5. Crop Improvement

IMPROVEMENT

Rice: Five varieties and one hybrid, at the regional/ central level and thirteen varieties and two hybrids at the state level have been released for different states of the country.

Released rice varieties and hybrids

Variety/Hybrid	Grain type	Farming system	Resistance to pests/ diseases	State/region of adaptation
JKRH 401 (Hybrid)	Long Bold	Irrigated, transplanted	Leaf blight, Bacterial blight, Rice tungro disease, White backed plant hopper, Sheath rot, Brown spot, Sheath blight, Neck blast	West Bengal, Bihar and Orissa
Abhishek	Short Bold	Irrigated	Bacterial blight, Shoot borer, Gall midge, Leaf folder, Sheath rot, Sheath blight	Uttar Pradesh, Bihar, Jharkhand and Asom
Shusk Samrat	Long Bold	Rainfed, upland (direct seeded)	Leaf blight, Shoot borer, Brown spot, Sheath rot, Gall midge, Sheath blight	Uttar Pradesh, Orissa and Bihar
Virender	Short Bold	Rainfed, upland (direct seeded)	Leaf blight; SB; Brown plant hopper and White backed plant hopper, Gall midge, Sheath rot, Brown spot	Orissa and Gujarat
VL Dhan 86	Short Bold	Irrigated, transplanted	Leaf blight and Neck blast, Sheath blight, Brown plant hopper, Leaf folder	Uttarakhand and Himachal Pradesh

Rice variety VL Dhan 86, suitable for Uttarakhand and Himachal Pradesh, possesses resistance to diseases and insects

Released rice varieties and hybrids

Variety/Hybrid	Grain type	Farming system	Resistance to pests/ diseases	State/region of adaptation
Bhuthnath	Long Slender	Waterlogged, coastal saline areas	MR– Leaf blight, Neck blast, Sheath blight, Rice tungro disease, Brown spot	West Bengal, Orissa, Maharashtra
		State releases		
Indra	Medium Slender	Irrigated (Saline soils)	Brown plant hopper, Gall midge, Bacterial blight	Andhra Pradesh
Pardhiva	Short Bold	Rainfed, shallow lowlands	Blast	Southern parts of Krishna, Godavari zone of Andhra Pradesh
Sree Kurma	Medium Slender	Shallow lowlands (Late planted conditions)	Gall midge, Blast	Andhra Pradesh
Warangal Sannalu	Medium Slender	Irrigated medium	–	Andhra Pradesh
Chandrama	Short Bold	Irrigated *boro* as well as rainfed shallow lowlands (*sali*)	Leaf blight and Neck blast; MR– Bacterial blight, Rice tungro disease, Sheath blight, Gall midge, Brown plant hopper and White backed plant hopper	Asom
Jaldubi	Medium Slender	Direct seeding/ transplanted in shallow lowlands	Blast, Gall midge	Chhattisgarh
Chandrahasini	Long Slender	Irrigated	Gall midge; MR– Brown plant hopper, White backed plant hopper, Neck blast, Blast	Chhattisgarh
Samleshwari	Long Slender	Rainfed uplands, rainfed bunded Matasi soils	Gall midge 1, 4; MR– Blast; T – Brown spot, Neck blast	Chhattisgarh
Indira Sona (Hybrid)	Long Slender	Irrigated médium	Gall midge	Chhattisgarh
Haryana Sankar Dhan 1 (Hybrid)	Long Slender	Irrigated medium	Sheath blight, Brown spot, Neck blast, White backed plant hopper, Leaf folder	Haryana
Phule Radha	Short Slender	Irrigated, transplanted	Bacterial blight; MR– Blast	Maharashtra
Pariphou	Long Slender	Irrigated, lowlands, *rabi* areas	–	Manipur
Ginphou	Long Slender	Uplands, irrigated lowlands	–	Manipur
VL Dhan 209	Short Bold	Rainfed, uplands	Leaf blight and Neck blast, Leaf folder and Brown spot	Uttarakhand
VL Dhan 65	Long Slender	Irrigated, hilly areas	Leaf blight, Neck blast, Brown spot; MR– Leaf folder, Sheath blight	Uttarakhand

MR-Moderately resistant, T-Tolerant

Wheat and barley: Five varieties of wheat, three of barley and one of triticale have been released.

Released varieties of wheat, barley and triticale

Variety	Farming system	Area of adaptation	Salient features
DBW 17	Irrigated, timely sown 	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division), Jammu and Kathua district, Una distt and Paonta valley and Uttarakhand (*tarai* region)	Yield advantage over PBW 343. Plant resistance to new yellow rust race 78S84 for which PBW 343 and PBW 502 are susceptible.Resistance to 5 (121R 63-1) and 104-2 (21R55), at seedling and adult plant stages. Karnal bunt resistance better than PBW 343. Good *chapati* making quality
K 0307	Irrigated, timely sown	Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, West Bengal, Asom and north-eastern plains	Yield advantage, disease resistance, better quality *chapati* and bread making than K 9107
GW 366	Timely sown, irrigated	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan, and Jhansi division of Uttar Pradesh	Yield advantage over GW 322
RAJ 4083	Late sown, irrigated	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu	Yield gain over HI 977
DDK 1029	Timely sown, irrigated	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu, Nilgiri and Palni hills	Yield gain over best *dicoccum* check variety DDK 1009
TL 2942	Rainfed/Irrigated, Timely sown	Western Himalayan regions of Jammu and Kashmir (except Jammu and Kathua distt); Himachal Pradesh (except Una and Paonta valley); Uttarakhand (except *tarai*/plain area); Sikkim and hills of West Bengal and NE states	Yield advantage and good amber grains
DWRUB 52	Irrigated, timely sown 	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division), Jammu and Kathua distt, Una district and Paonta valley and Uttarakhand (*tarai* region)	First 2-rowed barley having good yield potential and malting quality and resistance to yellow rust
RD 2668	Irrigated, timely sown	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division), Jammu and Kathua distt, Una district and Paonta valley and Uttarakhand (*tarai* region)	2-rowed barley having good yield potential and malting quality and resistance to yellow rust
		Feed Barley	
PL 751	Irrigated, timely sown	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	6-rowed barley, resistant to black rust

Registration of genetic stocks: Sixteen wheat genetic stocks showing resistance and quality traits have been registered.

Wheat genetic stocks registered

Name	I.D. No.	Institutions involved	Traits(s)
FKW 1	IC 546933	DWR, Shimla	Resistance to yellow and black rusts
FKW 3	IC 546934	DWR, Shimla	Brown rust resistance derived from durum wheat (HD 4672)
FKW 4	IC 549915	DWR, Shimla	Brown rust resistance derived from durum wheat (DWR 1006)
FLW 20	IC 548327	DWR, Shimla	Brown rust resistance (*Lr19*)
FLW 24	IC 549926	DWR, Shimla	Stem rust resistance (*Sr24*, *Sr25*)
FLW 25	IC 549927	DWR, Shimla	Brown rust resistance (*Lr28*)
FLW 26	IC 549928	DWR, Shimla	Brown rust resistance (*Lr42*)
FLW 27	IC 549929	DWR, Shimla	Brown rust resistance (*Lr45*)
VL 858	–	VPKAS, Almora	Excellent *chapati* quality
VL 824	IC 549923	VPKAS, Almora	Powdery mildew resistance
WBM 1587	IC 549931	IARI, Shimla	Yellow rust resistance
WBM 1591	IC 549932	IARI, Shimla	Yellow rust resistance
NAPHAL	–	DWR, Karnal	Glu-D1 double null with *pin A* gene
Tank	IC 398287	VPKAS, Almora	Exceptionally long awns
WH 730	–	CCSHAU, Hisar	Heat tolerance
DI 717	IC 546939	CCSHAU, Hisar	*NIL* of C 306 with *Rht-3* gene

Promising wheat and triticale genotypes identified from national nurseries

Trait(s)	Genotypes	Trait(s)	Genotypes
Resistant to three rust diseases	HD 2865, VL 895, VL 900, VL 905, PHS 0622, TL 2951 (T)	1,000 grain weight (> 50 g)	UP 2700, LBPY 05-3, GW 005-7, RD 1008(D), DBPY 05-1, DBPY 05-4(D), DBPY 04-2(D), RD 1018 (D), DBPY 04-5(D)
Tolerance to salinity-alkalinity	KRL 234, Raj 4188, KRL 237, KRL 236, DW 1367, KRL 229, KRL 233	Grains/spike (> 60)	GW 03-2, GW 03-5, LBPY 05-4, GW 03-11, LBPY 05-9
Early maturity (<110 days) and late heat tolerance	NIAW 1268, NIAW 1342, WR 1743	Spikes/m row length (>100)	LBPY 05-11, Raj 4128, WR 1392, WR 1387, LBPY 04-4
Early heat and drought tolerance	HI 1544, AKAW 3997, MACS 1967(D), WH 736, HI 1551, Raj 4140, RD 1271(D)	High protein (>13%) and high 1,000 grain weight (>40 g)	PHR 1011, UP 2672, UP 2671, WH 768, HUW 576, PBW 559, UP 2669, PBND 1625 (D), PQW 80,

(D) = Durum; (T) = Triticale

Rust resistance genes used for pyramiding in wheat varieties

Cultivar	Stripe rust genes	Leaf rust genes	Institution involved
HUW 234	*Yr10* + *Yr15*	*Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	DWR, Karnal
LOK 1	–	*Lr24* (*Sr24*) or *Lr28* + *Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	DWR, Karnal
PBW 343	*Yr10* + *Yr15*	*Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	PAU, Ludhiana
HD 2733	*Yr10* + *Yr15*	*Lr35* (*Sr39*) + *Lr37* (*Yr17/Sr38*)	PAU, Ludhiana
HD 2687	*Yr15*	*Lr24* or *Lr28* + *Lr37*	IARI, New Delhi
WH 147	–	*Lr24* or *Lr28* + *Lr37*	IARI, New Delhi

Pyramiding rust resistance genes in wheat. Genes for resistance to leaf rust (*Lr24, 28, 35, 37*) and stripe rust (*Yr10, Yr15*) have been targeted for introduction into wheat cultivars (PBW 343, HD 2687, HD 2733, HUW 234, Lok 1, WH 147) through marker assisted selection approach.

Maize: Nine varieties of maize have been released.

Quality protein maize hybrid, HQPM 5, rich in lysine and tryptophan is suitable for cultivation across the country

Maize cultivars released

Cultivar	Maturity	Area of adaptation	Cultivar	Maturity	Area of adaptation
FH 3288 (Vivek 27)	Extra early	Bihar, West Bengal, Orissa, Jharkhand, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu	HKI 1188 (HM 8)	Medium	Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu
FH 3248 (Vivek 25)	Extra early	Himachal Pradesh, Uttarakhand, Jammu and Kashmir, north-eastern region	V 33 (Malviya Makka 2)	Medium	Eastern Uttar Pradesh, West Bengal, Bihar, Orissa, Jharkhand, Chhattisgarh
JH 3892 (PAU 352)	Early	Delhi, Haryana, Punjab, western Uttar Pradesh	NECH 128 (NK 21)	Medium	Rajasthan, Gujarat, Madhya Pradesh
HKI 1191 (HM 9)	Medium	Eastern Uttar Pradesh, Bihar, West Bengal, Orissa, Jharkhand, Chhattisgarh	HQPM 5	Late	Across the country
			NECH 129 (NK 61)	Late	Delhi, Haryana, Punjab, western Uttar Pradesh

Sorghum: Two varieties of sorghum have been identified. CSV 23 (SPV 1714) is a dual purpose *kharif* sorghum variety proposed for cultivation in Andhra Pradesh, Tamil Nadu, Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Uttarakhand and Gujarat for deep soils. It has showed distinct superiority for dry fodder yield and resistance to anthracnose and leaf spot. SPV 1626 is a *rabi* sorghum variety proposed for deep soils of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Gujarat.

CSV 23 is a dual purpose *kharif* sorghum

TNAU 145 is a short-duration variety of proso millet

Pennisetum: new cytotypes identified

Cytotype of *Pennisetum pedicellatum*, INGR 06018 – IC 546954 is an octoploid (2n=8x=72), hitherto unreported from this species. Average number of associations per cell observed were 2.2VIII + 1.7VI + 0.05V + 3.15IV + 0.95III + 13.65II + 1.21I. It is perennial in habit as compared to other genotypes, which are annual. It forms tussocks with multi-tillering (up to 100 tillers) in nature. The plant has good regeneration and can be harvested 3–4 times in a year.

Other new cytotype *Pennisetum squamulatum* (2n = 56) INGR 06017 – IC 546955 has been identified with 2n = 56. Chromosome number, meiotic behaviour and crossability of this with *P. glaucum* justifies its octoploid nature based on x =7 and its inclusion in the secondary gene pool of *P. glaucum.* Its plant is perennial in habit.

Pearl Millet: Ten pearl millet hybrids have been identified for release.

Small millets: Fingermillet variety PRM 1, resistant to *Cercospora*, maturing in 110–115 days, yielding 2.3–2.5 tonnes of grains/ha and 8.0–8.5 tonnes/ha green straw, has been released for

Pearl millet hybrids identified for release

Hybrids	Area of recommendation	Salient features
GHB 757	Rajasthan, Gujarat, Haryana	Early maturity, medium tall, compact cylindrical earheads with purple anthers, globular grey-brown grains
GHB 744	Rajasthan, Gujarat, Haryana, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Medium maturity, medium tall, medium thick stem with basal pigmentation, compact cylindrical panicles with yellow anthers, globular grey-brown grains
B 2095	All India	Medium maturity, medium tall, compact candle panicles, globular grey grains
NMH 68	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Late maturity, tall, pubescent nodes, compact cylindrical earheads slightly tapering towards apex, yellow anthers, globular grey grains
JKBH 676	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Medium maturity, medium tall, semi-compact cylindrical earheads with yellow anthers, green fodder at maturity
GHB 732	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Medium maturity, medium tall, compact lanceolate earheads, purple anthers, globular grey-brown bold grains
HHB 197	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Early maturity, medium tall, dark green leaves, cylindrical medium Togo earheads with long bristles, highly resistant to downy mildew
PHB 2168	Rajasthan, Gujarat, Punjab, New Delhi, Uttar Pradesh, Madhya Pradesh	Early maturity, medium tall, compact cylindrical panicles with yellow anthers, obovate grey grains
MLBH 341	Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu	Medium maturity, medium tall, resistant to downy mildew
PB 727	Gujarat (Summer), Maharashtra, Rajasthan, Tamil Nadu	Late maturity, medium tall, compact cylindrical panicles with yellow anthers, obovate grey grains

cultivation in the crop-growing areas of Uttarakhand.

Kodo millet variety, RK 65-18, moderately resistant to head smut and shoot fly, yielding 20% higher than national check RBK 155, has been identified for release in Madhya Pradesh, Gujarat and Uttar Pradesh.

Proso millet variety, TNAU 145, a short-duration variety maturing in about 70 days with bold and golden yellow grains having yield superiority of 25% over check GPUP 21, has been identified for cultivation in Tamil Nadu and Karnataka.

Forage crops: Two varieties have been identified and released.

Forage crop varieties identified and released

Crop	Variety	Adaptation region/agro-ecology	Special features
Guinea grass	JHGG 04-1	Rainfed areas semi-arid conditions	Resistant to drought
Heteropogon	IGS 9901	Rangeland community grazing lands	Suitable for drought-prone areas

Underutilized crops: High-yielding entries identified in advance varietal trials, are IC 261963 (1.32 tonnes/ha) in buckwheat, LRB 22 (1.20 tonnes/ha) in ricebean, IC 107299 (0.62 tonne/ha) in chenopodium for hills and SKNA 503 (1.38 tonnes/ha) in *rabi* amaranth, SKNA 601 (0.813 tonne/ha) in *kharif* amaranth, LRB 334 (1.01 tonne/ha) in ricebean, HB 608 (1.92 tonnes/ha in fababean, EC 116887 (0.97 tonne/ha) and EC 142665 (1.19 tonnes/ha) in winged bean in plains, and SMLAB 6 (1.52 tonnes/ha) in adzukibean in hills.

Promising genotypes identified for quality are: BGA 2 (13.57%), Suvarna (12.57%) for protein content and Survarna (5.23%) for lysine content in amaranth; HB 430 (25.50%), HB 180 (25.37%) and Vikarant (25.20%) for protein content and HB 131 (0.90%) and PRT 7 (0.92%) for low vicine convicine in fababean; LRB 330 (20.90%) and LRV 351 (20.53%) for protein content, LRB 122 (4.80%) and RBL 6 (4.57%) for tryptophan, PRR 2 (0.95%) for methionine, and PRR 2 (0.23%) and PRR 9402 (0.22%) for free phenol in ricebean.

Groundnut: Five varieties have been released. A high-yielding variety PBS 24030 (Girnar 2) has been identified for release in the northern Rajasthan, Punjab and Uttar Pradesh. A field genebank of wild *Arachis* species consisting of 75 accessions from 21 species is being maintained, and a working collection of 9,800 accessions is conserved in the medium-term storage.

Groundnut varieties released

Variety	State(s)/area of adaptation	Special features
TG 38B	West Bengal, Bihar and north-eastern states	*Rabi*/summer cultivation
Dh 101 (Vasundhara)	West Bengal, Orissa, Jharkhand and Asom	Tolerant to stem rot, peanut bud necrosis disease,thrips and *Spodoptera*
SG 99	Gujarat, south Rajasthan and northern Maharashtra	Tolerant to peanut bud necrosis disease
GG 8	Northern Maharashtra and Madhya Pradesh	Moderately tolerant to bud necrosis, collar rot
GG 16	Tamil Nadu, Andhra Pradesh, Kerala and southern Maharashtra	Tolerant to bud necrosis, root rot, thrips, *Spodoptera* and leaf miner

Sunflower: DRSH 1 hybrid has been released and notified for *rabi* and summer cultivation in all sunflower-growing areas of the country. A variety, LSF 8, has been notified for Maharashtra.

Safflower: MRSA 521, first CMS-based hybrid, resistant to wilt and tolerant to aphids, exhibiting 19% and 14% increase in seed and oil yields over check, has been released for safflower-growing areas of the country. PBNS 40, a non-spiny variety, having 21–24% yield superiority to national check has also been released for all the crop-growing areas of India. In addition, spiny, sparsely spiny and non-spiny CMS lines using CMS cytoplasm from *Carthamus oxyacantha* have been developed.

Castor: RG 2819 (IC 346591, INGR 06010) having resistance to *Macrophomina* root rot and *Fusarium* wilt has been registered. Phenol content in purple leaves of castor contributes to its leafminer resistance.

Rapeseed-mustard: Three varieties—Indian mustard (2) and gobhi sarson (1)—have been released. *Toria* PHOT 2-2 (INGR 07033) with high oleic acid (70.1%) and low erucic acid (0.2%) and PHOT 8-2-11(INGR 07034) with low linolenic acid (3.03%) have been registered. The CMS-based hybrid NRCHB 506 outyielded best check Kranti variety by 30.6% under late-sown conditions.

Soybean: Soybean varieties Pratap Soya 2 (for North Eastern and Southern Zones) and TAMS 98-21 (for Vidharba Region of Maharashtra) have been released for cultivation.

Sesame: A high-yielding white-seeded variety TKG 306 possessing 2.8 g 1,000 seed weight and multiple resistance has been released for Madhya Pradesh.

Rapeseed-mustard varieties identified for release

Variety	Average oil content (%)	State(s)/ area of adaptation	Special features
Pusa Mustard	36.5	Haryana, Punjab, New Delhi and parts of Rajasthan	Low erucic acid, suitable for rainfed areas
CS 234-2	36.5	Haryana, Punjab and parts of Rajasthan	Suitable for late-sown areas, salt tolerant, 1,000 seed weight more than 6 g
NUDB 26-11	38.7	Himachal Pradesh and Jammu and Kashmir	Double low erucic acid, suitable for irrigated areas

Niger: IGPN 2004-1, a high-yielding variety of niger, has been identified for release in Maharashtra and Karnataka for *kharif* and early *rabi*.

Linseed: Kartika (RLC 76) and RLU 6 varieties have been released for cultivation. In addition, Deepika, LMS 9-2, NL165, RLC 92 and KL 215 have been identified as promising.

Chickpea: GNG 1581 variety has been identified for cultivation in Rajasthan, Punjab, Haryana, western Uttar Pradesh and plains of Jammu. It is semispreading with medium seeds (16.0 g/100 seeds), maturing in 151 days. It is tolerant to wilt, *Ascochyta* blight and stunt. Large-seeded, wilt-resistant *kabuli* chickpea genotype IPCK 2002-29 has shown promise in Central India and outyielded best check JGK 1 by 22%.

Pigeonpea: For Gujarat, first CMS-based hybrid GTH 1 has been notified for cultivation. TT 401 short-duration variety has been identified for Madhya Pradesh, Maharashtra and Gujarat.

Mungbean: H 2-15 (Sattya) variety has been identified for *kharif* cultivation in Rajasthan, Punjab, Haryana, western Uttar Pradesh and plains of Jammu. It outyielded best check, ML 818, by 15%. It has showed moderate resistance to yellow mosaic virus disease. UPM 02-17, developed from interspecific hybridization between mungbean and urdbean, has been identified for cultivation in North Eastern Hills Zone. It gave 17% higher yield than best check ML 5.

Fieldpea: Varieties, IPF 04-26, VL 45 and Pant Pea 42, have been identified for cultivation in different states.

Arid Legumes: Guar variety HG 884 identified as promising. It outyielded (25.34%) best check HG 365. It matures in 90–95 days and has field tolerance to major diseases. It contains 30–32.5% gum and viscosity profile of 2200–2500 Cp.

CRIDA 1-18R a promising variety of horse-gram, yielded 842.0 kg/ha against 696.2 kg/ha of the best check, PHG 9. It is also early in maturity (85–90 days).

Cotton: An intra-*hirsutum* hybrid CSHH 243 has been identified for cultivation in irrigated areas in North Zone. It has recorded a mean seed-cotton yield of 2.2 tonnes/ha; ginning outturn of 33.3%; 2.5% mean fibre length of 26.7 mm; micronaire value of 4.6; uniformity ratio value of 50.7%; and fibre strength of 24.0 g/tex; and has shown resistance to cotton leaf-curl virus.

Temperature-sensitive genetic male-sterile lines for economical hybrid seed production in diploid cotton have been identified from a cross between (*Bengalense* × *Cernuum*) × *G. anomalum*.

Indigenously synthesized genes *Cry 1 F* and *Cry 1 Aa3* have been successfully transferred in diploid cultivars PA 402, PA 255, PA 183, AKA 5, AKLA 7, RG 8 and *hirsutum* genotype LRA 5166 (Anjali).

Sugarcane: Sugarcane varieties, CoH 119, CoJ 20193, CoS 96268, Co 98014 and CoS 96275, for west and central Uttar Pradesh, Punjab, Haryana, Rajasthan and Uttara-khand and Co 99004 for plains of Tamil Nadu, Karnataka, Kerala, Gujarat, Madhya Pradesh and Maharashtra have been released and notified for commercial cultivation.

Co 99004 variety of sugarcane released for commercial cultivation

Red-rot resistant sugarcane genetic stocks IkshuISH 1 (PIO 91-190 × SIP 93-190) and IkshuISH 23 (PIO 91-829 × SIP 315) and high-sugar breeding germplasm LG 95053 have been registered.

Jute: Mesta variety Madhuri has been released and notified for roselle-growing tracts of India. Its yield potential has been higher than HS 4288, HS 7910 and AMV 4, and also showed increased tolerance to diseases and insect pests.

Jute varieties, JRO 2003 H, JRO 240 and AAU OJ 1, have been identified for release.

Tobacco: *Spodoptera litura* caterpillar-resistant chewing tobacco variety, Meenakshi (CR), having a yield potential of around 3,500 kg/ha, has been

Caterpillar-resistant chewing tobacco variety Meenakshi (CR)

released for cultivation in inland chewing tobacco tract, i.e. southern, central and western zones of Tamil Nadu in irrigated areas.

Mango: Mango hybrid H 39 (Amrapali × Vanaraj) was found promising with attractive red-blushed fruits, high TSS (24 °Brix), high carotenoids (7.8 mg/100 g), firm pulp (0.78 kg), regular-bearing habit, tolerance to anthracnose and dwarf tree stature.

Mango hybrid H 39

Guava: Guava CISH-G 1 was found as a promising selection with deep red fruits, attractive shape, high TSS (15° Brix) and long shelf-life. Guava Sardar gave significantly higher yield followed by Pant Prabhat, while Lucknow 49 gave the highest fruit yield followed by Allahabad Safeda and Lucknow 46-2. Allahabad Safeda gave high yield, maximum average fruit weight (232.50 g), high TSS (9.92 ° Brix), ascorbic acid content (285.00 mg/100 g pulp) and the lowest acidity (0.31%). Selections, MPUA&T S 1 and MPUA&T S 2, showed promise for high yield potential and quality fruits.

Papaya: An advanced generation papaya hybrid was developed which has red pulp with high TSS content and a good shelf-life. Banana hybrid NPH 02-01 (H 201 × Anaikomban) registered better bunch traits and was found resistant to *Fusarium* wilt race-1. Banana hybrids, H 212 and H 96/1, were found tolerant to nematode.

Grape: Two clonal selections were collected and added to National Grape Germplasm Repository. Field screening of germplasm was done for resistance/tolerance to diseases and insect-pests. Several promising hybrids were evaluated for their suitability for table and wine purposes. A computer-based molecular database has been developed. Hybridization work among popular varieties was undertaken to develop downy mildew-resistant varieties of table grapes. Forty-four accessions showing varying degree of resistance/ tolerance were characterized using molecular markers.

Sapota: High-yielding sapota clone DHS 1 (2/ 1) identified earlier confirmed its superiority.

Walnut: A total of 10 promising selections in walnut comprising 5 genotypes, each with a nut weight of 18.63–27.16 g and kernel weight of 10.69–12.76 g, were found promising. Vegetatively propagated walnut selections started bearing during the third year of plantation against 12–15 years by conventional seedlings.

Arid zone fruits: Ber hybrid Thar Sevika was found promising with 10–15 days early maturity, juicy fruits, high TSS (22%), high ascorbic acid (90 mg/100 g), and contents of total sugar (5.0 mg/100 g) and protein (16 mg/g). Thar Bhubhraj, a selection has ability to withstand extremes of temperature variation. A new cultivar of aonla has been released which has a proliferic-bearing habit and matures earlier than NA 7. Pomegranate, Ganesh and Anardana type Line H performed better under rainfed condition of Gujarat. Narendra Ber Selection 1 and Narendra Ber Selection 2 have been recommended for commercial cultivation in Uttar Pradesh.

Underutilized fruits: Promising genotypes, CISH-J 37 of jamun (*Syzygium cuminii*), CISH-K 10 of khirnee (*Manilkara hexandra*) and CISH-Kr 11 of karonda (*Carissa carandas*) were identified. The CISH-J 37 jamun recorded average fruit weight 24.05 g, length 3.90 cm and diameter 3.03 cm, pulp 92.26%, TSS 16.4 °Brix, ascorbic acid 49.88 mg/100 g and antioxidant 1,467.9 µg/100 ml AEAC unit. CISH-K 10 khirnee recorded average fruit weight 4.44 g, length 2.83 cm, pulp 89.18%, TSS 28.40 °Brix, ascorbic acid 16.8 mg 100/g and antioxidant 189.89 µg/ml AEAC unit and karonda CISH-Kr 11 recorded average fruit weight 6.0 g,

CISH-K 10 is a promising genotype of khirnee

length 2.30 cm, pulp 4.60 g, seed 1.40 g, TSS 6.10 °Brix, ascorbic acid 16.8 g 100/g and antioxidant 189.89 µg/100 ml AEAC unit.

CISH-J 37, a genotype of jamun, has 92.26% pulp

Vegetable crops: New hybrids and varieties in different vegetable crops were identified and recommended for cultivation in different states. These include brinjal PB 66 for Madhya Pradesh, Maharashtra, Uttar Pradesh, Punjab, Bihar and Jharkhand; hybrid brinjal Navina for Uttar Pradesh, Punjab, Bihar and Jharkhand; hybrid brinjal HABH 17 for Uttar Pradesh, Punjab, Bihar and Jharkhand; chilli LCA 353 for Chhattisgarh, Orissa, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, Punjab, Bihar and Jharkhand; and BC 25 for Rajasthan, Gujarat, Haryana, Delhi, Madhya Pradesh, Maharashtra, Orissa, Chhattisgarh and Andhra Pradesh; sponge gourd PSG 40 for Madhya Pradesh, Maharashtra, Jammu and Kashmir, Himachal Pradesh and Uttarakhand; ash gourd Pusa Ujwal for Karnataka, Tamil Nadu and Kerala; early-group pea VP 101 for Uttar Pradesh, Punjab, Bihar, Jharkhand, Jammu and Kashmir, Himachal Pradesh and Uttarakhand; mid-group pea PC 531 for Rajasthan, Gujarat, Haryana, Delhi, Madhya Pradesh, Maharashtra, Jammu and Kashmir, Himachal Pradesh and Uttarakhand; cowpea IIVR- CP 4 for Uttar Pradesh, Punjab, Bihar, Jharkhand, Orissa, Chhattisgarh, Andhra Pradesh, Madhya Pradesh and Maharashtra; onion B 780-5-2-2 for Rajasthan, Gujarat, Haryana and Delhi; okra JNDOL 03-1 for Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala; hybrid okra SOH 1016 for Uttar Pradesh, Punjab, Bihar, Jharkhand, Madhya Pradesh and Maharashtra, and NBH 180 for Madhya Pradesh and Maharashtra; and hybrid cabbage Green Emperor for Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

Varieties released: Kashi Unnati, a new cowpea variety, is photo-insensitive, highly tolerant to golden mosaic virus and *Pseudocercospora cruenta* diseases. Its plants are dwarf/bush type with an average length of 40–45 cm. This is recommended for cultivation in spring-summer and rainy seasons in different parts of the country. It flowers 30–35 days after sowing and exhibits commercial pod maturity 45–50 days after sowing. It bears 40–45 pods/plant with an average yield of 125–150 q/ha. It is adopted for cultivation in traditional and non-traditional, replacing almost all varieties. Due to short-duration, this is highly suitable for rice-wheat cropping system.

Kashi Unnati, cowpea variety, replacing almost all varieties, is tolerant to golden mosaic virus

Kashi Kanchan is another photo-insensitive cowpea variety which is highly tolerant to golden mosaic virus and *Pseudocercospora cruenta* diseases. It is suitable for sowing in both spring-summer and rainy seasons. It flowers 40–45 days after sowing and becomes ready for picking 50–55 days after sowing. It bears 40–45 pods/plant. The pods are dark green, tender, pulpy with less fibre and free from parchment layer. This gives an average yield of 150–200 q/ha.

Bhima Raj is a new onion variety which produces dark red and oval-shaped bulbs with single centre and thin neck. The TSS ranges from 10.0 to 11.0%. This variety is suitable for *kharif* and late *kharif* seasons in Maharashtra, Karnataka and Gujarat. This is also suitable for *rabi* season in Rajasthan, Gujarat, Haryana and Delhi. Bhima

Onion Bhima Raj, a variety of onion with thin neck and oval bulbs

Raj matures 120–125 days after transplanting and produces no bolters. Its average yield is 25–30 tonnes/ha.

Bhima Super is suitable for *kharif* and late-*kharif* cultivation in Maharashtra, Karnataka and Gujarat. With round bulbs tapering towards neck,

its TSS varies from 10 to 11%. The variety produces quality bulbs with maximum number of single centred bulbs and average yield of 26–28 tonnes/ha in *kharif* and 40–45 tonnes/ha in late-*kharif* season. Bulbs attain maturity 110–115 days after transplanting.

Development of promising lines: *Tomato:* Two new hybrids, H 71(38.6 tonnes/ha) and H 70 (36 tonnes/ha), were found promising. Hybrids TLBRH 5, TLBRH 6, TLBRH 9 and PH 5, were found suitable for polyhouse cultivation. Two individual plant selections from crosses of Arka Meghali × RF_4AF_2-15-14 and Arka Vikas × RF_4A showed promise for yield (up to 2 kg/plant) and tolerance to moisture stress. Two F_1 hybrids of Arka Meghali × IIHR 2249 and Arka Abha × IIHR 2223 were found promising for yield (29 tonnes/ha) and heat tolerance.

Tomato Hybrid 70 ready for fresh marketing

Okra. Hybrid, OH l gave highest fruit yield (16.98 tonnes/ha) followed by OH 5 (15.21 tonnes/ha) in summer, while highest fruit yield in *kharif* was recorded in hybrid OH 4 (18.84 tonnes/ha), followed by OH 5 (18.27 tonnes/ha) and OH l (17.79 tonnes/ha). Okra Arka Anamika was found suitable for polyhouse cultivation.

Okra hybrid OH 5

French bean. Arka Suvidha gave maximum pod yield of 19.5 tonnes/ha. Five test accessions, IIHR 125, Arka Bold, IC 525232, IC 525233 and IC 525236, were found resistant to rust under field conditions. Breeding line of cross IC 525224 × IC525239 was resistant to stem fly (0.67 maggot/plant) and possessed good pod quality. Thirty-three plants were selected with tolerance to high temperature, good pod quality and high yield attributes from the crosses between IC 525224 (heat tolerant) and Arka Komal or Arka Anoop. Arka Komal and 'Hebbal Avare 3' were found suitable for polyhouse cultivation.

Watermelon. Watermelon IIHR 70 was found to be a promising genotype with a high yield potential. Eight identified accessions were found free from watermelon bud necrosis virus (WBNV). Evaluation of 45 progenies of a T3 transgenic watermelon confirmed the presence of a single copy of gene showing complete resistance to WBNV.

Muskmelon. IIHR 138, muskmelon hybrids Gyno~998 × Punjab Sunehari (33.77 tonnes/ha), Arka Jeet × IIHR 616 and MS 5 × Punjab Sunehari recorded maximum fruit yield (32.53 and 31.5 tonnes/ha).

Capsicum. Seven promising individual plant selections were identified for heat tolerance from eight F_4 populations.

Cauliflower. IIHR 316-1 (430 g), IIHR 73-56 (417 g) and IIHR 371 (423 g) recorded maximum curd weight.

Carrot. Inbred lines carrot Sl 14 (26.961 tonnes/ha), Sl 264 (26.40 tonnes/ha) and Sl 260 (26.25 tonnes/ha) recorded high yield.

Garden pea. Yield was more in lines IIHR 697 and IIHR 756. Thirty plant selections were made from F_3 progenies of the crosses between high-yielding varieties/lines (IIHR 7-6, IIHR 7-2, IIHR 18, IIHR 19 and CHPMR 1) and high temperature tolerant lines KTP 4, IIHR 544 (Magadi local) and Oregon Sugar Pod.

Dolichos bean. The lines, IIHR 05-16 and IIHR 05-29, were found high-yielding. The IIHR 3-3 (19.1 tonnes/ha), IIHR 2-1(19.85 tonnes/ha) and IIHR 1-1 (16.13 tonnes/ha) were found promising advanced breeding lines with high pod yield.

Amaranth. JSR 04-86, IC 469607 and IC 469621 were found promising lines with respect to leaf weight (55–65 g) with high yield of 104-156 g/plant.

Arid vegetables: Of the cultivars of arid vegetables released, Thar Manak is a variety of mateera developed through selection from a cross of Mateera AHW 19 × Sugar Baby. Its fruits contain very big, bold and blackish seeds, which are free from cracking under extreme arid conditions. Thar Samridhi bottle gourd was derived from a cross of Banswara Local l × Gujarat Local 1. It could be harvested earlier than other varieties.

Yellow onion for export: Onion Mercedes, Couger, Linda Vista varieties/hybrids are suitable for growing from September to February. The trials conducted on broad bed furrow (BBF) with drip irrigation indicated the yield potential up to 50 tonnes/ha as against 13 tonnes/ha (national average). This successful technology is transferred to farmers' fields in Pune and Nashik districts. The trial consignments of yellow onion organized for export to Germany through private traders indicated a promising chance for enhancing export to European Union. Finalization of forward linkages

Onion Mercedes is ideally grown during September–February

and transhipment with established backward linkages can help in developing export market to 2–3 lakh tonnes additionally. This technology will help in diversification of traditional onion, which normally creates problem of glut during February-March.

Resistance sources: Of the 307 field-resistant genotypes of pepper leaf curl virus (PepLCV) (2004–05), selfed progenies of eight symptomless and highly resistant lines were challenged by viruliferous white fly in a glasshouse. Three genotypes, viz. GKC 29, BS 35 and EC 497636, showed no symptom. Using scion and rootstock of susceptible genotype (Pusa Jwala), these three putative symptomless genotypes were further challenged by alternate grafting. The resistant reactions of GKC 29, BS 35, EC 497636 were confirmed. The DNA of these lines were further subjected to PCR amplification with degenerate primers designed to detect begamovirus like PepLCV. None of the genotypes showed any amplification, suggesting that the resistant reaction in three identified resistant sources was because of the absence/non-replication of viral genome and these lines are not the symptomless carrier.

ToLCV resistance in tomato: The F_4 population derived from *L. hirsutum* and *L. chilense* carrying *Ty1* and *Ty2* genes were grown and highly resistant families with desirable agronomic traits have been selected in F_5 generation. These *Ty1* and *Ty2* genes complement each other and offer enhanced resistance for management of tomato leaf curl virus.

Potato: A high-yielding, early-maturing hybrid, JX 123, was registered as a unique germplasm. The hybrid produces yellow peel, oval tuber with shallow eyes having light yellow flesh. It has a very good general combining ability for yield and very early (60 days) and early (75 days) harvesting. Hybrid MP/97-644 was released as first processing potato variety Kufri Himsona for cultivation in hills of Himachal Pradesh. It has not only superior processing qualities and higher dry-matter content than a popular variety Kufri Jyoti, but also resistance to late blight. Its cultivation will fulfil the long-felt need of processing units, particularly in and around Delhi, Haryana and Punjab, where Kufri Chipsona 1, Kufri Chipsona 2, Kufri Chipsona 3, and Kufri Himsona will provide round-the-year availability of good-quality processing raw material.

In India, there is no variety exclusively suited for preparation of French fry. A hybrid, MP/98-71, producing oval-long tubers, more than 20% evenly distributed dry matter and good yield in north-western plains has been developed. The hybrid is suitable for preparation of French fries which has been verified by the industry.

Hybrid SM/93-237 has been identified as high-yielding as compared to Kufri Jyoti and Kufri Giriraj. It has better resistance to late blight and higher dry-matter content than Kufri Jyoti and Kufri Giriraj. It is also better under controlled and ambient temperature conditions. Besides, its attractive medium-sized, oval-oblong, synchronous tubers are free from cracking.

Potato hybrid J/93-86 is ideal for growing in north India

Hybrid J/93-86 has been identified as a high-yielding and early-maturing white tuber hybrid with moderate resistance to late blight. It has performed well for yield in entire north Indian plains under both replicated and on-farm trials. Its keeping quality is better than Kufri Ashoka and Kufri Pukhraj. It is ideal for Haryana, Punjab, Rajasthan, Uttar Pradesh, Gujarat, Bihar, Madhya Pradesh and West Bengal. This is likely to be a good alternative for early-maturing Kufri Ashoka, Kufri Chandramukhi and Kufri Pukhraj.

Plantation crops: VTL 12, a high-yielding arecanut (Saigon), was identified with an average yield of 3.88 kg challi/palm/year. Arecanut hybrid VTLAH 1 was developed with an average challi yield of 2.54 kg/palm/year.

Ten superior *oleifera* palms No. Eo 23 (66.76), Eo 22 (66.53), Eo 05 (66.44%), Eo 11 (65.28%), Eo 02 (63.84%), Eo 04 (63.84%), Eo 19 (63.54%), Eo 20 (63.54%), Eo 18 (63.13%) and Eo 17 (62.17%) were found promising parents for interspecific hybridization.

Four hybrids, Vittal Cocoa Hybrid 1 (VTLCH 1), ICS 6 × SCA 6 (VTLCH 2), II 67 × NC 29/66 (VTLCH 3), I 56 × II 67 (VTLCH 4) and a clone

NC 45/53 (VTLCC 1) with an average yield potential of 1.245, 1.145, 1.478, 1.481 and 1.238 kg dry beans/plant/year respectively, were developed. These hybrids/clone meet the international standard of bean size of more than 1 g, contain internationally acceptable levels of fat content (>50%) and low shelling (10–12%).

Spices: Four black pepper hybrids, viz. IISR Thevam, IISR Sakthi, IISR Girimunda, and IISR Malabar, and two high-yielding value-added (high curcumin) turmeric varieties, viz. IISR Alleppey Supreme and IISR Kedaram, with resistance to leaf blotch disease were released. Sweet fennel accession AF 254 was found to contain more sweetness and high essential oil content. It is being utilized in crop improvement programme through hybridization. The large-seeded fenugreek accessions, AM 108, AM 92 and AM 35, have been identified for high yield.

A high-yielding anise NRCSS A-Ani 1, with a yield potential of 1.15 tonnes/ha, bearing attractive seeds and high volatile oil content (3.5%) is suitable for cultivation in semi-arid region under irrigated conditions. Celery line, NRCSS A-Cel 1, was developed with an average seed yield of 8 q/ha under semi-arid condition and high essential oil content of 2.4%.

Carnation Hybrid IIHR P1 is resistant to *Fusarium*

Flowers: Two superior breeding lines of rose, IIHR P 13 and IIHR P 15, were identified. Eight lines were identified resistant to thrips under polyhouse condition. In carnation, a hybrid IIHRP 1, was developed showing resistance to *Fusarium* wilt.

Medicinal and aromatic plants: A genotype HAV 5-11 of aloe (*Aloe barbadensis*) for higher leaf yield (2,675 g), and HAV 04-4 for highest mucilage (70%) against the local check HAV 1 (60%) were identified. Selection 4B, 13 carrot and 15 baruch of ashwagandha (*Withania somnifera*) have been identified for 21.24, 30.89 and 21.62% increased dry root yield, respectively, over the existing variety WS 100. The highest seed yield (8.96 g/plant) of isabgol was recorded in genotype RI 49 followed by RI 149 (8.82 g), RI 87 (7.98 g), RI 99 (7.83 g), RI 9808 HI 8 (7.12 g) and HI 6 (6.88 g) as against the best check HI 5 (5.86 g).

Tuber crops: Varieties identified and recommended in different tuber crops are: Sree Jaya, Sree Vijaya and Sree Prakash of cassava; IGSP 4, IGSP 17, RNSP 3, Indira Sakerkand, Bidhan Jagannath and 90/704 of sweet potato; PKS 1, RNCA 1, BK Col 1, Jhankri, Bidhan Chaitanya, Indira Arvi 1, Ahinakatchu and Kadma Arvi of taro; NDB 21 and NDB 3 of banda; NDA 9 of elephant-foot yam and Orrisa Elite of yam.

BIOTECHNOLOGY

A novel constitutive promoter identified and cloned from *Arabidopsis thaliana*

A novel ***Arabidopsis thaliana* promoter** identified is capable of driving high-level constitutive expression; and considered to be better than the widely used promoter CaMV 35S. **Transgenic mustard** (cv. Varuna) that expresses ß-farnesene synthase with repellency to mustard aphids has been developed.

Transgenics in crops: ICAR Network Project on Transgenics in Crops, a new initiative since 2005–06, has two main components-functional genomics and transgenics development.

Functional genomics. The focus of this component is on gene discovery for important agronomic traits in rice, wheat, maize, brassica, chickpea, tomato and banana. Genome databases for these have been created to retrieve information on ESTs (expressed genes), DNA markers, cloned genes, and other important information from a single web portal, that provides easy links to different statistical and genome analysis software.

Specific genes and pathways related to drought-stress response in maize have been identified. Allele mining has been done for *teosinte branched1* (*tb1*) gene, responsible for prolificacy trait in maize, and also initiated for *Yellow1* (*Y1*), a key gene of maize, regulating carotenoid biosynthesis.

Transgenics development. Transgenic

Pigeonpea genomics

A comprehensive genomics programme in pigeonpea has been initiated under the Indo-US Agricultural Knowledge Initiative (AKI) in network mode involving ICAR, Indian and US Universities and ICRISAT. More than 5,000 EST DNA sequences have been submitted in public databases. Several mapping populations are being developed. UC Davis has developed one bacterial artificial chromosome (BAC) library of pigeonpea to be used as a common resource for genome sequencing. The mapping populations and a mutant population being created in pigeonpea variety *Asha* will be used for discovery of genes involved in diseases resistance, yield and quality.

>592F well L06 CustomA02-
N20-E05-A18-C21+amit.y
Run01 Cimarron 3.12 275
GCGCCAAGCCCATGGAGTTN
AAGNTTTACAACAACTGCAGC
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NATTCCCCAAAGACGGACCA
ATCCAGCAGCTTCTACTGCTA
CCCATGCTC
CCACTCCCTTCGCCGCCGCC
GACGCCAGCTTTCCCCTCAG
CTACCAGATC
GGTAGTGCCAGCGGCCGCCG
ACGCCACCCCTCCACAAGCC
GTGATCAANC
TCGCCGGACCATGCCGGTGC
AGGCGCTGATGGACCCACGC
GCCGGCCGCC
GGCCTAAACCAGGAAAGCCT
GGGGCCCGCCCTTNGCCGAC
CCACGCTAGG
TTCGCCAGNANANGCGAATC
CCAGGNGACGGCCNCCACGA
CCCATCCGAA

Allele mining for prolificacy gene *tb1* in Sikkim primitive maize line IML 592

development is going on in 14 crops for resistance to insect/pests, viral, fungal and bacterial diseases, and that enahnces tolerance to drought and salinity. These are at different stages of testing. Mustard transgenic expressing transcription factor encoding genes *ZF1* and *DREB1* has responded favourably

Comparative response of transgenic mustard wild type to water stress lines (*left*, wild type; *centre* and *right*, transgenic lines)

to water stress in Phytotron conditions compared to wild types.

Transgenics of chickpea and pigeonpea. Chickpea (DCP 92-3 and C 235) and pigeonpea (Bahar and MAL 13) have been transformed with *Cry1Ac* gene. Transformation frequency was less in chickpea (5–9%) as compared to pigeonpea (21%). Well-established plantlets of these transgenics are maintained under controlled conditions.

Fruit crops: In banana, morpho-molecular characterization of newly identified species (*Musa kuppiana*) from north-eastern India revealed that this species appeared to be a transitional species between the two sections, viz. *Ensete* and *Musa*. It will be an interesting species to study the origin and evolution of bananas. Embryogenic cell suspension was successfully developed in Nendran, Rasthali and Ney Poovan bananas for developing transgenic varieties against Sigatoka leaf spot and wilt diseases. Complete genome of banana streak

Improved Pusa Basmati 1 through Molecular Marker-Assisted Selection

An improved version of Pusa Basmati 1, resistant to bacterial blight, has been developed for the first time through MAS, and released for commercial cultivation. It combines with genes *xa13* and *Xa21* for bacterial blight (BB) resistance with basmati quality traits of Pusa Basmati 1, and 23.5% higher yield of well-known Taraori Basmati.

InsCot for cotton cultivars information

An Information System on Cotton Cultivars (InsCot) has been developed to provide information on all cultivars released by different agencies so far. This user-friendly CD has been developed using Visual Basic, NET as front-end and Microsoft Access as back-end for data storage. The information includes name of the cultivar, agency that developed, year of release, notification number, area adopted, species, pedigree/parentage, agro-ecology, yield, duration of crop, ginning outturn, staple length, micronaire value, bundle strength, counts, resistance and susceptibility to biotic/abiotic stresses, and special features.

virus (Accession No. DQ 859899) was cloned, sequenced and deposited in NCBI genbank. The viral genome was 6950 bp long with three ORF's and more similar to BSV-OL and GD sequences. Intergenic BSV sequence (900 bp) was cloned for assessing the promoter activity.

Three accessions of banana resistant to *Fusarium* were identified. The antimicrobial peptide gene was cloned and successful transformants with AMP gene were generated in Ney Poovan and Rasthali. In papaya, seeds were collected from electroporated plants of Solo papaya with a gene for coat protein of papaya ring spot virus (PRSV). Among them, 25 PCR positive seedlings were found resistant to PRSV.

A scion grafted susceptible Pusa Jwala variety of brinjal

Vegetable crops: Gene transfer has been achieved in tomato H 86 and brinjal Baigan 9 by the *Agrobacterium*-mediated transformation using *Cry 1Ac* gene. More than 125 putative transgenic plants have been regenerated. PCR analysis confirmed the presence of *nptII* and *Cry1Ac* gene, and Southern hybridization confirmed the single copy gene integration. The plants were also tested for strip test and ELISA test, which confirmed the gene expression. The transgenic plants are being used for insect bioassay and segregation analysis.

For drought tolerance, tomato plants were transformed with *DREB1A* gene, a transcription factor under the control of a desiccation inducible promoter Rd29A. Of the 21 lines of tomato, T1 plants from three lines have shown good tolerance to moisture stress with normal flowering, fruit setting and fruit bearing. Forty tomato selections were made with combined resistance against tomato leaf curl virus (TLCV), bacterial wilt and early blight, and one selection with combined resistance to TLCV, bacterial wilt and root-knot nematode.

The work on development of transgenic tomato for combined resistance to TLCV and PBNV in 4 different genotypes resulted in 65 T2 transgenic plants, of which 37 plants had the gene for TLCV, 10 had the gene for PBNV and 11 plants had resistance genes for both the diseases. Development of transgenic tomato Arka Vikas for resistance to *Alternaria solani* resulted in generation of 21 plants with *Trichoderma harzianum* and 5 with *Metarrhizium anisopliae* chitinase gene constructs. Among them, one plant each with *T. harzianum* and *M. anisopliae* showed resistance to *Alternaria solani* which was associated with the presence of transgene. Molecular characterization of one isolate of tomato was carried out.

Development of T-rep gene construct. Viral samples from infected field were used for cloning of replicase gene of TLCV. An amplicon of ~450 bp was amplified and cloned. In this way, 479 nucleotides long DNA stretch was cloned in at Pst I site of a binary vector pCAMBIA2301 having 35S promoter and terminator. The vector was transformed to *E. coli* strain DH5α**.** The binary vector pCAMBIA 2301 carrying conserved rep gene was finally mobilized in *Agrobacterium tumefaciens* strain LBA4404.

Potato: Genetic transformation studies with a new *Ntinhh* gene construct resulted in development of nearly 200 lines of Kufri Jyoti and 50 lines of Kufri Chipsona 1. Another 170 putative transgenic lines of Kufri Chipsona 1 encoding refined PTGS construct and invertase genes were also developed. Some of these lines, if characterized to be cold chipper, are likely to give boost to potato-processing units by making available large quantity of cold stored raw material.

In-vitro rooting in safed musli

Medicinal and aromatic plants: Shoot regeneration of safed musli (*Chlorophytum borivianum*) was achieved from immature inflorescence explants of safed musli on half-strength Murashige and Skoog (MS) medium supplemented with BA (1.5–3.00 mg/litre), Ads (50–100 mg/litre), NAA (0.01–0.1 mg/litre) and 3% (w/v) sucrose under a 16-hour photoperiod. Micropropagated plantlets were hardened in greenhouse success-fully.

SEED

Breeder seed production: Over 5,291 tonnes of breeder seed of crop varieties have been produced, including oilseeds (2,177 tonnes), cereals (2,049 tonnes), pulses (938 tonnes), forage crops (104 tonnes) and fibre crops (23 tonnes).

Quality seed production: Over 61,000 tonnes quality seed, including breeder seed of oilseed, cereal, pulse, forage and fibre crops has been produced under the Project, 'Seed production in agricultural crops and fisheries', which is double the quantity produced in the preceding year.

More than 8,000 tonnes seed was produced under the participatory seed programme at the farmers' fields, at the University of Agricultural

Sciences, Dharwad; Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpurl; Narendra Deva University of Agriculture and Technology, Faizabad, and Maharana Pratap University of Agriculture and Technology, Udaipur.

Seed production technology: More than 2,500 tonnes of breeder seed has been produced for state release varieties directly by the centres as per the indent of the respective states. *Panicum maximum* seed harvested 25 days after panicle emergence showed better seed quality.

Seed storage: Storage insects infesting wheat, pearl millet and paddy can be effectively controlled for three months using Emamectin benzoate at 2 parts per million (ppm), Lufenuron at 5 ppm or Deltamethrin at 1.0 ppm. Packaging at most of the farmers' houses can be suitably done using polylined jute canvas bags (PLJC) as well as high density polyethylene interwoven bags (HDPE).

Seed health: Seed treatment with neem oil at 5.0 ml/kg effectively controlled pulse beetle infesting mungbean, pigeonpea, chickpea and cowpea for 3–6 months without impairing seed germination.

A total of 224.92 lakh saplings and 0.5 lakh tonnes seeds of various horticultural and vegetable crops; and 2,800 packets of mushroom spawn have been produced.

Poverty alleviation in tribal areas through quality seeds

Rural appraisal showed that 67% of tribal farmers used their own farm-saved seeds and 40% did not follow seed treatment practices. Distribution of quality seeds of improved varieties to tribal farmers in Betul, Chicholi and Ghoda Dongri blocks of Madhya Pradesh enhanced seed yield over local varieties up to 60% in soybean, urdbean, rice, transplanted rice and maize.

PPV and FR Act and DUS testing through ICAR-SAU system

National Test Guidelines for 35 crops for the examination of their Distinctiveness, Uniformity and Stability (DUS) parameters as per the prevailing international standards have been developed. These can be applied for the implementation of the Protection of Plant Varieties and Farmers' Rights Act, 2001. Also, Reference Varieties for specific traits have been identified.

HONEYBEES AND POLLINATORS

Seed yield increased by 21% over control in mustard at Bhubaneshwar and by 15% in sunflower at Coimbatore through honeybee-mediated pollination.

Research work at the Kerala Agricultural University on stingless bees *Trigona irridipennis* for honey and pollination of crops resulted in development of earthen pots, bamboo splits and PVC for artificial nest material. Similar research at Assam Agricultural University, Jorhat, using wooden and whole bamboo nesting systems is in progress to home various stingless bee species. And successful development of colonies is in progress.

Bumble-bees are good pollinators but are available only in temperate conditions as in Himachal Pradesh. The Solan Centre of AICIRP on Honey Bees and pollinators in Himachal Pradesh is conducting experiments on artificial rearing, pollinators of important crops of that region. ❑