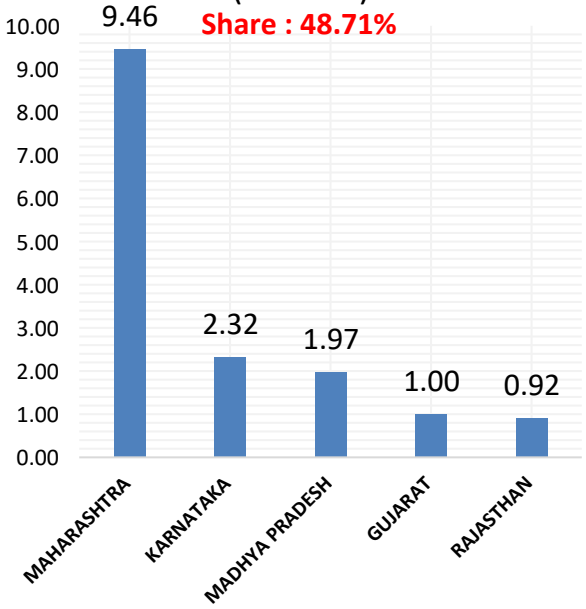
GARLIC	India	Rank	Top contributors	World total	India's share (%)
Area (million ha.) *	0.35	2	0.82 (China)	1.6	22
Production (million t) *	2.46	2	20 (China)	27	9.15
Productivity (t ha^{-1}) *	8.13	53	48.18 (Kuwait)	16.8	-
Export quantity (Million MT)*,#	0.057	3	1.14 (China Mainland)	4.43	1.28
Export value (Billion USD) *	0.01	-	1.79 (China)	5.14	0.19

Source: FAOSTAT (2021)*, DGCIS Annual Report (2021)#

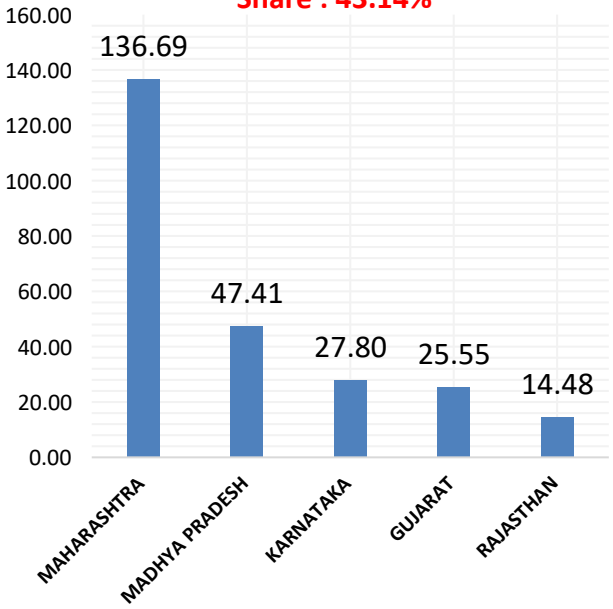
Onion Production Status: 2021-22

Onion

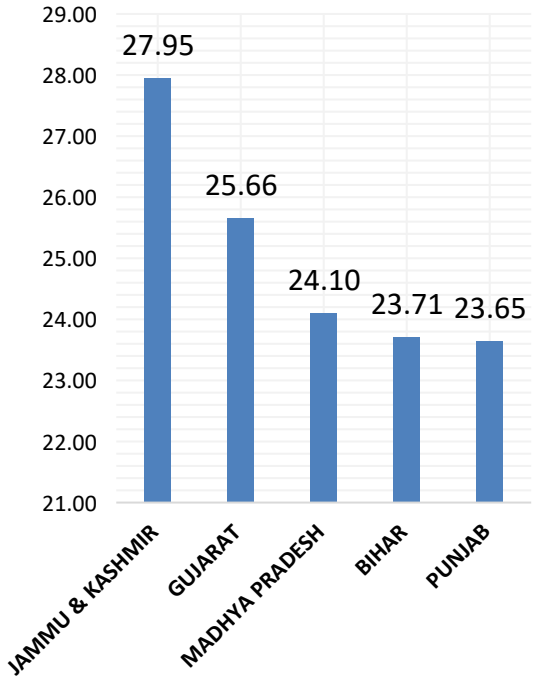
Area under Onion production (Lakh ha)



Onion Production (Lakh tonnes)



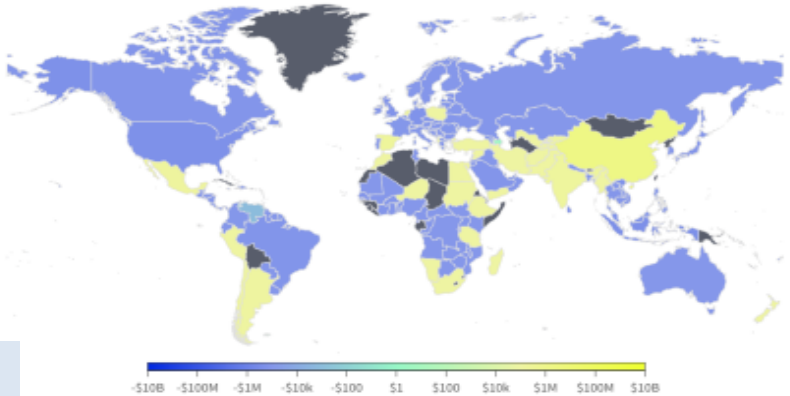
OnionProductivity (t/ha)



Source: MoAFW Stat:2021-22

Net Trade of Onion World-wide during 2021

Net Trade 2021



https://oec.world/en/profile/hs92/onions

Top 5 Onion Exporters of World

Rank (Exporters)	Country	Value
1	China	$2.56 Billion
2	Netherlands	$700 Million
3	Spain	$595 Million
4	**India**	**$ 455 Million**
5	Mexico	$ 382 Million

Top 5 Onion Importers of World

Rank (Importers)	Country	Value
1	Indonesia	$ 610 Million
2	United States	$ 527 Million
3	Vietnam	$ 474 Million
4	Germany	$ 390 Million
5	United Kingdom	$ 316 Million

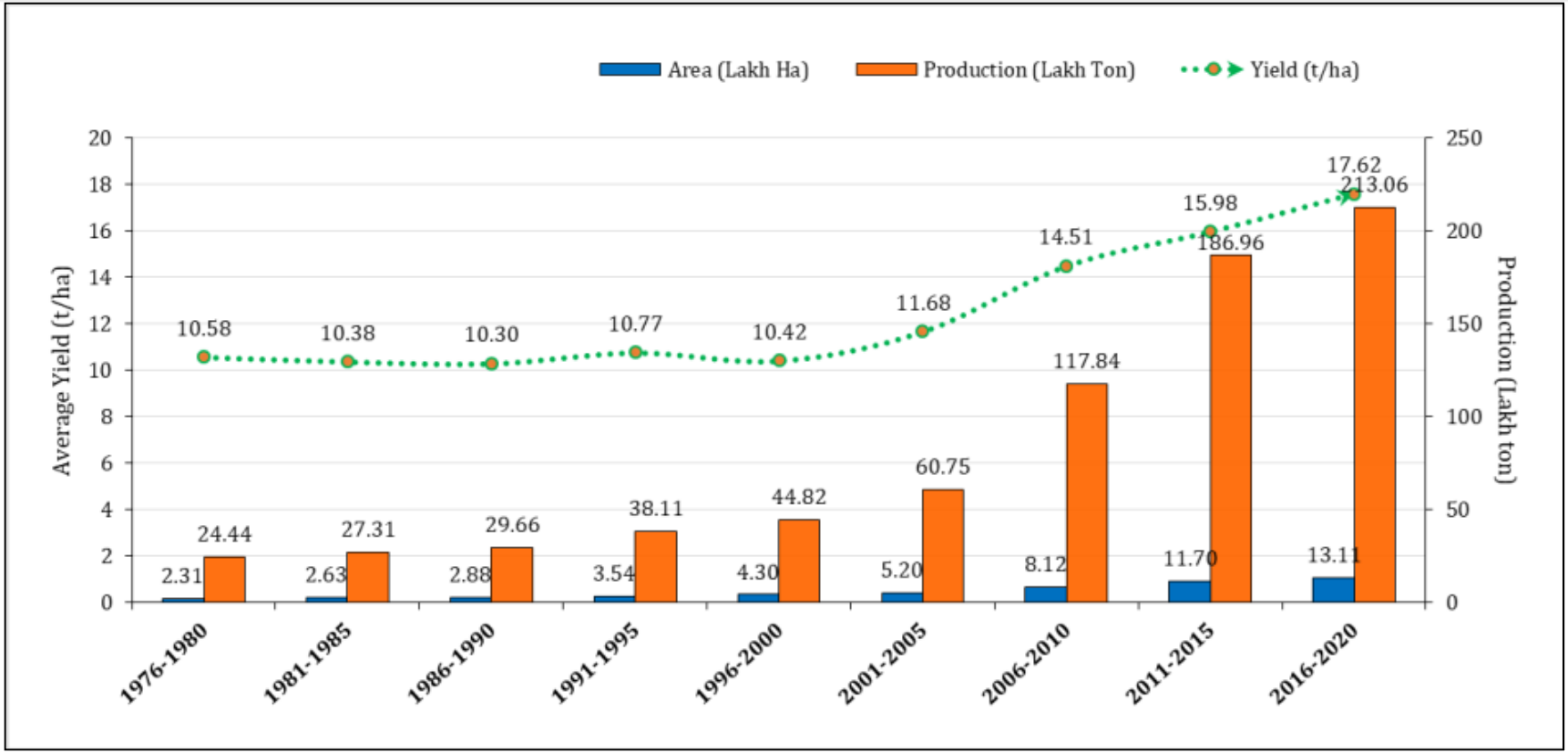
Top Onion Growers of India

- The ten major Onion producing states are contribute about 95% of the total Onion production of the country.
- Maharashtra alone produce 43.31% of the onion produced in the country.
- In Maharashtra, Madhya Pradesh and Karnataka, onion is grown in all three seasons *Kharif*, *Late-kharif* and *Rabi*

State	2021-2022	
	Production MT	% Share
Maharashtra	13301.7	43
Madhya Pradesh	4740.6	15
Karnataka	2279	9
Gujrat	1591	5
Rajasthan	2555	8
Bihar	1375	4
West Bengal	866.3	3
Andhra Pradesh	722.9	2
Tamil Nadu	555.7	2
Haryana	514	2

(Horticulture Statistic at a Glance, 2022)

Area, Production and Productivity of Onion in India



In past 20 years, production of onion in India has increased more than four times and productivity increased more than 50%

Onion and Garlic Scenario in India

Onion

2021-2022

Area (lakh Ha)	19.41
Production (lakh T)	316.87
Productivity (t/ha)	16.32

Productivity > 1.5 Times

Area > 4 Times

Production > 6 Times

2001-02

Area (lakh Ha)	4.96
Production (lakh T)	52.52
Productivity (t/ha)	10.6

18.32 Lac tonnes storage capacity created through govt. subsidy in Maharashtra (during 2002-21)

India accounts a 31.1 % share of total export of onion based processed products earning 1588.91 lakh USD

Major processing locations: Maharashtra, Gujrat

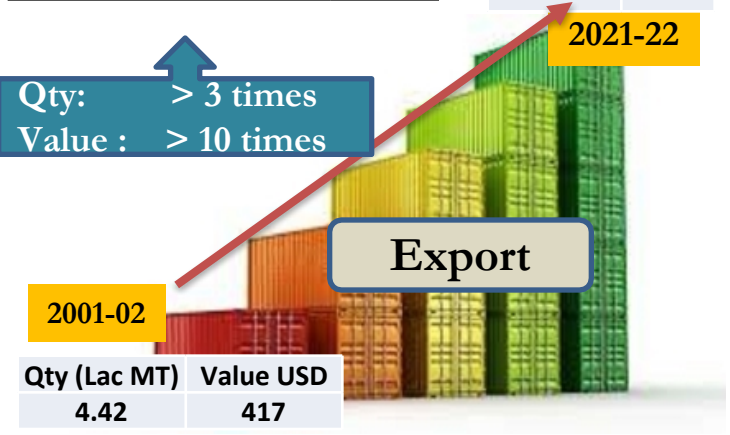
Export

Qty (Lac MT)	Value MUSD
15.37	3432

2021-22

Qty: > 3 times

Value : > 10 times



2001-02

Qty (Lac MT)	Value USD
4.42	417

2021-2022

Area (lakh Ha)	4.31
Production (lakh T)	35.23
Productivity (t/ha)	8.17

Productivity > 1.77 Times

Area > 3.74 Times

Production > 6.63 Times

2001-02

Area (lakh Ha)	1.15
Production (lakh T)	5.31
Productivity (t/ha)	4.6

Garlic

Variability in indigenous/ local cultivars

Low replacement rate in onion varieties

Onion is biannual crop takes 12 years to develop varieties

Bulb production & storage

Seed production & low viability

Need of Onion varieties for different seasons

Cultivating Season	Planting time	Marketing Months	Duration
Rabi	December – January	April – October	7 months
Early Kharif	February-April	May-July	3 months
Kharif	July – August	October – December	3 months
Late Kharif	September – October	January – March	3 months
Long Day Onion	October – November	July – November	5 months

Major crop is rabi covers : 60% area, kharif and late kharif : 20 % each

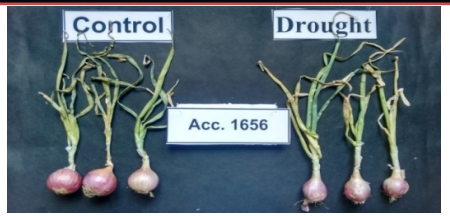
Challenges in Onion & Garlic Research in India

- **Drought/water scarcity**
- **Diseases and Pests**
- **Excess Rainfall (Affects Kharif harvest & Rabi storage)**
- **Onion Export (Govt. firm policy and irregular supply)**
- **Climate fluctuation (Temperature, rainfall, humidity)**

Effect of Water scarcity on Onion

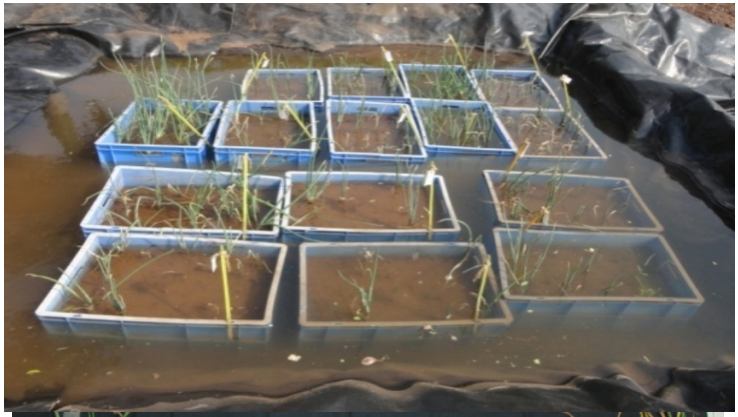
- Drought stress **reduces plant growth and photosynthesis**
- Crops reaches **forced early maturity** results **in immature/ partially matured bulbs**
- Increased quantity of small bulbs & reduced single-centre onion bulbs
- **Drought stress during 40-85 DAT is crucial & reduced onion yield**
- Water stress for a period of 25 days from 40-65 DAT, and 61 to 85 DAT reduced onion yield by 26.5% and18.2%, respectively

DAT	Growth stages	Yield (T/ha)
1-110	Control	35.6
15 - 40	Bulb initiation	34.1
40 - 65	Bulb formation	26.5
61 - 86	Bulb enlargement	18.2
86-120	Bulb maturity	34.7



Excess Rainfall

- **Reduce crop yield by up to 34%-80%**
- **Critical growth stage for water logging: 30–60 Days After Transplanting**
- **Excessive rainfall during active growing stages hinders root growth, nutrient uptake, nutrient translocation and photosynthesis, thereby reducing crop growth and development**



Waterlogging from 30 to 60 DAT reduced bulb size

- **Systematic breeding programme was started as early as 1960 at Pimpalgaon Baswant, Nasik and later on at IARI, New Delhi and in other organizations**

- **It was further strengthened under coordinated project & AINRPOPG through SAUs and ICAR institutes, as a result, about 66 varieties of common onion and multiplier onion have been developed in India**

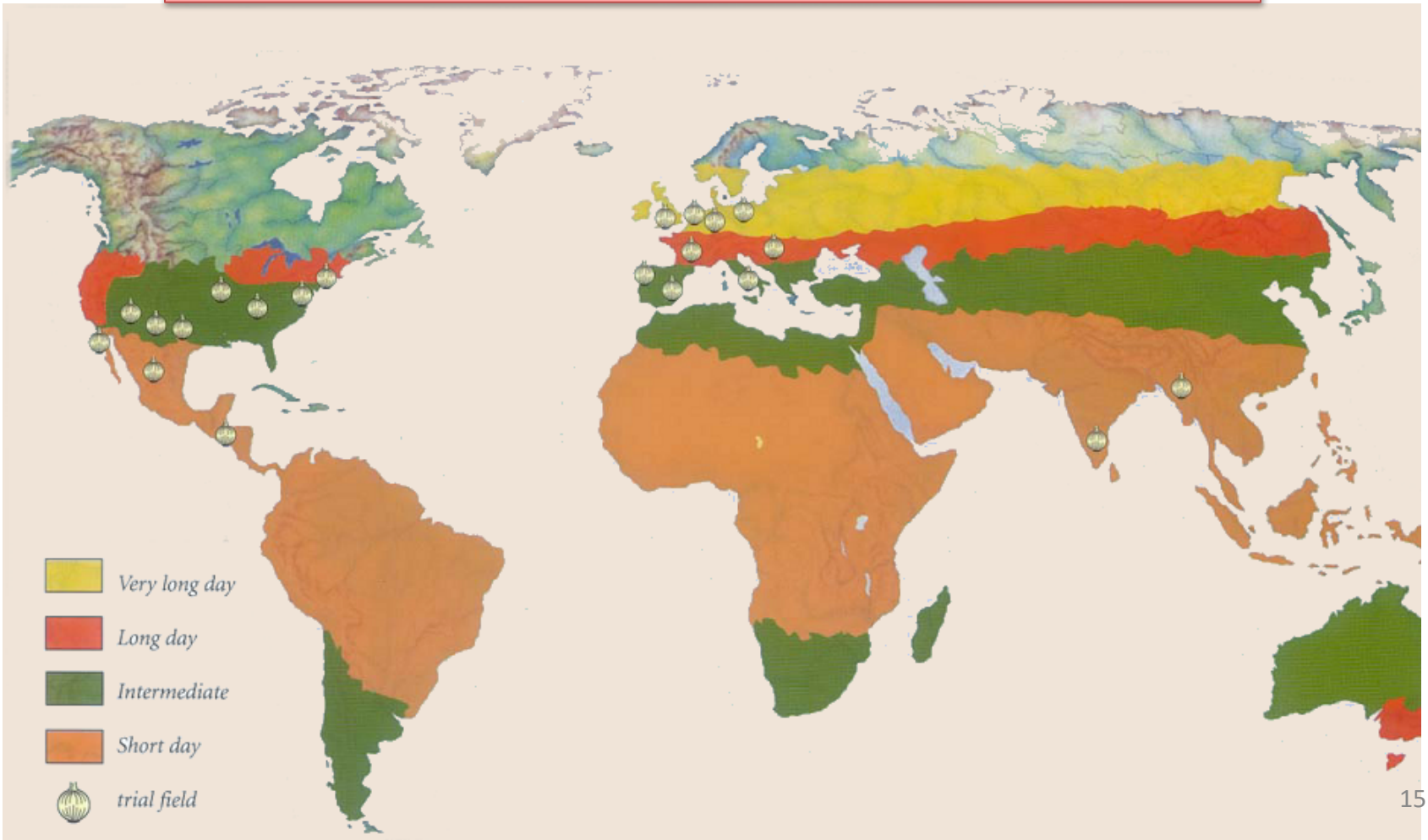
- **The improvement of onion crop has not attracted much attention of the breeders in India**

- **Because of its biennial habit of the crop requiring longer time for breeding and difficulties in attaining and maintaining genetic uniformity due to high degree of natural cross pollination and rapid inbreeding depression**

- **Poor storability and lack of facilities for storage of selected bulbs of breeding lines in controlled storage conditions is another factor for slow progress in onion breeding (Swarup, 1991)**

- **Non-availability of sufficient seed at reasonable price is the secondary important factor**

Day-length wise geographical distribution of onion



Need for development of varieties

- High yield, uniform bulbs
- Different seasons
- Biotic (Pest mainlt thrips and diseases viz. Fungal & bacterial : purple blotch, basal rot, *Stemphyllium* blight, anthracnose, pink root rot and bacterial rot)
- Abiotic stress (moisture stress (flood/ drought) high temperature, salinity and alkalinity)
- Processing
- Green foliage
- Export quality, without doubles and bolters
- Mechanized farming for large as well as small farmers
- Better keeping quality in kharif & rabi
- Consumers demand (Small, Big, Colour wise)
- Enriched nutritional qualities
- Set planting
- Face Climate Change
- Capable of producing good seed yield

CHARACTERISTICS OF VARIETIES SUITABLE FOR KHARIF SEASON

1. High Yielder with average yield upto 150q/ha.
2. Preferably dark red to red in colour
3. White onion varieties for consumption and processing
4. Resistant to diseases and pests
5. Withstand rainfall
6. Thin neck
7. Less sprouting and rotting up to 1-2 months of storage

CHARACTERISTICS OF VARIETIES SUITABLE FOR LATE KHARIF SEASON

1. High Yielder with average yield 250q/ha.
2. Preferably dark red to red in colour and white varieties for consumption & processing.
3. Resistant to diseases and pests
4. Less bolters
5. Less doubles
6. Thin neck with some degree of neck fall before harvesting
7. At least 2-3 months of storage

CHARACTERISTICS OF VARIETY FOR RABI SEASON

1. High yielder with average yield upto 300-350 quintal/ha

2. Less doubles & bolters

3. Preferably light red in colour but now medium & dark red is
4. also preferred in Northern India and white in some pockets

5. Resistant to diseases & pests

6. Thin neck & Proper neck fall before harvesting

7. Good storage life for 5-8 months

Genetics of traits in onion

S.no.	Onion traits	Genetic condition
1	Albino seedling	a/a
2	Yellow seedling linked with glossy	y1/y1
3	Yellow seedling not linked with glossy	y2/y2
4	Pale green seedling	pg/pg
5	Virescent seedling	v/v
6	Glossy foliage	gl/gl
7	Exposed anther	ea /ea
8	Yellow anther	ya/ya
9	Pink root resistance	pr/pr
10	Male sterility nuclear gene (Interaction between nuclear gene and plasmagene, S)	ms/ms
11	Brown seed colour	b/b
12	Bulb colour	Five major genes (ICGLR) dominant white (*I*-), recessive white (*cc*), yellow (*iiC-llR-, iiC-L-rr*, and *iiC-llrr*), and light-red to red (*iiC-L-R*-) *L2: Another locus governing red colour*

Breeding Methods in Onion

Introduction

Mass selection

Hybridization followed by Mass selection/ pedigree selection

Heterosis breeding (F1 hybrids)

Progeny selection

Composites

Synthetics

Mutation breeding

Introduction

- Early Grano and Brown Spanish were introduced and acclimatized for growing in Indian conditions.
- Brown Spanish is a long day type variety grown on hills.
- Mercedes, Linda Vista, Couger, Collina yellow onion for plains

Selfing followed by massing

Jones and Mann (1963) suggested for onion to **overcome inbreeding depression**. **Pusa Madhavi** such variety developed at IARI.

Synthetic varieties

Arka Bheem & Arka Akshay developed at IIHR, Bangalore

Pedigree Selection

IIHR, Bangalore, developed a yellow onion variety, Arka Pitambar through pedigree selection from the cross U.D. 102 x IIHR-396.

• Heterosis breeding

- Cytoplasmic-genic male sterility in onion by H.A. Jones in 1925
- **Heterosis for yield, earliness, uniformity in shape, colour, size, storage quality and dry matter content has been observed in onion**
- In U.S.A. and Japan, F_1 hybrids occupy large growing areas, while in
- European countries like Netherland, U.K., the open pollinated varieties are more commonly grown
- The reason being that, the open pollinated varieties may be equally good, if not superior to hybrid varieties, **as in general individual bulb is a hybrid result of cross pollination with unknown parent**.
- Major problem is availability of stable MS line in short-day onion
- Lack of true inbred lines results in variability in produce
- Till now it is not exploited in India though two hybrids were developed by IIHR and further work is in progress at DOGR and 6 hybrids are being tested in AINRPOG trials

Varieties developed by ICAR-DOGR

(All varieties are notified by CVRC, Gov. of India)

Bhima Red

Bhima Dark Red

Bhims Super

Bhima Kiran

Bhima Light Red

Bhima Shakti

Bhima Raj

Bhima Shubhra

Bhima Shweta

Bhima Safed

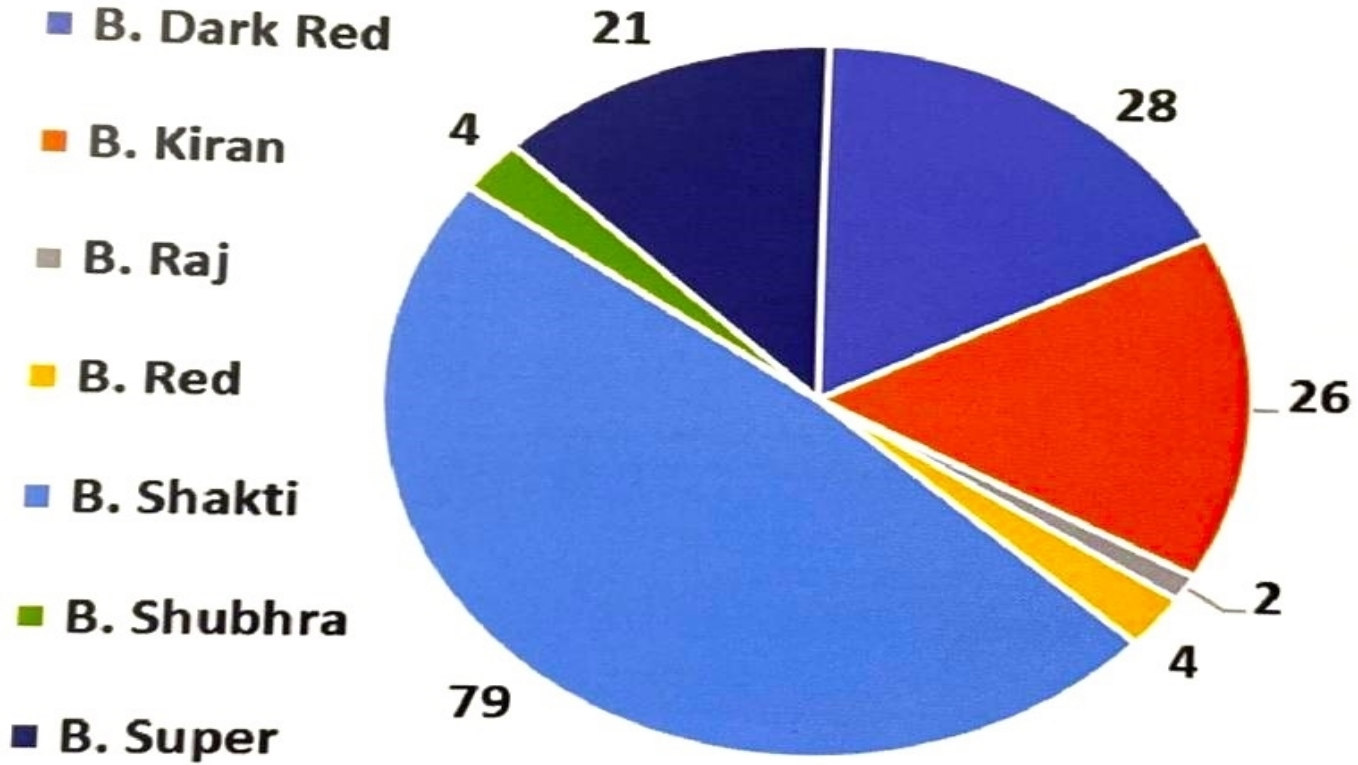
Bhima Omkar

Bhima Purple

High TSS lines: Four high TSS lines viz. HT1, HT2, HT3 and HT4 showed >16°Brix

Photo less sensitive cultivars Bhima Dark Red and Bhima Super

ICAR-DOGR LICENCED VARIETIES WITH 162 STAKE HOLDERS INCLUDING 30 FPO’s



Kharif onion cultivars

- **Bhima Super, Bhima Dark Red, Bhima Shubhra and Phule Samarth** showed better plant growth and produced a higher yield during the high-rainfall years

Bhima Dark Red

Bhims Super

Phule Samarth

Single centre -------

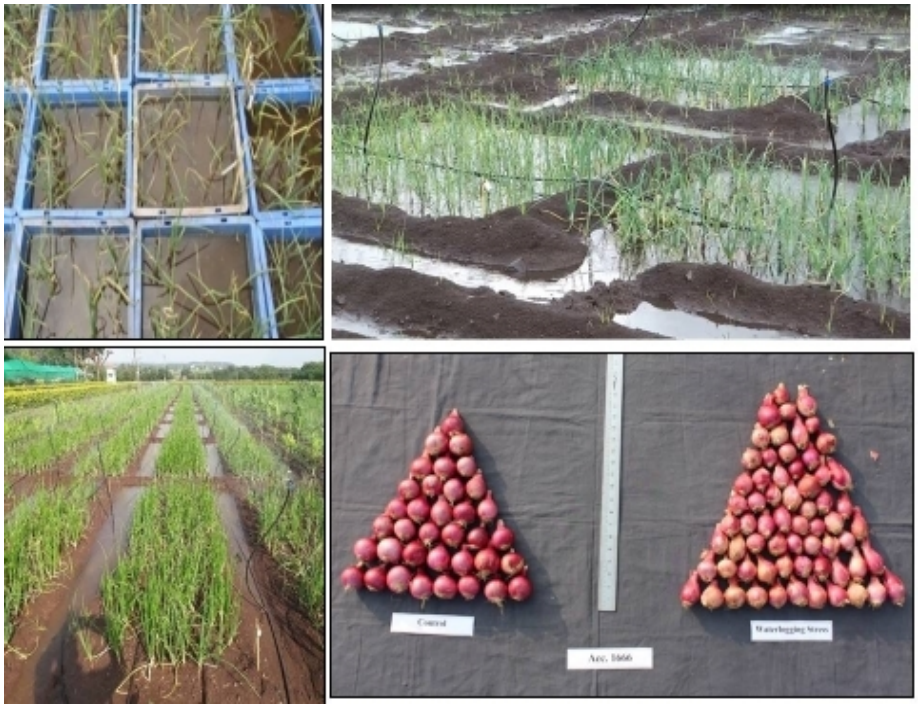
Selection of bulbs for improvement according to centerness

------ double/ multiple centre

Improvement in single centerness in onion bulbs over generation through mass selection

Year	Cycle	Bhima Super
1998	0	20
1999	1	39
2000	2	50
2001	3	65
2002	4	79.8
2003	5	85
2004	6	90
2005	7	92
2006	8	94
2007	9	96
2008	10	98

Waterlogging tolerant Accession 1666 (INGR22082)



➢Yield reduction ranged from 44.5 and 63.6% during high-rainfall years in comparison to the low-rainfall years

- Screened 410 onion genotypes for waterlogging tolerance
- Identified four genotypes namely **Accession 1666, Accession 1630, BDR-WL and W-355**
- Accession 1666 exhibited 100% survival during water-logging
- **Showed better plant growth with 100% recovery** after water-logging.
- Exhibited 36.2% bulb size reduction compared to the control plants
- Produced bigger size bulbs compared to sensitive genotypes
- Confirmed through transcriptome study

Rabi onion cultivars during drought

- Yields of Bhima Shakthi and Bhima Kiran decreased by 38.1% and 67.6%, respectively in comparison to the well-watered condition when exposed to drought stress during 50–75 DAT

- The drought tolerance efficiency of Bhima Kiran and Bhima Shakthi were 61.9% and 32.4%, respectively

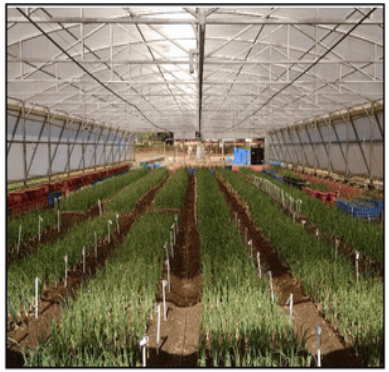
- Need for drought tolerant cultivars

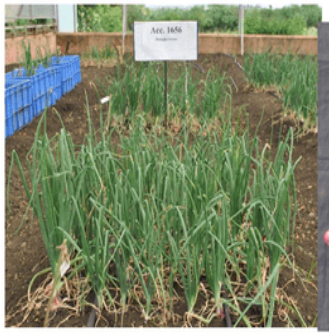
Bhima Shakti

Bhima Kiran

NHRDF Red3

Drought tolerant Accession 1656 (INGR22083)





- Screened 400 onion genotypes in four years
- Onion genotypes **Accession 1656 showed tolerance to drought**
- Exhibited higher plant height and leaf area compared to the sensitive genotypes
- Showed improved physiological and biochemical traits, and lower yield reduction of 7.05% under drought stress
- Confirmed through transcriptome sequencing and phenomics study

UNIFORM MATURITY SUITABLE FOR MECHANICAL HARVESTING IN ABROAD

Breeding for disease and insect resistance

S.No	Disease/pest	Level of resistance	Name of variety/line
1	Purple blotch	R	IHR 56-1
		MR	Arka Kalyan, AFDR, IHR-25, VL-67, Red Creole, and Pusa Red
		T	local and Patna Red
2	*Stemphylium* blight	T	40 accessions (NBPGR)
3	*Stemphylium* blight and purple blotch combined resistance	R	IC 32176, IC 48954, IC 48710, IC 48724, IC 485754 and IC 49012
4	Basal rot	R	IHR-506, IHR-141, Sel-13-1-1, Bellary Red
5	Thrips	R	White Creole, N 2-4-1, Sel-171, Kalyanpur Red round
		T	Hisar-2, Panipat Local, White

Source: Veere Gowda, (1997)

Storage conditions

Type of Loss	Onion	Reason
Physiological weight loss	20-25%	High Temp & Low RH
Rotting	10-12%	High Temp & High RH
Sprouting	10-12%	Low Temp and High RH




Varieties developed by ICAR-DOGR for Storage Purpose

Bhima Shakti

- Matures in 125-135 days after transplanting
- Average yield 28-30 t/ha (*Rabi*) and 35-40 t/ha (*Late kharif*)
- Attractive medium red colour, Uniform neck fall
- Bolting less than 5%
- Storage 5-6 months, TSS 11-12^0 Brix,
- Moderately tolerant to thrips and foliar diseases
- ***Rabi***: AP, Bihar, Chhattisgarh, Delhi, Gujarat, Haryana, Karnataka, MP, MS, Orissa, Punjab, Rajasthan and UP.
- ***Late-kharif***: Gujurat, Karnataka and MS
- More than 43.5q seed produced which may covered about 0.7 lakh ha area

Varieties developed by ICAR-DOGR for Storage Purpose

Bhima Kiran

- **Matures in** 125-135 days
- **Average yield** 28-32 t/ha (*Rabi*)
- Light red colour
- Bolting less than 5%,
- Good storage 5-6 months, TSS 11.5-12.5^0 Brix
- Tolerant to thrips and foliar diseases
- ***Rabi*:** AP, Bihar, Delhi, Haryana, Karnataka, MS, Punjab and UP
- More than 48q seed produced which may covered about 0.76 lakh ha area

Breeding for processing quality

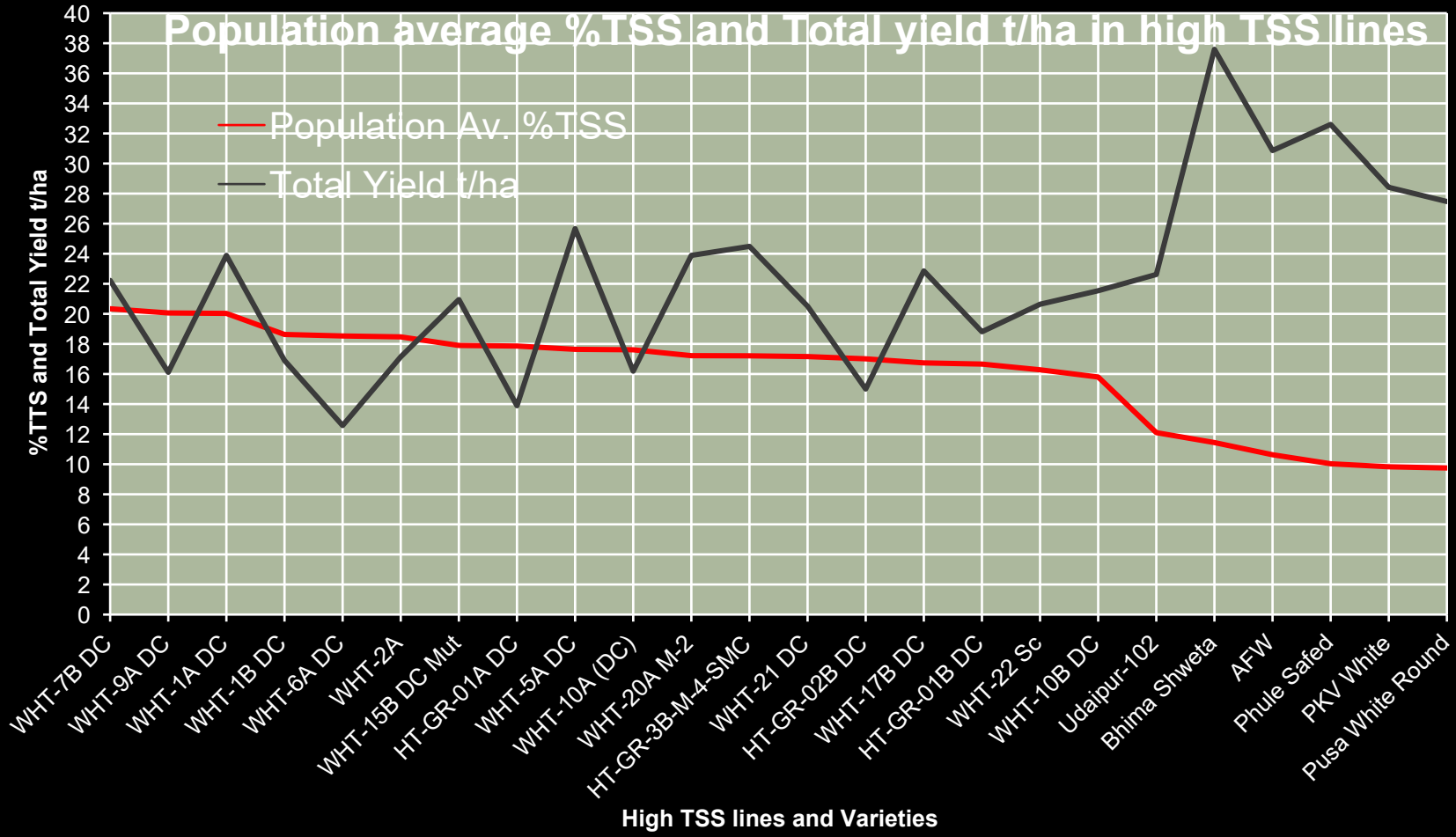
Why breeding white onion —

- **In some parts of world white onions are more preferred for consumption & have good export potential**
- **Suitable for dehydration & easy to use**
- **Solar energy can be exploited for processing in India**
- **Help to generate more employment**
- **Dehydrated onion (DHO) can be commercialized by women SHG like Lijjat papad, will help to stabilize onion prices**
- **DHO requires less space and easy to transport**
- **Losses occurring in storage can be converted into product**
- **DHO has huge export potential in foreign countries**

Percent of bulbs in normal Indian white onion population having TSS >15%

T.S.S. Range	% of bulbs
15 - 15.9	0.70
16 - 16.9	0.34
17 - 17.9	0.15
18 - 18.9	0.13
19 - 19.9	0.05
20 - 20.9	0.09
23	0.01
Total	2.52

From these selections in 2002 now we are able to develop population where more than 15% TSS is available in 98% bulbs in population in 2023 against 0.7% bulbs in 2002


Population average %TSS and Total yield t/ha in high TSS lines
Population Av. %TSS
Total Yield t/ha
%TTS and Total Yield t/ha
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
WHT-7B DC
WHT-9A DC
WHT-1A DC
WHT-1B DC
WHT-6A DC
WHT-2A
WHT-15B DC Mut
HT-GR-01A DC
WHT-5A DC
WHT-10A (DC)
WHT-20A M-2
HT-GR-3B-M-4-SMC
WHT-21 DC
HT-GR-02B DC
WHT-17B DC
HT-GR-01B DC
WHT-22 Sc
WHT-10B DC
Udaipur-102
Bhima Shweta
AFW
Phule Safed
PKV White
Pusa White Round
High TSS lines and Varieties

Onion processing

- Jain irrigation System Ltd. and about 150 plants in Gujarat & FPO's produce dehydrated onion, flakes and powder
- One kg dehydrated onion =10 kg fresh onion
- Costs of dehydrated product is about ₹150/kg
- During glut, onion may be used in vinegar, beverage, chutney, pickle, oil and wine preparation
- Setting up dehydration plant across the country will absorb excess onion & generate employment
- Processing industry are closed during higher onion prices
- Processing industry having the ability to handle multiple commodities should be developed

Powder

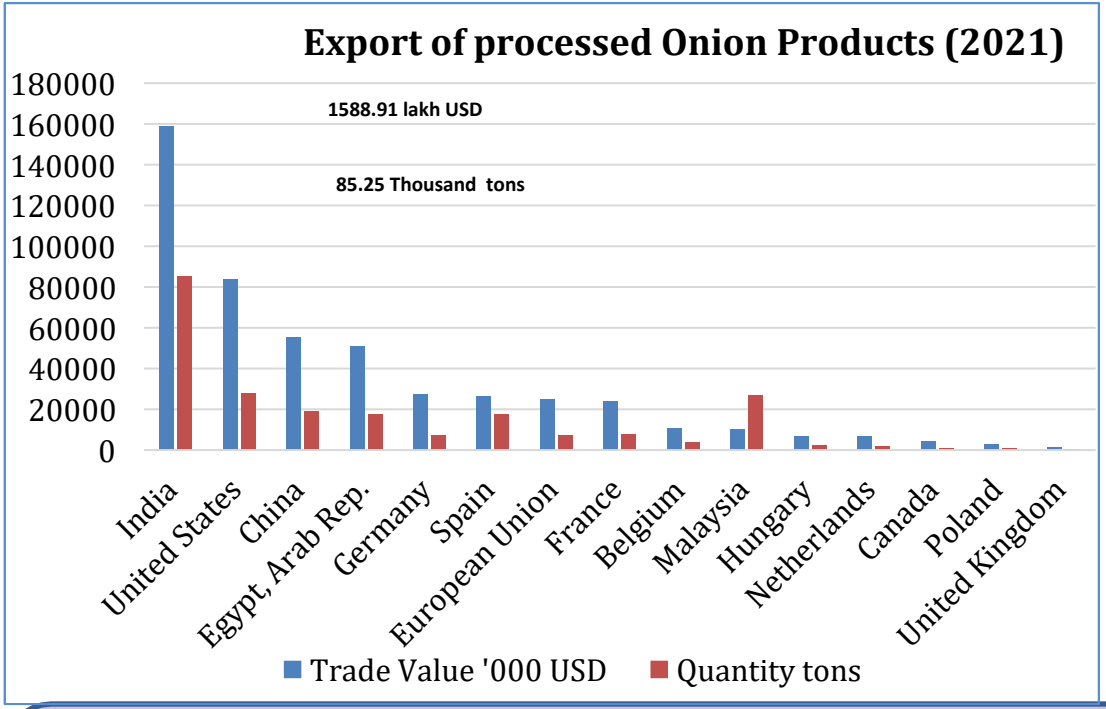
Dehydrated Onion

Beverage

Pickle

Onion Oil

Chutney



- India exports 85.25 thousand tons (31.1 %) share of total export of onion based processed products earning 1589 lakh USD foreign currency.
- The market size of onion processed product was 233.84 Thousand tonnes in year 2021

- **Asia's largest plant of Onion dehydration is Jain Food Park in Jalgaon Maharashtra**
- India's 90 % medium scale dehydration industries are located in Bhavnagar Dist. of Gujarat with 130 Plants & 85 Cold storages have been developed in Bhavnagar

Source : WITS 2021

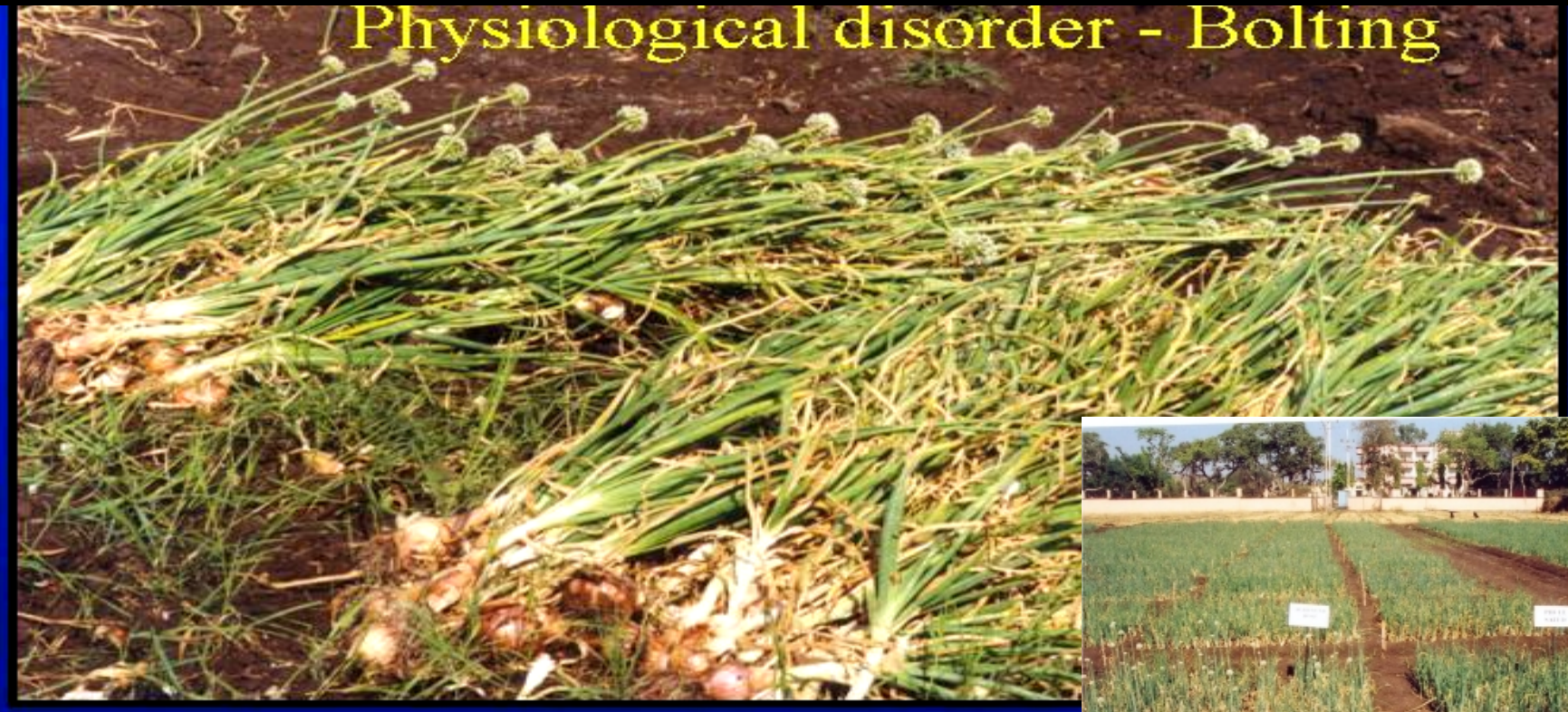
Reduction of breeding cycle/off season seed production

- Since, onion is biennial in nature, with short seed viability, there is need for identification of areas and seasons where seed can be produced apart from the traditional *rabi* season

- This will reduce the time of breeding from biannual to annual particularly for late *kharif* and *rabi* season varieties.

- Efforts were made to produce seed during *kharif* season by providing polythene shade (Mahajan *et al*., 2002)

Bolting in onion is another problem and may go up to 50-80 % in early *rabi* and late *Kharif*



Breeding for Export

India is the leading exporter of onion followed by Netherlands

India's export is mostly to South-East Asia and Gulf countries.

Only two such varieties are developed, viz., Phule Swarna from MPKV, Rahuri and Arka Pitambar from IIHR, Bangalore but not exploited

ICAR-DOGR initiated work & recommended Mercedes, Linda Vista, Cougre and Collina for growing in late *Kharif* season.

IIHR, Bangalore has developed two rose onion varieties viz., Arka Bindu and Arka Vishwas exclusively for export markets

Crossing programme has been taken up in 2006 at CITH Srinagar to transfer desirable traits from exotic onion to short day Indian genotypes and selection is in progress in 3rd generation with encouraging results in desired direction

Exotic onion recommended for Export to European Countries

Linda Vista

Collina

Trials on BBF with drip irrigation indicated yield potential of 50 - 70 t/ha as against 16 t/ha national average.

Mercedes

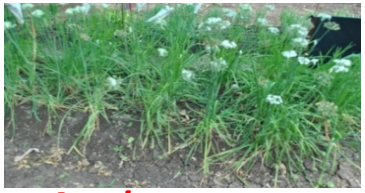
Couger

This technology is transferred to farmer's fields in Pune & Nashik districts.

Maintenance of different Allium sp. at ICAR-DOGR

(At present 28 species, recently collected & 90 lines are being maintained at ICAR-DOGR)

A.hookeri



A.tuberosum

A.alticum

Pran

A.guttatum

A.schoenoprasum

A .ampeloprasum

A.cepa agrregatum

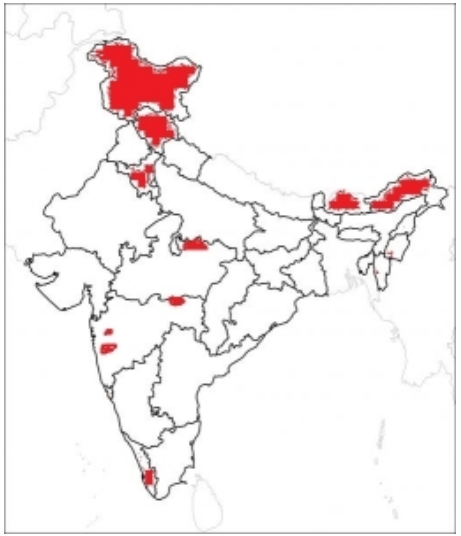
A.chinens

Zimmu

A.cepa common

Why Allium tuberosum?

- Can be cultivated throughout the year (for better yield: Early monsoon or in winter)
- Mostly tolerant to insects and pests
- Intercropping in Banana: lowers Panama wilt disease
- Soil: Well drained, light to medium with 6.5 to 7.5 pH



Allium tuberosum can be taken in any area throughout India

Stages of harvesting & Yield

3 month old

After cutting

4 days after cutting

One week after cutting

One month after cutting

- Harvesting: First harvesting should be done at 3 months after planting
- Afterwards, tender leaves of 15-20 cm size harvested at a monthly interval
- Can be soled in bunches of 200-250 g
- Yield: First cutting: 5-6 t/ha, Second cutting: 6-7 t/ha, 10th cutting: 15-16 t/ha,
- Total yield: 100-120 tons/ha/year

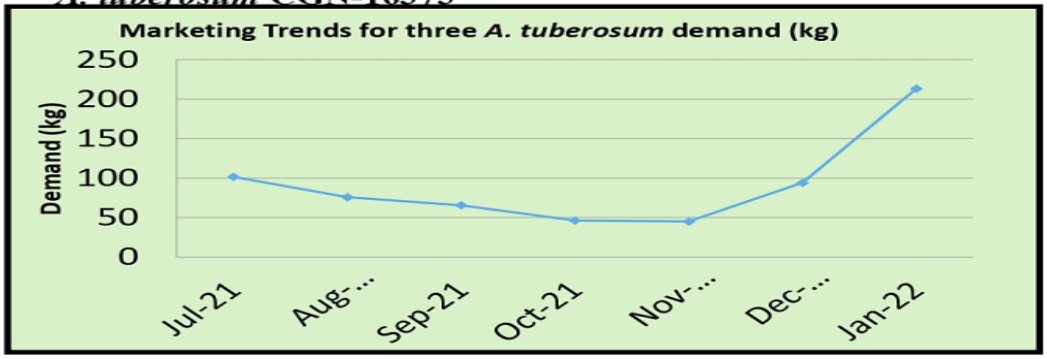
Identified 3 lines of *Allium tuberosum*

Three *Allium* lines were mass cultivated for popularization for foliage for culinary and table purpose during 2021

Price: *A. tuberosum* is being sold at Rs. 200/kg (i.e.30 Rs/150 g)

A. tuberosum CGN-16373

A.tuberosum All-1587



Poultry feeding *A. tuberosum* chopped foliage

Different preparations of A. tuberosum

Chatni

Salad

Pakoda

Paneer

Brinjal Bhurta

Momo's

Leaf role

Dried powder & Leaf

List of onion varieties released worldwide using various population improvement methods

Sr. No.	Variety released	Improvement Method Used	Scientists Involved/ References
1	Improvement of ancient Russian variety 'Spasskii'	Mass selection and Intravarietal recurrent hybridization	Efimochkina, 1970
2	N – 53	Mass Selection (Collection from Nashik, Maharashtra)	MPKV, Rahuri, 1975
3	Punjab Selection	Mass Selection in indigenous material (Collection from Punjab)	PAU, Ludhiana, 1975
4	Pusa White Flat	Mass Selection (Local Collection)	IARI, New Delhi, 1975
5	Pusa White Round	Mass Selection Local collection (106)	IARI, New Delhi, 1975
6	Co 2	Mass Selection (Collection from Tamil Nadu)	TNAU, Coimbatore, 1978

8	Punjab – 48	Mass Selection (Collection from Punjab)	PAU, Ludhiana, 1978
9	Pusa Ratnar	Mass Selection (Selection from Red Granex from USA)	IARI, New Delhi, 1978
10	Pusa Red	Mass Selection (Local Collection)	IARI, New Delhi, 1978
11	Co 3	Mass Selection (Collection from Tamil Nadu)	TNAU, Coimbatore, 1982
12	Kalyanpur Red Round	Mass Selection (Collection from U P)	CSUAT, Kanpur, 1983
13	Arka Pragati	Mass Selection (Collection from Nashik,)	IIHR, , 1984
14	N – 2 – 4 – 1	Mass Selection (Collection from Pune,)	MPKV, Rahuri, 1985
15	Arka Niketan	Mass Selection (Mass selection from a local collection IIHR – 153)	IIHR, , 1987
16	Agrifound Dark Red	Mass Selection (Collection from Nashik,)	NHRDF, Nashik, 1987

17	Pusa Madhavi	Mass Selection (Collection from Muzaffarnagar, U P)	IARI,1987
18	'Dorata di Parma' resistant for *F. oxysporum* f. sp. cepae Snyd. et Hans.	**Combination of Mass and recurrent selection**	Fantino and Schiavi, 1987
19	Arka Kalyan (Sel-14)	Mass Selection (Mass selection from a local collection IIHR – 145)	IIHR, , 1987
20	Baswant – 780	Mass Selection (Collection from Pimpalgaon,)	MPKV, Rahuri, 1989
21	'VL Piaz 3'	**F_2 of cross 'In-13 x L-43' followed by 3 cycles of Mass selection**	Mani *et al*., 1999
22	'Composto IPA-6' and 'Belem IPA-9'	Mass selection for tolerance to *C. gloeosporioides, T. tabaci* and good post-harvesting conservation qualities	De Franca *et al*, 1997

23	Cobriza INTA	Mass Selection from Valenciana type onions	Galmarini, *et al.* 2001
24	Navideña INTA	Mass Selection from Torrentina local population	Galmarini *et al.* 2001
25	Antártica INTA	Mass Selection from Valenciana type onions	Galmarini *et al.* 2001
26	NuMex Chaco' Onion	**Recurrent Selection**	Cramer and Corgan, 2001a
27	NuMex Snowball' Onion	**Recurrent Selection**	Cramer and Corgan, 2001b
28	NuMex Arthur' Onion	**Recurrent Selection**	Wall and Corgan, 2002
29	Gholy	Mass Selection (Ghesseh Local Onion)	Javad *et al.,*2004
30	Purifying the popular land variety "Abu Ferewa"	**Phenotypic recurrent mass selection and Inbreeding followed by bulking**	Bakheet, 2008
31	Arka Pitambhar	**Pedigree selection from the cross, U.D. 102 x IIHR-396**	IIHR, Bangalore

32	Bhima Super	Rigorous mass selection for single centeredness & bulb shape	Lawande *et al*., 2007
33	Bhima Red & Bhima Raj	Single bulb selection up to three generations followed by mass selection	Lawande *et al*., 2009
34	Bhima Shakti & Bhima Kiran	Mass selection for good keeping quality	Lawande *et al*., 2010a & b
35	Bhima Shweta	**Selection of 12 elite lines from germplasm followed by random mating and later mass selection for *rabi* season white onion & also kharif**	Mahajan *et al*., 2010, 2011
36	Bhima Shubra	**Selection of white segregating bulb from red germplasm** followed by mass selection for *kharif* & late *kharif* season	Mahajan *et al*., 2010, 2011
37	Arka Bheem & Arka Akshay	**Synthetic variety**	IIHR, 2011

Status of Onion varieties in India

- More than **65 onion varieties** including **2 F_1 hybrids and 6 multiplier** type have been developed and released.

- Out of which **36 onion varieties** have been released through AICVIP/ AINRPOG including 10 onion varieties from ICAR-DOGR

- **AINRP on Onion and Garlic** plays major role in developing varieties and production and protection technologies in Onion.

Breeding achievements of open pollinated varieties of onion in India

No. Var.	**Organization**
3	Agril. Dept., Maharshtra
4	MPKV, Rahuri
8	IARI,
11	IIHR,
2	HAU, Hissar
7	NHRDF, Nashik
2	VPKAS, Almora
3	RAU, Rajasthan
1	PDKV,
1	GAU, Junagarh
1	CSAUAT,
5	PAU, Ludhiana
6	TNAU,
3	RARS, Durgapura
10	DOGR, Rajgurunagar

Breeding achievements of open pollinated varieties of onion in India

No. Var.	Organization	Variety	Bulb color	Planting season	Year of release
3	Agril. Dept., Maharshtra	N-53	Red	*Kharif*	1975
		*N-2-4-1	Red	*Rabi* and late*Kharif*	1985
		*N-257-9-1	White	*Rabi*	1985
4	MPKV, Rahuri	Baswant -780	Red	*Kharif*	1989
		Phule Safed	White	Late *Kharif* and *Rabi*	1994
		Phule Suvarna	Yellow	*Rabi* and late *Kharif*	2001
		*Phule Samarth (S-1)	Red	Late *Kharif*	2006
8	IARI,	Pusa White Flat	White	*Rabi*	1975
		Pusa White Round	White	*Rabi*	1975
		Early Grano (Long Day type)	Yellow	Late *Kharif* and *Rabi*	1975
		Brown Spanish (Long Day)	Brown	Hills	1975
		*Pusa Red	Red	Late *Kharif* and *Rabi*	1975
		*Pusa Ratnar	Red	*Rabi*	1975
		*Pusa Madhavi (Line-120)	Red	*Rabi*	1987
		*Selection 126	Brown	*Rabi*	2012

11	IIHR,	Arka Pragati	Red	*Kharif* and *Rabi*	1984
		*Arka Niketan	Red	*Rabi* and late *Kharif*	1987
		*Arka Kalyan	Red	*Kharif*	1987
		Arka Pitamber	Yellow	*Rabi*	2006
		Arka Bindu	Red	*Kharif,* late *Kharif* and *Rabi*	2006
		Arka Ujjwal (multiplier onion)	Red	*Rabi*	2010
		Arka Swadista	White	*Rabi*	2010
		Arka Vishwas (Rose onion)	Dark red	*Kharif* and *Rabi*	2011
		Arka Sona	Yellow	*Rabi*	2011
		Arka Bheem (tri-parental synthetic)	Red	*Rabi*	2011
		Arka Akshay (tri-parental synthetic)	Dark Red	*Rabi*	2011
2	HAU, Hissar	Hissar- 2	Red	*Rabi*	1976
		*HOS-1	Red	*Rabi*	2006
7	NHRDF, Nashik	*Agrifound Light Red	Red	*Rabi* and late *Kharif*	1988
		*Agrifound Dark Red	Red	*Kharif*	1996
		*NHRDF Red (L-28)	Red	*Rabi*	2006
		* NHRDF Red (L-355)	Red	*Rabi*	2012
		Agrifound Rose	Red	*Rabi*	1987
		Agrifound Red (Multiplier)	Red	*Kharif* and *Rabi*	1987
		Agrifound White	White	*Rabi*	1994

2	VPKAS, Almora	VL-67 (Long Day)	Red	Hills	1973
		*VL-3 (Long Day)	Red	Hills	1990
3	RAU, Rajasthan	Udaipur -101	Red	*Rabi*	
		Udaipur -102	White	*Rabi*	
		Udaipur-103	Red	*Rabi*	
1	PDKV,	*PKV White	White	*Rabi*	2009
1	GAU, Junagarh	White Onion (GWO) - 1	White	*Rabi*	2000
1	CSAUAT,	Kalyanpur Red Round	Red	*Rabi*	1983
5	PAU, Ludhiana	Punjab Selection	Red	*Rabi*	1973
		* Punjab Red Round	Red	*Rabi*	1993
		Punjab-48 (S-48)	White	*Rabi*	1978
		Punjab White	White	*Rabi*	1998
		* Naroya (PBR-5)	Red	*Rabi*	1997
6	TNAU,	Co-1 (Multiplier)	Red	*Kharif* and *Rabi*	
		Co - 2	Red	*Kharif* and *Rabi*	1978
		Co - 3	Red	*Kharif* and *Rabi*	1982
		Co - 4	Red	*Kharif* and *Rabi*	1984
		Co - 5	Red	*Kharif* and *Rabi*	
		MDU-1	Red	*Rabi*	1982

3	RARS, Durgapura	Rajasthan Onion-1 (RO-1)	Red	*Rabi*	2004
		Arpita (RO-59)	Red	*Rabi*	2005
		RO 252	Red	*Rabi*	2010
10	DOGR, Rajgurunagar	*Bhima Super	Red	*Kharif,* late *Kharif* and *Rabi*	2006, 2013
		*Bhima Raj	Red	*Kharif* and *Rabi*	2007
		*Bhima Red	Red	*Kharif* & late *Kharif*	2009, 2013
		*Bhima Shakti	Red	Late *Kharif* and *Rabi*	2011
		*Bhima Kiran	Red	*Rabi*	2010
		*Bhima Shweta	White	*Kharif* and *Rabi*	2010, 2013
		*Bhima Shubhra	White	*Kharif* and late *Kharif*	2010, 2013
		*Bhima Dark Red	Red	*Kharif*	2013
		Bhima Light Red	Red		2015
		Bhima Safed	White	Kharif	2017

NEED FOR CROP SPECIFIC EXHIBITION IN INDIA

Innovations for year round availability

- Less photo & thermo sensitive cultivars
- Drought tolerant genotypes
- Water-logging tolerant genotypes
- Kharif onion production technology
- Kharif onion production through set technology
- Drip irrigation and Fertigation
- Innovations in onion storage
- Protected onion cultivation
- Green onion
- Onion processing
- Underutilized Alliums

Future thrusts

1. Data analytics and modelling aids in predicting rainfall and drought/flood dynamics
2. Estimation of onion area using remote sensing and onion production through yield simulation modelling
3. Development of climate resilient cultivars for drought and excess rainfall
4. Need to identify photo and thermos-insensitive varieties
5. Robust agro-advisories to be provided to the farmers for effective diagnosis and management of biotic and abiotic stresses in time
6. Kharif & rabi onion production technology to be demonstrated in non-traditional areas

7. **Identifying potential non-traditional areas for growing onions in the country.**

8. **More area under drip irrigation technology through awareness programmes & water harvesting**

9. **Reducing total storage losses & promote community storage to increase availability**

10. **Increasing onion processing by involving farmer producer organizations, start-ups and entrepreneurs**

11. **Promotion of underutilized alliums for year round availability & price stabilization**

Just add more onion and garlic to your diet

&

be healthy, wealthy & Wise

Thank You