

Crop Improvement

IMPROVEMENT

Rice: Eighteen hybrids/varieties have been released for various agro-ecologies.

Rice varieties/hybrids released			
Variety	Ecosystem	Resistant to pests/diseases	Recommended
Central Releases			
Hybrid 6129*	Irrigated	Blast, brown spot, brown plant hopper (BPH), white backed plant hopper (WBPH) Blast	Irrigated areas of Punjab, Tamil Nadu
Improved Pusa Basmati 1	Basmati		Basmati-growing areas of Delhi, Punjab, Jammu and Kashmir, Uttarakhand
Improved Samba Mahsuri	Rainfed shallow lands	Blast, bacterial blight	Irrigated/shallow lowlands of Andhra Pradesh, Chhattisgarh, Jharkhand, Orissa, Bihar, Gujarat, Maharashtra
State Releases			
Chandrama	Shallow lowland/ boro	Blast, bacterial blight, rice tungro virus (RTV), sheath blight, BPH, WBPH	Shallow lowlands/boro areas of Assam
Madhuri	Rainfed lowlands	Blast sheath rot, bacterial blight	Lowlands of Karnataka
Karma Mahsuri	Irrigated	Blast, brown spot, gall midge	Irrigated areas of Chhattisgarh
Varun Dhan	Irrigated hill	Blast	Irrigated hills of Himachal Pradesh
MAS 946-1	Aerobic	Bacterial blight	Limited water environments of eastern dry zone in Karnataka
MAS 26	Aerobic		Limited water environments of eastern and central dry zones in Karnataka
Annalakshmi	Irrigated	Bacterial blight, RTV, brown spot	Irrigated areas of Pudducherry
CO (R) 48	Irrigated		Irrigated areas of Tamil Nadu
RMD (R) 1	Irrigated	Moderately resistant to shoot-borer and leaf folder	Irrigated areas of Tamil Nadu
Karjat 7	Irrigated	Neck blast, leaf folder BPH, blast, bacterial blast	Irrigated areas of Maharashtra
Satya Krishna	Irrigated and rainfed shallow lowlands		Irrigated and rainfed lowlands of Orissa
Nua Kalajeera	Rainfed shallow lowlands		Shallow lowlands of Orissa
Nua Dhusara	Rainfed shallow lowlands		Shallow lowlands of Orissa
Hanseswari	Semi-deep water ecology		Semi-deep lowlands of Orissa
Chandan	Boro ecology		Boro irrigated areas of Orissa
			Improved Samba Mahsuri has good agro-morphological features (a,b) and excellent grain quality (d,f) similar to Samba Mahsuri (c,e)

*Hybrid rice

Wheat: Seven varieties of wheat have been released and notified.

Wheat varieties released			
Variety	Area of adaptation	Production conditions	Remarks
Bread Wheat			
VL 892	Hills of Himachal Pradesh and Uttarakhand	Late sown, medium fertility restricted irrigation conditions	Yielded more than check varieties
HPW 251	Hills of Himachal Pradesh and Uttarakhand	Early sown, low fertility rainfed conditions	Gave high yield over check varieties. In addition to being resistant to brown rust, it showed better resistance than checks against yellow rust. It also showed high degree of resistance to Karnal Bunt and immunity against flag smut
PBW 550	Punjab, Haryana, west Uttar Pradesh (except Jhansi division), Delhi, Rajasthan (excluding Kota and Udaipur divisions), <i>Tarai</i> of Uttarakhand, Paonta Valley and Una district of Himachal Pradesh	Timely sown, high fertility irrigated conditions	Possessed higher degree of resistance to yellow and brown rusts and flag smut in comparison to checks. And found resistant to 78S84 race of yellow rust to which PBW 343 has now become susceptible
WH 1021	Punjab, Haryana, west Uttar Pradesh, Delhi, Rajasthan, (excluding Kota and Udaipur divisions), <i>Tarai</i> of Uttarakhand, Paonta Valley and Una district of Himachal Pradesh	Late sown, medium fertility irrigated conditions	Yielded higher than UP 2425, PBW 373 and Raj 3765. It has more protein content, higher loaf volume (12.21%), (572cc) and much better bread-making quality. Besides better nutritional quality, showed high degree of resistance to yellow rust, brown rust and flag smut
HI 1544	Madhya Pradesh, Rajasthan (Kota and Udaipur divisions) and Gujarat	Timely sown, high fertility irrigated conditions	Yielded higher than Lok 1. It showed resistance to leaf and stem rusts
HD 2932	Madhya Pradesh, Chhattisgarh, Rajasthan (Kota and Udaipur divisions), Gujarat, Maharashtra and Karnataka	Late sown, medium fertility irrigated conditions	It out-yielded all check varieties in the central parts of the country. It exhibited high magnitude of adult plant resistance to leaf and stem rusts. It is an early-maturing variety with acceptable grain quality
HI 8663(d)	Maharashtra and Karnataka	Timely sown, high fertility irrigated conditions	It exhibited high beta-carotene content, high protein content, high sedimentation value (35ml), and high contents of iron, manganese, copper and zinc to make it a very good durum wheat. It showed desirable pasta cooking quality. It maintained high degree of field resistance to leaf and stem rusts and foot rot

Wheat varieties identified		
Variety	Area of adoption	Salient features
HS 490	North Hills Zone (Hills of Jammu and Kashmir except Jammu and Kathua districts), Himachal Pradesh (except Paonta Valley and Una district), Uttarakhand (excluding <i>Tarai</i> region), Sikkim and hills of West Bengal and north-eastern states. Late sown, restricted irrigation	Good biscuit quality
PBW 590	North Western Plains Zone (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 <i>Tarai</i> region of Uttarakhand. Late sown, irrigated conditions	Tolerance to terminal heat stress and good bread quality
CBW 38	North Eastern Plains Zone (East Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Orissa, Assam and plains of north-eastern states. Timely sown, irrigated conditions	Resistance to leaf blight and leaf rust, high sedimentation value (58cc), bread quality and grain nutritional characteristics
RAJ 4120	North Eastern Plains Zone. Timely sown, irrigated conditions	Resistant to Ug99, superiority in leaf rust resistance and good chapati quality
MP 1203	Central Zone (Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur division of Rajasthan and Jhansi division of Uttar Pradesh). Late sown, irrigated conditions	High protein (13%) and extraction rate (70%), good bread quality and grain appearance
UAS 415	Plains Zone (Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu). Timely sown, irrigated conditions	Durum for superior pasta quality
PBW 596	Plains Zone, Timely sown, irrigated conditions	Goof for limited irrigations
MACS 2971	Plains Zone, Timely sown, irrigated conditions	Dicoccum variety
RD 2715	Central Zone, Timely sown, irrigated conditions	Dual-purpose variety for green fodder and grains

Registration of genetic stocks. Ten new genetic stocks of wheat have been registered by the Plant Germplasm Registration Committee.

Wheat genetic stocks registered				
Name	Reg. No.	I.D. No.	Developed by	Traits(s)
FLW 28	INGR 08001	IC 553913	DWR, Shimla	Resistant to brown and yellow rusts
FLW 29	INGR 08002	IC 553914	DWR, Shimla	Resistant to all rusts
FLW 30	INGR 08003	IC 553915	DWR, Shimla	Resistant to all rusts
GW 2002 18	INGR 08004	IC 553917	WRS, SDAU, Gujarat	High tillering
GW 2002 51	INGR 08005	IC 553919	WRS, SDAU, Gujarat	High grain weight in durum wheat
HS 424	INGR 08006	IC 557719	IARI, RS Shimla	Resistant to leaf and stem rusts
HS 431	INGR 08007	IC 557720	IARI, RS Shimla	Resistant to leaf and stem rusts
LBRL 4	INGR 08056	IC 549912	DWR, Karnal	Leaf blight resistance
LBRL 6	INGR 08057	IC 549913	DWR, Karnal	Leaf blight resistance
LBRL 1	INGR 08058	IC 549914	DWR, Karnal	Leaf blight resistance

To mitigate the threat posed by the stem rust virulence Ug99, 318 wheat varieties were screened at its hot spot Njoro (Kenya). The screening revealed that 78 genotypes were resistant to Ug 99. Four wheat varieties HD 2781, DL 153-2, NI 5439 and HI 8498(d) have been reconfirmed for their resistance to Ug 99.

Barley: Dual-purpose barley RD 2715 has been identified for release in Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur division of Rajasthan and Jhansi division of Uttar Pradesh for timely sown, irrigated conditions. This showed resistance to yellow rust.

Maize: Five hybrids, four composites and two quality protein maize (QPM) hybrids have been released for different agro-ecological zones of the country.

Sorghum: A new multicut forage sorghum hybrid CSH 24MF (UTMCH 1302) has been identified for release in all forage zones of India. It has lower HCN content (90-100 ppm), and is resistant to anthracnose, zonate leaf spot and grey leaf spot, and is tolerant to stem borer and shoot-fly.

Dual-purpose hybrid sorghum CSH 25 has been identified for cultivation in *kharif* in Maharashtra,

Maize hybrids/composites released		
Hybrids/composites	Area of adaptation	Characterization
Hybrids		
PMH 3	Delhi, Punjab, Haryana and western Uttar Pradesh	Late-maturing, orange flint grains, single-cross hybrid
HM 10	Delhi, Punjab, Haryana, western Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka	Late-maturing, yellow grains, single-cross hybrid; resistant to <i>Sesamia inferens</i> ; released for winter
HM 8	Punjab, Haryana, western Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra (<i>rabi</i> and <i>kharif</i>)	Medium-to-late maturing single-cross hybrid, orange grains; suitable for <i>kharif</i> and <i>rabi</i>
PRO 368	Rajasthan, Gujarat and Madhya Pradesh	Double-cross hybrid, yellow grains
Vivek maize hybrid 33	Uttarakhand, Jammu and Kashmir	Extra-early maturing hybrid; orange dent grains
Composites		
Pant Sankul Makka3	Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Rajasthan, Gujarat and Madhya Pradesh	Yellow grains
Bajaura Makka Chandramani	Uttarakhand and Himachal Pradesh	Orange grains
Pratap Kanchan	Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Jammu and Kashmir and Uttarakhand	Composite with yellow to orange grains Yellow grains, moderately resistant to stem borers and major diseases
QPM Hybrids		
HQPM 7	Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Yellow grains quality protein single-cross hybrid, medium-to-late maturing
Vivek 9 QPM	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Extra-early maturing yellow grains; developed by SSR marker-assisted selection; semi-dent QPM single-cross hybrid

Andhra Pradesh, Karnataka, Madhya Pradesh and Gujarat. It is tolerant to grain mold.

Pearl millet: Four hybrids MH 1340, MH1385, MH1351 and MH1352 and an open-pollinated variety MP 443 have been identified for release.

Small millets: Proso millet TNAU 151 and barnyard millet VL Madira 207 have been identified for release in Tamil Nadu, Andhra Pradesh, Bihar, Karnataka, Uttarakhand and across the country, excepting Gujarat and Tamil Nadu.

Forage crops: *Oat JHO 991 (Bundel Jai 991)*. Its seed-to-seed maturity period is 150-155 days and seed-to-flowering is 120-125 days. It is moderate to highly resistant to leaf blight and moderately resistant to nematodes, and resistant to highly resistant to grasshoppers and aphids. It contains crude proteins 9.7%, acid digest fibres 46.7%, neutral digestible fibres 63.5% and its *in-vitro* dry matter digestibility is 57.4%. This variety has been released for cultivation in the hilly zone under single-cut system.

Forage crop varieties identified and released		
Forage crops	Variety	Adaptation region/ Agro-ecology
Maize	Pratap Makka Chari EC 3135	North West Zone covering Punjab, Haryana, Rajasthan, western parts of Uttar Pradesh and Uttarakhand
Cowpea	UPC 625	Cowpea-growing areas in North West, Central and North East Zones
Pearl millet	BAIF bajra 1	Pearl-millet growing areas in North West and Central Zones
	JHPM 05 02	All pearl-millet growing areas except South Zone
	NDFB 2	Pearl-millet growing areas in North East Zone under salt-affected soils

Underutilized crops: Grain-amaranth RM 4 and GA 3 have been identified for release for



Grain-amaranth has been identified for release in *rabi* in Rajasthan, Orissa, Jharkhand and Gujarat

cultivation in *rabi* in Rajasthan, Orissa, Jharkhand and Gujarat.

Phytochemical characterization was done of promising genotypes identified in Grain-amaranth IC 35399, for protein content and lysine content (6.4 %), and in faba bean HB 502 for protein (26.30%), and HB 30 for low vicine-convicine content (0.82%).

Groundnut: Two varieties have been released and notified, and 3 have been recommended for release.

Groundnut varieties		
Variety	State(s) area of adaptation	Special features
Released and notified		
Girnar 2 (PBS 24030)	Uttar Pradesh, Punjab, northern Rajasthan	Virginia bunch type with 'stay green' leaves and bold seeded. Tolerant to rust, leaf spot, peanut stem necrosis disease (PSND) and sucking pests
AK 265	Southern Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu	Drought tolerant, suitable for rainfed areas, resistant to foliar fungal diseases
Identified for release		
R 2001-2	Orissa, Jharkhand, West Bengal and north-eastern states	High yielding than JL 24 and tolerant to foliar diseases and sucking pests
VG 9816	Tamil Nadu, Andhra Pradesh, Karnataka and southern Maharashtra	Tolerant to foliar diseases and consistency in yield performance
ICR 48	Rajasthan and Gujarat	Identified for terminal drought areas

Rapeseed-mustard: Two hybrids of Indian mustard NRCHB 506 and DMH 1 have been



NRCHB 506 Indian mustard hybrid



NRCYS 05-02 yellow sarson variety



Castor 48-1 is resistant to wilt, capsule borer, and is tolerant to jassids

identified for release. Similarly, 7 varieties of rapeseed-mustard have been identified for release for various agro-ecologies of the country. These are ONK 1 (Gobhi sarson), NRCYS 05-02 and YSH 0401 (Yellow sarson), RB 50, RGN 145, NRCHB 101 and LESI 27.

Soybean: Three improved varieties, VLS 59, VLS 63 for Northern Hill Zone and JS 97-52 for Central Zone have been identified for release.

Safflower: NARI 38 and AKS 207 with wilt resistance and yield advantage have been released and notified for the safflower-growing areas of the country and Vidarbha region of Maharashtra. And SSF 658 superior to NARI 6 and JSI 7 in yield with resistance to wilt has been identified for all safflower-growing areas.

Sunflower: DRSF 113 has been released and notified. It is suitable for *kharif* and *rabi*, and is recommended for



TAS 82 sunflower has been notified for Maharashtra

Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra; and TAS 82 for Maharashtra and CO (SFV) 5 for Tamil Nadu have been notified.

Castor: 48-1, exhibiting distinct superiority over the checks in seed (15-30%) and oil yields (19.9-50.2%), has been released for castor-growing areas. It is resistant to wilt and capsule borer, and is tolerant to jassid.

Sesame: Two varieties of sesame RT 346 and SWB 32-10-1 have been identified for release and notification. RT 346 having 20% superiority over the check with higher oil percentage has been identified for Rajasthan, Haryana, Gujarat and parts of Maharashtra and Uttar Pradesh. SWB 32-10-1 having 15% yield superiority has been identified for summer in coastal ecosystem of Andhra Pradesh, Karnataka and Orissa.

Niger: BNS 10 has been recommended for release in niger-growing areas, and KBN1 has been released for Karnataka.

Pulses: Five varieties have been identified in pulse crops.

Pulse varieties identified			
Crop	Variety	Special features	Area of adoption
Chickpea (Kabuli)	IPCK 2002-29	Extra large seeds (33.8 g/100 seeds)	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, southern Rajasthan, Maharashtra, Chhattisgarh, Gujarat
Pigeonpea	TJT 501	Tolerant to pod borer and pod fly	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, southern Rajasthan, Maharashtra, Chhattisgarh, Gujarat
	GTH 1	Resistant to SMD and wilt	First CMS-based hybrid notified for Gujarat and identified for Madhya Pradesh, Bundelkhand region of Uttar Pradesh, southern Rajasthan, Maharashtra, Chhattisgarh, Gujarat
Mungbean	KM 2241	Resistant to MYMV	Jammu and Kashmir, Himachal Pradesh, Uttarakhand
Urdbean	IPU 02-43	Resistant to MYMV and powdery mildew	Andhra Pradesh, Karnataka, Tamil Nadu, Orissa
	NDU 5-7	Resistant to MYMV	Punjab, Haryana, western Uttar Pradesh, north Rajasthan
	Vallabh Urd 1	Resistant to MYMV	Punjab, Haryana, western Uttar Pradesh, north Rajasthan
Lentil	WBL 77	Resistant to rust, small seeds	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Assam

Arid legumes: Guar VLG 15 and HG 2-20 have been identified for release and notification. VLG 15 having advantage of higher grain yield and tolerance to diseases has been identified for Northern and Central Zones. HG 2-20 identified for Northern Zone is moderately resistant to foliar diseases with 31.14% gum content.

Sugarcane: Among red-fleshed clones, NG 77 75 recorded appreciably higher antioxidants than the other tested clones.



CoLk 94184 (Birendra) has been recommended for commercial cultivation. It withstands moisture stress and waterlogging in eastern Uttar Pradesh and Bihar

Two new improved sugarcane varieties, resistant to red rot and smut and tolerant to drought and salinity Co 2001-13 and Co 2001-15 were identified for cultivation in Peninsular Zone. They showed significant improvement over standard varieties.

A high sugar-yielding cane variety CoLk 94184 (Birendra) has been recommended for commercial cultivation. This is early maturing and withstands moisture stress and waterlogged conditions in eastern Uttar Pradesh and Bihar.

Jute: JRO 2003 H (IRA) has been recommended for entire *tossa* jute-growing belt of the country for cultivation during mid-March to last week of April. Its yield was 10-15% higher than JRO 524 and JRO 8432, i.e. the check varieties. The variety showed better resistance to biotic stress and also had less body defects and root content as compared to national checks.

JRO 204 (Suren) has been notified for the entire jute-growing tracts of India. It is a high-yielding *tossa* jute variety, showing better fibre quality. As the variety is highly resistant to premature flowering, it can be sown from the first week of March, and can be easily accommodated in multiple cropping systems in Assam, Bihar, Orissa and West Bengal. It is least affected by major pests and diseases as compared to widely cultivated *tossa* jute varieties. It produced finer quality fibres (2.3-2.4 tex), which were 21% and 15% finer

Tobacco as oilseed crop

Oil content in seed was estimated in 108 tobacco germplasm accessions of various tobacco types. Among the 43 germplasm accessions of exotic air-cured type, the seed oil content varied between 33.06 (EAC 145) and 44.94% (EAC 101). Among the Burley tobacco accessions, the seed oil content varied from 23.09 (BGP 33) to 45.61% (BGP 35). The peroxide value increased from 8.24 to 84.24 me peroxide/kg within 90 days from the date of extraction; in sunflower oil, it varied from 6.24 to 50.12 me peroxide/kg within 90 days.

than JRO 524 and JRO 8432. The fibre of JRO 204 is free from body defects and root content.

AAU OJ-I (Tarun) has been notified for the entire jute-growing tracts in India. The variety fibre yield surpassed national check JRO 524 by 7% at the all-India level. It showed better biotic stress resistance.

C. capsularis entries C 517 and C 532 and one of mesta JMB 2004D have been recommended for release at the national level.

Tobacco: Sangami variety was released for cultivation in Bhavani, Anthijur and Kurichi areas of Erode district and Edapady area of Salem district of Tamil Nadu. This is a narrow-leaf country cheroot tobacco variety. It showed an increase of 22.4% in average cured leaf yield over the ruling variety I-737, coupled with good smoking quality. The variety showed less susceptibility to tobacco mosaic virus, black shank and leaf curl. Torsa, new motihari tobacco variety, has been approved for release. It recorded significantly higher cured leaf yield.

Horticulture

Mango: A new mango hybrid, Arunika, was released. A cross between Amrapali and Vanraj, it has regular bearing and good fruit qualities. Twelve STMS primers, modified with fluorochromes for high resolution genomic analysis were utilized for molecular characterization of 150 cultivars of mango. In general, fluorescent-based analysis revealed single main peak in homozygotes and two different size allelic peaks in heterozygotes. Polymorphic information content (PIC) values ranged from 0.630 to 0.855. A total of 149 alleles were amplified. The number of alleles detected per locus ranged from 7 to 21. Four set of primer pairs were found sufficient to identify the accessions. In mango, Hybrid 311 (Alphonso x Neelum) having good yield and quality and freeness from spongy tissue were found promising at RFRS, Vengurle. At IARI, New Delhi, five hybrids, viz. H 1-1 (Amrapali x Lal Sundari), H 1-6 (Amrapali x Sensation) and H 2-6 (Amrapali x Sensation), H 4-12 (Dashehari x Sensation) and

H 8-11 (Amrapali × Sensation) were found promising.

Grape: In grape, two hybrid seedlings of Thompson Seedless × Seveye Villard showed tolerance to powdery mildew (12/6 and 15/2), anthracnose (10/4 and 11/3) and rust (7/5, 11/4 and 15/3). A mother block of quality planting material comprising 12 table/raisin varieties, 6 wine varieties and 9 rootstocks was established. About 150 varieties including 28 wine/juice and 25 crosses were evaluated for their various desirable attributes. The F₁ hybrids, Flame Seedless × Seveye Villard and Thompson Seedless × Seveye Villard were maintained in the greenhouse and some progenies were transferred to the field. *In-vitro* screening of these available hybrids was also done against *Plasmopara viticola*. DNA from 41 hybrids was analysed with 32 microsatellite primers.

Sapota: In sapota, plant spacing of 8 m × 4 m (312 trees/ha) registered highest yield/ha (24.96 tonnes/ha) while number of fruits (1,650) and yield of fruits/tree (95.00 kg) were more in 8 m × 8 m spacing in PKM 1 sapota at Periyakulam.

Citrus: Seven citrus genotype (NRCC Pummelo 1, NRCC Pummelo 2, NRCC Pummelo 3, NRCC Pummelo 4, NRCC Pummelo 5, NRCC Pummelo Galgal 1 and NRCC sweet lime 1) were promising. About 61,200 disease-free plants of Nagpur mandarin, Mosambi, acid lime and rootstocks were sold to different government departments and farmers. And 46,000 certified elite STG derived disease-free planting stock were released to citrus growers of Maharashtra, Andhra Pradesh and Madhya Pradesh.

Banana: Fourteen accessions of banana were collected, which include 3 wild accessions and 11 landraces. A high-yielding Cheeni Champa clone with better fruit quality was collected. Cryobanking of Musa germplasm was initiated with the transfer of 210 accessions as *in-vitro* to NBPGR, New Delhi.

Sweet orange: At Rahuri, Sweet orange selection 4 was released as Phule Mosambi and acid lime line, RHR-L 124, as Phule Sharbati. The rootstock Rough lemon 14-19-13 recorded highest yield, whereas Rough lemon Nematanga Assam and Rangpur lime Brazilian showed seedling resistance to root rot.

Cashew: In cashew, five collections having compact canopy and bunch bearing were collected from Ansurli which had bold nut character (> 8.0 g). The hybrids, H 66, H 68 and H 43, yielded 5.4, 4.9 and 5.4 kg/tree in fourth harvesting with a cumulative nut yield of 19.9, 18.8 and 19.5 kg/tree respectively. Hybrids, H 125 and H 126, of cross combination NRCC Sel 2 × Bhedasi gave a yield of 5.6 and 5.0 kg/tree in the fourth harvesting and a cumulative yield of 19.5 and

17.8 kg/tree respectively. The cumulative yield of 14 years was higher in cashew JGM 34/7 (276.64 kg/tree), followed by JGM 70/2 (211.56 kg/tree), and JGM 48/1 (174.72 kg/tree).

Acid lime: In acid lime, intermediate hybrids of the cross Kagzi lime × Nepali round and Kagzi lime × Nepali oblong were found resistant to citrus bacterial canker. The hybrids had lemon like character.

Apricot: Ten promising apricot genotypes were evaluated under medium-density accommodating 400 trees/ha. Four varieties were found promising under Kashmir conditions. CITH selection KS 1 (8.0 tonnes/ha) gave the maximum yield followed by Harcot, AS 1 and AS 2. The TSS of these elite varieties ranged from 13.87 to 15.98° Brix, indicating their suitability for table purpose.



KS-1, a promising apricot

Underutilized fruits: In ber, phylogenetic relationships revealed that the pooled chromatogram of eight cultivars possessed a total of 28 flavonoid spots. Spot No. 3 and 12 were encountered only in single taxon and hence, they proved to be marker spots for respective cultivars. In pomegranate, number of spots varied from 12 to 17 in different genotypes, maximum in cv. Mridula and minimum in cvs. Kabul and Jalore Seedless. Regeneration protocol for genetic transformation of pomegranate Bhagwa with nodal blight resistant gene was standardized. In pomegranate, seeds of Bhagwa and Ganesh were irradiated with 0-30 kR gamma rays and sown in polythene bags. Branching was more at lower doses of gamma irradiation (0-6 kR) and there was decreasing trend in branching habit with increase in irradiation doses beyond 6kR in Ganesh. In contrary, higher doses (beyond 6kR) of gamma irradiation increased branching in seedlings of Bhagwa. The plant height in Ganesh and Bhagwa was not influenced by irradiation treatments at 0-9 kR and 0-18kR respectively. But higher doses

of gamma irradiation induced dwarfing effects at 27 and 30 kR in Ganesh and Bhagwa. Wedge grafting on 30th January was found optimum for grafting. Pomegranate, viz. Dholka, Bedana and Kandhari, planted under 2.5 m × 2.5 m spacing were found promising under Karewa conditions of Kashmir. The maximum yield was recorded in Dholka (11.52 tonnes/ha) followed by Bedana and Kandhari. The number of spots in date palm varied from 6 to 9 in different genotypes. In date palm Halawy, axillary bud formation in shoot tip was achieved. Direct morphogenesis of shoot and root formation was achieved in lasoda (*Cordia myxa*), mulberry (*Morus alba*) and citrus (*Citrus aurantifolia*).

Vegetable crops: A total of 10 varieties / hybrids including six open-pollinated varieties and 4 hybrids were identified for release. They are Pusa Santushti (bottle gourd), IIVR MC 12 and DC 76 (cauliflower), VR 5 and Swarna Harita (cowpea), GMM 3 (muskmelon), JNDOH 02-22 (okra), HATH 5 and ARTH 734 (tomato) and Vivek bitter gourd. Two promising gourd varieties, CHTG 2 (teasel gourd) and CHSG 28 (spine gourd), were selected at Central Horticultural Experiment Station for yield and quality. Kashi Agahani, a mid-late maturity group (December-January) cauliflower was developed.

In muskmelon (*Cucumis melo*), line AHMM 17, AHMM 26, AHM 32, AHM 46 and CIAH Selection 1, showed potential for better fruit quality and yield attributes under high temperature conditions, while in bottle gourd, line AHLS 11 and AHLS 24 exhibited better fruit quality and high yield potential. In varietal trial, advanced lines of Indian bean (AHDB 16) exhibited superiority for earliness under high temperature conditions. In Luffa gourds, purified genetic material of AHSG 4 was found to be superior for uniform harvesting and early marketing.

Mushroom: Out of 7 strains/SSI of paddy straw mushroom evaluated, OE 274, BBH and BBH 5 and SSI-OE 55-0% gave more than 25% mushroom yield in first flush. However, in overall yield OE 274 and BBH outyielded other strains/SSI. Button mushroom strains CM 3, CM 7 and CM 9 gave higher yield. Out of 53 hybrid strains of *Pleurotus sajor-caju* developed for fructification, mycelial growth in 33 strains was observed. Three strains gave significantly higher yield on wheat straw. Of the six strains of *Agaricus bisporus* evaluated, CM 13 and CM 16 gave higher yield. In paddy straw mushroom (*Volvariella volvacea*), strains Vv 09, Vv 11 and Vv 12 gave higher yield and milky mushroom (*Calocybe indica*) strain C 1-6 gave higher yield. The hybrids, PSc 1 of *Pleurotus sajor-caju* and PF 01 of *P. florida* gave higher mushroom yield than their parents and other hybrid strains.

Potato: A new potato variety Kufri Sadabahar was released for cultivation in Uttar Pradesh. It gives an average yield of 35 tonnes/ha and has dry-matter content of 19-20%. Late blight resistant variety Kufri Girdhari, was released for hills. Hybrid, J. 93-86, an early bulking potato line for fitting in rice-wheat system was also identified. This hybrid is likely to be a good replacement of Kufri Ashoka and Kufri Chandramukhi for cultivation in the plains specifically for Haryana, Punjab, Rajasthan, Uttar Pradesh, Gujarat, Bihar, Madhya Pradesh and West Bengal.

Advance hybrid for French fry developed

An advanced hybrid, MP/98-71, suitable for making French Fries was developed for cultivation in the Indo Gangetic plains. Promising hybrids of Kufri Bahar/Kufri Jyoti × RB-transgenic Katahdin were identified. Similarly, putative transgenic lines of Kufri Jyoti and Kufri Chipsona 1 with reduced cold-induced sweetening developed.



MP/98-71: a potato hybrid for French fry

Coconut: Three coconut varieties, viz. Kalpa Dhenu, Kalpa Mitra and Kalpa Pratibha, were released for commercial cultivation. A new coconut variety, Kalparaksha was recommended for release as a high-yielding and resistant (field resistance) to root (wilt) disease. Three coconut ecotypes, viz. Bedakam type in Kasaragod district, Anjarakandy type from Kannur district and Kuttiadi type from Kozhikode district, were identified for *in-situ* characterization. Putative *in-situ* drought-tolerant coconut palms were identified in Sivaganga district of Tamil Nadu. Coconut, Kalyani Coconut 1, was released for West Bengal. Coconut IND 003 S is a high-yielding coconut variety (12,813 nuts/ha/annum) with sweet taste of nut water (sugar content 6.40 g/100 ml) with a very high quantity of nut water (446 ml) and high potassium content (2035 ppm). It was released for Andhra Pradesh, Tamil Nadu and Maharashtra. It was named as Gauthami Ganga. Coconut hybrid, Konkan Bhatye Coconut Hybrid 1, was released for the Konkan coastal region. Varieties Kalpa Dhenu, Kera Keralam, Kera Bastar, Kalpa Prathiba, Kalpa Mitra, and hybrid Kahikuchi of Coconut Hybrid 1, were released.

Oil palm: Eleven oil palm hybrids, 4 from ASD Costa Rica, 4 from Palode, India, 2 from Ivory coast and 1 from Papua New Guinea were evaluated. In Dura mother palms, maximum germination (97.6%) occurred when fruit reached Stage 4 (165/days after anthesis-DAA) where least moisture content was recorded. At Stage 5 (180 DAA), decline in germination (94%) was noticed. High dry-matter accumulation and low moisture content were recorded in both the stages. Seedlings obtained from Stage 4 showed superior quality. Oil formation initiated (6.62%) at Stage 1 (75 DAA) and highest content (74.93%) was recorded at Stage 5. The virescence palms showed early maturity and germination than normal nigrescence palms.

Black pepper: In black pepper, Cul 5489 showed highest spike length (13.34 cm) followed by Cul 5308 and Panniyur 1. At Panniyur, maximum yield/vine was recorded in Cul. 5489 (1.847 green berry kg/vine) and was on par with Karimunda OP, Cul.5308, Panniyur 1, Karimunda and Coll. 1041. Hybrid P 6 × P 5 was promising with a fresh yield of 3.54 kg/vine.

Ginger: In ginger, there was maximum yield in V1E 4 -5 (29.21 tonnes/ha), followed by V2E 5-2 (28.29 tonnes/ha) with 32.29 and 28.12% higher yield over the control Suprabha. The genotypes, viz. SG 27/04, SG 45/04, SG 896 707, SG 827, SG 716, SG 682 and 51/04, were identified as high-yielding and high-quality lines.

Coriander: Coriander entries, DH 220 and DH 233, were identified as high-yielding in IET at Hisar. The CVT trials at Coimbatore identified LCC 170 and UD 206 as high-yielding with a yield potential of 928.33 and 923.33 kg/ha respectively. Three entries, COR 5 (1913 kg/ha), COR 4 (1825 kg/ha) and COR 2 (1670 kg/ha) were identified as high yielders from Hisar. LCC 244 (18.9 tonnes/ha), LCC 233 (18.5 tonnes/ha) and LCC 234 (18.0 tonnes/ha) were identified as good leafy types at Coimbatore. COR 4, COR 10, COR 11, COR 12, COR 13, COR 14 and COR 15 were identified as early-maturing types at Dholi. At Kumarganj, COR 9 (1.99 tonnes/ha) and COR 8 (1.94 tonnes/ha) were identified as high-yielding.

Cumin: Of the 10 entries in IET tested against wilt, blight and powdery mildew, UC 331 and UC 225 were found resistant to wilt, blight and powdery mildew at Jobner.

Fennel: Fennel, HF 131 and HF 143, from Hisar and NS 63, NS 46, RF 125 and RF 101 from Jobner were identified as promising. The maximum volatile oil (2.47%) was found in FNL 17, followed by FNL 15, FNL 20 and FNL 14. The FNL 15 ranked first in volatile oil yield (41.36 litres/ha), followed by FNL 16 (40.04 litres/ha),

RF 125 check (34.36 litres/ha), FNL 17 (32.93 litres/ha) and FNL 14 (28.52 litres/ha).

Fenugreek: In fenugreek, JF 270 recorded higher yield (573 kg/ha) which was at par with Rmt 303 (543.33 kg/ha) from Coimbatore. FGK 14 was identified promising from Dholi centre with a yield of 2.18 tonnes/ha. HM 348 and HM 355 were identified as promising at Hisar.

Flowers: Two carnation interspecific hybrids, IIHRIS 1 and IIHRIS 2, were found potential for commercial exploitation. Crossandra, F₁ Hybrid IIHR 2004-9, was characterized by large-sized flowers, novel orange colour. In gladiolus, two hybrids each from the IARI, New Delhi and MPKV, Pune; 6 new varieties in chrysanthemum from PAU, Ludhiana, are under multilocational testing. Two promising gerbera hybrids IIHR 99-1 and IIHR 99-2, were identified for open cultivation. They were tolerant to thrips and leaf spot with double flowers having deep orange and yellow florets.

In orchids, random amplified polymorphic DNA (RAPD) markers were used to study the genetic diversity of 10 cymbidium species. Newly-developed hybrids NRCO 42 (*Dendrobium whitae* × *Dendrobium pompadour*) and H × B (Cymbidium cross) were good for flowering and other floral traits.

Betelvine: Flowering was observed for the first time in 11 female and 9 male accessions. A total of 141 different cross-combinations were carried out using 1,713 catkins involving 25 female and 21 male clones. A total of 480 fruits were harvested from 83 crosses. The germination varied from 2.2 to 67.2% among the crosses. Maximum number of hybrid seedlings was raised in the cross SGM1/ Vasani Kapoori (169) followed by SGM1/ Tellaku Ponnuru (140). Wide variability was observed for many morphological traits like plant vigour, leaf size, leaf shape, leaf colour, petiole length, internodal length and stem pigmentation.

Cassava: In cassava, Hybrid 6-6 was superior with a mean tuber yield of 40.5 tonnes/ha and 31.0% extractable starch. The 164 SSR marker-tested cassava mosaic resistant clones were evaluated for four years. Flour clones, CR 43-11, CR 43-7, CR 54A-3 and CR 59-8 had high yield (>40 tonnes/ha) coupled with resistance to CMD.

Taro: In taro, out of 1,820 first clonal hybrids evaluated, 12 were symptom-free and being evaluated along with Mukhtakeshi. The hybrid seeds were also generated incorporating TLB-free wild taro as one of the parents (seven crosses) to produce TLB resistant hybrids. Fifteen high-yielding hybrids (17.0-22.5 tonnes/ha) were identified from the replicated trial and being evaluated to confirm the performance.

Region-wise recommended entries/varieties for release			
Crop	Entry	Region/state for which it is recommended	Average yield (tonnes/ha)
Cassava	IGT 1	Bihar	31.40
		Chhattisgarh	34.50
Sweet potato	Kamalasundari (rich in β carotene)	West Bengal	29.00
		Orissa	20.00
Taro	JCC 25KCS 2	Assam	18.10
		Andhra Pradesh	28.90
Elephant-foot yam	Sree	Assam	20.00
	Padma	Bihar	30.70
	Gajendra		
Bunda	NDB 1	Assam	18.50
		Jharkhand	11.30
Swamp taro	BCST 5	Assam	14.00

Elephant-foot yam: In elephant-foot yam, 118 hybrids were evaluated. Of them, 52 were high-yielding.

BIOTECHNOLOGY

Rice: Two varieties released, Improved Pusa Basmati (IET 18990) and Improved Samba Mahsuri (IET 19046), are the first products of biotechnology. Both were developed through marker-assisted selection (MAS) for pyramiding three bacterial blight resistant genes in the background of the most popular aromatic variety Pusa Basmati and the popular and widely cultivated variety Samba Mahsuri.

Sorghum: Sorghum transgenics with *Cry1B* gene that can control stem borer were produced and tested with 10 artificially reared borer larvae till four generations. Transgenics from two

Pyramiding additional bacterial blight resistance genes in basmati rice background

Background analysis revealed that Improved Pusa Basmati inherited most of the regions from Pusa Basmati 1, which are linked to Basmati quality traits. Possibility of linkage drag was also minimum in respect of chromosomes 8 and 11, carrying genes *Xa 13* and *Xa 21* for BB resistance respectively. Marker-based analysis suggested that this variety can be used as a combiner in Basmati hybrid-breeding programme. With the objective of adding more BB resistance genes in the Basmati background, a large segregating population was generated using Basmati 370 and IRBB 60, a non-Basmati rice line, carrying four genes *Xa4*, *xa5*, *xa13* and *Xa21*. This population will now be screened for identification of suitable recombinants possessing all the 4 BB resistance genes and Basmati traits.

Transgenic rice for blast resistance

From rice line Tetep blast resistance gene *Pi-k^h* has been fine mapped and cloned. Blast susceptible line Taipei 309 (TP309) has already been genetically transformed with cloned rice blast resistance gene *Pi-k^h*. Further evaluation of the transgenic lines containing *Pi-k^h* genes with same isolate of *Magnaporthe grisea* in T2 generation was carried out.

independent events were very effective. *Bt* protein level in the leaves was as high as 3 μ g/g of leaf tissue (comparable to commercial *Bt* cotton).

Quantitative trait loci (QTL) resistant to target leaf spot, zonate leaf spot and *Dreschlera* leaf blight were located in sorghum (genomic) chromosome SBI-06. This genomic region is syntenic with regions on rice chromosome 4, and maize chromosome 2.



Reduced feeding and reduction in stem borer larval growth on sorghum transgenic plants in insect bioassay. (A) Control leaf fully damaged with stem-borer larvae; (B) Minor nibbling marks on transgenic leaves (arrows indicate the dead larvae on transgenic leaves); (C) Larvae survived in non-transgenic control; (D) Dead larvae in transgenic plants

HH 67 (new), which was bred using DNA markers for downy-mildew resistance, has significantly arrested spread of the disease in the country. Both the parents of three most popular hybrids RHB 121 in Rajasthan, GHB 538 in Gujarat, and HHB 117 in Haryana have been converted into downy-mildew resistant using markers, and are in the final stage of testing.

Forage crops: *Reproductive pathways in apomictic guinea-grass*. Three components of apomixis, apomeiosis (formation of unreduced embryo sac formation), parthenogenesis (fertilization-independent embryogenesis) and functional endosperm development, were found to be frequently recombining in the germplasm lines. Reconstruction of reproductive pathways yielded a total of 8 different pathways of seed development.

Hybridization-supplemented apomixis components partitioning approach (HAPA) for ploidy manipulations. Apomeiosis and parthenogenesis when partitioned (following recombination, expressivity or modifying effects) yielded high frequency of triploids and haploids. Utilizing this hybridization-supplemented apomixis-components partitioning approach (HAPA), the largest ploidy

series in a crop-plant from a single progenitor in guinea-grass was generated.

Molecular markers. A RAPD primer (10-mers, Operon Series) showed differential pattern in apomictic and sexual guinea-grass; yielding a band of about 300bp, exclusively represented in apomictic genotypes and absent in sexual forms.

Tissue-cultured lucerne. Multiple shoot induction from apical meristematic axis on MS medium supplemented with BAP and kinetin showed high frequency of plantlets regeneration in lucerne.



Tissue-cultured lucerne

Oilseeds: *Castor.* Whole plant bioassays were done for 69 transgenic castor lines derived from 20 independent transformation events showing tolerance to *Spodoptera* and semilooper. Among the tested events, PCP202 AMT18 conferred maximum resistance to both the target pests. The transgenic castor plants PCP 202 AMT 1, 9, 11, 18, 37 with *Cry-I EC* gene showed less than 20% defoliation due to semilooper and *Spodoptera*.

Safflower. Delta 6-desaturase gene isolated from borage was developed into a cassette, and the construct cloned into binary vector is being used for developing transgenic safflower plants with gamma linolenic acid in seed oil.

Soybean. Fifteen putative transgenics with replicase gene were developed. Genomic DNA was isolated from the leaves of these as well as the control plants. PCR analysis was carried out

Pigeonpea genomics initiative

A total of 21 cDNA libraries have been prepared and about 9,776 ESTs sequenced. Pigeonpea varieties Asha, UPAS 1210 and a wild species *Cajanus scaraboides* were used for RNA isolation and cDNA synthesis. Out of the total ESTs produced, 776 sequences have been submitted to the NCBI GenBank and rest of them are under the process of submission. EST database was mined for presence of SSRs, and 28 SSR markers have been developed and are used for polymorphism survey between these two varieties for the creation of first reference genetic map of pigeonpea.

with replicase specific primers. Presence of an expected amplicon of 566 bp with DNA from putative transgenic plants confirmed the presence of replicase gene. No amplified product was observed in untransformed plants.

Pulses: *In-vitro regenerated fieldpea.* Medium containing MS+B5+4mg/litre BAP+0.6mg/litre NAA produced 16-18 shoots/embryonic axis across the genotypes and media containing MS+B5+2mg/litre BAP+0.4mg/litre NAA produced 20 shoots/cotyledonary node. In rooting medium, 1mg/litre IAA was found better across genotypes.

Commercial crops: *Sugarcane.* Transgenic sugarcane plants with *cryIAb* gene were produced through particle bombardment as well as by *Agrobacterium*-mediated transformation. Southern analysis was carried out for selected plants, and *cryIAb* gene integration was confirmed. *In-vitro* bioassay was carried out to study efficacy of different *Bt* toxins Cry1Aa, Cry1Ab and Cry1Ac on sugarcane shoot borer. High larval mortality was observed with Cry1Ab. Eight transgenics expressing Cry1Ab were screened against shoot borer. Plants showing dead hearts varied from 0 to 24 % in transgenics; 50 % of the plants in control showed dead hearts.

Cotton: First public sector transgenic *Bt* cotton variety Bikaneri Narma(BNBt) has been released for commercial cultivation to all cotton-growing areas in *kharif*. The advantage of this variety is that farmers can reuse the seeds year after year.

Male sterility induced in *Arabidopsis thaliana*

A novel mitochondrial gene was identified to be associated with the cytoplasmic male sterility in *Brassica juncea* alloplasmic lines. To test whether it is directly involved in causing male sterility, the coding sequences of this gene were translationally fused with a mitochondrial targeting signal and the fusion construct was cloned downstream to CaMV35 S promoter in a plant transformation vector. Transgenic *Arabidopsis* plants containing the gene were obtained following floral dip transformation and selection of T1 seeds on kanamycin-containing medium. Most of the transgenic plants showed varied degrees of pollen sterility, indicating that the gene is involved in causing cytoplasmic male sterility.



Transgenic *Arabidopsis* expressing male sterility

SEED

Breeder seed production: Breeder seeds 9,950.5 tonnes of different field crops were produced; including centrally and state released varieties as per requirement (*see table on p.40*).

Quality seed production: The total quality seed production of field crops was 0.85 lakh tonnes. And production of saplings and tissue-cultured plantlets was 285.33 lakh, and seed production of horticultural and vegetable crops was 1,130.56 tonnes.

Breeder seed production			
Production in tonnes			
Crop	Centrally released varieties	State released varieties	Total
Cereal crops	3,275.9	1,287.3	4,563.2
Oilseed crops	2,603.8	1,074.1	3,677.9
Pulse crops	1,123.4	387.0	1,510.4
Forage crops	140.2	26.8	167.0
Fibre crops	19.1	12.9	32.0
Total	7,162.4	2,788.1	9,950.5

In the fish component, 1,502.5 lakh spawn of carps, 504.94 lakh fry + fingerlings of carps, 5.1 lakh fry and spawn of catfish, 22.03 lakh larvae of sweet-water prawn, 185.97 lakh larvae of marine prawn, 12.17 lakh seed of ornamental fishes, 12.7 lakh brackishwater fish fry and 848.87 lakh seed of other marine fishes were produced.

In general, 40.91% increase in quality seed production of field crops and almost double fish seed production were observed at various centres.



Mass multiplication of planting material of horticultural crops

Participatory seed production: A total of 5,775 tonnes of seeds were produced under the participatory seed programme at the farmers' fields at the University of Agricultural Sciences, Dharwad, Indira Gandhi Viswa Vidyalaya, Raipur, Narendra Deva University of Agriculture and Technology, Faizabad, Indian Agricultural Research Institute, Regional Station, Karnal, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Mahatma Phule Krishi Vidyapeeth, Rahuri, Rajendra Agricultural University, Dholi, Himachal Pradesh Krishi Vishwa Vidyalaya, Palampur, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Assam Agricultural University, Jorhat, Tamil Nadu Agricultural University, Coimbatore and Punjab Agricultural University, Ludhiana

Seed production technology: Single rice seedlings 12-15 days old transplanted at 25 cm × 25 cm spacing were most suitable under the system of rice intensification for breeder seed production.

Seed processing: Processing damage in soybean seeds could be minimized considerably with the

inclined belt conveyor in place of bucket elevator.

Sieve sizes for the unprocessed seeds of safflower, chickpea and pigeonpea have been standardized. Specific gravity separator-based improvement of marginal seed-lots of cotton, soybean and safflower, respectively was attained to the minimum acceptable levels.

Seed treatment. Pre-sowing seed hydration for 17 hr at ambient temperature, followed by dry dusting with Thiram at 0.25% are recommended for rapid and uniform field emergence and plant establishment for better seed yield in sunflower and pigeonpea.

Seed storage: CO₂ provided complete killing of storage insects at 40% (v/v) concentration up to 12 months of storage under ambient conditions at the Coimbatore, and seed germination was above IMSCS (80%) level.

HONEYBEES AND POLLINATION

Apple : Fruit set was 26.2% when four colonies of *Apis mellifera* per hectare were introduced, and fruit set was 16.7% without honeybees colonies.

Radish : For efficient pollination in radish seed-crop, 5 *A. mellifera* colonies each at 10 frames bee-strength per hectare were required.

Cucumber: Fruit set was 74.9% with honeybee pollination and it was 12.2% in open pollination. And 6 *A. mellifera* colonies produced 21.80 fruits per plant and yielded 10.83 tonnes/ha compared to 8 tonnes/ha in open pollination.

Thai Sac Brood Viral and Sac Brood Viral molecular characterization

Genomic sequences of virus isolates from Himachal Pradesh of Thai Sac Brood Viral disease and Sac Brood Viral disease of honeybees obtained after sequencing of the amplicons with SB 9f/SB 10r and TS3f/TS4r, respectively and phylogenetic analysis have revealed that present SBV isolate of *A. mellifera* is closely related to China and UK SBV strains, and phylogenies of TSBV isolate have showed that it is different from the SBV strains available with gene bank database of the USA.

Litchi : Fruit set recorded was 38.4% in open panicles where honeybees were main pollinators as compared to 0.4% in caged panicles; to exclude insects pollinators.

Champakka (*Eugenia jambos*): Fruit set in *A. cerana* augmented plants was 43.50% with average fruit weight of 60.61 g, and fruit set in caged plants was only 29.54% with average fruit weight of 46.83 g.

Winged-bean: In *A. cerana* introduced plots, fruit set was 63.96% and in stringless bees, fruit set was 83.16% compared to 22.22% in plots not introduced by bee-colonies.