Crop Improvement

Rice: The Central Sub-committee on Crop Standards, Notification and Release of Varieties released two hybrids (Sahyadri 4 and GK 5003) and eight varieties (Akshaydhan, Varadhan, Sampada, Pushyami, Pusa Basmati 6, Gontra Bidhan 1, Amal mana and CR Dhan 40). The State Variety Release Committees have recommended 16 varieties and one hybrid for different situations in 6 states.

Based on three years of testing (2006-08) in

the All India Coordinated Rice Improvement Programme, 33 cultures were identified as most promising for various ecosystems.

Swarna Sub-1: Swarna Sub-1, a rice variety, was released for cultivation in shallow lowland areas of coastal Orissa. It is similar to its parents in all qualities, excepting dark green colour of foliage and hull colour. It yields 5–5.5 tonnes/ha in 140–145 days. It is tolerant to complete submergence of about two weeks

Variety	Grain type	Ecosystem	Resistant to pests/diseases	Recommended for state/region
		Cen	tral Releases	
Akshaydhan	LB	Irrigated	R-NBI, MR-ShR, BS, LB, RTD, WBPH	Irrigated areas of Jharkhand, Andhra Pradesh, Tamil Nadu, Karnataka
Varadhan	SB	Irrigated	R-LBI, RTD, WBPH	Irrigated areas of Uttarakhand, Haryana, Uttar Pradesh, Jharkhand
Sampada	MS	Irrigated	R-LBI, MR-WBPH	Irrigated areas of Bihar, Chhattisgarh, Maharashtra, Tamil Nadu, Kerala
Pushyami	LB	Irrigated	R-BPH, WBPH, MR-ShB	Irrigated areas of Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra
Sahyadri 4	LS	Irrigated	MR-LBI, NBI, BS, RTD	Irrigated areas of Maharashtra, Punjab, Haryana, Uttar Pradesh, West Bengal
GK 5003	LS	Irrigated	R-LBI, NBI	Irrigated areas of Andhra Pradesh, Karnataka
Pusa Basmati-6	LS	Irrigated	MR-LBI, RTD	Traditional basmati growing areas of Harvana, Uttarakhand
Gontra Bidhan-1	MS	Irrigated	MR-BPH	Irrigated areas of Punjab, West Bengal
Amal Mana	ELS	Rainfed/ irrigated/ coastal saline soils	R-SB, LF, whorl Maggot case worm and blue beatle MR-LBI, BS, ShBI	Waterlogged and coastal areas of West Bengal, Orissa, Andhra Pradesh
CR Dhan 40	SB	Direct seeded and transplanted	R-GM, MR-LBI, BS	Direct seeded areas of Jharkhand and transplanted areas of Maharashtra
State Releases				
JRH-8 Thanu CR Boro Dhan-2 Hanseswari (CR Dhan 70)	LS MS MS SB	Rainfed/irrigated Irrigated Boro season Semi deep water	Tolerant to abiotic stress MR-BL, ShR R-BL, ShBI; MR-YSB T-WBPH; MR-LBI, ShBI, SB, BPH, GM	Madhya Pradesh Irrigated areas of Kanataka Boro areas of Orissa

Varieties released by Central and State Variety Release Committees during 2008-09

Variety	Grain type	Ecosystem	Resistant to pests/diseases	s Recommended
Jaldihan-6	LB	Irrigated	_	West Bengal
Nua Kalajeera	MS	Irrigated	R-RTD, MR-BS, LBI, NBI, ShR, Plant hoppers, GM-5	Orissa
CR Sugandh Dhan-3	MS	Rainfed low land	MR-GM	Orissa
CR Dhan-10	LS	Irrigated	MR-GM	Orissa
AAUDR-1	MS	Upland direct seeding	T-SB	Gujarat
Phule Samrudhi	LS	Irrigated	MR-BL, SB	Maharashtra
Manaswini	LS	Irrigated	R-BS, GM1, LF, BPH, WBPH, SBWE, MR-BI, ShBI, RTD	Orissa
PKV Khamang	SS	Rainfed/irrigated	MR-LBI, NBI, BLB	Maharashtra
Narendra Mayank	SG	Irrigated	Submergence tolerance	Uttar Pradesh
Narendra Jal Pushp	LB	Irrigated late	Submergence tolerance	Uttar Pradesh
Malviya Sugandh-105	MS	Irrigated	MR-LBI, NBI, BS, SB	Uttar Pradesh
Malviya Sugandh 4-3	LS	Irrigated	MR-LBI, BLB, BPH,	Uttar Pradesh

R, Resistant; MR, moderately resistant; MS, moderatey susceptible; BL, blast; BLB, bacterial blight; BPH, brown plant hopper; BS, brown spot; GM, gall midge; LB, long bold; LF, leaf folder; NBI, neck blast, SB, short bold; ShBI, sheath blight; ShR, sheath rot; RTV, rice tungro virus; WBPH, white backed plant hopper

and is also suitable for late planting with aged seedlings.



Improvd Samba Mahsuri has good agro-morphological features

Sahbhagi Dhan: Sahbhagi Dhan was identified for release for cultivation in drought affected areas of Jharkhand and Orissa. Drought-tolerant, Sahbhagi Dhan yields 3.8 – 4.5 tonnes/ha in about 100 days and can withstand terminal drought for at least two weeks. It is resistant to leaf blast and moderately resistant to brown spot and sheath rot, and also moderately resistant to stem-borer and leaf folder. It has good cooking quality and long-bold grain.

Wheat: Wheat varieties identified for release

Wheat varieties released			
Variety	Season	Areas for adoption	
HS 490	Late sown, restricted irrigated condition	Hills of Jammu and Kashmir (except Jammu and Kathua districts), Himachal Pradesh (except Paonta Valley and Una district), Uttarakhand (excluding tarai region), Sikkim and hills of West Bengal and NE states	
PBW 590	Late sown, irrigated condition	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), West Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and tarai region of Uttarakhand	
Raj 4120	Timely sown, irrigated condition	East Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Orissa, Asom and Plains of NE states	
CBW 38	Timely sown, irrigated condition	East Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Orissa, Asom and plains of NE states	
MP 1203	Late sown, irrigated condition	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	
UAS 415(d)	Timely sown, irrigated condition	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu	
PBW 596	Timely sown, restricted irrigated condition	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu	
MACS 2971 (dic)	Timely sown, irrigated condition	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu	

Promising genotypes for wheat products			
Product	Genotypes		
Chapati (>8.0/10.0)	GW 391, HD 2987, C 306, PBW 175, Raj 4120, K 0307, K 8027, HD 2888, Lok 1, GW 322, HI 1531, HW 2004		
Bread (>575 ml loaf volume)	WH 1061, WH 1062, AKAW 4627, MACS 6222, MACS 6273, UAS 304, UAS 305, HP 1913, HD 2987, WH 1021, NW 2036, GW 173, HD 2864, HD 2932, MP 1203, NIAW 917, NIAW 34, Raj 4083, HI 977, NI 5439, HD 2781		
Biscuit (>7.5 spread factor)	HS 502, HS 490		
Pasta(>6.5/9.0)	PBW 311, PDW 314, UAS 419, DDW 12, GW 1245, PDW 233, WH 896, HD 4672		

Promising genotypes were identified for individual quality parameters both for *T. aestivum* and *T. durum*

Genotypes for individual quality and individual parameters			
Parameter	T. aestivum	T. durum	
Sedimentation value	WH 1080, CBW 38, HD 3002, PBW 625, K 8027, HI 977, HD 2987, HD 2987, NI 5439	WH 896, A-9-30-1, GW 1250, HI 8699, HD 4720	
Grain hardness index	HS 240, C 306, HD 2888, HI 1531, NIAW 1415	UAS 415, HD 4720, AKDW 4021, PDW 315, MACS 1967, AKDW 2997-16	
Yellow pigment	HS 240, TL 2942, HS 490, DBW 17, PBW 373, NW 2036, NI 5439	UAS 419, PDW 233, WHD 943	
Iron	WH 1063, PBW 613, C 306, PBW 175, PBW 396, Raj 4120, MP 3224, K 0616, PBW 612, HD 2888, MACS 6222, UAS 304, NIAW 34	GW 1245, HD 8627, HI 8680, AKDW 2997-16	
Zinc	HS 502, HS 490, PBW 610, WH 1061, WH 1063, DBW 39, HD 2987, HI 1531, MACS 6222, UAS 304, HP 1913, AKAW 4627, Raj 4083	DDW 12, WH 896, MACS 1967	

Genotypes for individual quality and nutritional parameters

are: VL 907, HD 2967, PDW 314, DBW 39, HD 2967, HD 2985, MPO 1215 (d), UAS 304, MACS 6222, MACS 6273, AKAW 4627, HD 2987, HW 5207, KRL 210 and KRL 2.

Donors for resistance: The genotypespossessing multiple disease resistance were idetified. They are resistant to: Rusts +

MR to leaf blight (LB) + R to karnal bunt (KB)+flag smut (FS): VL 912 R to Karnal bunt (KB)+ flag smut (FS)+ powdery mildew (Pm):HPW 285, HW 2308 R to FS and Pm: TL 2955 (T) HR (infection 0.0%) to KB)+FS: UAS 414 (d) R to KB+ FS: HS 471, UP 2719. DDW 11 (d), HI 8672 (d), GW 385 Leaf and stem rusts + R to FS and Pm: MACS 2980 (dic.), DDK 1033 (dic.) R to KB+ FS: HW 3094. Stem and stripe rusts+ R to KB+ FS: HPW 267, VL 895. Leaf and stripe rusts+ R to KB+ FS: RAJ 4130, NIAW 1188. Rusts and loose smut: (highest loose smut infection up to 5.0%): HW 5202, TL 2945 (T).

Stem and leaf rusts + **loose smut:** MACS 2963 (dic), MACS 2971 (dic), DDK 1031 (dic), DDK 1032 (dic), HW 1095 (dic), HW 5305 (dic), WHD 938 (d),

All three Rusts+ + Root aphids (RA): VL 898, HW 5030, Raj 4101 +Flag smut (FS)+RA: HS 493 + Leaf blight (LB)+RA: VL 912 +Karnal bunt (KB)+FS+RA: DDW 11 + Shoot Fly (SF): HW 5207, HW 5209 Stem and leaf rusts+ +RA: KRL 210 +LB+RA: MP 1194 +KB+RA: DBW 32, KRL 213, MP 1200 +FS+RA: Raj 4119, PBW 573, HW 5104, HW 5103, PBW 587 + SF: DBW 32, MACS 3598 +Brown wheat mite (BWM): HW 2308, HD 2957, Raj 4119, HD 2956 +BWM+MR to FA: HW 3094, MACS 3598 Leaf and stripe rusts+ KB+FS+RA: MPO 1204 Quality Improvement: Product-specific genotypes were identified for chapati (>8.0 score

out of 10.0), bread (>575 ml leaf volume), biscuit (>7.5 spread factor) and pasta (>6.5 score out of 9.0).

Barley: A dual-purpose variety, RD 2715, with yield advantage of green and grain has been released for commercial cultivation. It is suitable for cultivation in Madhya Pradesh, Gujarat, and Kota and Udaipur divisions of Rajasthan and Bundelkhand division of Uttar Pradesh under irrigated timely sown conditions. This is a very good option for farmers using barley as a source of green fodder in December/ January. Some promising entries for malting purpose are given here.

Maize: Fourteen hybrids and two composites have been released for different agro-ecological conditions. The hybrids/composites released are given here.

Germplasm registration: Nine inbred lines of maize (seven normal and two QPM) have been registered at NBPGR, New Delhi. The characteristics and other details including INGR numbers are given below:

Sorghum: Varieties identified for release are SPSSV 6 (CSV 24SS) of sweet sorghum. It has higher fresh cane and ethanol yield, and total soluble sugars. The new variety responds to higher

fertility levels yielding more juice. Stem-borer damage is relatively lesser than that in SSV 84. SPSSV 6 matures in 119 days, 3 days earlier than SSV 84. The variety is identified for all sorghum-growing states for biofuel production,



Sorghum variety CSV 24 SS

Promising barley entries for malting quality traits			
Trait	Timely sown	Late sown	
Hectolitre weight Grain plumpness Protein content (low) Husk content (low) Malt friability Hot water extract Filtration rate Diastatic power	BH924, PL835, PL836, BH927 DWR85, PL837, DWRUB73, DWR82, PL836 RD2778, DWR81, RD2779, DWR83 BH927, PL835, BH926, RD2777 K913, RD2777, K914, DWR85 DWR83, PL835, DWRUB73, DWR85 DWR81, DWR85, DWRUB73, BH927 BH926, DWR85, PL835, DWR84, K913,	PL835, DWRUB52, BH931, RD2668 DWRUB78, DWRUB73, PL837, DWR81 RD2778, RD2552, DWR83, BH928, K914 RD2668, PL835, DWR83, DWRUB52 DWRUB52, RD2668, DWRUB78, RD2776 RD2777, DWRUB52 DWR83, DWR86, DWR81 DWR82, DWR86, K915, RD2779	
Beta glucan (%) Overall score	DWRUB76, PL836 K913, K914, K915, K551, RD2778, RD2779 DWR85, RD2779, DWRUB73, K913 and K914	RD2779, K914, K915, K551 DWR83 (six-row type), RD2776, PL835 and DWR86 (two-row type)	

Maize hybrids/composites released

Hybrid	Pedigree	Area for adoption	Characteristics
HM 11	HKI 1128 × HKI 163	Across the country except Himalayan belt (<i>rabi</i>)	Late, orange, semi-dent, resistant to MLB, nutrient responsive
NAH 2039	SKV 50 × MAI 135	Karnataka	Late, yellow, flint, resistant to SDM
EH 434042	-	Karnataka	Late, yellow, flint, resistant to SDM
DHM 111	BML 6 × BML 15	Andhra Pradesh	Late, yellow-orange, semi-flint, nutrient responsive
DHM 113	BML 2 × BML 7	Andhra Pradesh	Late, orange, semi-dent, tolerant to MLB, TLB
			001110

Hybrid	Pedigree	Area for adoption	Characteristics
DHM 117	BML 6 × BML 7	Andhra Pradesh	Medium, yellow-orange, flint, nutrient responsive
NK30	NK 191 × NK132	Punjab, Haryana, Delhi, Western Uttar Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra	Late, yellow-orange, flint, nutrient responsive
NK 6240	NK125 × NK 128	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Orissa, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Rajasthan, Gujarat, Chhattisgarh, Madhya Pradesh	Late, yellow, flint
PAC 740	(740 FF × 740 FM) × 740 M	Punjab, Haryana, Delhi, Western Uttar Pradesh	Late, orange, flint, resistant to MLB
JKMH 502	M104 × M101	Punjab, Haryana, Delhi, Western Uttar Pradesh	Late, yellow-orange, semi-flint
SMH 3904	MI201 × MI 211	Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra	Late, yellow-orange, semi-flint
Pinnacle	-	Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa	
DKC7074R	-	Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra	Early, orange, flint
900 M GOLD	-	Punjab, Haryana, Delhi, Karnataka, Andhrar Pradesh, Tamil Nadu, Maharashtra	Late, yellow, semi-flint
Vivek Sankul 35	Early heterotic pool 1	Jammu and Kashmir, Himahal Pradesh, Uttarakhand, North-Eastern hills	Extra-early, yellow
Vivek Sankul 37	VL Makka 16, Pop 31, C ₄ HS bulk (Alm), VL 87, VL 89, VL 90, D 831 and D 941 Extra-early, yellow	Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra	

and SPV 1746 with good fodder yield and tolerant to grain mold than CSV 15 and resistant to downy mildew is suited for Karnataka, Maharashtra, Madhya Pradesh and Gujarat.

Pearl millet: Six hybrids and three openpollinated varieties (OPVs) that have been identified for release for various agro-ecologies are HHB 216 (MH 1421), RHB 173 (MH 1446), PAC 909 (MH 1435), HHB 223 (MH 1468), KDBH 1151 (MH 1456), NMH 69 (MSH 199), CSBV 6 (MP 479), ABPC (MP 484), and Pusa Composite 612 (MP 480).

Small millet: VL 207, a high-yielding, grain smut resistant variety of barnyard millet was released at national level for cultivation in all barnyard-growing states except Tamil Nadu and Gujarat. Proso millet variety, TNAU 151, was released for all prose millet-growing states.

Three finger millet varieties were released for cultivation in different states. They are GPU 66, a high-yielding and suitable for cultivation in all ragi-growing zones in Karnataka; KMR 301, a high-yielding, long duration and suitable for both *kharif* and winter seasons of Karnataka and Sri Chaitnya (VR 847), a medium-duration variety, is suitable for cultivation in Andhra Pradesh.

Varieties for release

The GPU 67, a finger millet variety is highyielding and resistant to lodging because of its semi-dwarf stature and profused tillering ability. This variety has been recommended for cultivation in Karnataka, Chattisgarh, Jharkhand, Maharastra, Tamil Nadu and Uttarakhand.

The TNAU 164, a high-yielding proso millet, has been recommended for cultivation in Andhra Pradesh, Bihar, Karnataka, Maharashtra, Tamil Nadu and Uttarakhand. The OLM 208 and OLM 217, little millet varieties, were recommended for cultivation in Chattisgarh, Gujarat and Orissa.

Finger millet: Finger millet, GPU 67, is suitable for Karnataka, Chattisgarh, Jharkhand, Maharashtra, Tamil Nadu and Uttarakhand. It yields 16% more than checks. This is semi-dwarf with erect flag leaf and profused tillering.

Little millet: Little millet, OLM 217, has been identified for release for Chattisgarh, Gujarat and Orissa. It has 14% more yield than national check with high resistance to rust, grain smut and sheath blight.

Forage crops

Varieties identified for release: Among forage crops, Napier bajra hybrid, RBN 13, oat varieties,

NDO-1, OS-346 and JO-03-91; cowpea variety, UPC-628 and Tall Fescue variety, EC 178182, were identified.

Bundel Guinea-2 (*Panicum maximum*), IGHC 03-4 (*Heteropogon contortus*) and JHPM 05-2 (*Pennisetum glaucum*) have been identified.

Guinea grass: Effect of ploidy on expression of individual apomixis components (apomeiosis and parthenogenesis) was studied in a 38 member ploidy series represented by 3x, 4x, 5x, 6x, 8xand 9x ploidies developed by Hybridization-Supplemented Apomixis-Components Partitioning Approach (HAPA) utilizing embryo-sac clearing and FCSS. The data suggested that expression of individual apomixis components is enhanced with the increasing ploidy.

PearImillet: More than 1,200 F_1 s originating from pearlmillet (2n=4x=28) and *P. squamulatum* (2n=8x=56) were established in field and characterized cytologically utilizing leaf flow cytometry possessing similar genomic content showing non-involvement of any unreduced gamete from the parents.

Cenchrus: Rare occurrence of sexual plant in *Cenchrus ciliaris* was identified (IGFRI-CcSx-08/1) using pistil-clearing technique and characterized by DNA profiling. The plant shows distinct morphology and flowering behaviour as compared to any other commonly found apomictic plants of *C. ciliaris*. RAPD analysis of sexual plant using random primers (OPJ-13 and OPP-14) produced plant specific bands of 225 bp and 1.2 kb, respectively. Using DNA fingerprint, this plant can be easily distinguished from other *C. ciliaris* plants. This sexual plant of *C. ciliaris* is an elite genetic material for molecular studies of apomixis.

Mineral content of wheat straw varied across the country. The P (0.04–0.1%), Mg (0.15–0.19%), Cu (4.4–6.2 ppm) and Zn (12.2–18.36 ppm) contents were deficient in wheat straw, while Ca content (0.59–0.82%) was adequate. Iron concentration was several times higher in all the samples. Fibrolytic enzyme (avizyme) treatment @ 4 g/kg feed of wheat straw improved the digestibility of organic matter (65.7 vs 61.7%) and fibre fractions (NDF 61.5 vs 58.2%) in crossbreed calves.

The mineral status in paddy straw samples from different states revealed that only Ca content (0.49–0.88%) was adequate in dietary need of cattle, whereas P (0.03–0.15%), Mg (0.06–0.09%), Cu (4.8–6.7 ppm) and Zn (12.4–28.8 ppm) were deficient.

Underutilized crops: High-yielding entries identified in advanced trials for hills are IC 415477 (10.34 q/ha) in chenopod; EC 008707 (11.95 q/ha) in adzuki bean; H3765 (10.28 q/ha) in Job's

tear and for plains is SKNK-140 (7.78 q/ha) in Kallingada.

Promising genotypes for quality were SKNK-501 (13.6%) for protein content and IC415236 (5.8%) for lysine content in grain amaranth; PRR-2 (21.50%) for protein content in rice bean and EC 341953 (21.70%) for protein in adzuki bean.

The supplementation of rice-bean flour (20 and 40%) with wheat increased the quality parameters of biscuits in respect of protein, fat, ash and crude fibre. The texture and acceptability of sweet balls prepared by supplementation of rice bean flour (40%) with Bengal gram were also at par with un-supplemented ones.

The demonstrations conducted at farmers' fields in Gujarat and Maharastra indicated that growing Amaranth was profitable over wheat and chickpea and best suited to marginal farmers with scant resources. The crop requires lesser number of irrigation and is free from diseases and insect– pest attack The benefit:cost ratio in growing Amaranth ranged from 1.97 to 2.69 as against 1.37 to 1.83 in chickpea and 1.73 to 1.87 in wheat at different farmers' fields.

Groundnut: Five groundnut varieties, viz. VRI (Gn) 6, TG 51, Ajeya, Girnar 2, ICGV 00348 and Mallika (ICHG-00440), were released for different agroclimatic conditions. Groundnut variety, ICGH 00440, is large-seeded and suitable for export purposes.



Ground variety Girnar 3

Groundnut varieties identified for release: Varieties identified for release are: K 1319, R 2001-3, GPBG 5, CSMG 2003-19, HNG 69 and Girnar 3 (West Bengal, Orissa and Manipur).

Rapeseed-mustard: Four varieties (RB 50, RGN 145, NRCHB 101 and Pusa Mustard 21) and two hybrids (NRCHB 506 and DMH 1) of



NRCHB 506: the first Indian mustard hybrid

Indian mustard and two varieties of yellow sarson (NRCYS-5-2 and YSH 401) have been notified for different mustard-growing regions. DMH-1 and Coral 432 (PAC 432) (hybrids); NPJ 112 (Pusa Mustard 25) and NRCDR 601(varieties) of Indian mustard, and RYSK 05-02 of yellow sarson were identified for release.

Soybean: Germplasm line, EC 538828, was found to possess relative tolerance to terminal drought, whereas soybean variety, NRC 2, was identified drought tolerant. It showed delayed wilting symptom (7 days after the withdrawal of water) and took maximum time to reach permanent wilting genetic resource. Soybean variety, JS 97-52, was identified for cultivation in central Zone.

Sunflower: KBSH 53, a hybrid with seed yield of 20–27 q/ha and 42–44% of oil content and tolerance to powdery mildew, has been released for Karnataka. This hybrid is better than KBSH44. Another hybrid, PSH-569, has been identified for cultivation in Punjab. It gives seed yield of 20–22 q/ha and matures in 100 days. It has 40% oil content.

Safflower: SSF-658, a wilt and aphid tolerant variety, with seed yield of 15–18 q/ha was released for all safflower-growing areas of the country. It exhibited 14–28% yield superiority over the control. It matures in 128 days and it has 28% oil content.



Non-spiny safflower variety SSF-658

Castor: GC-3, a wilt resistant variety, having 30% more yield than GC-2, has been released for Gujarat. It is resistant to wilt and tolerant to *Macrophomina* root rot. It has 40% oil content.

Sasame: Varieties, RT-346 (Rajasthan Til -346), AKT 101 and Gujarat Til-3, having high yield and other desirable characteristics have been released for cultivation in different areas.

Niger: IGPN-2004-1 (Phule Karale-1), a highyielding, early-maturing variety was released for high rainfall areas of Maharastra and Karnataka. Another KBN-1, a high-yielding, early-maturing variety, was released for cultivation in *kharif* areas of Karnataka.

Linseed: Varieties identified for release are LC-2063 for Punjab, LCK 5021 for Bihar, Jharkhand, West Bengal and Uttar Pradesh, SLS-67 for Bundelkhand region of Uttar Pradesh, Madhya Pradesh and Rajasthan, LMS 149-4 for Chhatisgarh, Maharashtra, Karnataka, Andhra Pradesh and Orissa.

Pulses: Seventeen varieties in pulses have been identified for release for different regions of the country. They are: IPCK 2004-29, Shubhra, Phule G 0517and PKV Kabuli-4, (chickpea), IPM 02-03, Pusa 0672 and PKVAKM 4(greengram), KU 99021, COBG 653 and NUL 7(blackgram), IPF 5-19, Pant P 74, TRCP 8 and VL 46(fieldpea), Pant L063 and Pant L024(lentil), and Gujarat Rajmash 1(rajmash).

Arid Legumes: Horse gram entry, VLG-19, has been identified for release for northern India. It matures early (91 days) compared to the control (105–108 days).

Jute: Notified jute varieties, viz. Sidhartha (JRC 517) and Sashi (JRC-532) tolerant to drought and waterlogging for capularies jute growing areas and Monalisa (RRPS-27-C-3), tolerant to foot and stem-rot, yellow mite, stem weevil and semilooper were notified for midland jute growing areas. Sumit (JBM-2004-D), a mesta variety was notified for West Bengal, Orissa, Asom and Bihar. Sunhemp variety, Swastika (SUN 053), was notiifed for Uttar Pradesh, West Bengal, Orissa, Madhya Pradesh and Bihar.

As many as 43 germplasm accessions consisting of both jute (18) and sunnhemp (25) were collected from Haryana and Punjab. Donors for premature flowering resistance amongst the olitorius germplasm were identified. Flax germplasm accessions, Polf 15, Polf 31 and H 43, were identified as potential donors.

Application for registration of 15 notified extant varieties (JRO 632, JRO 3690, JRO 66, JRO 524, JRO 7835, JRO 878, JRO 8432, JRO 128, S 19, JRC 212, JRC 7447, JRC 321, Padma, JRC 698 and JRC 80) developed by CRIJAF, Barrackpore, one notified extant variety (Bidhan Pat-3)

Germplasm registration				
Name	INGR No.	IC No.	Centre	Characteristics
HKI-288-2	8071	IC563956	Karnal	Late maturity, yellow and flint grain and MLB resistant
HKI-1126	8072	IC563958	Karnal	Late maturity, yellow and flint grain and MLB resistant
HKI-1040-4	8073	IC563959	Karnal	Medium maturity, orange and flint grain and MLB resistant
HKI-1015WG-8	8074	IC563961	Karnal	Medium maturity, orange and flint grain and MLB resistant
HKI-1347-4LT	8075	IC563964	Karnal	Late maturity, white and flint grain and MLB resistant
HKI-164D-4(O)	8076	IC563965	Karnal	Late maturity, QPM, yellow and semi-dent grain and MLB resistant
HKI-164-7-6	8077	IC 563966	Karnal	Late maturity, QPM, orange and semi-dent grain and MLB resistant
VQL1	08011	IC 542343	Almora	Medium, yellow, semi-flint, trp >0.6%
VQL2	08012	IC 542344	Almora	Early, orange, flint, trp >0.6%

developed by BCKV, Kalyani, and two new varieties (JRO 204 and IRA) developed by CRIJAF, Barrackpore, have been send to PPV& FR Authority, for their registration. The DUS testing of two newly-released varieties (JRO 204 and IRA) are in progress.

Four olitorius accessions, OIN 125, OIN 154, OIN 651 and OIN 853, showing mean PDI of 5.0 or less were categorized as moderately resistant to *Macrophomina phaseolina*.

Phylogenetic analysis of begomovirus complexes associated with yellow-vein mosaic disease of mesta revealed that in eastern India, the disease was associated with different variants of MeYVMV and CLCuMB, whereas in northern India it is associated with different variants of MeYVMBV and LuLDB. Interestingly, in southern India the begomovirus complexs consisted of MeYVMBV and LuLDB.

Sugarcane: Identified sugarcane varieties for Punjab, Haryana and western Uttar Pradesh are Co 118 with moderate red rot resitance, Co 233; for both waterlogged and water stressed situations; Co 232 was identified for waterlogged and red rot disease for eastern Uttar Pradesh, Bihar, West Bengal and north-eastern states.

Collection of wild *Saccharum* germplasm: An exploration for the collection of wild *Saccharum* germplasm from Uttarakhand and Himachal Pradesh was organized during September-October 2009. A total of 53 accessions comprising *Saccharum spontaneum, Erianthus fulvus* and *Miscanthus nepalensis* were collected.

Cloning and tissue-specific of a new gene promoter: The upstream of one of a new *ubi* gene with 1929 bp was cloned and sequenced. Analysis of sequence data showed that the immediate upstream of start codon of the gene has introns and exons. Above it is the promoter sequence of 239 bp together forming the regulatory system. The promoter sequence has the promoter elements, TATA box and CAT box, and also *cis* activating sites for roots, guard cells and xylem specific expression. Tobacco transgenics with pCAMBIA 1305, where *gus* gene is driven by new promoter, were developed. In tobacco, tissuespecific expression (in guard cells, xylem and roots) of the *gus* gene was observed.

Genes for drought resistance: Attempts were made to identify candidate genes for drought resistance in sugarcane. The mapping population of Co $740 \times$ Co 775 was categorized as susceptible (23%), moderately susceptible (33%), moderately resistant (20%), resistant (14%) and tolerant (11%) based on cane yield and quality characters, and physiological parameters after imposition of drought during the formative phase. Polymorphism between drought resistant and susceptible clones has been observed in RT-PCR analysis for the candidate gene primers IGS, Nit, cAPX, DHAR, prokin, PIN1 and SOD in resistant clones, while GST 1 gave two specific bands in susceptible parent and progeny. SOD gene showed 98% homology with the drought inducible protein in Saccharum hybrid. The IGS showed 95% homology with rice genomic DNA and 80% homology with hypothetical proteins expressed in rice genome.

Tobacco: Two varieties / hybrids of FCV tobacco and two varieties of *bidi* tobacco with high yield potential or with resistance to pests were identified / recommended for cultivation in different regions of country.

The tobacco varieties, viz. N 98 for southern light and black soils of Andhra Pradesh, Sahyadri (KST 28) for light soils of Karnataka, Vedganga-I (NBD 43) for Nipani in Karnatak and ABD 105 for Gujarat were identified. The tobacco genotypes having potential alternative uses for high oil content, protein, nicotine and organic acids were identified.

Mango: At CISH, Lucknow, a hybrid namely Hybrid 1084 between Amrapali and Janardhan Pasand was found promising. It has got attractive dark red colour on peel and better shelf-life. The hybrid is dwarf in stature, heavy and regularbearer.

Guava: CISH GS 35 is a promising heavy-

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bearer, half-sib progeny of Allahabad Safeda guava. It produces roundish, smooth, medium large fruits (200–250g). Mature fruits have white flesh, sweet taste along with muskiness developing light yellow colour on ripening. Fruits have TSS 13.4°Brix, acidity 0.42% and vitamin 'C' > 250 mg per 100g fruit and present grittiness of outer flesh. It is soft and medium-seeded (0.93g 100 seed).

Papaya: At IIHR, Bangalore, advanced generation of hybrid progenies of papaya from the combination Surya \times Tainung-1 were evaluated for various characters. The hybrid progeny number 28-5 had desirable fruit quality, producing 600–800 g fruits with deep pink colour and high TSS (13–14° Brix) with good keeping quality.

Citrus: At NRC on Citrus, Nagpur; Nagpur mandarin-75, Acid lime-12 and Mosambi-5 were selected as superior clones. Two clones, one early-maturing-N₂ (early-March and early-November) and another less seeded-N₅ (less than 3 seeds/fruit) were identified.

In *in-vitro* regeneration of citrus, ovules were excised from 8–10 weeks old fruits of Nagpur mandarin and cultured in MS medium supplemented with various organic compounds. Cotyledonary embryoids obtained from MS + ME medium were subcultured and MS medium supplemented with various growth regulators. kinetin in combination with IAA promoted plantlet formation.

Calli derived from epicotyl segments of Troyer citrange (*Citrus sinensis* × *Poncirus trifoliata*) chethali, an important rootstock for Nagpur mandarin and acid lime, were subcultured on regeneration medium (MS fortified with BAP). Rooting occurred from one-month-old shoots subcultured in ½ MS medium supplemented with IBA. *In-vitro* regenerated plants successfully survived in sterilized soil mixture containing soil, sand and cocopeat with 50% survival

Multiple shoots were obtained from mature axillary bud explant / single node of mature trees (>10 years old) of *Citrus limonia* cultivars Rangpur lime Gonicoppal and Brazillian Rangpur lime. When cultured in MS medium supplemented with BAP, kinetin and NAA. *In vitro* proliferated shoots rooted when shoots were cultured on MS supplemented with IBA. Rooted complete plantlets transferred to micro pots having sterilized soil mixture with 50% survival.

The acid lime clone, TAL-94-14 (New), at Tirupati, mandarin selection - 5 at Akola, Khasi mandarin CRS - 4 at Tinsukia, sweet orange selection-2 at Rahuri and Kodur Sathgudi at Tirupati, are continued to be promising.

Banana: Embryo rescue has been standardized for wild species and hybrids involving wild species.

Germination efficiency of wild species even after 15 months has been achieved using hormonal pretreatments. Embryo rescue studies have shown that 80–95% mature embryos could be regenerated into plantlets through direct organogenesis. Genetically transformed banana cv. Rasthali with chitinase gene (chi-II) was confirmed for the presence of transgene through southern blotting. Forty differentially expressed EST's were identified in Sigatoka resistant cultivar Manoranjitham through SSH approach and deposited in NCBI.

The AFLP polymorphism has been studied for drought tolerant (Poovan and Imbogo) and susceptible (Nendran and Calcutta 4) lines of *Musa*. About 15 unique bands have been identified using 64 AFLP markers, of which, seven were specific for tolerance and eight were specific for susceptible. These putative diagnostic markers could be converted into SCAR marker for use in early screening of progenies for drought tolerance. The cDNA libraries have been created for identifying the resistant genes against Sigatoka leaf spot disease and nematode.

The Budu Bale (Pisang Awak) at Arabhavi, Mettupalyam (Pome) at Coimbatore, BRS-3 (Cavendish) at Jalgaon, KBS 8 (Dawarf Cavendish) at Kovvur and Kovvur Bontha (Monthan) at Kovvur have been found promising in banana.

Sapota: A high-yielding clone, DHS 1 (2/1), identified earlier continued to show its superiority.

Jackfruit: One off-season bearing type of jackfruit weighing 40 kg has been identified by Periyakulam centre.

Grape: About 157 accessions were evaluated for 10 fruit characters. Maximum heritability was obtained for seed weight, indicating importance of this character for selection. Bunch weight and number of berries per bunch contributed maximum to total variability among 157 accessions as revealed by principal component analysis.

Fifty-four different grape accessions were analysed with 22 microsatellite primers and their fingerprints were developed. Graphical user interface, functional design and coding for different modules were completed for creating database for molecular marker data of grape germplasm.

Pomegranate: Sixty-one varieties/ecotypes/ landraces of pomegranate were evaluated for growth parameters. The maximum variability was recorded with respect to leaf area (25.83%), followed by plant spread and thorn length. Bedana Sedana, Spendanader and IC-1203 recorded plant height > 275 cm and Nana was dwarf type (63.67 cm). However, flowering was recorded in more than 85% germplasm after two years.

Studies on flower biology revealed three kinds of flowers in pomegranate—Bisexual, Male and

Intermediate. The flower bud development took 19.29 days in Bhagwa and 20.40 days in Ganesh. The total number of flowers per plant from 2-year-old orchard was 124 and 133 in Ganesh and Bhagwa, respectively. The peak period of anthesis in pomegranate Bhagwa and Ganesh was between 10 AM and 12 noon. Pollen viability in pomegranate ranged from 84.0 to 95.0% and pollen viability was slightly higher in Ganesh than Bhagwa. More fruit setting in cross-pollinated fruits (47.77%) was recorded than in self-pollinated ones (16.6%).

Litchi: At NRC Litchi, Muzaffarpur; 24 desirable clones of litchi Shahi and China for extended harvesting season and improved quality characteristics have been identified. One bunchbearing clone of Shahi was also identified from the Motihari area of Bihar.



A bunch-bearing clone of Shahi litchi

Almond: Five exotic soft-shelled almond cultivars were evaluated to identify high-yielding cultivars having superior nut and kernel quality. Cultivar Waris was found highest yielder (5.14 kg/tree), followed by Makhdoom (4.94 kg/tree) and Non Pareil (4.64 kg/tree). Non Pareil was earliest (126 days), followed by Pranayaj (135) and Waris (137). Kernel recovery was highest in Non-Pareil (65.7%), followed by Merced (63.4%) and Pranyaj (59.9%).

Apricot: Ten apricot cultivars were evaluated for fruit yield and table quality. Genotype CITH-Apricot-1 was found most promising recording maximum yield (14.5 kg/tree), followed by CITH-Apricot 2 (10.5 kg/tree). However, genotype CITH-Apricot 3 has more sweetness (16.0°Brix), followed by CITH-Apricot 1(14.9°Brix). These varieties are being multiplied at large scale.

Walnut: A total of 178 indigenous selections and 15 exotic varieties have been established and are being evaluated for various economic traits. Out of 195 genotypes, 49 have come to bearing stage whose nut and kernel weight ranged from 6/23 to 24.46g and 5.09 to 11.11g respectively in



CITH-Walnut 1: an excellent walnut variety with export quality traits

4th year of age with CITH-Walnut 1, recording the highest nut weight (24.46 g) followed by LG 10 (20.30g) and KPT 5 (18.11g). On the basis of nut and kernel characters, genotypes namely CITHwalnut 1, CITH-walnut 2, CITH-walnut 3, CITHwalnut 4 and CITH-walnut 5 have been identified and being multiplied on large scale for testing and release at national level.

Strawberry: Twenty-one strawberry cultivars were evaluated under open field conditions at Mukteshwar during 2006–09. Blackmore, Chandler, Gorella, Camarosa and Oso-Grandy performed better in terms of plant growth, yield and fruit quality.

Almond: For better pollination, six honey bee colonies per hectare and cultivar IXL as a pollinizer were found beneficial for increasing fruit setting, higher nut and kernel yield. The fruit setting increased by 22% and nut yield by about 12–15%.

Apple: On the basis of blooming period the main cultivars and pollinizers in apple have been categorized as:

Very early bloomer: Mayan, Schlomit, Micheal; Early bloomer: Chaubattia Princess, Chaubattia Anupam, Summer Red, Prima, Vermouth Spur, Vance Delicious, Mollie's Delicious; Mid-to latebloomer: Gala Mast, Oregon Spur, Starkrimson, Cooper 4, Skyline Supreme, Top Red, Spur Type Red Delicious, Royal Delicious, D. K. Delicious, Well Spur, Red Chief, Hardy Spur, Star Summer Gold, Gala Mast, Red Spur, Rich-a Red and Red Delicious. The Pollinizer cultivars were categorized as: Very early to early: Manchurian crab, Crab apple (*M. baccata* USA), Tydeman's Early Worcester, Red Gold and Mid-to late. Snow Drift, Golden Hornet, Stark Spur, Golden Delicious and Golden Spur.

The low-chilling cultivars, Schlomit, Micheal and Mayan, were very early to bloom and the



Top-working with pollinizer varieties for increased pollen availability

blooming of *Malus baccata* (USA) synchronized with these cultivars as a good pollinizer, followed by flowering in Manchurian crab. The *Malus machurica* is very profuse bloomer and has a very good characteristic of extended blooming duration which synchronizes with most of main cultivars. The fruit setting was higher (37–43%) under controlled cross-pollination, followed by openpollination (32–52%) after placement of bee hives @ 7/ha in comparison to fruit setting of the previous years (9–25%) without bee hives placement.

During blooming period, rainy days accompanied by hail-storm and low temperatures (>13 °C) as well as high wind velocity affected the foraging of pollinators. The Apis mellifera was badly affected and bee causality was maximum under inclement weather. The Apis cerana indica was found to be better adapted under these climatic conditions. Top grafting of pollinizers on main apple cultivars during mid-February by cleft or side bark and tongue budding during 30 June -15 July gave higher success. Successive growth of scion wood of Golden Delicious, Tydeman's Early Worcester, Red Gold, Stark Spur and Golden Spur resulted in better shoot growth, however bloom intensity was better in crab apples like Manchurian, Golden Hornet and Snow Drift.

Arid Fruits: The individual cultivars could be identified using a specific flavonoid spot or combination of spots. The data were further analysed using NTSYS software to assess the relationship among cultivars. It was observed that popular Gola, Kaksol Gola and Ladu were more closely related than other cultivars.

At CHES, Godhra, 3 chironji germplasm lines (CHES-C 1, CHES-C 2 and CHES-C 7) were found to be promising. Two promising lines of jamun, viz. GJ 2 and GJ 8 were found promising and proposed for release.

Coconut: Of the 20 accessions evaluated, higher nut yield was recorded in IND 071S, IND 027S,

IND 148, while higher copra yield was obtained in IND 027S, IND 026S, IND 071S, IND 148, IND 002S, respectively. Of the 71 coconut accessions, including 58 tall accessions and 13 dwarf accessions, copra content ranged from 70.4 to 349 g. The accessions, IND 085S, IND 023S and IND 034S, were found promising for copra content; with 300 g copra/ nut. Among dwarfs, coconut germplasm accession, IND 092S, recorded copra content of 219.80 g.

Based on the storability and firmness of copra, IND 030S, WCT, Kalpa Mitra and IND 082, respectively, were found better suited for ball copra production. The hybrid IND 058S \times IND 069S, was found superior for nut, copra yield and tender nut traits.

Analysis of dwarfs using 14 microsatellite markers showed that, MYD and COD were monomorphic, whereas heterozygosity ranged from 0.3 to 0.4 in talls. The UV treatment was found to induce more growth in coconut embryos under tissue culture conditions.

The nucleotide and protein sequences pertaining to genes induced during somatic embryogenesis, viz. *SERK* (somatic embryogenesis receptor kinase) and *BBM* (*BABY BOOM*) were retrieved from the NCBI. Nucleotide sequences coding conserved domain amino acid was selected for oligomer designing. These degenerate primers were used to amplify, clone and sequence *SERK* and *BBM* genes in coconut.

For molecular tagging of coconut root (wilt) disease, 18 degenerate primer pairs were used to amplify Resistance Gene Analogues (RGAs) from coconut. Initially, the annealing temperature for each primer pair was standardized using gradient PCR. After PCR, electrophoresis was carried out and amplicons of expected sizes were eluted, cloned and sequenced. Two of the clones showed homology to RGAs from other plant species.

Kalpatharu: Considering higher coconut yield (15,750 nuts/ha), better copra outturn of 2.7 tonnes/ ha @ 15.48 kg/palm/year with oil content of 67.2%, drought tolerance attributes and adaptability to water deficit regions, accession IND 125 S is recommended for cultivation in Karnataka, Tamil Nadu and Kerala.

Kalpa Samrudhi: Considering the superiority of coconut hybrid IND 376 (a hybrid between IND 058 S \times IND 069 S) for higher nut yield, (117 nuts/palm), high copra out turn (25.72 kg/ palm/year), oil yield of 3.04 tonnes/ha under rainfed conditions, semi-tall habit, good tender nut water quality (TSS 6% Brix), and yield (346 ml/ tender nut) and drought tolerance nature, this hybrid is recommended for cultivation in Asom and Kerala.

Arecanut: Performance of arecanut germplasm accessions collected from NE region was found

to be better than others and, accessions, VTL-29 II, VTL-12, VTL 18 III, Nalbari and K & J hills, recorded higher yield ranging from 2.81 to 3.58 kg chali/palm/ year.

Forty-nine tissue culture derived plantlets from YLD resistant arecanut palms were field planted for evaluation against YLD. Clonal fidelity test using RAPD indicated that 98% of progenies are similar to mother palms.

The DNA of arecanut sample from YLD resistant and susceptible palms was screened with ISSR primers (UBC 820-840) and 40 RAPD primers (OPAF and OPAB). Reproducible primers are selected (UBC828, UBC835, UBC822, OPAF11, OPAF13, OPAF18, OPAB3 AND OPAB7) for further testing of resistant and susceptible palms. The CNZ 01, CNZ 03, CNZ05, CNZ 18, CnCirB3 and CnCirC09 primers showed amplification of arecanut DNA. Resistant genes were collected from NCBI database and analyzed for conserved regions based on multiple sequence alignment. The primers were synthesized for NBC-LRR regions. The primers were used to amplify the resistant genes from YLD resistant areca palm. Amplicons at expected size were eluted from the gels and cloned, and are being sequenced. Resistant genes from different categories from various crops were analyzed for consensus region and motifs.

Under bioinformatics, databases on plant growth promoting rhizobacteria (PGPR) and sequences of all the available phytoplasma have been developed. Protein kinase gene family in palms was analyzed for disease resistance, OBP sequences were analyzed for red palm weevil of coconut.

Oil palm: Under characterization of interspecific hybrids of Elaeis oleifera or the American oil palm produces more liquid oil due to higher unsaturated fatty acid content compared to commercial species (Elaeis guineensis). However, due to erratic and poor yield, E. oleifera is not cultivated commercially. Interspecific hybrids have potential of combining yield and quality in oil. Interspecific crosses were made involving E. guineensis and E. oleifera palms. Bunch component analysis of hybrids showed intermediate values for bunch weight as well as bunch related parameters including proportion of parthenocarpic fruits. However, oil/mesocarp oil/bunch were lower than those of the parents. Fatty acid composition showed intermediate value between the two parental species for all fatty acids. Wide variability in fatty acid composition was found in progenies of two specific interspecific crosses. Since performance of each palm is different, individual interspecific hybrid palms were assessed based on total unsaturated fatty acids and oleic acid content and 20 superior palms were selected, which could be employed for further back crossing to combine quality of palm oil and yield.

After several extensive experiments with spear leaves collected from mature palms, callus induction, somatic embryo induction and maturation including plantlet regeneration have been obtained from spear leaves. Standardization of media for callus induction and somatic embryo induction was also possible from immature inflorescence collected from mature palms. Refinement and confirmation of the above protocols are under progress.

Cashew: Three hybrids, H-66, H-68 and H-43, yielded 4.0, 5.2, and 5.6 kg/tree in fifth harvesting with a cumulative yield of 23.8, 24.0, and 25.1 kg/tree, respectively. Hybrids, H-125 and H-126, yielded 7.0 and 6.0 kg/tree in fifth harvesting with a cumulative yield of 26.4 and 23.7 kg/tree, respectively. At Jhargram, maximum nuts were recorded with Kanaka (14.75), followed by Vengurla 6 (13.75) and Dhana (11.75).

Onion: Bhima Red variety has been developed through bulb to row selection method from a base population of B-780. After transplanting it takes 120-140 days for harvesting. The bulbs possess attractive red colour, round shape with higher marketable bulbs. This variety yields around 30 tonnes/ha in *rabi* season. This variety is also suitable for late *kharif* season with a yield potential of 50 tonnes/ha.

Garlic: Bhima Omkar line has been identified for high yield and better quality. It has been developed through clonal selection. Its bulbs are medium in size, compact and white in colour. Average marketable yield is 7.7 tonnes/ha with an average of 18-31 cloves per bulb.

Mushroom: Among the 19 strains of *Pleurotus florida* evaluated for yield, strain Pl-900 gave earliest fruiting and highest biological efficiency (108.3%).

Potato: Two hybrids, Kufri Nilima and Kufri Frysona, were recommended for release as varieties.

Kufri Nilima is a medium-maturing hybrid, resistant to late blight and cyst nematodes. It is suitable for cultivation in Nilgiris hills of Tamil Nadu.

Kufri Frysona produces oblong tubers of attractive shape with shallow eyes and white flesh colour. Its tubers are free from most of the external and internal defects. The average total tuber yield is 39.8 tonnes/ha with an average French fry grade tuber yield of 25.8 tonnes/ha. The tubers contain on an average 22% dry-matter content and have very low reducing sugar content (< 100 mg/100 g fresh tuber weight) and negligible enzymatic browning. The variety is suitable for planting in the main season in Indo-Gangetic plains and matures 100–110 days after planting.

Coconut: Two varieties, Kalpatharu and Kalpa

Samrudhi, have been developed.

Kalpatharu gives higher coconut yield (15,750 nuts/ha), better copra outturn of (2.7 tonnes/ha) with oil content of 67.2%, drought tolerance and adaptability to water deficit regions. It is recommended for cultivation in Karnataka, Tamil Nadu and Kerala.

Kalpa Samrudhi hybrid, IND 376, gives higher nut yield (117 nuts/palm), high copra outturn (25.72 kg/palm/year), oil yield of 3.04 tonnes/ha under rainfed conditions. It is semi-tall and provides good tender nut water quality (TSS: 6% Brix), and yield (346 ml/ tender nut), and drought tolerant. It is recommended for cultivation in Asom and Kerala.

Black pepper: Two advanced lines, INGR 8099-*Piper thomsonii* (IC-398863) - for sex change from male to bisexual plant and INGR 8100- *Piper nigrum* (IC-563950) – a novel spike variant with proliferating spikes were registered with NBPGR for their unique characters.

Cardamom: Evaluation of hybrids under PET 1 and PET 2 led to the identification of five hybrids, namely CCS-1 \times RR-1, RR-1 \times CCS-1, MB-5 \times GGASH, NKE 19 \times GG, GG \times NKE 19.

Cassia: The elite line A1 (IC No. 370400) with high cinnamaldehyde content in bark oil (81.5%) and leaf oil (80.5%) has been registered with NBPGR, New Delhi.

Ginger: A high-yielding ginger variety, Subhada, has been recommended for release.

Cumin: A cumin variety, RZ-345, from Jobner was recommended for release.

Fennel: UF-205 from Jobner, LFC-84 from Guntur and HM-219 from Hisar were identified for release.

Fenugreek: The entries RMt-361 from Jobner, LFC-84 from Guntur and HM-219 from Hisar were identified for release.

Coriander: Three varieties, RCr-728, LCC-170 and DH 206, were identified for release.

Cassava: Three cassava hybrid lines, CMR-3, CMR-63 and CMR-70, with extractable starch content of 24.6-25.8% were identified as promising under irrigated plains of Tamil Nadu.

Mandookaparni: A distinct elite plant type of medicinal plant mandookaparni (*Centella asiatica*), collected from Faizabad, Uttar Pradesh, was characterised at DMAPR. The new plant type having accession No. IC 561247 was bigger in leaf size and superior to local plant type in yield and quality. Fresh herbage yield was about three times more the elite plant type compared to local plant type. Asiaticoside was 1.62% in registered material while local type had 1.47% active principle. Characterisation based on molecular markers also revealed the distinctness of IC 561247. It is registered as INGR No. 08105 as an elite germplasm with superior yield and quality.

Orchid: Two clones of cymbidium hybrids, namely $H \times B/2008$ clone-01 and $H \times B/2008$ clone-02, were identified as promising.

Gladiolus: Under multilocational testing of AICRP, Pune, Hybrid GKGL-94-77 is superior in spike qualities.

Gerbera: At Hessaraghatta, gerbera line, IIHR 99-1, has been identified for release as Arka Krishika.

BIOTECHNOLOGY

Novel genes and promoters: For the development of effective and efficient transgenic crop mutant populations of *Arabidopsis* tagged with promoterless GUS gene were generated. A mutant line of *Arabidopsis* exhibiting wound inducible expression of GUS exclusively in stems has been identified from a T-DNA tagged mutant population. The GUS expression is stem-specific and observed only after wounding.

Biparental inheritance: Using progenies of crosses involving different CMS lines and fertility restorer/euplasmic lines, it is established that mt-DNA is biparentally inherited in *B juncea*. Pollen mediated mt-DNA transmission was found in all the progenies. Further, paternal mt-DNA was transcribed and maintained throughout the lifespan of progeny plants. The first instance of mitochondrial recombination under natural conditions from biparental inheritance of mt-DNA, has been documented and could be useful for detailed studies on mitochondrial inheritance in angiosperms and for mitochondrial genome manipulation through sexual hybridization.

Targeted integration of *Bacillus thuringiensis* cry1Fa1 gene at *Flavonoid-3-glucosyltransferase* (*F3G*) (anthocyanin biosynthesis pathway) locus in brinjal was achieved. Gene targeting resulted in high level expression of cry1Fa1 in leaf, stem epidermis and fruit epidermis, susceptible to 'Brinjal Fruit and Shoot Borer' (BFSB). In addition, gene targeted transgenic brinjal did not show any phenotypic effect or loss of function of the target gene (*F3G*).

Tomato Genome Sequencing: Of the total 31 BACs in the BAC minimum tiling path of long arm of chromosome 5 of tomato with total size of 3.435 Mb, 16 of BACs have been sequenced. Additional 9 BACs of total size 1.046 Mb have been sequenced that have now gone to other chromosomes, giving total of 4.481 Mb of BACs identified for sequencing. The sequence data of 29 BACs (3.212 Mb) in the MTP of chromosome 5 has been processed to high quality of international standards. Further annotation of 2,342 predicted genes from 170 tomato BACs for ITAG has been made functional. The genome wide annotation of

R-genes for tomato genome snapshot paper has also been done. All the Phase III BACs from SGN have been downloaded and done gene prediction, total 11,019 genes predicted in 645 BACs. Submission of 8 BACs in Phase III and 16 BACs in Phase II to NCBI and SGN portals, including 5 BACs for other tomato chromosomes has been done. Additional 11 BACs for chromosome 5 are in phase I that will be upgraded to Phase II and submitted soon.

SpicEST: A database of ESTs of two major spices, turmeric and ginger, was developed and hosted (<u>www.spices.res.in/spicest</u>). SpicEST contains all ESTs of these plants, their annotation, and information on SSRs and SNPs.

Cassava: In cassava, drought responsive genes, Dehydrin, LEA and WRKY genes PCR product, were amplified (400–600 bp) using CE-165 parent. The disease resistant gene, NBS region of Resistance Gene Analog (RGA), was amplified (600 bp) using MNga-1 parent and all genes were cloned to plasmid vector for sequencing.

Guggal: Sixty different random decamer primers were screened with the three bulks to identify markers associated with sex expression of which only three primers were found to be associated with sex expression.

Potato: The institute has successfully validated a Sequence Characterized Amplified Region (SCAR) marker RYSC3 for the detection of Ry_{adg} and used it to identify a parental line (YY-6/3 C11) carrying the gene in triplex state. The triplex status of line was confirmed by studying segregation ratio of marker in its test cross progeny and PVY resistance of this line was also confirmed by challenge inoculation, followed by ELISA and Immuno Electron Microscopy to check virus multiplication. This is the first instance where MAS has been used as a tool in pre-breeding of potato.

SEED

Breeder Seed Production: Breeder seed of cereals (3,707 tonnes), pulses (1,336 tonnes), oilseeds (2,185 tonnes), fibre crops (11.5 tonnes) and forage crops (154.3 tonnes) was produced.

Quality seed production: The total quality seed production of field was 63,416.3 tonnes.

Participatory seed production: A total of 31,898.3 tonnes of quality seed was produced under participatory seed production programme at farmers' fields at various centres.

Seed production technology

To avert the problem of Zn deficiency in many parts of the country in seed production, application of $ZnSO_4$ either @ 50 kg/ha as basal dressing or 25 kg/ha as basal along with foliar spraying @ 2g/litre twice at one week interval enhanced seed yield and seed quality.

Spraying of ethrel @ 0.1% 45 and 60 days after sowing was found to effectively suppress interspersed staminate flowers in NES pistillate and also maintains genetic purity considerably in castor.

Seed Storage

Polylined gunny bags/ polylined cloth bags were emerged as most useful packaging material over conventional gunny bags for storing seeds of field crops for one planting season at 10% moisture content. It was found to maintain seed quality above IMSCS. Being cheaper, such bags are to be popularized among farmers in the country for storing seed material of field crops.

Cotton seed (fuzzy seed, wet acid delinted seed and dry gas delinted) can be safely stored for 12 months in polylined jute bags.

Seed processing

In grading safflower seeds, presently recommended sieve of 1.2 mm has been found to be ineffective since inert matter even cannot pass through it. For grading safflower seeds, 2.2 mm sieve was found to be economical and highly effective.

For grading hybrid rice seeds, $1.85 \text{ mm} \times 20$ mm sieve was found to be effective for higher seed recovery, more physical purity and higher seed vigour index.