

6. Crop Improvement

High-yielding crop varieties and hybrids with tolerance to pests /diseases and to various farming constraints such as soil and water salinity, soil acidity, drought, flood and such other factors have been developed.

For different designated agro-climatic regions/zones of the country, improved varieties of cereals, oilseeds, pulses, fruits, vegetables and commercial crops have been notified for cultivation.

Cereals

Two rice hybrids, VNR 2245 and VNR 2355, were released by the Central Sub-committee of Crop Standards, Notification and Release of Varieties. The State Variety Release Committees have recommended 21 rice varieties and two hybrids, Sahyadri 5 and CO(R) H 4.

During 2012, nine rice hybrids and two varieties were

Rice hybrids/varieties released

Variety/hybrid	Grain type	Reaction to pests/diseases	Ecosystem
Central Releases			
VNR 2245 (Hybrid)	LS	MR-LBI	Irrigated areas
VNR 2355 (Hybrid)	MS	MR-LBI, NB	Irrigated areas
State Releases			
Ratnagiri 5	SS	MR-BLB, BL	RUP, Konkan areas of Maharashtra
Sahyadri 5 (Hybrid)	LS	MR-BLB, BL	RSL, Konkan region of Maharashtra
Karjat 8	SS	MR-BL, NB, BLB, WBPH, G	RSL, Konkan region of Maharashtra
Improved Lalat	LS	R-G; MR-SBD	Irrigated areas of Odisha
Improved Tapaswini	SB	R-BPH, YSB, WBPH; MR-BB, SBD	Irrigated areas of Odisha
CR Dhan 200	SB	MR-LB, NB, BS, SBD, DH, RWM, G, LF	Aerobic conditions of Odisha
CR Dhan 902	LS	R-NB, G; MR-ShR, SBD	Irrigated areas of Odisha
CR Dhan 404	LB	R-LBI, SBD, LF, G; MT-BS, BLB, SBD, ShR, GLH, G, RT	RSL conditions of Odisha
CR Dhan 100	MS	R-SBD, LF, RWM; MT-WBPH, G, RH, RTV, LBI	RUP of Odisha
CR Dhan 503	MS	MR-LF, GLH, LBI, NB, BS, G, DH SBD, RWM	DW of Odisha
CR Dhan 502	MS	MR-LBI, NB, SBD, ShR	DW of Odisha
CR Dhan 301	LS	R-G; MR-ShR, RTD, G1	Irrigated areas of Odisha
CR Dhan 406	MS	T-LBI; MT-LF, SBD	CS of Odisha
CR Dhan 405	MS	T-LBI, MT-SBD	CS of Odisha
Jyotirmayee	MS	MR-LBI, SBD, G	RUP of Odisha
Hiranmayee	MS	MR-SBD, ShR, RTV, BLB, BS, G1	Irrigated areas of Odisha
Tanmayee	SB	MR-NB, LBI, SBD, RTV, BLB, G1	RSL of Odisha
Nua Acharamati	SB	MR-SBD, RTV, BLB, G, BPH	Irrigated areas of Odisha
CO(R) H 4 (Hybrid)	MS	R-BL, BS; MR-WBPH, GLH ShR, RTD	Irrigated areas of Tamil Nadu
Shalimar Rice 2	MB	R-BL	Irrigated lowlands of Jammu and Kashmir
Shalimar Rice 3	MB	R-BL	Irrigated lowlands of Jammu and Kashmir
Puspa	SB	R-BL, ShBI, ShR, BLB, BS, BPH; MR-RTV, LF, SBD	RUP of West Bengal
Dhiren (BNKR 1)	SB	R-LBI, NB, BS, ShR, LF	Irrigated areas of West Bengal

BL: Blast; BLB/BB: Bacterial Leaf Blight; BPH: Brown Plant Hopper; BS: Brown Spot; CS: Coastal Saline; DH: Dead Heart; DW: Deep Water; G: Gall Midge; GLH: Green Leaf Hopper; LB: Long Bold; LBI: Leaf Blight; LF: Leaf Folder; LS: Long Slender; MB: Medium Bold; MR: Moderately Resistant; MS: Medium Slender; MT: Moderately Tolerant; NB: Nodal Blast; R: Resistant; RSL : Rainfed Shallow Lands; RT: Rice Thrips; RTD: Rice Tungro Disease; RTV: Rice Tungro Virus; RUP: Rainfed Uplands; RWM: Rice Wheat Maggot; SB: Short Bold; SBD: Stem Borer Disease; ShBI: Sheath Blight; ShR: Sheath Rot; SS: Short Slender; T: Tolerant; WBPH: White Backed Planthopper

identified for release. Hybrids are US 382, NPH 924-1, PNPB 24, 27P 31, 25P 25, JKRH 3333, TNRH 174, HRI 169 and RH 1531, and the varieties are RP 3644-1-19-5-5 and RP Bio 4918-2485.

Nine wheat varieties were released for commercial cultivation in different production conditions of the country.

A six-row malt-barley variety DWRUB 64 has been recommended for cultivation in the North-Western Plains



DWRUB 64, first six-row malt- barley variety



DPW 621-50 wheat for timely sown irrigated areas of the North-Western Plains Zone

Barley for malting quality

Malting quality is a combination of several grain and malt quality traits. Based on the overall score of 30, barley entries DWRB 102, DWRB 103, DWRB 104, RD 2848, RD 2849, DWRUB 52 showed better overall malting quality score under timely sown areas. In the late-sown trials, BH 968, DWRUB 52 were promising.

Entries BK 306, BCU 4966, BCU 5070, BCU 5474 and DWR 49 showed higher protein content coupled with good grain development. And entries with low protein content and good grain development were DWRUB 68 and VM 152. Among the entries included on the basis of beta- glucan content, DWRUB 76 (high beta glucan) was found with good grain development.

Wheat varieties released

Variety	Production condition	Area of adaptation
HD 2985	Late sown, irrigated	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Odisha, Asom and plains of north-eastern states
DPW 621-50	Timely sown, irrigated	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and <i>tarai</i> region of Uttarakhand
WH 1080	Timely sown, rainfed	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and <i>tarai</i> region of Uttarakhand
HD 2967	Timely sown, irrigated	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and <i>tarai</i> region of Uttarakhand
HD 3043	Timely sown, restricted irrigation	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and <i>tarai</i> region of Uttarakhand
PBW 644	Timely sown, rainfed	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), western Uttar Pradesh (except Jhansi division), Jammu and Kathua districts of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh, and <i>tarai</i> region of Uttarakhand
HD 2987	Timely sown, rainfed and restricted irrigation	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
UAS 428 (durum)	Timely sown, irrigated	Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
MP 3288	Timely sown, rainfed and restricted irrigation	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh

Zone (Punjab, Haryana, western Uttar Pradesh, Delhi and Rajasthan) in the irrigated late sown areas. This will provide an option to the farmers under late sown conditions, where only DWRB 73, a two-row malt-barley, was available so far.

Nineteen maize hybrids, including 9 late-maturing, 8 medium-maturing and 2 extra-early maturing, were

Maize hybrids released

Hybrid	Area of adaptation
Co 6	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
HM 12	Uttar Pradesh, Bihar, Jharkhand and Odisha
Vivek 43	Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, West Bengal, Odisha, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh
Vivek 39	Uttarakhand and Himachal Pradesh
KMH 218 Plus	Uttar Pradesh, Bihar, Jharkhand and Odisha
KMH 3426	Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
NMH 731	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
NMH 803	Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
KMH 25 K 60	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
KMH 3712	Uttar Pradesh, Bihar, Odisha, Jharkhand, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
NMH 920	Uttar Pradesh, Bihar, Odisha and Jharkhand
Bisco 506	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu
X8B 691	Punjab, Haryana, Delhi, western Uttar Pradesh, Uttar Pradesh, Bihar, Jharkhand, Odisha, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
X8B 562	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
NK 30	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
NK 6240	Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu
Bio 9682	Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh, Punjab and Haryana
SMH 3904	Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Rajasthan, Gujarat, Chhattisgarh and Madhya Pradesh
P 3501	Uttar Pradesh, Bihar, Odisha, Jharkhand, Madhya Pradesh, Rajasthan and Gujarat



Maize hybrids HM 12 (top); Vivek 39 (bottom left) and Vivek 43 (bottom right)

released and notified for cultivation in different parts of the country. HM 12, a medium-maturing, white-seeded semi-dent type single-cross hybrid, was released for Uttar Pradesh, Bihar, Jharkhand and Odisha. Co 6, a late-maturing hybrid, was notified for cultivation in Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh. For Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka, four late-maturing single-cross yellow-seeded hybrids KMH25K60, NK 30, NK 6240 and X8B562 were released.

Dual-purpose (grain and stover) *kharif*-sorghum variety CSV 27 was notified by the Central Subcommittee of Crop Standards, Notification and Release of Varieties. It recorded a grain yield of 2,802 kg/ha and a fodder yield of 19.3 tonnes/ha.

Kharif grain-sorghum hybrid CSH 30 (SPH 1655) is an early-maturing hybrid, recommended for Maharashtra, Karnataka, Madhya Pradesh, south Gujarat and north Andhra Pradesh. It showed good tolerance to grain moulds.



CSH 30, an early-maturing sorghum hybrid

Rabi-sorghum CSV 29 R (SPV 2033), recommended for Maharashtra, Karnataka and Andhra Pradesh in deep-black soils in *rabi* season, is a tall (210 cm), semi-compact variety with cylindrical, epearly-white, lustrous seed. It matures in 115–120 days. It showed tolerance to shoot-fly, stem-borer, shoot-bug, sugarcane aphid, charcoal-rot and rust, besides, moderate tolerance to drought.

Nine pearl millet hybrids and two varieties were notified for various agro-ecologies of the country.



Pearl millet hybrid RHB 173

Pearl millet hybrids/varieties

Hybrids/varieties	States
Shine (VBBH 3040) (MH 1578)	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
86 M 66 (MH 1617)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh
PAC 909 (MH 1435)	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
Mandor Bajra Composite 2 (MBC 2)	Western Rajasthan and drier parts of Gujarat and Haryana
HHB 226 (MH 1479)	Western Rajasthan and drier parts of Gujarat and Haryana
RHB 177 (MH 1486)	Western Rajasthan and drier parts of Gujarat and Haryana
RHB 173 (MH 1446)	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Uttar Pradesh and Madhya Pradesh
Pusa Composite 612	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
MH 1540 86 M 53	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
MH 1541	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
MSH 203	In summer season in Rajasthan, Gujarat, Maharashtra and Tamil Nadu

Minor millets

VL 351 of fingermillet, SiA 3121 of foxtail millet and TNAU 86 and RK 390-25 of kodo millet were identified for release.



Surya Nandhi is one of the earliest-maturing varieties of foxtail millet. It matures in 70 days, and is suitable for double cropping in rainfed areas

PPR 2700 (Vakula) and VRW 936 (Hima) of fingermillet, and SiA 3088 (Surya Nandhi) of foxtail millet in Andhra Pradesh; KMR 204 of fingermillet in Karnataka; Indira Ragi 1 of fingermillet, and Indira kodo 1 of kodo millet in Chhattisgarh; and Phule Nachni (KOPN 235) of fingermillet variety in Maharashtra were identified for release.



KMR 204 is a short-duration variety of fingermillet, maturing in 95–100 days. It is resistant to blast disease and is suitable for late *kharif* sowing

Oilseed crops

Fifteen varieties/hybrids of oilseed crops were released, including four varieties each of groundnut and Indian mustard; two varieties each of castor and sesame; and one variety each of linseed, soybean and niger.

Fusarium-wilt resistant high-yielding castor variety DCS 107 with 11% yield increase over DCS 9 (1,602 kg/ha) was notified for release across the country. Safflower variety SSF 748 showing 11% and 7% superiority in terms of seed and oil, respectively, over the best check, PBNS 12, has been identified for safflower regions of the country, and NARI-H 23, a hybrid with 11% superiority in oil yield, has been identified for all safflower-growing areas, except Uttar Pradesh. Him Alsi 2 linseed gave maximum retted straw yield along with the best fibre softness and fineness in reduced

Oilseeds varieties/hybrids

Crop	Variety	Maturity days	Recommended state/ season/situation	Special traits
Castor	DCS 107	100–135	Castor-growing areas of the country; both rainfed and irrigated	Non-lodging, non-shattering type; responsive to fertilizers; resistant to <i>Fusarium</i> wilt; tolerant to leaf hoppers
	JI 273	–	Gujarat; irrigated	Highly resistant to <i>Fusarium</i> wilt
Linseed	Mau Azad Alsii 2	–	Chhattisgarh, Odisha, Maharashtra and Karnataka in timely sown rainfed areas	Resistant to rust
Soybean	SL 744	139	Timely sown irrigated conditions of Punjab	Resistant to yellow mosaic virus and soybean mosaic virus
Groundnut	Divya	–	Uttar Pradesh and Rajasthan; timely sown <i>kharif</i> (irrigated) areas	
	ICGV 00350	114	Tamil Nadu and Andhra Pradesh in <i>rabi</i> -summer (irrigated) and <i>kharif</i> (rainfed)	Resistant to late leaf spot and rust; tolerant to stem-rot diseases
	HNG 123	123–125	Rajasthan, Uttar Pradesh and Punjab in <i>kharif</i> (rainfed) timely sown	Tolerant to collar-rot, stem-rot, early leaf-spot diseases, <i>Spodoptera litura</i> and leaf miner
	Raj Mungfali 1	112–138	Rajasthan and Punjab in <i>kharif</i> (rainfed)	Tolerant to collar-rot, stem-rot, early leaf spot, rust, peanut stem necrosis diseases, thrips, jassids and grass hopper
Indian mustard	Pusa Mustard 28	97–131	Jammu and Kashmir (Plains), Punjab, Haryana, Rajasthan, Delhi and western Uttar Pradesh, early sown irrigated areas	Tolerant to stem rot, white rust and powdery mildew
	Pant Rai 19	99–133	Jammu and Kashmir, Punjab, Haryana, Delhi in irrigated <i>rabi</i>	Average yield under normal condition
	CORAL 437	140–150	Punjab, Haryana, Delhi, Jammu and Rajasthan in irrigated condition	Tolerant to white rust <i>Sclerotinia</i> rot, <i>Alternaria</i> and downy mildew
	RLC 2	142–150	Punjab, Haryana, NCR, parts of Rajasthan	–
Sesame	Gujarat Til 4	80–82	North Saurashtra	White-seeded variety, high-yielding, early-maturing
	DSS 9	85–90	Karnataka, <i>kharif</i> season	White bold seeded
Niger	Utkal Niger 150	105–110	Odisha	Black-seeded, tolerant to <i>Alternaria</i> , <i>Cercospora</i> and <i>Cuscuta</i>

time when it was inoculated with *Bacillus subtilis* strain (identified for microbial retting).

Pulse crops

Total of 19 varieties were released, including five of chickpea; three each of urdbean (Co 6, VBN (Bg) 7, VBN 6) and field-pea (IPF 4-9, Gomati, HFP 529); two each of lentil (VL Masoor 514, LL 931), pigeonpea (TS 3R, Anand Grain Tur 2) and horsegram (Indira Kulthi 1, Gujarat Dantiwada Horsegram 1); and one each of mungbean (IPM 02-14) and guar (RGC1033).

Commercial crops

Three new improved sugarcane varieties were released—Co 0403 was for Peninsular Zone and Co 0237 and Co 05011 were for the North-West Zone. Co 0403

(Samridhhi) is an early, high-yielding and a high-quality clone with a good ratoon potential and showed resistance to red-rot and smut. Co 0237 (Karan 8) was found superior to standards, CoJ 64 and CoPant 84211, for crude cane sugar (CCS) (tonnes/ha) and cane yield (tonnes/ha). Improvement in cane and CCS yields was more in the ratoon-crop than in the plant-crop.

NBD 119 identified as an early, high-yielding most promising



NBD 119 bidi-tobacco variety

Varieties/hybrids of pulses

Crop	Variety	Maturity days	Recommended state/ season/situation	Special traits
Mungbean	IPM 02-14	62–70	Tamil Nadu, Andhra Pradesh, Karnataka, Odisha in summer	Resistant to Mungbean Yellow Mosaic Virus (MYMV) and leaf crinkle virus (LCV)
Urdbean	Co 6	70	Rainfed/irrigated conditions in <i>rabi</i> season in Southern Zone	Resistant to powdery mildew (PM)
	VCN (Bg) 7	63–90	Tamil Nadu, Andhra Pradesh, Karnataka and Odisha in <i>kharif</i>	Resistant to MYMV, PM, LCV and root-rot diseases
	VCN 6	70–80	Tamil Nadu	Resistant to MYMV
Lentil	VL Masoor 514	140	Uttarakhand	Resistant to lentil rust
	LL 931	146	Timely sown irrigated conditions in Punjab	Resistant to lentil rust; tolerant to pod-borer
Chickpea	Raj Vijay Kabuli gram 101	105	Timely sown semi-irrigated conditions in Madhya Pradesh	Moderately resistant to <i>Fusarium</i> wilt and tolerant to <i>Helicoverpa</i> pod-borer
	Raj Vijay gram 201	105	Timely sown rainfed conditions in Madhya Pradesh	Resistant to <i>Fusarium</i> wilt; tolerant to <i>Helicoverpa</i> pod-borer
	HK 4	136	Eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal under rainfed/irrigated condition	Moderately resistant to wilt disease
	Raj Vijay Gram 202	100-105	Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh and southern Rajasthan; irrigated	Suitable for late sown condition, resistant to wilt and moderately resistant to dry-root rot and collar-rot
	Raj Vijay Gram 203	100	Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh and southern Rajasthan; irrigated	Suitable for late sown condition, moderately resistant to wilt and dry-root rot
	Field-pea	IPF 4-9	125	Uttar Pradesh
Pigeonpea	Gomati	139	North-eastern states under irrigated conditions	Tall; tolerant to pod-borer and stem-fly
	HFP 529	120–125	Uttar Pradesh, Haryana, Punjab	Resistant to PM and tolerant to rust
	TS 3R	155–160	Karnataka	Medium-large seeded
Horsegram	Anand Grain Tur 2	155-160	Gujarat	Wilt resistant
	Indira Kulthi 1	92	Chhattisgarh, <i>kharif</i> rainfed	Black-seeded variety, tolerant to shattering
Guar	Gujarat Dantiwada Horsegram 1	94	Gujarat, Rajasthan, Uttarakhand, Jharkhand, Uttar Pradesh and Maharashtra under <i>kharif</i> rainfed	Moderately resistant to PM. Dark brick-red bold seeded with 26.4% protein
	RGC 1033	95–106	Guar-growing areas of Rajasthan	Plants are branched with non-serrated leaves and pink flowers. Seeds contain 34–35% gum



Sugarcane varieties — A. Co 0403 (Samridhhi); B. Co 0237(Karan 8); C. Co 05011(Karan 9)

Secondary phloic (bast) fibre (SPF)-shy (*bfs*) mutant of dark jute

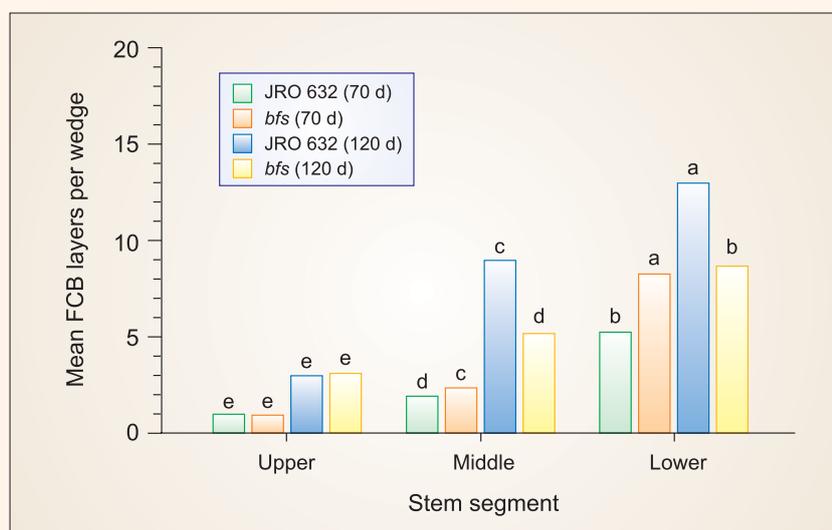
Bast fibre development in jute involves differentiation of secondary phloic fibres from cambium, followed by lignification of fibre-wall. A unique radiation-induced bast fibre-shy (*bfs*) mutant of dark jute (*Corchorus olitorius*) has been identified. It is defective in differentiating SPF and secondary xylem (wood) but develops lignified fibre cells. A multi-fold reduction of bast fibre yield in the mutant is related to development-specific loss of cambium function along the length of the stem from top to bottom. Lignification of the fibre wall in the mutant is not only normal but uniform; this indicates cambium function may be unrelated to lignification process. The architecture of mostly triangular fibre cell bundle (FCB) wedges is governed by a balanced growth between radially elongating FCBs and tangentially expanding ray cells due to development-specific activation of the fusiform and ray initials of the cambium; conditioning fibre fineness. Mutation could specifically impair cambial activity by rendering those initials nonfunctional that differentiate SPF and secondary xylem.



Diagnostic morphology of dark jute *bfs* mutant (A, C) in comparison with its wild-type JRO 632 (B, D). The mutant is characterized by trilobed dissected ribbon leaves and a spreading-type root architecture



KMnO₄-HCl-stained (Maüle reaction) lower stem segments of 120-d-old dark jute mutant *bfs* [A (× 100), C (× 400)] and its wild-type JRO 632 [B (× 100), D (× 400)]. Arrows indicate fibre cell ultimates with large lumens. (ca, cambium; ep, epidermis; FCB, fibre cell bundle; PPF, primary phloic fibre bundle; mrc, medullary ray cells; pp, pith parenchyma; SPF, secondary phloic fibre bundle; sxy, secondary xylem; tc, tannin-containing cell)



Mean layers of fibre cell bundles per triangular wedge in the transversal sections of the three different stem segments of dark jute mutant *bfs* and its wild-type JRO 632 at the two different growth stages (70 and 120 days after sowing). Means with common letters at a growth stage are not significantly different at $P \leq 0.05$, according to Tukey's honestly significant difference (HSD) test

Cotton leaf curl virus resistant cotton transgenics

Cotton leaf curl virus (CLCuV) resistant transgenics were developed in elite genotypes of cotton, H777, HS 6, F 846, with sense coat protein, antisense coat protein, antisense *rep* (replicase protein) gene via *Agrobacterium*-mediated transformation. Gene integration was confirmed by PCR, RT PCR and Southern blot.

The transgenic plants screened in the polyhouse with viruliferous whiteflies (24 hours after acquisition period) did not show any symptoms, and were resistant to cotton leaf curl disease.



CLCuV resistant transgenic plants showing no symptom of the disease

bidi-tobacco variety is found suitable for cultivation in rainfed areas, especially in deep-black cotton soils of Kurnool (Andhra Pradesh). It has more leaf thickness as compared to A 119, and has higher burning quality, good colour and higher smoking quality.

Biotechnology

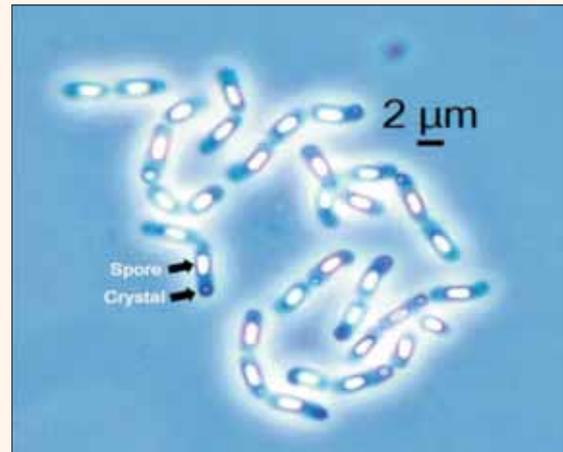
Isolation and characterization of wound- inducible promoter in rice: The expression patterns of four wound-inducible genes, *chitinase*, *PR1a*, *PR10* and *HRGP*, were analyzed using real time PCR; expression of *PR10* was found highly induced through wounding compared to other three genes. Relative expression of *PR10* was the highest at the adjacent site of wounding also, immediately after wounding. After 3 hours of wounding, relative systemic expression of *PR10* was highest in unwounded next lower leaf. The upstream of *PR10* gene has been cloned and sequenced. In-silico analysis has shown the presence of different putative promoter elements. The promoter sequence isolated was fused with *gus* gene, and was transferred to heterologous systems to study efficacy of this sequence for expression on wounding.

DNA fingerprinting

With the use of amplified fragment length polymorphism, simple sequence repeat and expressed sequence tag-derived simple sequence repeat markers, 285 genotypes of *Jatropha curcas* were identified into five distinct and diverse groups. SSR markers were used

New *cry8* gene harbouring *Bacillus thuringiensis* isolated

A new *cry8* gene harbouring *Bacillus thuringiensis* (Bt 62) with 130 kDa protein has been isolated from India, which can encode insecticidal proteins that are toxic to white grub, *Holotrichia serrata*. Preliminary bioassay studies against first instar *H. serrata* indicate potential to use this gene for further research on means of sowing sugarcane. This is the first report of Bt exhibiting toxicity to *H. serrata*.



Cells of a new coleopteran isolate of *Bacillus thuringiensis* (Bt 62) showing spores and crystals

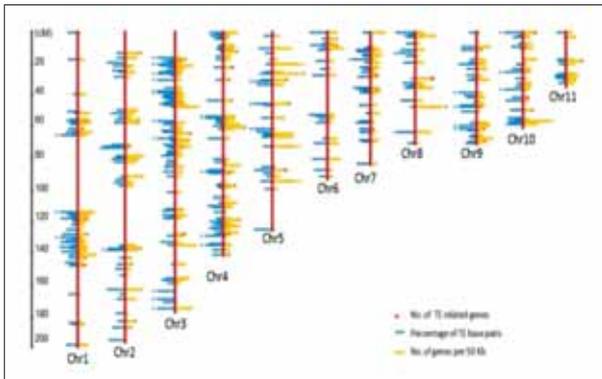
to characterize wheat, cotton and flax (32, 25 and 15, respectively) germplasm, and mini-core collection of finger millet (using two genomic and six functional markers), and of sesame for identification of twelve yield-related quantitative trait loci.

Marker development: New SSR markers were developed through genomic library construction in finger millet, *Andrographis*, *Tinospora*, bittergourd and mungbean, and by transferability from related species in bottlegourd and jute.

GM detection: Detection protocols were developed for GM maize events, including stacked events (using simplex/multiplex PCR assays), and for Bt brinjal and Bt cabbage (construct-specific PCR-based using nested PCR). Molecular testing was done of imports (18 samples) including transgenic rice (429 samples) for specific transgene/promoter/terminator/marker genes and for ensuring absence of embryogenesis deactivator gene with primers specific to *cre-lox* system.

Seed-specific gossypol reduction in cotton-seed: To silence gossypol biosynthesis in cotton-seed through RNA interference, RNAi construct was generated for target gene coding for δ Cadinene synthase under seed-specific promoter and was confirmed through restriction analysis.

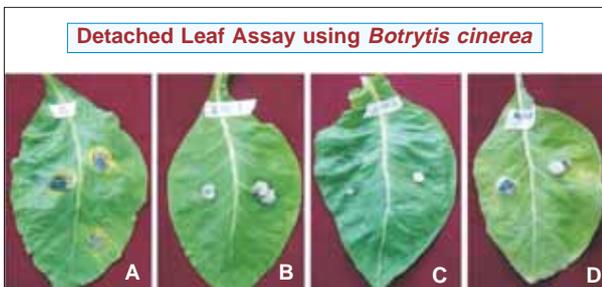
Pigeonpea genome: This Whole Genome Shotgun project has been deposited at the DDBJ/EMBL/GenBank under the accession AFSP00000000. The 454 GS-FLX large sequence contigs, containing ~511 Mb of high quality sequence, were used for gene prediction using FGENESH software. Total 59,515 genes have been predicted; out of which 47,004 are protein-coding genes



High density intra-species reference genetic map of pigeonpea

and 12,511 genes are TE related. All protein-coding genes are further classified into several functional categories.

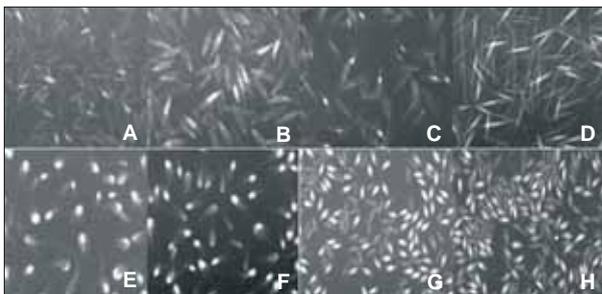
Botrytis resistance in castor: Multigene cassettes were developed for imparting tolerance against *Botrytis*, a major disease in castor. Each of these cassettes carries three introduced genes, *BIK 1*, *ERF 1* and *EBP 1* which were previously reported to impart partial resistance against *Botrytis* pathogens.



Detached Leaf Assay using *Botrytis cinerea*
BIK 1, *ERF 1* and *EBP 1* tobacco transgenics were more tolerant to *Botrytis cinerea* than control (Four days of infection with *Botrytis cinerea*). A. Control; B., C., D., transgenic tobacco leaves

Seed technology

Quick method for determining seed-setting in grasses: Soft X-ray radiography method was used for determining filled and unfilled seeds of range grasses. Filled seeds were shining, whitish, and unfilled or partially filled seeds were dull-gray or dark. In all the grasses, Deenanath grass (*Pennisetum pedicellatum*), guinea grass (*Panicum maximum*), anjan grass (*Cenchrus*



Seeds of different grass species: A. *Sehima nervosum*, B. *Pennisetum pedicellatum*-BD 1, C. *P. pedicellatum*-BD 2, D. *Heteropogon contortus*, E. *Cenchrus ciliaris*-CAZRI 2178, F. *C. ciliaris*-CAZRI 75, G. *Panicum maximum* – BG 2, H. *P. maximum*-BG 2 DC.

ciliaris), lampa grass (*Heteropogon contortus*), *Chrysopogon fulvus*, *Brachiaria decumbens*, *Dichanthium annulatum*, filled/ unfilled grains ranged from 6 to 44%.

Seed production: New areas for hybrid-seed production, identified based on the favourable climatic conditions, higher seed yield and better benefit : cost ratio for different crops, are as follows.

Rice	: New areas are Koppa, Tumkur and Kollegal districts of Karnataka; Bagpat district of Madhya Pradesh
Sunflower	: Bagepalli taluk of Chikkaballapur district in Karnataka
Sorghum	: Akola in Maharashtra
Pearl millet	: Bundi area of RAU, Durgapura
Pigeonpea	: Jabalpur and Seoni in Madhya Pradesh

Seed germination: Seed treatment with *Trichoderma viride* at 6 g/ kg of soybean-seeds was found most effective in increasing seed germination by 15.71% and reducing seed-rot-causing pathogens by 72.73% and seedling blight by 87.50%.

Treatment of maize, soybean, hybrid rice and cotton seeds with vitavax 200 at 2 g/kg of seeds or Polykote™ at 3 ml/kg + vitavax 200 at 2 g/kg of seeds and storing in poly-lined gunny bags was found most effective in improving seed germination and in reducing mycoflora associated with seed storage.

Seed storage: Seeds stored in 40% CO₂ can provide complete protection against *Rhizopertha dominica* in wheat up to 9 months storage and *Sitotroga cerealella* in paddy up to 6 months, *Callosobruchus* spp. in mungbean and urdbean up to 12 months of storage without affecting seed quality.

Soybean seed processed at 12–14% moisture content showed minimum mechanical damage and maximum seed quality.

Breeder seed production: In 2011–12, 9,838.30 tonnes of breeder seed, 13,228.20 tonnes of foundation seed, 20,540.80 tonnes of certified seed, 14,860 tonnes of truthfully labelled seed and 4,436.60 tonnes of planting materials were produced. Besides this, 402.84 lakh planting materials and 0.39 lakh tissue culture plantlets of field crops were produced.

A total of 309.1 tonnes seed-cane of released sugarcane varieties was produced and supplied to farmers. Eight hundred and sixty tonnes of sugarcane seed of recently released varieties was produced at Lucknow for distribution to farmers in the subtropical regions through sugar-mills.

Pollinators

In pigeonpea, bumblebees *Megachile* spp. were relatively abundant, followed by *Xylocopa* spp. and in sunflower, *Apis dorsata* was dominant, followed by *Megachile* spp. and *Xylocopa* spp.

The weed, *Spermacoce hispida*, supported pollinators on pigeonpea and sunflower, and the main pollinators were *Apis cerana*, *A. florea* and *A. dorsata*.

HORTICULTURE

Fruit crops

Banana selection (NRCB Sel-003) for second consecutive year was superior in all biometric traits and recorded 17.53% yield increase over local Monthan. Of the 30 hybrids screened, hybrids 4 and 15 were observed resistant to nematode, *Pratylenchus coffeae* and *Meloidogyne incognita*, respectively.

Two clones of Nagpur mandarin, one early-maturing-N₂ (February first week) and another less-seeded-N₄ (lesser than 3 seeds/fruit), were identified and are being further evaluated at different locations.

Inter-generic papaya hybrid progenies, confirmed through molecular characterization using ISSR markers [(cv. Surya (*Carica papaya* L.) and *V. cauliflora*)] were evaluated for field tolerance to papaya ring spot virus (PRSV). The progenies, viz. R₁P₁₆, R₁P₁₇, R₂P₁₇, R₁P₂₀ and R₁P₂₄, were selected and sibmated for advancing to next generation (F₅).



Intergenic papaya hybrid, Arka Surya x *V. cauliflora*, selected in F₄ generation, has good TSS (12-13°Brix), pink pulp and field tolerance to PRSV

In apple, 14 new indigenous Ambri selections were made, and CITH-A-37, 38, 39, 40 and 41, were superior in yield and quality. In almond, CITH-Almond 7, 10, 22, 23, 24 and 25, and apricot, CITH-Apricot 7, Erani, Afghani and CITH-Apricot 32, were promising.

In cherry, 21 new clones superior in yield and quality have been identified through extensive survey and CITH-Cherry 24, CITH-Cherry 25 and 28, were most promising. In pear, two high-yielding sweet and juicy Kashmiri Nakh selections, CITH-Nakh 1 and CITH-Nakh 2, were collected and maintained in field gene bank.



CITH-Cherry 24 CITH-Cherry 25 CITH-Cherry 28

Promising cherry selections

Six hybrid crosses with 609 pomegranate plants were screened for resistance to bacterial blight using challenge inoculation. Sixty plants of hybrid [Bhagawa × (Ganesh × Nana)] × Daru, 13 of Bhagawa × 3/3 [(Ganesh × Nana)

× Daru], 12 of Bhagawa × 3/5 [(Ganesh × Nana) × Daru] and 10 of NRCP hybrids were free from bacterial blight after inoculating them with a local strain of *Xanthomonas axonopodis* pv. *punicae*. Two accessions of Rambutan (CHES-R 27 and CHES-R 31), a promising future fruit was identified. These are early-maturing, having higher Brix (17.5°) and yield potential of 1,000–1,500 fruits/plant.

Strawberry hybridization was effected in 21 parental combinations for introgression of fungal disease resistance; 416 fruits were harvested to yield 3,266 seedlings. Three hundred forty-four hybrids with various degree of tolerance to different fungal diseases (based on one season of screening/field survival) are being furthered for rigorous screening. The survival rate of hybrid population derived from Howard 17 as one of the parents was higher compared to either Gorella or Earliglow.

Over 3,000 hybrid passion fruit (cv. Kaveri) seedlings crossed using pollen from two different yellow types were raised and evaluated. High variability and heterosis for yield and most of the characters were observed. Fruit weight ranged from 2.15 to 124.1 g and TSS from 13 to 21° Brix. Some low acid-sweet types (direct consumption as table fruit) have been identified for further evaluation.

Vegetable crops: Improved chilli varieties (Arka Kyati), cauliflower (Arka Vimal and Arka Spoorthi), pole type dolichos (Arka Swagath), yard long bean (Arka Mangala) and garden peas (Arka Priya and Arka Pramodh) were identified for release. Yellow vein mosaic virus (YVMV) disease resistant lines in okra (IIHR 285-54-11-1, IIHR 296-22-4 and IIHR 299-52-5), powdery mildew resistant lines in ridge gourd (RGDMR 1 and RGDMR 2) and mungbean yellow mosaic virus resistant lines in French bean (IC 525283 × IC 525260)–09-1-5-2) were further evaluated. Two varieties of chilli (Kashi Sinduri and Kashi Gaurav) and one hybrid of tomato (Kashi Abhimaan) were notified by the central varietal release committee.

Three onion (Bhima Shubra, Bhima Shweta and Bhima Shakti) and one garlic (Bhima Purple) varieties were released. Further, haploid induction in onion was tried through gynogenesis. Root tip squash from a few gynogenic regenerants were evaluated. In garlic, five collections of long day type having higher yield and quality were made. The clone, CITH-G 5, recorded highest plant height (109.75 cm) and number of leaves/plant (8.25), while highest yield was recorded in CITH-G 2 (212.25 q/ha), closely followed by CITH-G 1 (202.99 q/ha).

Marker-assisted selection was carried out to identify pyramided lines in F₆ and F₇ families, segregating for three major genes against tomato leaf curl virus (TLCV). The marker assays included the CAPS marker for *Ty-1* and SCAR markers for *Ty-2* and *Ty-3* genes. A total of six lines carrying all three major genes in homozygous state were identified. Evaluation of these lines for agronomic and morphological traits was completed in two seasons. Pyramided line, D6-1-4, was observed superior to other lines in resisting TLCV infection.

To develop moisture-stress tolerant tomato, 'BcZAT12' gene, (Accession no. DQ166621), driven by drought-specific promoter 'lea1' cloned in *Agrobacterium tumefaciens* strain GV 3101, was used for transformation. A total 16 lines from 10 independent events were obtained and rooted on 100 mg/litre rooting medium. These lines were tested for gene integration by PCR and southern blot using P³² labelled BcZAT12 probes. Physiological and biochemical data of these events revealed significant moisture tolerance.

Ornamental crops: In gladiolus, five promising selections and a mutant were selected based on qualitative traits. The promising hybrid selections, i.e. in orange-red group (IIHRG 3), in yellow group (IIHRG 4), and in purple-violet group (IIHRG 12), which are suitable for cut flower purpose, were further multiplied. Further, IIHRR 7-1, IIHRR 7-2, IIHRR 7-7, IIHRR 204 and IIHRP 3-18-2 entered AICRP trials.

Spices: Eight cardamom hybrids, NKE 12 × MB 5 (1,499 kg/ha), MB 5 × NKE 19 (1,461 kg/ha), GG × NKE 12 (1,350 kg/ha), RR 1 × CCS 1 (1,245 kg/ha), CCS 1 × RR 1 (1,022 kg/ha), ASH (1,930 kg/ha), NKE 12 × GG (1,746 kg/ha), GG × NKE 19 (1,635 kg/ha), were identified for high yield and resistance to mosaic and rhizome rot diseases. Two unique mutants, AFgM-3 and AFgM-4, for powdery mildew resistance were isolated in fenugreek. In ajwain, AA 93 has been developed which flowers 40 days earlier compared to other varieties. Thirty-two elite saffron clones were selected and evaluated for fresh and dry weight of pistil, stigma and style length, and weight. CITH 125 (4.5 kg/ha), CITH 123 (4.3 kg/ha), CITH 124 (4.3 kg/ha), CITH 122 (4.0 kg/ha), CITH 12 (4.5 kg/ha), CITH 121 (3.9 kg/ha), CITH 107 (3.8 kg/ha), CITH 120 (3.8 kg/ha) and CITH 104 (3.7 kg/ha), having higher saffron yield were identified.



Elite saffron clones in flowering

Palms and nuts: Three coconut varieties (IND 045S, IND 048S and IND 058S), two arecanut varieties (VTL



The 6-year old promising dwarf oil palm

62-Shriwardhan selection and VTL7-Nalbari) and two selections of cocoa (VTLC 1 and VTLC 57) were identified for commercial cultivation. Coconut variety, Kalpa Samrudhi, was recommended for commercial cultivation in Kerala and Asom, and Kalpa Sankara and Kalpasree for coconut root (wilt)-affected tracts in Kerala. Molecular-markers associated with hybridity in coconut, dwarfness and resistance to root (wilt) and yellow leaf diseases were utilized. Homology-based modelling of somatic embryogenesis receptor-like kinase (SERK) protein in coconut, development of a computational tool for detection of microsatellites in whole genome sequences, development of algorithm for gene annotation and genome-wide analysis of microsatellites in strains of plant growth promoting (*P. fluorescens*) are achievements in bioinformatics.

To develop dwarf and compact oil palm, Dwarf Tenera 1 from Palode (Kerala) was selfed and its progeny was evaluated. Of the 58 palms evaluated, 23 recorded lesser than 40 cm and of which 4 palms recorded increased height of lesser than 30 cm per annum. One palm which recorded lesser than 25 cm height increment had a Bunch Index of 0.43 against the standard value of 0.3 for normal D × P material.

Medicinal crops: A pure line selection of *aswagandha* (IIHR-WS-3) was released having significantly high dry root yield (12 q/ha) and withanolide content (0.58%) for Karnataka. Of the 13 *Coleus forskholii* hybrids evaluated, Hy 08-129 recorded significantly higher root yield (95.53 g) over control (K 8).

□