# Salient Achievements

# 2. Salient Achievements
## Crop Improvement and Management

**Germplasm exploration and collection**

Total of 5,856 accessions were collected through 85 explorations undertaken. These accessions comprise cereals and pseudocereals (930), millets and minor millets (255), pulses (1,073), oilseeds (503), vegetables (1,449), horticultural crops (608), fibre crops (60), spices and condiments (23), forages (53), medicinal and aromatic plants (736) and other crops (156) – representing 4,671 cultivated and 1,185 wild accessions. Herabarium specimens 1,186, comprising 164 taxa, were added to the National Herbarium of Cultivated Plants.

Accessions, totalling 16,900, including 43,885 samples of international trials and transgenics, were introduced from various countries, and 5,409 accessions were exported. Inland supply of germplasm comprised 7,217 samples.

*Hippophae rhamnoides* collected from Ladakh region

**Plant quarantine**

Trial materials and germplasm lines 43,885 were processed for quarantine clearance. Of the 3,232 samples found infested/ infected with pests, 2,992 have been salvaged.

Transgenic planting sample materials totalling 6,690 (*Gossypium* spp., *Oryza sativa*, *Solanum tuberosum* and *Zea mays*) were processed for quarantine clearance. Pests intercepted in *Oryza sativa* from Singapore were *Cryptolestes ferrugineus*, *C. pusillus*, *Sitotroga cerealella*, *Drechslera oryzae* and *Phoma glumarum*.

Phytosanitary certificates numbering 136 were issued for germplasm export.

Indigenous 2,902 seed samples were processed for pest-free conservation. Of the 225 samples found infested/ infected with insects and pathogens, 200 were salvaged, and total of 2,887 samples have been released.

In the field surveys in Haryana, Madhya Pradesh and Uttaranchal,

*Lavender* (Lavendula angustifolia) *IC-212822*. This has been introduced in Uttaranchal for extraction of essential oil, apiculture and various other medicinal purposes. So far, more than 20,000 plants have been supplied to progressive farmers of the Central Himalayan Region by the Regional Station, Bhowali, NBPGR

- Salvaged 2,992 samples, out of 3,232 infested samples
- Phytosanitary certificates 136 issued for germplasm export
- At the National Seed Gene Bank added 22,964 accessions of orthodox-seed species for long-term conservation at –18°C
- RAPD and ISSR analyses indicated genetic stability of *in-vitro* conserved *Colocasia* spp., *Curcuma* spp. and *Zingiber* spp.
- Varieties/landraces 787 of 12 crops fingerprinted using AFLP, microsatellite and ISSR markers
- PCR-based detection protocols standardized for *Cry* IA(c) gene in Bt cotton; *Barnase*, Barstar gene for male sterlity in transgenic mustard and *EPSPS* gene for herbicide tolerance in transgenic soybean
- Produced 100 transgenic lines of tomato Pusa Ruby and Pusa Uphar

through group ELISA of leaf samples, bean common mosaic virus infection was found in 1.4–16.34% samples of mungbean and 1.3–28.3% of urdbean, and soybean mosaic virus infection in 0.7–36.0% of soybean samples.

**Germplasm conservation**

At the National Seed Gene bank, for long-term conservation at

EC 530886 *Phaseolus* has been identified for high-podding, is dwarf, and is early in maturing

*Abelmoschus pungens* (wild okra) is being maintained at the Regional Station, Bhowali, NBPGR

Snake-gourd collections

–18°C, 22,964 accessions of orthodox-seed species of cereals (8,294), pseudocereals (481), millets (2,207), forages (630), fibre crops (136), grain-legumes (3,558), oilseeds (4,560), vegetables (1,862), medicinal and aromatic plants (208), spices and condiments (530), narcotics (166) and agroforestry species (332) have been added. In addition, 4,973 accessions have been stored in medium-term storage; 2,856 have been sent for multiplication and 2,420 have been stored for 10 years, besides monitoring for seed viability. Passport data were reviewed for 2,476 accessions. Germination protocols and dormancy breaking methods have been standardized in *Citrullus*, wild species of okra and brinjal, and medicinal plants, *Tephrosia jamnagarensis*, *Desmodium motorium*, *Chlorophytum borivilianum* and *Kigelia pinnata*.

Total of 639 accessions as seeds, embryonic axes, dormant buds and pollen have been cryopreserved. About 100 accessions of fruits and nuts, black-pepper, medicinal and aromatic plants and agroforestry species, cryostored for 1 to 18 years, on retesting have showed that their original viability values are still retained. About 140 accessions of fruit crops, tuber crops, bulbous crops, spices and medicinal and aromatic plants have been added to *in-vitro* gene bank and 1,685 accessions of 47 genera belonging to 125 species are being maintained. Germplasm of *Allium fistulosum*, *Bacopa monnieri*, *Centella asiatica*, *Colocasia esculenta*, *Curcuma longa* and *Mentha* spp. could be conserved *in vitro* up to 6, 15, 10, 17, 11 and 48 months, respectively. RAPD and ISSR analyses indicated genetic stability of *in vitro*-conserved germplasm of *Colocasia* spp., *Curcuma* spp. and *Zingiber* spp.

**Germplasm characterization, evaluation and maintenance**

Accessions 14,685 of various crops have been evaluated/ characterized and maintained. Germplasm accessions identified as promising include pearl millet for basal tillers, spike length and 1,000 grain weight; lentil for earliness; pea for earliness and pod length; *Phaseolus* for high podding, dwarf and early maturity; Indian mustard for long pods and high-oil content; *toria* for earliness and high-oil content; sunflower for broad head size and high-oil content; tomato for higher fruit weight/ plant; *methi* for early green-leaf harvest; *palak* for long and broad leaves and coriander for early green-leaf harvest.

Quality traits analyses have reflected presence of wide variability in percentage oil content in *Brassica* (28.28–44.22%), safflower (25.5–37.4%), perilla (38.72–48.55%), walnut (62.57–73.20%) and sunflower (24.27–51.00%); and percentage protein content in amaranth, (13.91–17.81%), barley (9.89–16.14%), wheat (10.41–19.81%), pigeonpea (17.38–21.50%), chickpea (17.53–28.83%) and cowpea (17.34–26.43%).

**Monitoring Global Plan of Action**

The FAO funded project on "Establishment of Information Sharing Mechanisms for Monitoring the Implementation of Global Plan of Action (GPA)" for conservation and sustainable use of plant-genetic resources was initiated in January 2005. Stakeholders comprising 110-institutes/departments/NGOs in three regions of the country have been identified for providing information.

## DNA fingerprinting

***Cereals and millets:*** Rice varieties 132 have been fingerprinted, employing 30 microsatellite markers. One-hundred-twelve wheat varieties are being DNA fingerprinted using microsatellite markers. Ninety-four accessions of fingermillet have been fingerprinted using ISSR markers.

### Phylogenetic analysis of brinjal

AFLP analyses of *Solanum melongena* and its related wild and weedy taxa have established close relationship between cultivated brinjal and its wild species *S. incanum* and *S. insanum*. And *S. macrocarpon*, *S. sysimbrifolium* and *S. viarum* have showed distant relationship.

***Pulses and oilseeds:*** Released 26 varieties of Frenchbean were analyzed with 12 AFLP and 28 microsatellite markers. STMS profiling of 75 released varieties of soybean and 32 landraces has been completed with 18 microsatellite markers. Ninety-six germplasm lines of pigeonpea have been fingerprinted using selected 12 AFLP primer pairs. Forty-one cultivars and landraces of lentil have been fingerprinted with 5 AFLP primer pairs.

***Medicinal plants:*** DNA fingerprinting has been completed in 21 accessions of *Chlorophytum borivilianum*, 34 accessions of palmarosa and 24 accessions of vetiver, using ISSR markers.

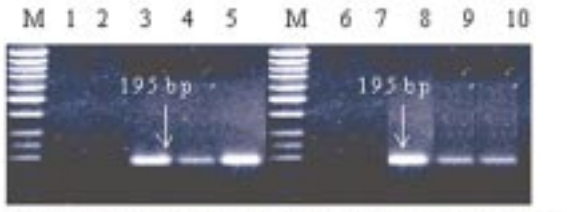
## Plant biotechnology

***Cloning of novel genes and promoters:*** This includes: (i) characterization of genes for protease inhibitor and lectin proteins for insect resistance/tolerance; (ii) identification of several new *cry* genes from native strains of soil bacterium, *Bacillus thuringiensis;* (iii) isolation of defence response genes from mustard; (iv) isolation and cloning of drought stress-responsive transcription factors (*TaCBF5* and *TaCBF9*) from drought-tolerant wheat variety C 306 and (v) cloning of LEA1 cDNA from mustard, which is expressed in response to drought.

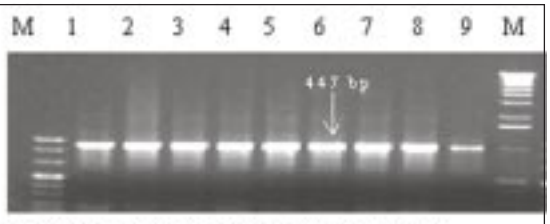
In addition, green tissue-specific promoters (*rbcS3A* and *rbcS*) have been isolated from green-pea and pigeonpea, and characterized by fusion with ß-glucuronidase (GUS) reporter gene expression in transgenic tobacco.

*Productivity enhancement in mustard:* Pusa Jai Kisan and BIO 322-93 are identified as best heterotic female and RLM 198, CSR 499, JMG 401, BIO YSR, BIO 467-95 as best male parents in mustard. Now both CMS and fertility-restoring lines of mustard with alien cytoplasm of *Moricandia arvensis* have been diversified into above-said parents, respectively, by backcross procedure, and BC4 generations could be obtained. Using these diversified heterotic parents, five experimental mustard hybrids have been produced.

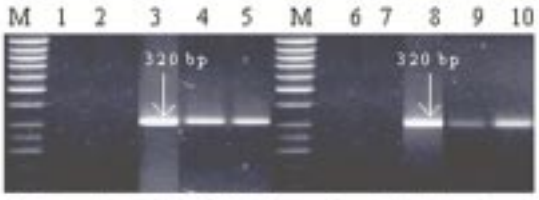
***Genomics and molecular markers:*** Bacterial artificial chromosomes (BACs) 46 of rice were sequenced and submitted to GenBank. Out of these, 44 finished to Phase III (PLN) quality, and 2 BACs have been submitted as Phase I.



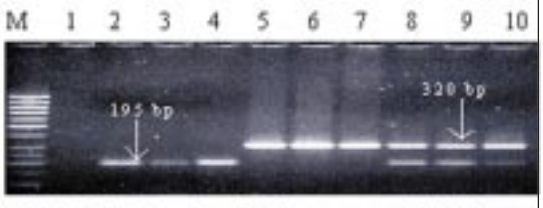

PCR detection of *35S* promoter in GM soybean and GM maize
Lane M-Marker; Lane 1, 2, 6, 7- Negative controls; Lane 3, 8-Positive controls; Lane 4-5, GM soybean and Lane 9-10, GM maize samples




PCR based detection of *Cry1Ac* gene in Bt cotton
Lane M-Marker; Lane 1, Positive control; Lane 2-9, Bt cotton samples

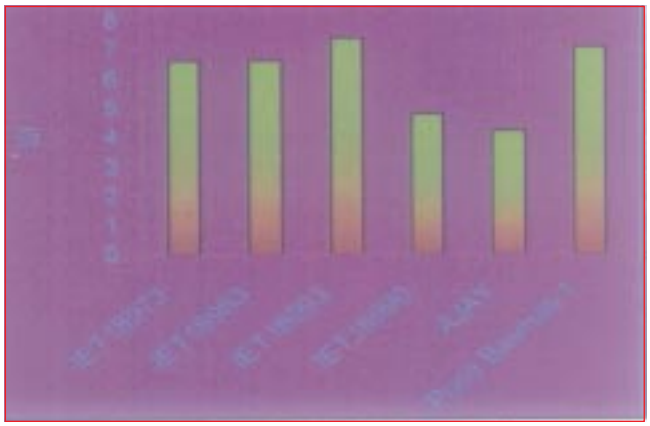



PCR based detection of *EPSPS* gene for herbicide tolerance in GM soybean and GM maize
Lane M-Marker; Lane1, 2, 6, 7- Negative controls; Lane 3, 8-Positive control; Lane 4-5, GM soybean and Lane 9-10, GM maize samples




Multiplex PCR detection of *35S* promoter and *EPSPS* gene in GM soybean
Lane M-Marker; Lane1, Negative control; Lane 2-4, samples with *35S* promoter, Lane 5-7, samples with *EPSPS* gene; Lane 8-10, samples with both *35S* promoter and *EPSPS* gene

A comparative analysis of rice and wheat genes on rice chromosome 11 has revealed common origin of wheat group 4 chromosomes and rice chromosome 11. The Biotechnology centre has also made significant progress in tagging and mapping of important genes in crop-plants and their application in crop variety improvement through molecular breeding. This includes: (i) molecular marker assisted pyramiding and development of varieties (IET 18990) with bacterial leaf-blight resistant genes *xa13* and *Xa21* in rice variety Pusa Basmati 1; (ii) evaluation of molecular markers in *Brassica*; (iii) fine mapping of aroma gene on rice chromosome 8; (iv) identification of candidate gene for fertility restoration in rice; (v) development of microsatellite markers in sugarcane; (vi)use of rep-PCR for identification of



Mean bacterial-leaf-blight disease reaction of aromatic rice line IET 18990 and 3 others with susceptible Pusa Basmati 1 and resistant non-Basmati check

**Comparative yield performance of bacterial-blight resistant rice selection IET 18990**

| Characters | IET 18990 | | Pusa Basmati 1 (Check) | |
|---|---|---|---|---|
| | Delhi | Kaul | Delhi | Kaul |
| Days to 50% flowering | 110 | 117 | 110 | 114 |
| Plant height (cm) | 109.0 | 117 | 119.35 | 127 |
| Grains/panicle | 118.0 | – | 75.0 | – |
| Grain yield (kg/ha) | 4,563 | 4,479 | 3,333 | 3,489 |
| % yield increase over Pusa Basmati1 | 37.50 | 28.37 | – | – |

CMS lines in mustard; (vii) tagging of *Moricandia* fertility restorer locus by AFLP technique; (viii) mapping of QTLs for Basmati quality traits in rice variety Pusa 1121; (ix) mapping of QTL for salinity tolerance in rice line CSR 27; and (x) high resolution mapping and map-based cloning of blast resistant gene *Pik*$^{h}$ in rice variety Tetep.

**Development of transgenics in tomatoes**

Presently more than 100 transgenic lines have been produced of tomato Pusa Ruby and Pusa Uphar using different constructs

Development of transgenic tomato harbouring plasmid PA4 A2 AB: (i) shoot and callus from cotyledon explant of Pusa Ruby (ii) shoot generation after 6 weeks of subculturing (iii) putative transgenic shoots after 8–10 weeks of culture (iv) putative transgenic in rooting medium (v) rooted transgenic in pot (vi) fertile transgenic of Pusa Ruby and Pusa Uphar (vii) wild plant with ripened fruits (viii) putative transgenic with delayed ripening

of anti-sense ACC synthase gene with fruit-specific and constitutive promoters for delayed ripening. Transgenic tomato with expansin gene (*LeExp1*), driven by *LeACS4* promoter, has also been developed with improved texture.

*Plant-microbe interaction:* Microbes are known to synthesize compounds that control plant pathogens naturally in all agricultural ecosystems. With the advent of genetic engineering, it is now possible to isolate genes for antifungal properties and manipulate them for better efficacy against the target pathogen. Microbes were isolated from the soil samples from the IARI rice field (New

**Antagonistic microbes isolated from different soil samples**

| Region | No. of microbes inhibitory isolated ($10^{-2}$) | Microbes showing effect |
|---|---|---|
| Rice field, IARI, Delhi | 45 | Nine |
| Banks of river Ganges, Allahabad | 68 | Nil |
| Bank of river Yamuna, Delhi | 56 | Seven |

**Intellectual property rights**

New patent applications 40 in number have been filed with the Patent Office, New Delhi. Thus, a total of 175 applications for patents have been filed up to December 2005. National Phase applications of the Patent Co-operation Treaty (PCT) application entitled 'Rapid detection of Bt-cry toxin' of the CICR, Nagpur, has been filed for the IPR protection in China, South Korea, South Africa, Uzbekistan and Mexico.

Seventy (70), First Examination Reports (FERs) of patent applications, were received and were examined in the Council, and replies thereof were submitted to the Patent Office within the stipulated time during the year.

Twenty Six (26) Formal Scrutiny Reports (FSRs) were received from the Patent Office Branch, New Delhi, and replies thereof were submitted with the Patent Office Branch, New Delhi within the stipulated time.

A three-day conference on the IPR and Management of Agricultural Research was organized during 27–29 August 2005 at the NASC Complex, New Delhi. Its recommendations have been circulated to all the ICAR Research Institutes/NRCs/PDs/Bureaux.

Delhi), river Yamuna bank (New Delhi) and river Ganga bank (Allahabad) by serial dilution technique effective against the hyphal growth and sclerotial germination of *Rhizoctonia solani*, pathogen of rice, causing sheath-blight disease. Based on their effectiveness, out of 169 isolates, 16 have been found to inhibit growth of fungal pathogen. The IARI isolates were more effective in inhibiting the pathogen as compared to from other regions. Isolates 2w and 2o from the IARI inhibited mycelial growth by more than 40%, and sclerotial germination inhibition was 100%. None of the microbes isolated from river Ganga bank (Allahabad) were effective in inhibiting the pathogen.

## Rice

***Crop improvement:*** Eleven varieties have been released for different ecosystems

*Hybrid rice technology:* PA 6201, EXPH 664, and PHB 71 and KRH 2 hybrids have recorded 12–16% yield advantage over check variety in rainfed uplands. Hybrid MPH 5401 (Suruchi) performed better under moderate sodicity at Karnal (0.8 tonne advantage) and at Lucknow (1.5 tonnes advantage). Three mid-early duration hybrids CRHR 7, CRHR 5 and CRHR 4 are found superior to check Tapaswini by 10–22% under rainfed, shallow lowlands.

***Crop production:*** *Agronomic efficiency of cultivars:* IET 17648 and IET 17655 under rainfed direct-seeded condition and IET 18033 and IET 18004 under transplanted conditions have been found promising in their response to applied nitrogen.

- Released 11 varieties of rice, 5 of wheat, 1 of barley, 11 of maize and 2 of small millets
- Rice hybrids PA 6201, EHPH 664, PHB 71 and KRH 2 recorded 12–16% yield advantage over check variety in rainfed uplands
- Both, System of Rice Intensification and Integrated Crop Management, found equally good with mean grain yield increase of 18% and 17% over normal transplanting
- Identified donors genotypes of wheat and barley for diseases and insect-pests
- In pearl millet, 50% N through urea and 50% N through FYM yielded maximum
- Grain-amaranth BGA 2 for Karnataka, Orissa and Tamil Nadu, and buckwheat Shimla B 1 and Sangla B 1 for mid and high hills of Himachal Pradesh and Uttaranchal identified for release

ADTRH 2 and CNR 3 exhibited tolerance to low P, as these produced some grains even at zero P level during *rabi*, while other test-cultures failed to flower. In *kharif*, IET 14554, PRH 122, Dhanarasi, IET 15358, IET 17467 and IET 17475 could tolerate low P.

*Crop establishment:* As crop establishment methods, System



*CRHR 5 and CRHR 7 rice*. These are mid-early duration hybrids found superior to check Tapaswini by 10–22% under rainfed, shallow lowlands

**Rice varieties released**

| Variety | Days to 50% flowering | Grain type | Ecosystem | Yield (tonnes/ha) | Reaction to pests/ diseases | Recommended state/region |
|---|---|---|---|---|---|---|
| **Central releases** | | | | | | |
| Sugandhamati | 114 | LS | Irrigated | 4.13 | R-NBL, BS | Aromatic, traditional basmati-growing areas of Haryana, Punjab, Delhi and Jammu and Kashmir |
| Pusa Sugandh 5 | 102 | ELS | Irrigated | 4.75 | MR-BLB, ShR, BS, LF | Aromatic, traditional basmati-growing areas of Delhi, Haryana and Jammu and Kashmir |
| Richa | 98 | LS | Irrigated | 4.10 | R-WBPH, LBl, NBl; MR-BS, ShBl | Irrigated and rainfed lowlands of Madhya Pradesh and Chhattisgarh |
| Suruchi (Hybrid) | 100-105 | MS | Irrigated | 5.90 | R-LBl; MR-WBPH | Suitable for irrigated areas of Haryana, Andhra Pradesh, Karnataka, Mahrashtra, Gujarat, Orissa and Chhattisgarh |
| **State releases** | | | | | | |
| Rajendra Sweta | 105 | MS | Irrigated | 4-5 | MR-PH, LF, SB, BLB, ShBl, ShR, BS, Bl | Aromatic, irrigated, medium lands of Bihar plains |
| Lunglinaphou | 85-90 | LS | Rainfed/ Irrigated lowlands | 6.5 | R-LBl, BLB; MR-GM, SB | Suitable for rainfed/irrigated lowlands of Manipur and also for organic cultivation, has good cooking quality |
| Bhogawati | 100 | LS | Irrigated | 4.5 | MR-SB, LBl, BLB | Aromatic, irrigated areas of Maharashtra |
| Kadamba | 105-110 | MS | Irrigated | 6.5-7.0 | MR-LBl, SB | Irrigated areas of southern transition zone of Karnataka |
| Pant Sankar Dhan 3 | 92 | LS | Irrigated | 6.20 | MR-LBl, BLB, BS, RTD, SB, BPH, WBPH | Plains of Uttaranchal (Udham Singh Nagar, Naini Tal, Haridwar and Dehra Dun) |
| Pant Sugandh Dhan 17 | 105 | LS | Irrigated | 4.5 | MR-LBl, NBl, SB Uttaranchal | Basmati-growing areas of Uttaranchal (Udham Singh Nagar, Naini Tal, Haridwar and Dehra Dun) |
| NDR 2026 | 80-85 | LS | Irrigated | 4.5-5.0 | R-BS, ShR; MR-ShBl SB, WM, LF | Uttar Pradesh |

R-Resistant, MR-Moderately resistant, MS-Moderately susceptible; BL-Blast, BLB-Bacterial blight, BPH-Brown planthopper, BS-Brown spot, GLH-Green leaf hopper, GM-Gall midge, LB-Long bold, LF-Leaf folder, LS-Long slender; MB, Medium bold, NBL-Neck blast, SB-Short bold, ShBl-Sheath blight, ShR-Sheath rot, RTV-Rice tungro virus, WBPH-White backed planthopper

Rice Intensification (SRI) and Integrated Crop Management (ICM), were equally good with a mean grain-yield increase of 18 and 17% over normal transplanting. With SRI, hybrids PHB 71, DRRH 1 gave 46–48% higher yield and varieties Tulasi, Rasi, Krishnahamsa and Jaya 5.2 to 17% higher yield.

*Weed control:* Bensulfuron-methyl and Triasulfuron were found highly effective in controlling all types of weeds; being least toxic in transplanted rice. In *kharif*, Triasulfuron alone (0.012 kg a.i/ha) or in combination with Pretilachlor (0.012 + 0.60 kg a.i/ha) have been found effective.

*Post-harvest processing:* Out of the four threshing methods, beating against stone platform, threshing with cylindrical drum, tractor treading and conventional thresher with electric motor, highest percentage of broken rice was observed in treading with tractor. For parboiling, soaking paddy in hot water at 60°C for 3 hours, followed by steaming for 14 minutes and drying increased head rice recovery from 3.2 to 12% over raw rice from all varieties.

***Crop protection:*** Clothianidin at 15ga.i/ha and a combination product of Acetamiprid + Chlorpyriphos at 510 g a.i./ha against brown planthopper; two formulations of Flubendiamide at 24 and 25 g.a.i/ha against leaf folder and stem borer; and acaricide Milbemectin

at 4.5 g a.i./ha against leaf mite have been found effective.

Neem-cake or *Simaruba*-cake at 5 g/kg of soil and root dip + soil drench with 5% and 2.5% seed extract of *Simaruba* effectively checked root-knot nematode population in pot-culture study in greenhouse. Among new fungicide formulations, Azoxystrobin and Kresoxi-methyl are found effective in checking blast severity and increasing grain yield. Propiconazole and Difenconazole combination product was effective in checking blast, sheath blight and glume discoloration at most of the test locations.

*Integrated pest managment:* Pusa Basmati as trap crop in 9 : 1 row ratio reduced stem-borer damage in main crop of Swarna during *kharif* and Krishnahamsa during *rabi* as compared to sole crops.

**Bacterial leaf-blight resistant gene(s) pyramided line(s) of rice**

Bacterial leaf-blight resistant genes (*xa 5, xa 13* and *xa 21*) lines developed in the background of BPT 5204 and Triguna were evaluated for resistance reactions under controlled glasshouse conditions. Cultures B 189, B 226, B 197, and B 210 have exhibited high level of resistance against all isolates tested at five-leaf and maximum tillering stages.

**Wheat and barley**

***Crop improvement:*** Five of wheat varieties and one of barley have been released and notified by the Central Variety Release Committee (CVRC). In wheat, 3 are bread wheat and 2 are durum wheat.

*Varieties released by State Variety Release Committee:* Eleven varieties of wheat and three varieties of barley have been released by the State Variety Release Committee (SVRC).

Wheat HD 2864 developed by the IARI is a late sown, irrigated bread wheat

**Wheat and barley varieties released by the CVRC**

| Variety | Year of release | Developed by | Production conditions | Area of adaptation | Average yield (tonnes/ha) |
|---|---|---|---|---|---|
| | | | **Bread Wheat (*Triticum aestivum*)** | | |
| HD 2864 | 2004 | IARI, New Delhi | Late sown, irrigated | Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh | 4.18 |
| MACS 6145 | 2004 | ARI, Pune | Timely sown, rainfed | Eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of north-eastern states | 2.55 |
| SKW 196 | 2005 | SKUAT, Srinagar | Timely sown, rainfed/restricted irrigation | Higher hills of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim and north-eastern states | 2.29 |
| | | | **Durum Wheat (*Triticum durum*)** | | |
| PDW 291 | 2005 | PAU, Ludhiana | Timely sown, irrigated | Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), west Uttar Pradesh (except Jhansi division), Kathua and Jammu districts of Jammu and Kashmir, Una and Paonta Valley of Himachal Pradesh and *tarai* region of Uttaranchal | 4.85 |
| HI 8627 | 2005 | IARI Regional Station, Indore | Timely sown, rainfed/restricted irrigation | Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh | 1.67 |
| | | | **Barley (*Hordeum vulgare*)** | | |
| NDB 1173 | 2005 | NDUAT, Faizabad | Alkaline/saline soils | Entire country | 3.52 |

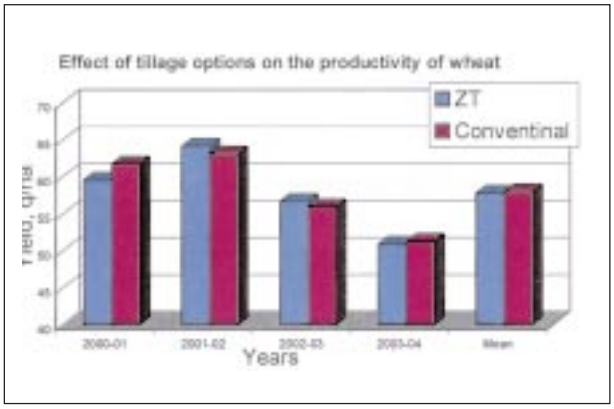
### Wheat and barley varieties released by the SVRC

| Variety | Production conditions | State |
|---|---|---|
| | **Wheat** | |
| K 9423 (Unnat Halna) | Irrigated late and very late sown | Uttar Pradesh |
| HD 2851 (Pusa Vishesh) | Irrigated, timely sown | Delhi |
| WR 544 (Pusa Gold) | Irrigated late and very late sown | Delhi |
| PBW 509 | Irrigated, late sown | Punjab |
| Raj 6560 (durum wheat) | Irrigated, timely sown | Rajasthan |
| Raj 4037 | Irrigated, timely sown | Rajasthan |
| VL 746 (Kailash) | Rainfed, timely sown in high altitudes (above 5500') | Jammu and Kashmir |
| HS 342 (Mansarovar) | Rainfed, timely sown in high altitudes (above 5500') | Jammu and Kashmir |
| SWL 8 (Singchen) | Summer sown in very high altitudes | Jammu and Kashmir |
| NW 1067 | Irrigated, timely sown in saline-alkaline soils | Uttar Pradesh |
| VL 802 | Irrigated and rainfed sown in mid-altitudes | Uttaranchal |
| | **Barley** | |
| NBL 4 (Nurboo) | Summer sown in very high altitudes | Jammu and Kashmir |
| NBL 11 (Sindhu) | Summer sown in very high altitudes | Jammu and Kashmir |
| VL Jau 56 | Rainfed, timely sown in mid-altitudes | Uttaranchal |

Barley NDB 1173 is found suitable for alkaline/saline soils

### Tillage requirement in rice-wheat system

Tillage in rice had no effect on the equivalent wheat yield and tillage in wheat affected mean equivalent wheat yield. For the rice-wheat systems' productivity, rotary tillage in wheat in combination with any of the four tillage options in rice was the best, followed by zero and conventional tillages, and the lowest yield was recorded in FIRBS. The rotary tillage that required single tractor pass for field preparation or puddling resulted in saving on tillage costs with similar yields of rice. The results were converted into equivalent wheat yield by considering a price of Rs 5,600 per tonne for rice and Rs 6,400 per tonne for wheat.




Equivalent wheat yield of rice-wheat system under various tillage options of rice and wheat (mean of 4 years)

| Tillage options in wheat | Tillage options in rice | | | | Mean equivalent wheat yield, tonnes/ha |
|---|---|---|---|---|---|
| | Dry field preparation | | Puddling | | |
| | Rotary tillage | Harrow | Rotary tillage | Harrow | |
| ZT | 12.424 | 12.241 | 12.342 | 12.455 | 12.365 |
| Rotary | 12.765 | 12.637 | 12.633 | 12.740 | 12.694 |
| FIRBS | 11.581 | 11.757 | 11.857 | 11.776 | 11.743 |
| Conven-tional | 12.330 | 12.152 | 12.485 | 12.498 | 12.366 |
| Mean | 12.275 | 121.96 | 12.329 | 12.368 | |

**Bread and durum wheat varieties identified for quality parameters**

***Triticum aestivum* (Bread wheat)**

**Sedimentation Value (>50 ml):** HS 240, HS 420, K 9107, HUW 468, NW 1014, K 8027, HUW 533, GW 273, Lok 1, HW 2004, HI 977, NIAW 34, HI 1500, Lok 45, HD 2781, NI 5439
**Glu-1 Score 4 with HMWGS '20':** C 306, HUW 533, Sujata, HW 2004, MACS 6145
**Glu-1 Score 10 with HMWGS '5+10':** Lok 1, HI 977
**Extraction rate (>72%):** VL 738, HS 277, HS 295, HD 2285, UP 2425, K 8027, Lok 1, GW 322, HW 2004, HD 2189, HI 977, HD 2501, HUW 234, MP 4010, PBW 343, K 9107, HUW 468, DL 788-2
**Iron (>75 ppm):** HUW 533, NIAW 34, HW 1085, NW 1014, HW 2044
**Zinc (>50 ppm):** NW 2036, K 8027, GW 322
**Copper (>5.5 ppm):** HD 2687, HD 2285, GW 173, NW 1014, HW 533, NIAW 34
**Manganese (>50 ppm):** VL 616, HS 277, VL 829

***Triticum durum* (Durum wheat)**

**Sedimentation Value (>35 ml):** WH 896,HI 8498, A 9-30-1
**ß-carotene (>6.0 ppm):** PDW 233, WH 896, NIDW 295
**Iron (>40 ppm):** HD 4672, HI 8627, NIDW 295, A 9-30-1
**Zinc (>40 ppm):** HI 8627, HD 4672
**Copper (>5.5 ppm):** PDW 291, HD 4672, HI 8627
**Manganese (>30 ppm):** PDW 291, A 9-30-1, HD 4672, MACS 1967

**Superior wheat varieties identified for various products**

**Chapati (Score 8.0/10.0):** C 306, Raj 3765, HD 2285, PBW 226, PBW 175, PBW 373 (NWPZ); C 306, K 8027, K 9107, MACS 6145, UP 262, NW 1014, HUW 234, HUW 533 (NEPZ); LOK 1, C 306, Sujata, HI 1500, HW 2004, DL 788-2,GW 173, GW 273, GW 322, Raj 3077 (CZ); LOK 1, HD 2833, GW 496 (PZ)
**Bread (Loaf Volume ~ 575 cc):** HS 240, VL 738 (NHZ); HD 2285, PBW 396 (NWPZ); HD 277, HD 2733, NW 2036 (NEPZ); Lok 1, GW 120, GW 173, GW 190, GW 496 (CZ); HI 977, HD 2189, HD 2501, HD 2781, DWR 162, DWR 195, MACS 2496, Lok 1, NI 5439 (PZ)
**Biscuit (Spread Factor ~ 7.5):** Sonalika (NHZ); UP 2425 (NWPZ)
**Pasta (Score ~ 6.5/9.0):** PDW 233, WH 896, PBW 34, PDW 291 (NWPZ); HI 8498, HD 4672, RAJ 1555, A 9-30-1 (CZ); MACS 2846, DDK 1009, NP 200 (PZ)

NHZ, North Hills Zone; NWPZ, North Western Plains Zone; NEPZ, North Eastern Plains Zone; CZ, Central Zone; PZ, Peninsular Zone

***Crop production:*** In a manually harvested rice field, almost free from rice stubbles, a 4-year study has showed that mean yield of wheat under zero tillage was marginally lower compared to conventional tillage. The yield under ZT was higher for 2 years,

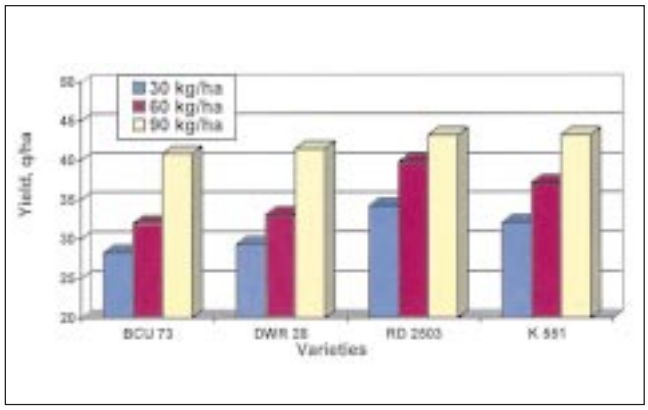
**Resistant genotypes of wheat and barley against diseases and insect-pests**

| Resistance | Varieties |
|---|---|
| **Wheat** | |
| Resistant to stem, leaf and stripe rusts + leaf blight | HD 2867 |
| Resistant to stem, leaf and stripe rusts +moderately resistant to leaf blight | NIDW 295, HPW 217, HPW 224, HPW 228, HS 443, HS 456, HS 460, VL 867, VL 868, HD 2865 |
| Resistant to stem, leaf and stripe rusts +moderately resistant to leaf blight + resistant to karnal bunt | NIDW 309, NIDW 29 |
| Resistant to stem, leaf and stripe rusts +powdery mildew + karnal bunt | TL 2930 (Triticale) |
| Resistant to stem, leaf and stripe rusts+ root aphids + brown wheat mite + moderately resistant to leaf blight | HS 443, HD 2865 |
| Resistant to stem, leaf and stripe rusts+ root aphids + brown wheat mite | UP 2594, HD 2834 |
| Resistant to stem, leaf and stripe rusts+ shoot fly+root aphids | PBW 525, NIDW 295 |
| Resistant to leaf and stripe rusts+ brown wheat mite + shoot fly+root aphids | Raj 6566 |
| Resistant to leaf and stripe rusts+ shoot fly+root aphids | HD 2830, AKDW 2997-16 |
| Resistant to stem, leaf and stripe rusts+ root aphids | HPW 224, HS 456, HS 460, VL 868, PBW 530 |
| **Barley** | |
| Highly resistant to three rusts | BH S355, BH S357, BHS 362, RD 2637, RD 2657, RD 2658, RD 2660, BH 646, RD 2666, RD 2667, RD 2669, RD 2670, BH 364, RD 2658 RD 2552, BH 657, VLB 91, DWRUB 52, |
| Resistant to stripe rust+ stem rust+ leaf rust+ leaf blight | RD 2624, DWR 47, DWR 49 |
| Resistant to leaf blight +cereal cyst nematode | RD 2035 |
| Resistant to stripe rust +moderately resistant to cereal cyst nematode | RD 2624 |

and for other two years, yield marginally higher was recorded in conventional tillage. It can be concluded that zero tillage gives as high yield as realized in the conventional tillage but at lower costs; due to savings of 7% in production cost.

Barley 2-rowed, BCU 73, DWR 28 and 6-rowed, RD 2503 and K 551, evaluated at 30, 60 and 90 kg N/ha have showed that all excepting RD 2503 responded to nitrogen application up to 60 kg/ha only.

*Effect of tillage practices on weeds:* Zero tillage reduced *Phalaris minor* infestation significantly compared to conventional tillage in wheat. Integration of tillage (zero tillage and FIRBS) practices with chemical control proved effective and economical. In long-term trials, reduction in the population of *Phalaris minor* but build up of *Rumex* sp. and *Malva parviflora* was observed. Carfentrazone (new), has been found effective against these weeds. None of the Sulfonylurea herbicides (Metsulfuron, Iodfosulfuron) were effective against *Malva parviflora*.



Effect of nitrogen on barley 2-rowed BCU 73, DWR 28 and 6-rowed RD 2503 and K 551

## Maize

***Crop improvement:*** Eleven cultivars of maize have been released by the Central Variety Release Committee.

**Maize cultivars released**

| Cultivars | Maturity | Grain colour | Area of adoption |
|---|---|---|---|
| Pratap Composite Makka 4 | Early (80–85 days) | White semiflint | Released for Jammu and Kashmir, Himachal Pradesh, hills of Uttaranchal, hills of West Bengal, north-eastern region |
| Pusa Early Hybrid 5 | Early (80–85 days) | Yellow orange, semi-flint | Single-cross hybrid released for Delhi, Haryana, Punjab and Uttar Pradesh |
| Pragati | Early (80–85 days) | Orange semi-flint | Released for eastern Uttar Pradesh , Bihar, Assam, Orissa, West Bengal and Jharkhand |
| Deccan Hyb. 115 | Early (80–85 days) | Orange, flint | Single-cross hybrids released for eastern Uttar Pradesh, Bihar, Assam, Orissa, West Bengal and Jharkhand, Jammu and Kashmir, Himachal Pradesh, hills of Uttaranchal, hills of West Bengal, north-eastern region, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra for *kharif* |
| PRO 345 | Medium (90 days) | Orange, semi-flint | Hybrids released for eastern Uttar Pradesh, Bihar, Assam, Orissa, West Bengal and Jharkhand |
| JKMH 68-2 | Full season (100–110 days) | Orange-yellow, flint | Hybrids released for Jammu. and Kashmir, Himachal Pradesh, hills of Uttaranchal, hills of West Bengal, north-eastern region, Andhra Pradesh, Karnataka, Tamil Nadu, and Maharashtra for *kharif* |
| BIO 9682 | Medium season | Orange-yellow, flint | Released for Delhi, Haryana, Punjab and Uttar Pradesh |
| Pratap Maize Hybrid 1 | Early | White semi-flint | Rajasthan |
| Vivek Comp. Maize 11 | Early | Orange, flint | Uttaranchal |
| Comp. Girija | Medium | Orange, flint | Himachal Pradesh |
| Comp. Sharadhamani | Medium | Orange, flint | Uttar Pradesh |

***Crop production:*** To reduce waterlogging impact 25% nitrogen, 10 days after sowing plus 50% at knee-high stage + 25% at tasselling stage or in combination with 3% urea spray 45 days after sowing is recommended.

Nitrogen at 120 kg and plant spacing of 15 cm has been found optimum for sweet-corn production in peninsular zone and 180 kg N and 10 cm spacing for baby-corn production. For popcorn, 120 kg N and 20 cm spacing has been found profitable for quality production.

***Crop protection:*** Maize genotypes 6 have been identified for tolerance to biotic stresses.

**Maize genotypes tolerant to biotic stress**

| Genotypes | Tolerant to |
|---|---|
| Bio 22060 | MLB, TLB, BSDM, CR |
| JH 10655, IC 0301 | RDM, SDM, BSDM, CR, BS |
| BIO 31006 | RDM, DM, ESR, CR |
| PHS 79 | BSDM, ESR, CR, BS |
| JKMH 1701 | MLB, BSDM, PFSR |

BS, Brown spot; BSDM, Brown striple downy mildew; CR, Common rust; DM, Downy mildew; ESR, *Eriwinia* stalk rot; MLB, Maydis leaf blight; RDM, Rajasthan downy mildew; SDM, Sorghum downy mildew; TLB, *Turcicum* leaf blight; PFSR, Post-floweing stalk rot

**Sorghum**

***Crop improvement:*** *SPV 1616 (dual-purpose variety):* This variety has been identified for release in Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh and Uttar Pradesh (Bundhelkhand), where both grain and fodder (stover) are equally important.

*SPH 1398 (JKSH 528):* This hybrid has been identified for release for the northern Karnataka, Maharashtra, Madhya Pradesh and Gujarat.

***Crop production:*** Sorghum + safflower at 2 : 1 and sorghum + chickpea at 12 : 3 ratio have resulted in higher sorghum equivalent yield (1,501 and 1,527 kg/ha) compared to sole sorghum (1,434 kg/ha).

***Crop protection:*** Among bioagents *Trichoderma viride*, *T. harzianum* and *Pseudomonas fluorescens* have showed promise in enhancing seed germination and seedling vigour and the effect

SPV 1616 is a dual-purpose sorghum variety identified for Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh and Uttar Pradesh (Bundelkhand)

was superior to chemical control (spray with Propiconazole (Tilt) at 0.02%).

Of the 46 entries of sorghum tested at Port Blair, 11 entries GMRP 97, GMRP 86, GMRP 13, GMRP 78, GMRP 9, GMRP 91, GMRP 65, GMRP 88, GMRP 84, GMRP 94 and BN 1480 are found resistant (disease score of < 2) against grain-mould.

**Pearl millet**

***Crop improvement:*** Two hybrids of pearl millet have been identified for release at the national level.

***Crop production:*** Intercropping of pearl millet with pigeonpea exhibited higher grain and fodder yields over sole crop in South-Central India. Application of 50% N through urea and 50% N through FYM in pearl millet gave maximum grain yield.

***Crop improvement:*** Fingermillet GPU 48 for Karnataka and foxtail millet TNAU 186 for Tamil Nadu have been released. Kodo millet RK13 has been identified at the national level for Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Karnataka, Tamil Nadu and Uttar Pradesh.

**Pearl millet cultivars released**

| Hybrids/Varieties | Areas of recommendation | Mean grain yield (tonnes/ha) | Salient features |
|---|---|---|---|
| HHB 67 Improved | Western Rajasthan and drier parts of Gujarat and Haryana | 2.02 | Extra early maturity, high resistance to moisture stress, resistant to downy mildew |
| Sagar 205 | Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh | 3.24 | Late maturing, superior in grain and fodder yields, resistant to downy mildew |

GPU 48 fingermillet has been released for Karnataka. It matures in 95–100 days and is suitable for late sowing

***Crop production:*** With continuous farmyard manure at 7.5 tonnes /ha, inorganic fertilizer dose could be reduced to half of the recommended without any reduction in the fingermillet yield. In the hills of Uttaranchal,application of only organic manure was sufficient to realize sustainable yield. Intercropping/border hedge cropping of niger along with fingermillet enhanced natural predators, and thus helped minimizing problem of pests in fingermillet.

***Crop protection:*** In foxtail millet SIA 1513, 1535, 1538 and 1548 accessions were tolerant to shoot fly. In barnyard millet VL 196, VL 200, VL 201, K1, TNAU 8 and VL 205 were free from shoot-fly incidence.

***Crop improvement:*** Identified 3 varieties for cultivations: Grain amaranth BGA 2 with a yield of 1.326 tonnes/ha for cultivation in Karnataka, Orissa and Tamil Nadu, and buckwheat varieties Shimla B 1, extra early maturing and Sangla B 1 with a yield of 1.265 tonnes/ha and of medium maturity for mid and high hills of Himachal Pradesh and Uttaranchal.

***Crop improvement:*** Forage crop varieties, one of cowpea, anjan grass and berseem and 3 of oats have been released.

***Crop production:*** Guinea grass + Desmenthus intercropped in 3 : 1 ratio in banana plantation gave higher green fodder (198.43 tonnes/ha) and highest net monetary returns (Rs 93,558/ha/yr) than other combinations.

**Forage crop varieties released**

| Forage crops | Variety | Adaptation region/Agroecology | Green forage yield (tonnes/ha) | Important characteristics |
|---|---|---|---|---|
| Cowpea | UPC 618 | Irrigated summer and rainfed *kharif* in North-West, North-East and Central Zones comprising Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Uttaranchal, Jharkhand, West Bengal, Assam, Orissa, Gujarat and Maharashtra | 30–35 | Resistant to yellow mosaic virus, bacterial blight, collar/root rot and aphids; better crude protein content, drymatter digestibility– non-digestible fibres (%) and acid digestible fibres (%) |
| Anjan grass | Bundel Anjan 3 | Arid and semi-arid tracts comprising Rajasthan, western Uttar Pradesh, Haryana, Punjab, Maharashtra and Andhra Pradesh | 10–12 (dry-matter yield) | Superior in drymatter content and highly suitable for arid and semi-arid situations of the country |
| Oat | Bundel Jai 2001-03 | Tropical and subtropical areas of North-West and South Zones comprising Uttaranchal, Haryana, Rajasthan, Punjab, Andhra Pradesh, Karnataka and Tamil Nadu | 50–55 | Single-cut variety, superior in per day production potential with better quality attributes and leaf-stem ratio |
| | Bundel Jai 99-01 | Temperate and sub-temperate areas in *rabi* | 30–35 | Single-cut variety for Hill Zone; resistant to leaf blight, aphids and lodging. At a par in quality with check OS 6 and Kent |
| | RO 19 | All India (In oat-growing areas) | 50–55 | Superior in forage yield and crude protein yield; has high leaf-stem ratio; is resistant to leaf-blight disease and aphids |
| to Berseem | BL 180 | North-West and Hill Zones comprising Jammu and Kashmir, Punjab, Haryana, Rajasthan, Himachal Pradesh, Uttaranchal, Uttar Pradesh | 30–35 (Hill) 600–650 (NW) | Profuse tillering type, less incidence of stem-rot and root rot; good seed yield, medium sized seeds with bright-yellow colour |

- Identified 5 groundnut varieties, 3 sesame varieties, 1 safflower hybrid and 3 niger varieties
- Developed CS19, a semi-spreading, high-yielding Virginia groundnut, which showed multi-disease resistance
- Saline water of 4 dS/m can be safely used for groundnut
- *Trichoderma* isolates T 071 and T 29 showed more than 50% inhibition of *Aspergillus flavus* growth in groundnut.
- Tingid bug found as new pest of common occurrence on all wild species of sunflower during *kharif*
- *Agrobacterium*-mediated transformation of safflower using constructs harbouring reporter (*GUS*) and selectable marker genes (hpt) optimized
- Registered at the NBPGR, a novel germplasm line B10 YSR of rapeseed-mustard with white-rust resistance and high seed yield and oil content
- In castor, 110 independent transformants are being multiplied and maintained through tissue culture
- Identified first time signature markers in castor that can unambiguously establish hybrid purity

In Faizabad, sowing of berseem in standing rice (no tillage) with seed rate of 40 kg/ha, higher net monetary returns of Rs 33,886/ha were realized as compared to normal tillage.

Fluchloralin applied at 0.90 kg a.i./ha as preplanting incorporation produced highest green fodder (65.85 tonnes/ha) and dry matter (8.48 tonnes/ha) of shaftal with remarkable weed-control efficiency (65.9%) in the north-west situations.

Pearl millet-oat-cowpea fertilized with 75% recommended dose of NPK+10 tonnes of FYM/ha in *kharif* was the best for forage yields; green fodder was 62.49 tonnes/ha and dry matter was 14.62 tonnes/ha), and net monetary returns were Rs 31,288/ha/yr.

In acidic soil, lime + recommended dose of P and K + VAM to *kharif* and *rabi* in rice-bean-oat sequence produced highest forage yield; green fodder-54.19 tonnes/ha and dry matter-11.46 tonnes/ha; and also realized highest net monetary returns of Rs 13,905/ha/yr.

Neem-seed kernel extract spray at 3% either alone or in combination with seed treatment with biocontrol agents, *Trichoderma viride* and *Paecilomyces lilacinus* at 5g/kg or neem-seed powder at 50 g/kg of seed in cowpea intercropped with sorghum/maize, reduced pests, diseases and nematode incidences in an eco-friendly way and increased fodder yields considerably.

## Groundnut

***Crop improvement:*** Germplasm accessions 789, comprising Virginia bunch (HYB): 215, Virginia runner (HYR): 133, Spanish (VUL): 306, and Valencia (FST):135, and unknown: 114, were scored for 6 qualitative and 5 quantitative traits. They exhibited variations for majority of traits. In evaluation of 48 genotypes along with two drought-tolerant check varieties in regularly irrigated and simulated drought conditions, least drought susceptibility index observed was for genotypes JUN 24, JUN 40 and JUN 15 for early-season drought; JUN 13, JUN 4, JUN 20 and JUN 42 for mid-season drought and JUN 26, JUN 34 and JUN 36 for end-of season drought.

On the basis of the desirable combinations of transpiration, transpiration efficiency and harvest-index, 181 breeding lines have been developed and multiplied for conducting further trials for identifying high water-use efficiency lines.

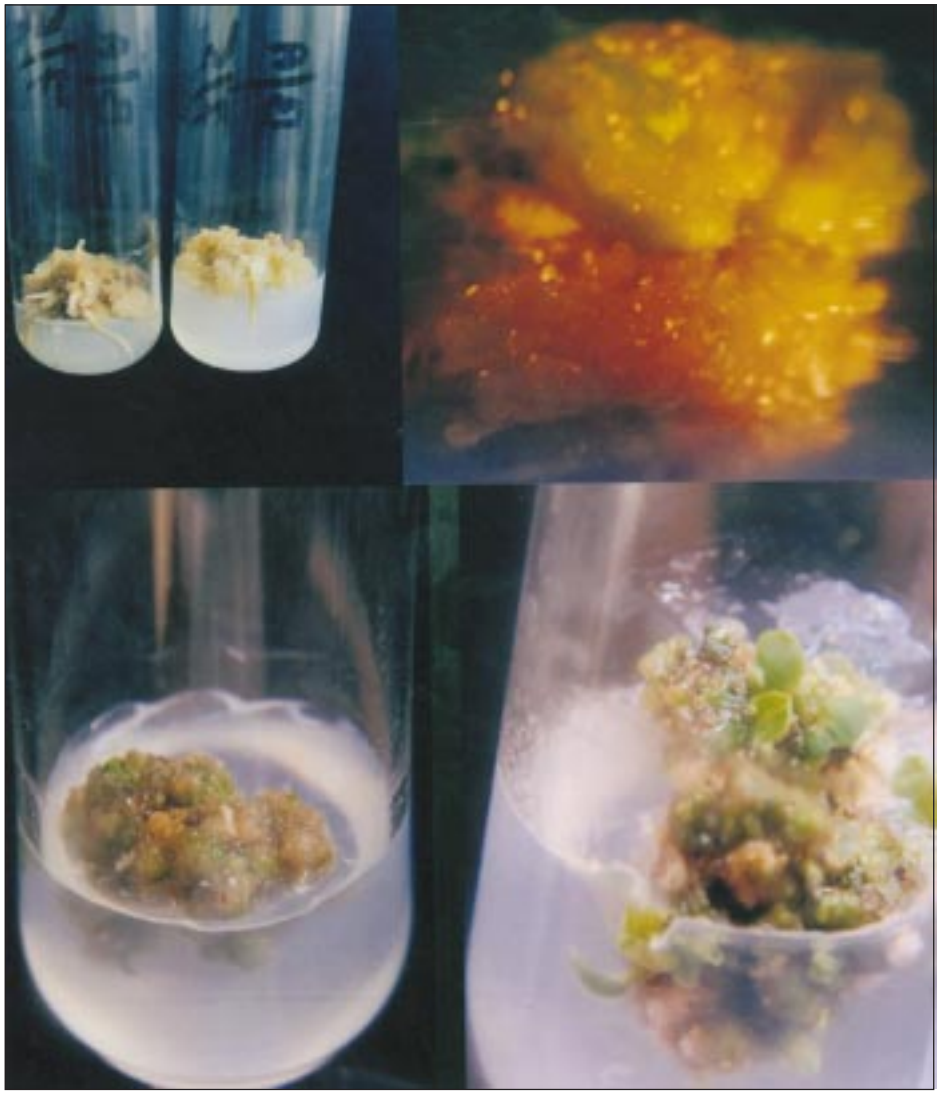
CS 19 (INGR No.04096), a high-yielding (2.0-3.0 tonnes of pod yield /ha) and multiple-disease (stem rot, collar rot, *Alternaria* blight) resistant, semi-spreading, Virginia groundnut has been developed through interspecific hybridization (cv. TMV 2 × *A. chacoense*). The culture has also showed tolerance to early leaf spot, late leaf spot, rust and moderate resistance to peanut bud necrosis disease. CS 19 matures in 120–125 days with 73% shelling out-turn and 46.9% harvest index. Kernels contain 48% oil and 26% protein.

**Groundnut varieties identified**

| Variety | Salient features | Recommended areas/seasons |
|---|---|---|
| J 53 | High-yielding (1,716 kg of pods and 1,193 kg of kernels/ha), early-maturing (106 days), erect groundnut variety | For Maharashtra and Madhya Pradesh during *kharif* |
| JSP 39 | High-yielding (1,992 kg of pods, and 1,338 kg of kernels/ha), early-maturing (119 days) and medium-bold seeded (43 g/100 kernels), spreading groundnut variety | For *kharif*-rainfed areas of southern peninsular states, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala, in addition to southern Maharashtra |
| Dh 101 | High-yielding (2,879 kg of pods and 1,980 kg of kernels/ha), diseases (stem rot, dry root-rot) resistant and insect-pests (thrips, *Helicoverpa armigera*) tolerant, erect groundnut variety | For Zone IV comprising Jharkhand, Orissa, West Bengal and north-eastern states for *rabi*/summer cultivation |
| TG 38 B | High-yielding (2,768 kg of pods and 1,984 kg of kernels/ha), high-shelling (71%) and medium-bold seeded (44 g/100 kernels), erect groundnut variety, tolerant to stem rot | For Zone IV |
| ANDG 50 | High-yielding (2,537 kg of pods and 1,988 kg of kernels/ha), high-shelling (71%) and high-oil content (53%), erect variety, tolerant to thrips | For Zone IV |

**Standardized protocol for anther culture of groundnut**

Callus induction from anthers ranged from 28% to 72% in *Arachis hypogaea* cultivars TMV 2,TAG 24, JL 24, GG 2 and CS 19 and from its wild species *A. glabrata, A. rigonii* and *A. pusilla* in MS medium. Media for shoot differentiation and root induction have also been standardized. Plants have been regenerated from anther-derived calli of GG 2 and TAG 24. Protocols are under testing for repeatability and for production of doubled haploids.



***Crop production:*** Pod yield of *kharif* groundnut was maximum (1,365 kg/ha) in groundnut–wheat–greengram sequential cropping system. Organic-carbon in soil was maximum in groundnut + pigeonpea system, and activities of phosphate solubilizing micorrhiza and fluorescent pseudomonads were higher in groundnut–wheat sequence and least in the sole groundnut; results of a long-term experiment that started in 1998. Groundnut with castor as an intercrop gave higher cost : benefit ratio (1 : 3.76), followed by with sesame (1 : 3.65) and pigeonpea (1 : 3.60). Castor gave the highest income of Rs 39, 492 followed by pigeonpea (Rs 37,848) as compared to control, which gave only Rs 28,940 /ha at Junagarh.

Irrespective of chemical treatment, dry seeding recorded 23.8% higher pod yield in groundnut as compared with sowing recorded with onset of monsoon. Controlled laboratory experiments to evaluate 48 groundnut germplasms have showed that saline water of 4 dS/m can be safely used for groundnut. On the basis of threshold salinity values and relative tolerance, these germplasms were classified into sensitive, moderately sensitive and moderately tolerant genotypes of groundnut. Field demonstrations (20) in 4 villages of Junagadh district revealed that improved method of moisture conservation gave higher pod yield (20.5%) in Spanish cultivar GG5 and in Virginia cultivar GG 13 (23.2%) compared with farmers practice. Additional oil yields of 172 kg/ha in Spanish cultivar and 225 kg/ha in Virginia cultivar were also realized.

***Crop protection:*** Groundnut cultures CS 168, CS 86, PBS 29058, CS 19 and CS 160 have been found to possess resistance against ELS; CS 168, CS 185 and PBS 12169 against LLS and CS 168, CS 151, CS 25, CS 19 and CS 157 against stem rot. CS 168 and ICR 12 have showed multiple disease resistance. NRCG breeding lines (NRCG 1 to 6) have exhibited resistance to LLS and rust at hotspot location (Aliyarnagar) of these diseases. Genotypes PBS 29071 and PBS 14010 have showed high level of resistance to leaf hopper, and NRCG 10628, NRCG 12698, NRCG 10818, ICG 12367, ICG 12620, ICG 12621, ICG 9981, ICG 7846, ICG 15119, ICG 11721, ICG 2462, ICG 3037, ICG 4032, ICG 5403, ICG 9889, ICG 2701, ICG 2748 and ICG 4248 to groundnut

leafminer in field conditions under optimum disease pressure. Seed treatment with *Trichoderma harzianum* at 4g/kg of seed and foliar application of cell-free culture filtrate of *Verticillium lecanii* (a biocontrol agent) together have been found most effective in management of early leaf spot, late leaf spot and rust diseases. Out of 17 isolates of *Trichoderma* isolates T 071 and T 29 have showed more than 50% inhibition of growth of *Aspergillus flavus*. Seed bacterization with consortia of non-fluorescent pseudomonads enhanced pod yield by 18% in JL 24 and by 16% in GG2, rainfed cultivars. Newly identified groundnut rhizobial strains, NRCG4 and NRCG9, have resulted in 14–15% increase in pod yield on inoculation and are found at a par with others, IGR6 and NC92.

**Sunflower**

***Crop Improvement:*** Maximum genetic diversity was obtained line PS 2048, a derivative from a cross involving *Helianthus petiolaris* and cultivated sunflower while maximum phenotypic diversity was detected in PS 4083 and PS 4093, derived from a tri-specific cross involving *H. argophyllus, H. annuus* (wild) and cultivated sunflower.

PKVSH 52, PKVSH 54 and PKVSH 58 at Akola; PEH Kh04-15 at Bangalore; CSFH 4014, CSFH 4032, CSFH 4038, CSFH 4043, CSFH 4089, CSFH 4164 and CSFH 4165 at Coimbatore; SCH 35, TWCH 02-11 and SCH 02-18 at Laturs PSFH 682 at Ludhiana; RSFH 130 at Raichur are identified as superior hybrids. The new populations of GAUSUF 12 and DRSF 113 are found superior for seed and oil yields in multilocation testing.

***Crop production:*** In Alfisols, highest yield of sorghum (4,998 kg/ha) in sorghum-sunflower system was recorded with 150% NPK to both the crops which was on a par with NPK-FYM, NPK-NPK+B and NP-NP. The highest seed yield (2,133kg/ha) of sunflower was obtained with NPK+FYM-NPK, followed by 150%NPK-150%NPK and NPK-NPK+B. Highest sunflower yield (1,535kg/ha) was recorded in mungbean - sunflower sequence, followed by fallow-sunflower (1,531kg/ha), which were significantly superior to sunflower – sunflower (1,253kg/ha) sequence after three cycles.

At Coimbatore and Raichur, in groundnut + sunflower (3 : 1) intercropping, pod yield of groundnut and seed yield of sunflower were significantly highest when groundnut was grown with its RDF in combination with 100% N (50% basal and 50% topdress, along with 100% PK as basal) for sunflower. Similarly in Verisols of Marathwada region of Maharashtra (Latur), fertilizing pigeonpea + sunflower (1 : 1) intercropping system with RDF of pigeonpea on an area basis along with 50% N as basal or as topdressing to sunflower was optimum for realizing higher productivity and profit.

In Vertisols of Raichur district, moisture conservation through opening furrows between rows at 30–35 DAS and with fertilizer dose of 35 : 50 : 35 kg N : $P_2O_5$ : $K_2O$/ha an yield advantage of 52.9% and 31.5%, apart from additional net returns of Rs 4,165/ha and Rs 1,662/ha was obtained over farmers' practice, in *kharif* and *rabi*.

***Crop protection:*** Tingid bug is found as the new pest of common occurrence on all wild species of sunflower during *kharif*. Wild species *Helianthus hirsutus*, *H. strumosus* and *H. tuberosus* showed resistant to highly resistant reaction and KBSH 1 was susceptible to most of the isolates of *Alternaria helianthi*.

Newer insecticides viz., Profenophos 0.05%, Thiodicarb, followed by Indoxacarb 0.015%, Spinosad 0.018% and Novaluron 0.01% are found effective for controlling *Helicoverpa* at most of the locations. Integrated pest management module developed at Bangalore (use of seed treatment with Imidacloprid 70 WS at 5 g/kg of seed + NSKE 5% + HaNPV 250 LE/ha) was eco-friendly and economical for management of *Helicoverpa*.

**Safflower**

***Crop improvement:*** A new safflower hybrid NARI-H 15 has been identified for pre-release multiplication for limited irrigation or assured rainfall regions of safflower-growing areas. Twelve interspecific derivatives derived from crosses between *Carthamus tinctorius, C. lanatus* and *C. turkestanicus* have recorded resistance reaction against *Alternaria* leaf spot under high-disease pressure. *Agrobacterium*-mediated transformation of safflower using constructs harbouring reporter (*Gus*) and selectable marker genes (*hpt*) has been optimized.

Twelve cDNA clones each of *nad3* and *atp9* genes of safflower have been sequenced along with five corresponding genomic clones to identify editing sites. This is the first report of RNA editing in safflower mitochondrial genes. Kill curves for hygromycin, phosphinothricin (PPT) and kanamycin have been worked out, and selection regime for recovery of putative transformants on hygromycin has been achieved.

***Crop production:*** For soybean-safflower sequence at Indore in irrigated areas, there is a need for 100% P to both the crops. However, at Parbhani and Phaltan in irrigated areas and at Solapur and Tandur in rainfed areas, substitution of 100% recommended P with phosphate solubilizing bacteria + 5 tonnes of FYM/ha is possible when one of the crops has received 100% recommended P. At Parbhani, application of $FeSO_4$ at 30 kg/ha resulted in highest yield, and it was comparable with application of elemental sulphur at 5.1 kg/ha.

***Crop protection:*** Germplasm lines GMU 1301, GMU 1105, GMU 1405, GMU 1101, GMU 1284, GMU 1404, GMU 1102, GMU 1364 and GMU 1409 are found tolerant to aphid infestation. Control of aphids only on the periphery of safflower crop (1.8 m all-around the field) with NSKE 5%, followed by Dimethoate 0.05% was economical, compared with complete coverage of the field with

**Improved machinery for soybean**

- A seed coverer attached with seed drill for planting soybean has been developed, refined and validated to ensure optimum emergence.
- Developed and validated BBF seed drill/Key-line furrow machine which can sow four rows of soybean and make channels on both sides of the rows facilitating *in-situ* moisture conservation.
- A tractor-drawn FIRBS seed drill has been developed that consists of an array of alternating ridges and furrows. The ridges are about 20 cm high and 75 cm apart. This tractor-drawn equipment can form two full and two half ridges on which simultaneously six row of soybean can be sown.
- A cross-mechanism attachable to seed drills for straight-row planting of soybean and other crops to facilitate subsequent mechanized cultural operations during crop growth has been developed. The use of the cross mechanism is able to minimize losses of crops from 10–15% to 3–4%.

insecticides. Newer insecticide Thiamethoxam 0.005% provided maximum protection from aphids and highest returns of safflower.

**Rapeseed-mustard**

***Crop improvement:*** Total of 760 lines of toria, 2,243 of Indian mustard, 270 of yellow sarson, 48 of gobhi sarson, 54 of karan rai, 1 of brown sarson, 104 of taramira, 6 of *Brassica tournefortii*, 3 of *B. oleracea*, 4 of *Sinapis alba*, 1 of *B. caudatus*, 12 of Banarasi rai (*B. nigra*), 1 of *Raphanus sativa* and 3 of *B. caudatus* are being maintained through appropriate mating systems. A novel germplasm line, Bio YSR (IC 443623), having white-rust resistance, yellow seed coat, high seed yield and oil content has been registered with the National Bureau of Plant Genetic Resources, New Delhi; thus bringing total germplasm lines registered up to 31 till date.

In view of the low realizable heterosis in available hybrids, attempts have been made to widen genetic base of *Rf* lines using synthetic *B. juncea* and newly introduced germplasm types.

***Crop protection:*** *B. carinata* line NPC 15 and *B. napus* lines NPN 1, PBN 2004-1 are found highly resistant to white rust on leaves as well as for staghead formation across locations, which may be utilized as donors for resistance to white rust and other diseases of mustard, and *B. carinata* line PBC 9221, *B. napus* lines PBN 2001 and PBN 2002 possess multiple (white rust, downy mildew, powdery mildew)-disease-resistant traits and may be used as donors for resistance to these diseases.

Extract of *Allium sativum* bulbs 1% (w/v) and of *Eucalyptus globosus* 1% (w/v) individually has been found to be at a par ($P < 0.05$) with fungicidal check Mancozeb in disease reduction and in increasing yield, and hence either of them can be recommended for *Alternaria* blight and white-rust disease management.

**Castor**

***Crop improvement:*** The wilt-resistant accession RG 1608 (IC 373978, INGR No. 04104) collected from Bihar and *Macrophomina* root-rot resistant accession RG 2722 (IC 306138, INGR No. 04103) collected from Andaman islands have been registered with, NBPGR.

Three hybrids with resistance to wilt (DPC 11 × JI 227, DPC 11 ×JI 258 and DPC 11 × PCS 124) yielded more than best check DCH 177 (2,229 kg/ha) . A total of 110 independent transformants are being multiplied and maintained through tissue culture. For the first time, signature markers have been identified that can unambiguously establish hybrid purity of each of the tested hybrids.

***Crop production:*** Sorghum and pigeonpea yields in intercropping were higher when they were succeeded by castor + clusterbean intercropping. Sole pigeonpea and sole soybean yields were not significantly influenced by preceding castor-based cropping systems. Integrated moisture conservation (key line cultivation and opening furrows between 2 rows at 40-45 DAS) and fertilizer (60 : 40 : 30 kg N : $P_2O_5$ : $K_2O$/ha) practice enhanced seed yield by 25.2% and oil yield by 16.9% with additional net returns of Rs 1,057/ha over farmers' practice. At Sardar Krushinagar, castor raised after *kharif* groundnut or urdbean is more productive system in terms of castor equivalent yield, and the crop responded up to 80 kg N/ha in *rabi*. At Mandor, application of 20 kg S/ha either through SSP or gypsum was found remunerative. At Sardar Krushinagar in irrigated areas, intercropping castor + mungbean and castor + sesame in 1 : 1 or 1 : 2 ratio proved more productive than sole castor. At Sardar Krushinagar, for *rabi* castor raised after clusterbean or cowpea, application of 75% N (fertilizer) + 25% N (FYM) or 50% N (fertilizer) + 50% N (FYM) gave distinctly higher seed yield than N through fertilizer alone.

***Crop protection:*** Spraying Carbendazim + Iprodione 0.1% was found superior and economical (B:C ratio of 4.1) for management of grey rot; recorded lowest disease incidence (6.9%) and maximum seed yield (1,539 kg/ha). The newer insecticides, Thiodicarb 0.075% and Indoxacarb 0.015% were very effective against semilooper and *Spodoptera*, and Spinosad 0.018% was effective against capsule borer at Hyderabad.

**Soybean**

***Crop improvement:*** Advanced breeding lines VLS 59, RKS 24, MACS 985 have exhibited lower level of Lox-I and DSb 6 1, JS 97 52, MACS 1010 and NRC 65 have showed higher level of Lox-I activity.

***Crop production:*** With *in-situ* rainwater management through broad bed and furrow method significantly increased soybean seed yield and S uptake from soils. BBF with FYM and mineral

fertilization produced significantly higher soybean seed yield and S uptake compared to traditional practice. Soybean-wheat-maize-wheat (S-W-M-W) recorded significantly higher yield of soybean compared to S-W rotation. Maize inclusion in crop rotation resulted in significantly higher wheat yield that continuous soybean.

***Crop protection:*** *Bacillus thuringiensis*, chemical insecticides and fungicides have proved effective in field without any adverse effect on the efficacy. Highest grain yield 1,950 kg/ha was recorded with Bt + Methomyl, followed by Monocrotophos alone 1,940 kg/ha and with Bt + Monocrotophos (1,939 kg/ha). The IPM module comprised recommended fertilizers dose, seed treatment with *Rhizobium*, PSB and *Trichoderma viride*, need-cake at 500 kg/ha, bird perches, removal of girdle beetle, tobacco caterpillar and Bihar hairy caterpillar infested plants or plant parts, foliar spray of *Beauveria bassiana* at 1.00 kg/ha and need-based chemical insecticides, Trizophos at 0.8 litre/ha. The IPM plots showed significant lower incidence of insect-pests and also recorded 0.75 tonne/ha more yield than non-IPM plots.

**Sesame**

***Crop improvement:*** *CST 2001-3:* It is a high-yielding, white, bold-seeded, early-maturing variety suitable for *kharif*. It is recommended for Rajasthan, Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Bihar.

*PKDS 11 and OSC 24-95-2-1-3:* These have been identified for summer for Andhra Pradesh, Tamil Nadu, Chhattisgarh, West Bengal and Madhya Pradesh.

***Crop production:*** Technology has been developed for organic cultivation with FYM at 3.75 tonnes/ha + neem-cake at 800 kg/ha+wood-ash at 75 kg/ha + bone-meal at 75 kg/ha + elemental sulphur 20 kg/ha+PSB (5 kg/ha)+ *Azotobacter* (5 kg/ha) + *Trichoderma viride* (0.04%) seed treatment + 3 neem-oil spray (neem oil 2% at 15 and 45 days after sowing), Azadrichitin (0.3%) at 30 DAS.

Sesame intercropped with blackgram 3:1 at Mauranipur and Vrindhachalam has been found promising.

***Crop protection:*** Seed treatment with Thiram (0.3%) or Thiram (0.2%) + Bavistin (0.1%) or *Trichoderma viride/T. harzianum* (0.4%), Bavistin (0.1%) or Apron 35 SD (0.6%); seed soaking in Streptomycin (500 ppm) or Agrimycin 100 (250 ppm) or Streptocycline (500 ppm) for 30 minutes and hot-water treatment at 52°C for 10 minutes, controlled effectively fungal (*Macrophomina*, *Rhizoctonia* and *Fusarium*) and bacterial root-root diseases. Spray Endosulfan 0.07% at 30 days after sowing for control of leaf-roller/capsule-borer and gall-fly (repeat spray at 15 days interval, if need arises), Ridomil MZ (0.2%) or Mancozeb (0.25%) for control of *Phytophthora* blight and Agrimycin 100 (250 ppm) or Streptocycline (500 ppm) bacterial blight.

**Niger**

***Crop improvement:*** JNS 26, JNS 18 and IGPN 9628 have been identified as high-yielding entries.

***Crop production:*** Niger responded up to 20 kg S/ha through different sources at Semiliguda, lgatpuri and Kanke.

Two sprays of NSKE 5% and one spray of Endosulfan 0.07% at Tikamgarh proved effective in controlling leaf-roller/capsule-borer and bud-fly, starting from 15 days after sowing.

**Linseed**

***Crop production:*** For rainfed and irrigated areas many cropping systems have been recommended.

***Crop protection:*** Endosulfan 4% dust at 20–25 kg/ha or Endosulfan 35 EC at 0.07% or Daltamethirin 2.8 EC at 0.002% or Imidacloprid 200 LS at 100 ml/ha have been found promising for leafminer, leaf-eating caterpillar and budfly.

**Linseed cropping systems**

| Areas recommended | Intercropping |
|---|---|
| Rainfed | Linseed + Chickpea (3 : 1) |
| | Linseed + Chickpea/lentil (3 : 1) or (1 : 3) |
| | Linseed + Wheat (1 : 3) |
| | Linseed + Safflower (different ratios) |
| | Linseed + Chickpea/lentil (3 : 1) or (1 : 3) |
| Irrigated | Linseed + Mustard (5 : 1) |
| | Linseed + Wheat (4 : 1) |
| | Linseed + Wheat (4 : 2) |
| | Linseed + Mustard (5 : 1) |
| | Linseed + Potato (3 : 3) |

**Chickpea**

***Crop improvement:*** A mutant BGM 547 of chickpea variety BG 256 and a *desi* variety Phule G 9425 with yellowish-brown seeds have been identified for cultivation in the late-sown areas of north India. Another kabuli variety BGD 128 having resistance to *Fusarium* wilt, dry root rot and stunt has been identified for cultivation in Madhya Pradesh, Maharashtra, Gujarat, parts of Rajasthan and Bundelkhand region of Uttar Pradesh.

Resistant donors for *Fusarium* wilt (IPC 97-29) and dry root rot (IPC 2K-25) have been identified. IPC 2000-17, IPC 2001-20 and IPC 2002-36 have exhibited moderate resistance against *Botrytis* grey mold. A kabuli genotype IPCK 00-112 having resistance to *Fusarium* wilt has been developed through *desi*-kabuli introgression. It has yield potential of 2,182 kg/ha with 100-seed weight of 36 g. Osmotic adjustment with small leaflets, and large number of leaves and branches has been identified as an additive factor contributing towards higher yield stability in chickpea in terminal drought situations.


A mutant BGM 547 of BG 256 chickpea and a *desi* variety Phule G 9425 with yellowish-brown seeds have been identified for cultivation in late-sown areas of north India. Kabuli variety of chickpea BGD 128 has showed resistance to *Fusarium* wilt, dry root-rot and stunt, and has been identified for Madhya Pradesh, Maharashtra, Gujarat, parts of Rajasthan and Uttar Pradesh (Bundelkhand)

- In chickpea idenfied resistant donors for *Fusarium* wilt and dry root-rot
- In terminal drought situations, osmotic adiustment with small leaflets and large number of leaves and branches identified as additive factor contributing towards higher yield stability in chickpea
- Mungbean CO4, ML 515, BM 4 and TM 98-50 identified as resistant to *Cercospora* leaf-spot disease
- Lentil PL 01, PL 02 and L 4666 identified as multiple-disease-resistant donors
- Released and notified CAZRI Moth 3 (mothbean), Pratap Kulthi 1 (horsegram) and Co (CP) 7 (cowpea) for commercial cultivation

***Crop production:*** In rice–chickpea cropping system, medium-duration genotype of rice NDR 359 recorded higher yield (13.7%) than short-duration genotype Pant Dhan 12 (3,387 kg/ha). A preceding crop of rice decreased nodulation in chickpea. Nodule number per plant reduced by 20–45% due to rice as compared to urdbean/mungbean in *kharif*.

In DCP 92-3 planted on 18 December, foliar application of 2% urea or DAP at branching and pre-flowering stages increased productivity by 15–20%. Foliar spray of 2% urea at flower initiation and 10 days thereafter improved grain yield significantly in rainfed areas, and gave 12% higher yield over no spray. Sowing two rows of chickpea 30-cm apart on 67.5 cm wide-raised beds proved highly beneficial than flat-bed sowing in heavy soils. Combined use of *Rhizobium* + PSB + plant-growth promoting rhizobia proved beneficial chickpea.

***Crop protection:*** Out of 838 genotypes screened in sick wilt plot, 17 were found resistant and 25 moderately resistant. Resistant genotypes are GNG 1488, GNG 1515, GNG 1581, GNG 1594, GNG 2136, H 00104, H 00216, IPC 97-29, 2K-3-20, 2000-52, 2100-04,

NDGH 3-31, H 82-2, HK 00290, RSG 963, CSJ 103 and P 9425-9. NIC 18852, NIC 18865 and NIC 18878 exhibited resistance to bruchids (*Callosobruchus chinensis*) under free-choice conditions. New insecticides like Emamectin Benzoate 5 SC at 8–9 a.i./ha and Novaluron 10 EC 50–75g a.i./ha proved effective over Endosulfan.

**Pigeonpea**

***Crop improvement:*** Genetic transformation using *bar* (marker gene) and *bt* (*Cry* 1 Ab, *Cry* 1Aa) genes via *Agrobacterium* has been optimized with two explants. Apical shoot meristems showed more transformations than decapitated embryonic axes. Among genotypes, T 7 has showed better response (2.45%) as compared to Bahar (0.86%). Transformed plantlets could be established by rooting as well as micrografting method into the pot/field.

Thirty early- and medium-duration genotypes have been converted into CMS lines. About 232 fertility restorers have also been identified against these CMS lines.

***Crop production:*** Pigeonpea + sorghum intercropping system was the most beneficial and productive system in hill planting (3 seeds of pigeonpea and 2 seeds of sorghum placed in each hill in 1 : 1 row ratio with 60 cm row-to-row spacing and 20 cm plant-to-plant spacing). CCC application after sowing shortened plant height, and enhanced primary and secondary branches, chlorophyll content and nitrate-reductase activity, resulting in higher biomass production. Higher pod number, seed set/pod and seed size were noted in treated plants. Translocation efficiency was enhanced that resulted in higher harvest index. One row of rice in furrows between two rows of pigeonpea sown on ridges with 100% recommended dose of fertilizers to rice was found beneficial. Among the *Rhizobium* strains tested, RGR-10 gave maximum grain yield in all varieties and at Khargone, PH-9022 gave maximum grain yield of JKM 7 variety. Among PGPR strains tested, combined inoculation of CRB-3 with *Rhizobium* produced more number of nodules with high nodule dry weight and grain yield at Gulbarga and CRB-1 performed better at Coimbatore.

***Crop protection:*** Based on the morphological characters, 22 isolates of *Fusarium udum* from Kanpur Dehat and Fatehpur districts of Uttar Pradesh were categorized in 3 distinct groups. Another 27 isolates from central Uttar Pradesh (Bundelkhand) were categorized as low, moderate, high and as strong pathogenic. Isolates from IIPR Kanpur and Kanpur Dehat were highly pathogenic, while those from Bundelkhand were moderately pathogenic.

Among recommended donors, 19 genotypes have showed stable resistance against Kanpur isolate of *Fusarium* wilt. These are AWR 74/15, BDN 1, BDN 2, BWR 377, Banda Palera, GPS 33, JAW 5-6A, IPA 38, ICP 8858, ICP 8859, ICP 8862, ICP 8863, ICP 9046, ICP 9174, ICP 89048, ICP 89049, ICP 93012, Sujata and PI 397430 Sel. Germplasm lines IPA 7-1-1, IPA, 7-1-7, IPA 7-2-2, IPA 8-1-1, IPA 8-1-5, IPA 8-1-9, IPA 8-1-11, IPA 8-1-17, IPA 8-1-19, JJA 33-2 and BSMR 55-2 showed stable resistance to *Phytophthora* blight.

Study on biotic potential of gram pod borer (*Helicoverpa armigera*) in north India revealed that the pest could multiply 362.75 times in a generation time of 54.54 days with intrinsic rate of increase of 0.1081/day (November-January). Emergence from diapause pupae (37.5%) occurred mostly during 1–9 March, after a lapse of 44–93 days, as against normal duration of 16–28 days, leading to severe damage to pigeonpea and chickpea. Short-duration genotypes, ICPL 98005, ICPL 98008 and DSLR 120 exhibited tolerance to borer complex with pest susceptibility rating value of 2–3 (4–6% pod damage). Long-duration genotypes, SL 21-7-2-3, ICPL 7542, IPA 04-11, MA 2, PDA 88-2E, 92-1E, 92-3E and 93-2E were moderately resistant to pod fly.

A new species of entomopathogenic nematode (EPN) *Steinernema seemae* has been identified from sandy-loam soils in pigeonpea fields in Madhopura village of Hamirpur district; collected from 40 to 45°C temperature regimes. This species can be multiplied at room temperature (35°C) and can be effective as one of the components of integrated pest management.

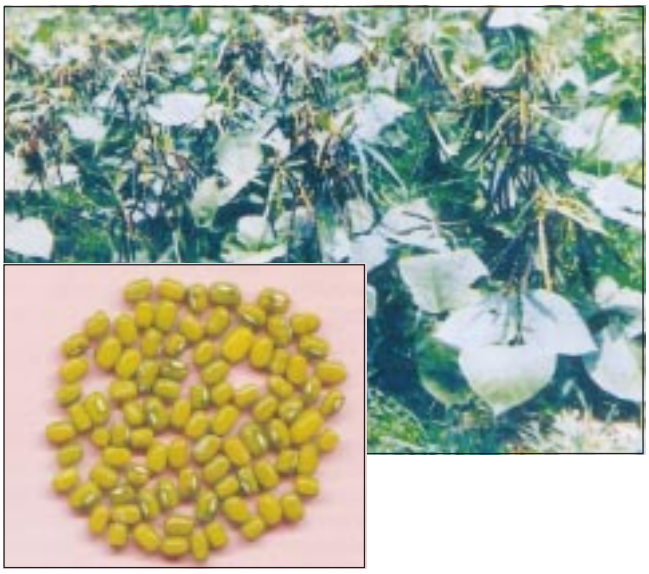
Among newer insecticides tested, Emmamectin (Proclaim) 5 WSG at 11 g a.i./ha, Flubendiamide (RIL 038) 20 WG at 50 g a.i./ha, KN 128 15 EC at 50 g a.i./ha and Spinosad (Tracer) 45 EC at 73 g a.i./ha showed good control of pod borer.

**SUCCESS STORY**

**Rural entrepreneurship through value-addition of pulses**

To promote post-harvest management technology among rural-youth and for their taking up employment, especially in rural area, Self Help Group (SHG) of 6 members was formed in the first week of May 2005 at Helapur village of Hamirpur district in the name of IIPR *Dal Samuh*. The SHG was motivated to purchase and install IIPR mini *dal* mill and *dal*-processing machine in participatory mode with 15% cost to be borne by the SHG and the remaining 85% by the ICRISAT. The SHG is actively involved in preparation of quality *dal* (dehusked split) of chickpea, pigeonpea and lentil as well as other products. On an average, 300 kg of pigeonpea, 200 kg of chickpea and 150 kg each of lentil and blackgram are processed for *dal* in a month. This provides a sizable income to the group with a processing fee of Rs 2/kg of grains.

With local processing, farmers are able to generate additional income of Rs 6,000 to Rs 7,000 per tonne. For instance, pigeonpea-grain is usually sold in the market at Rs 17 per kg and *dal* at Rs 30 to Rs 32 per kg. Farmers sell their *dal* at Rs 27 per kg; benefiting them and consumers. Besides, farmers retain husk and broken *dal* as cattle-feed.



*Mungbean Hum 16.* This has been developed from Pusa Bold 1 × Hum 8 and matures in 60 days. It is large-seeded, weighing 5.7 g/100 seeds

**Mungbean**

***Crop improvement:*** HUM 16, developed from the cross Pusa Bold 1 × HUM 8, has been identified for cultivation in Uttar Pradesh, Bihar, West Bengal and Assam. It has large, green seeds (5.7 g/100-seed weight) with average yield of 1,017 kg/ha during summer. It matures in 60 days.

Variety NDM 97-1 having resistance to mungbean yellow mosaic virus (MYMV) has been identified for cultivation in eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam. It has average yield of 1,100 kg/ha and has showed yield advantage of 25% over best check variety in North Eastern Plains Zone.

***Crop production:*** Mungbean biomass incorporation as green manure after grain harvest considerably improved productivity of rice in rice–wheat system. Chopping mungbean-straw and its incorporation gave highest available N (206–304 kg/ha) as compared to without chopping (170–195 kg available N).

***Crop protection:*** The crop could be protected from the onslaught of *Cercospora* leaf spot with 1–2 sprayings of 0.05% Carbendazim. CO 4, ML 515, BM 4 and TM 98-50 genotypes have been identified as resistant to disease.

**Urdbean**

***Crop improvement:*** Inheritance of plant types involving sympodial vs nonsympodial parents showed involvement of a single recessive gene. Evaluation of $F_1$ and $F_2$ generations of the cross between early insensitive genotype (PDU 103) and early sensitive (PLU 65) genotype at different dates of sowing showed insensitivity to be dominant over sensitivity and governed by a single dominant gene.

*IPFD 1-10 fieldpea.* It has showed a yield advantage of 27% over KPMR 400 in Central Zone. The variety has resistance to powdery mildew

***Crop production:*** Foliar application of humic acid was found highly beneficial to urdbean. Urdbean (var. Uttara) sown at two different spacings (45 cm and 60 cm) and sprayed with 1.5 ml/litres of humic acid yielded more than 1,000 kg/ha. The urdbean provided with recommended dose of fertilizers and sprayed with 2% urea or 1.5 ml/litres of humic acid was found the best.

***Crop protection:*** Genotypes IPU 99-3, 99-25, 99-33, 99-62, 99-186, 99-246, 99-248, 99-249, U 5, U 297 and UK 3 have been found highly resistant against mungbean yellow mosaic virus.

**Upgraded model of IIPR *dal chakki* developed**

An upgraded model of IIPR *dal* mill has been developed which has provision for grading raw-grains as well as finished products. An emery roller attachment has also been incorporated in the mill; which makes pitting process easier and this also enables production of dehusked whole, i.e. gota. Incorporation of the units in the upgraded model along with refinement in other components like disc-holding mechanism and quality of rubber-disc, has made this mill a complete mini *dal* mill, wherein grading of raw-grains, pitting of grains, milling of all types of pulses like dehusked splits (pigeonpea, chickpea, pea, lathyrus etc.), unhusked splits (greengram and blackgram), and dehusked gota (malka masoor), cleaning and separation of husks, and grading of finished products (*dal*) are done in the same machine, and all the operations can be done simultaneously also. The commercial prototype of this mill costs Rs 41,000 only (ex-works). The product quality obtained from this mill is similar to the quality of *dal* available in the market.

**Breeder seed production of pulse crops**

| Crop | Number of varieties in the seed chain | DAC indent (tonnes) | Breeder seed produced (tonnes) |
|---|---|---|---|
| Chickpea | 56 | 375.90 | 546.17 |
| Pigeonpea | 33 | 11.2 | 28.96 |
| Mungbean | 37 | 21.43 | 40.16 |
| Urdbean | 26 | 26.12 | 26.95 |
| Lentil | 18 | 20.35 | 26.52 |
| Fieldpea | 16 | 39.12 | 57.75 |
| Rajmash | 2 | 2.10 | 2.40 |

And T 65, K 116-86 have been identified as resistant to *Cercospora* leaf spot. Genotype PLU 648 has been identified as resistant against root-knot nematode (*Meloidogyne javanica* pathotype 2).

### Fieldpea

***Crop improvement:*** *IPFD 1-10:* A dwarf variety from a single cross of PDPD 8 × HUDP 7 has been identified for cultivation in Madhya Pradesh, Maharashtra, Gujarat, Bundelkhand region of Uttar Pradesh, Jammu and Kashmir, Uttaranchal, Himachal Pradesh and hilly regions of north-eastern states. It has an average yield of 2,104 kg/ha with 27% yield advantage over KPMR 400 in the Central Zone and 31% over HUDP 15 in the North Hills Zone.

### Lentil

***Crop improvement:*** A large-seeded variety VL Masur 507 evolved through selection from ILL 7978 has been identified for cultivation in Jammu and Kashmir, Uttaranchal, Himachal Pradesh and hilly regions of north-eastern zone states. It has an average yield of 1,204 kg/ha in the North Hills Zone with 100-seed weight of 3.32 g. It has exhibited yield superiority of 14.9% over best check DPL 62, and has also showed resistance against wilt.

**Allelopathic effect of root exudates and plant extracts on important soil pathogens of pulse crops**

EC formulation developed from the non-polar fractions (A, B and C) of sorghum root exudates was found detrimental to 7 important pathogens of pulse crops. Its LC 50 values were recorded as 17, 22, 250, 270, 182, 146 and 87.5 ppm for pathogens *Sclerotinia sclerotiorum, Sclerotium rolfsii, Fusarium udum, Fusarium oxysporum* f. sp. *ciceri, Rhizoctonia bataticola, Alternaria alternata* and *Choenephora cucurbitarum*. EW formulations developed from sesame allelo-compounds inhibited root biomass of nutsedge by 15.1, 30.5, 50.6, 51.9, 63.9, 81.3% and 15.8, respectively.

***Crop production:*** Seed priming (seed soaking in water for 6 hours) and 2% urea spray were found effective. In rice–lentil cropping system, large-seeded genotype DPL 62 outyielded other genotypes. In lentil, 60 kg $P_2O_5$, 30 kg S, 15 kg Zn and 5 kg Boron/ha were found most productive (1,646 kg/ha) and remunerative.

***Crop protection:*** PL 01, PL 02 and L 4666 have been identified as multiple-disease-resistant donors.

### Arid Legumes

***Crop improvement:*** Following varieties have been released and notified for commercial cultivation.

*CAZRI Moth 3 (mothbean):* It was induced from cv. RMO 40, following 30 kR $Co^{60}$ gamma rays. This cultivar with erect upright growth habit, flowers in 32–34 days and matures in 64–66 days. It is suited for low (250–350 mm) and erratic rainfalls in all mothbean-growing areas of India. Characterized with very high grain yield potential of 550–1,000 kg/ha, may be planted at 30–35 cm inter-row spacing in rainfed areas. It has tendency to escope yellow mosaic virus incidence.

*Pratap Kulthi 1 (horsegram):* Selected from a local germplasm of Bheelwara district (village Bemera), it is an early-maturing variety with almost 50 and 85 days taken to flowering and maturity. It has high yield potential (1,162 kg/ha); 16% more over national check AK 21 (872 kg/ha). The variety has been recommended for rainfed northern-western locations of India.

*Co (CP) 7 (cowpea):* It is developed through mutation breeding, following 20 kR $Co^{60}$ gamma-ray treatment to Co 4 cowpea variety. It being a medium maturing (67–73 days) variety has potential to yield (991 kg/ha); more than 25.0 and 41.4% over V 240 (725.0) and V 585 (643.3 kg/ha). It has field tolerance against pod-borer damage and leaf curl virus. This variety has been recommended for rainfed areas of southern states.

***Crop production:*** In guar, one spray of 0.5% $ZnSO_4$ either at 25 or at 45 DAS or in combination with 0.5% $FeSO_4$at 25 DAS gave significantly higher yield than control, but statistically at a par to soil application of $ZnSO_4$ at 25 kg/ha. Higher net returns were obtained when crop was applied with 1 foliar spray of 0.5% $ZnSO_4$ at 25 DAS (Rs 2,735/ha) or 2 spray at 25 and 45 (Rs 2,757/ha). Maximum net returns in guar were obtained when seed was inoculated with *Rhizobium* + phosphate solubilizing bacteria (PSB) at Gwalior (Rs 12,141/ha) and at Hisar (6,867/ha), and at Durgapura, maximum net income (Rs 6,238/ha) was obtained, when seed was treated only with PSB. At Hisar, *Rhizobium* the inoculation increased crude protein, and PSB alone or in combination with *Rhizobium* increased both crude protein as well as gum content in seed.

***Crop protection:*** Soil amendments with mustard residue at

*CAZRI Moth 3 (mothbean)*. It is suitable for low 250–350 mm and erratic rainfall areas, where mothbean is grown

*Pratap Kulthi 1 (horsegram)*. It is a selection from local germplasm of Bheelwara district (Rajasthan) and is recommended for rainfed north-western locations of India


*CO (CP) (cowpea)*. It has field tolerance against pod-borer damage and leaf-curl virus, and is recommended for rainfed areas of southern states

2.5 tonnes/ha along with seed treatment with *Bacillus thuringiensis* (4 g/kg of seed) and one summer irrigation was best in reducing percentage seedlings mortality (pre and post emergence) and increasing seed yield of guar. In cowpea, seed treatment with Thiram (3 g/kg), followed by three sprays of Carbendazim at 0.1% at 15, 30 and 45 days after seedling emergence were best in managing anthracnose disease during *rabi* in southern India. There was significant reduction in pod-borer damage due to spray of Profanophos 50 EC at 1 ml/litre in cowpea at Pattambi.

Zn Application to guar increased grain yield by about 13% at farmers' fields.

**Sugarcane**

***Crop improvement:*** Twenty-one Co canes (Co 0501 to Co 0521) were selected based on the evaluation made at Coimbatore, Karnal, Chagallu and Motipur, of which 6 belong to early group and 15 to midlate types. Co 98013,Co 99012 and Co 99004 are found on

*Saccharum spontaneum,* tallest collection from Mizoram

**Total sugarcane fluff supplied to various centres**

A total of 442 crosses, 843 general crosses (GCs) and 11 selfs from Coimbatore and 155 crosses, 26 GCs and 22 selfs from Agali were made, and 28,571.75 g of fluff has been supplied to 22 centres, representing Peninsular Zone (8,876.29 g), East Coast Zone (3,793.71 g), North-East Zone (898.29 g), North Central Zone (4,097.57 g) and North-West Zone (10,905.89 g).

- A reference collection of 116 sugarcane varieties has been established under the DUS project
- For good sprouting of sugarcane in winter, pre-harvest application of ethrel at 500 ppm is recommended
- A very sensitive assay, evaporative immunosorpent assay, standardized to detect ratoon-stunting bacterium infection in sugarcane
- In Maharashtra, intra-*hirsutum* hybrid of cotton Mahabeej 106 and intra-*arboreum* Mahabeet DH 986, and *G. arboreum* varieties PA 402, Phule JLA 794 notified for commercial cultivation
- In assured rainfall areas in Dharwad, sunflower intercropped with cotton in 2:1 or 3:1 resulted higher seed-cotton yield
- Released and notified S 19, JRC 80 (jute); MT 150 (mesta) and SH 4 (sunnhemp)
- Jute JRO 3352 found good donor for tolerance to *Macrophomina phaseolina*
- With *Trichoderma viride* and *Azotobacter* application in jute, highest disease control and biomass increase was noticed
- Resistant genotypes of tobacco found for tobacco aphid, whitefly, budworm and tobacco caterpillar
- In tobacco, *Nomurea rileyi* at $10^3$ spores/ha found effective in containing capsule damage caused by *Helicoverpa armigera* in the northern light soils area

a par with Co 86032 for yield; Co 98013 and Co 99012 were best clones combining yield and quality with good field stand; Co 99012 had relatively higher number of millable canes; and stalk thickness and single cane weight were higher in Co 98013. Co 99012 was the best entry for sucrose (19.55%) at 300 days. And Co99004 is found best for jaggery.

Molasses was used as a substitute for sugar in MS medium. Higher shoot multiplication was obtained at 6% concentration after two subcultures. Sucrose content in 105 *Saccharum spontaneum* clones ranged from 0.2% to 11.11%. In *Erianthus arundinaceus*, sucrose ranged from 0.16 to 3.49%.

**Mechanization of ring-pit planting technique of sugarcane**

To facilitate package for large-scale adoption, the IISR has designed and developed a two-row pit-digger for ring-pit planting of sugarcane to harness high cane productivity. The pit-digger is operated from a 35-hp tractor PTO and has a capacity of digging 175–200 pits/hr (pit dimensions: dia 75 cm, depth 30 cm, pit-to-pit distance 30 cm)

Co 86032, Co 94008, Co 94012 and Co 85019 were multiplied for breeder seed production in 0.40 hectare, and 31.73 tonnes of breeder seed was distributed to sugar mills and farmers. A reference collection of 116 varieties has been established under the DUS project.

***Crop production:*** Ratooning in sugarcane has become inevitable for reducing cultivation cost and for increasing profit margin. However, decreasing factor productivity and declining soil quality are the major concerns in sugarcane ratoon. The maximum cane yield (81 tonnes/ha) of the first ratoon was recorded on sulphitation with press-mud cake (SPMC) + *Acetobacter*, which was closely followed by 79, 78, 78, 78, tonnes/ha with vermin-compost + *Acetobacter*, NPK at 150 : 60 : 60 kg/ha, SPMC and vermin-compost, respectively.

One of the major causes of low productivity of sugarcane ratoon-crop is-poor sprouting in the winter initiated ratoon. The sprouting could be improved by pre-harvest application of ethrel (500 ppm), post-harvest application of zinc sulphate (45 kg/ha) and muriate of potash (100 kg/ha). Improvement due to these chemicals was 157.82 65.28 and 78.52% in Co Pant 90223, and 62.01, 26.0 and 21.63% in CoSe 92423.

Pre-harvest foliar spray of zinc sulphate or manganese sulphate (1,000 ppm), three day prior to harvest, reduced sucrose losses on staling in CoS 92423. There was 10% decline in CCS in Mn-treated cane after 6 days of staling as compared to over 20% in untreated control during March.


*Sugarcane tolerant varieties. Co 94012* peninsular variety tolerant to salinity (*right*); *Co 86032* tolerant to iron deficiency (left)

***Crop protection:*** Evaporative immunosorbent assay has been standardized to detect ratoon-stunting bacterium infection in sugarcane, and assay has been found more sensitive than DAC-ELISA.

The indigenous pheromones of shoot, internode and top borers have been found economical and effective in trapping moths in fields.

A set of sugarcane differentials and tropical pathotypes of red-rot pathogen have been identified. And factors responsible for *Colletotrichum falcatum* pathogenecity have also been identified. Differential accumulation of pathogenesis-related (PR) proteins have been found to be associated with induced resistance, as concomitant induction of chitinases was observed in red-rot pathogen inoculated canes pretreated with inducers of resistance.

**Cotton**

***Crop improvement:*** PSB CT8 (879), UPL C2 (699) for seed-cotton yield, MHR 11 (4.4 g.) for boll weight, PCB CT 10 (32.3 mm) and NM 970513 (31.0 mm) for mean halo length, and PSB CT 8 (41%) and PCB CT 10 (39%) for high-ginning outturn have been identified as superior genotypes.

One new GMS line CISA 2 with yellow flowers, in *desi* cotton has been identified. In *G. arboreum*, new restorer lines CIR 97 P1, CIR97 P3, CIR119 P1, CIR119 P3, CIR126 P1, CIR526 P1, CIR526 P3, CIR 920 P1, CIR 926 P2, CIR 926 P3, CIR 1169 P1 and CIR 1169 P2 have been identified. An intra-*hirsutum* hybrid CSHH 238 and a *G. arboreum* culture CISA 310 ranked first over three years, and have been recommended for agronomic trials for identification.

Intra-*hirsutum* hybrid Mahabeej 106 and intra-*arboreum* hybrid

**SUCCESS STORY**

## Sex pheromones – practical pest-management tools for sugarcane ecosystem

Though resistant varieties are best management tools against pests, complexities of sugarcane genetics and priorities of its breeding mandates make it almost impossible to develop a variety resistant to pest with all other desirable attributes. Even if such a variety is developed, it may not suit all agroclimatic regions wherever target pest is prevalent, and it may not be resistant to other key pests of the region. Pheromones on the other hand, operate across regions and simultaneously tackle different pest species in one and the same trap. Their advantage over bioagents is that, pheromones once identified, can be produced on a industrial scale. As time becomes a minimum barrier for their synthesis, mass production, modification, transportation and storage, it is much easier to handle pheromones. Pheromones are effective round the year and even at low pest densities. They are highly compatible with all components of IPM, are species-specific and safe.

**Internode borer (INB)—*Chilo sacchariphagus indicus* Kapur.** It is a major pest of sugarcane in peninsular India. In recent years, it has modified its feeding habits. It has extended its feeding region in sugarcane from the top tender internodes to the spindle across the apical meristem. In this type of attack, yield and quality loss is severe and jaggery quality is also very poor. Borer economic threshold level (ETL) has fallen below 10% from 25%. The present management practices of detrashing and inundative releases of *Trichogramma chilonis* are not sufficient to contain this pest.

Pheromone trap in sugarcane

**Advantages of pheromones in INB management**

- Economical. The cost of 10 × 4 septa with ten SBI Wuri water-traps may be Rs 400 per acre.
- Detrashing exclusively to manage INB at 5th and 7th months can be dispensed with.
- Timing of *Trichogramma* releases in accordance with moth catch will improve percentage parasitization of INB eggs.

**INB sex pheromones.** INB pheromone has been identified as Z - 13 Octadecenyl acetate and Z-13-Octadecenyl alcohol and is found effective at 7 : 1 ratio in mass attraction of male-moths of INB in field trials.

**Field application.** Synthetic pheromones are impregnated at 3mg strength in rubber septa, which act as lure. Eight to ten water-traps housing synthetic pheromone septa are required for one acre. The traps are suspended at spindle height on 5th month of crop at 30-metre grid. Well propped cane clumps are used as support for suspending traps. At 9th month, trap height is reset to the spindle height, as maximum efficiency was observed at spindle height. A thin film of engine waste oil is added to water in trap to trap and kill moths. The septa are changed at 7th and 9th months and if needed at 11th month. The water-trap is maintained by removing dead moths and recharging with water and engine waste oil at regular intervals to have maximum efficacy.

Mahabeej DH 986 and *G. arboretum* varieties PA 402 and Phule JLA 794 have been notified for commercial cultivation in Maharashtra. Similarly, intra-*hirsutum* hybrids Navkar 5 for the North Zone and Ajeet 90-2 for the Central Zone and the genetic-male sterile based hybrid NACH 6 for the Central and South Zones have been identified for release.

**SUCCESS STORY**

**Economical pest management in cotton through IRM**

Management of insecticide resistance in the American bollworm *Helicoverpa armigera* has been a challenging task. Insecticide resistance management (IRM) strategies were designed with a long-term objective of reducing intensity of resistance of insect to insecticides all-over the country. The strategies emphasize on the efficient use of insecticides to conserve ecosystem for better pest management. These reduced insecticide use by 50–90% with yield increases of 10–25% in Maharashtra, Andhra Pradesh, Tamil Nadu and Punjab.

Encouraged by the IRM strategies, the Government of India has sanctioned a massive programme to popularize IRM in 28 cotton-growing districts of 10 states, which utilize 85% of total insecticides. The IRM strategies are disseminated to farmers through street plays and folk theatre.

During 2004–05, the strategies were implemented in 59,233 hectares in fields of 20,525 farmers of 444 villages in 30 districts of 10 cotton-growing states. The overall benefit due to project implementation was estimated at Rs 4,807 lakh; due to yield increase it was, Rs 3,097 lakh and from reduced insecticide usage, it was Rs 1,710 lakh. Resistance of bollworm to insecticides was found to have decreased tremendously in almost all districts wherever the programme was implemented over a continuous period of 3–4 years. Ready acceptability by farmers has been due to simplicity of the strategies and sustainability of the technology components.

***Crop production:*** Maximum water-use efficiency (2.46 kg/ha-mm) was recorded when greengram was intercropped in cotton, closely followed by (2.40 kg/ha-mm) when blackgram was intercropped and the minimum (2.01 kg/ha-mm) was under control.

Cotton genotypes showed decline in growth and yield beyond 7EC salinity. *G.arboreum* and *G.herbaceum* genotypes exhibited better tolerance to salinity. Tolerant genotypes possessed higher accumulation of proline and higher K/Na ratio.

At Rahuri (Maharashtra), integrated nutrient-management practices in cotton-chickpea crop sequence produced maximum seed-cotton yield. Maximum net monetary returns of Rs 15,668/ha and highest B : C ratio of 1 : 1.59 were recorded with FYM at 5 tonnes/ha + green manure *dhaincha in-situ* + *Azotobacter* + *Azospirillum* + phosphate-solubilizing bacteria (seed treatment).

Sunflower intercropped in cotton in 2 : 1 or 3 : 1 ratio ensured higher seed-cotton yield in assured rainfall areas of Dharwad and cotton : sesamum (3 : 1) produced significantly higher total yield than cotton: castor in Siruguppa. At Bhawanipatna (Orissa), higher net returns ranging between Rs 20,000 and Rs 23,000 per hectare could be realized in cotton–blackgram, cotton–onion and cotton–castor intercropping systems.

***Crop protection:*** Foliar applications on cotton of Confidor (350 SC or 70 WG) and of Clothianidin 50 WDG (Water dispensable granules) were found effective against sap-sucking pests. Polo 50 SC (Diafenthiuron) was found effective in reducing white-fly population. Spinosad (75 and 100 g), NNI 0001, E 237, KN 128, RIL 038 and Karate Zion 5SC showed efficacy against bollworm complex.

Use of talc-powder formulation of *Pseudomonas fluorescens* Pf1 and CHAO at 30,60 and 90 DAS gave effective control of *Alternaria* leaf spot, grey mildew and bacterial blight in Central and South Zones.

**Jute and allied fibres**

***Crop improvement:*** Four varieties of jute and allied fibres have been released and notified for cultivation.

Genetic diversity analyses of some exotic germplasm accessions, released varieties of two cultivated jute species (*Corchorus olitorius* and *C. capsularis*) and two wild relatives of jute were carried out using RAPD, ISSR and STMS markers. All accessions of *C. olitorius* grouped with wild species *C. aestuans* and those of *C. capsularis*

**Modified CRIJAF bast fibre extractor**

The machine helps to extract fibres from canes with broken or unbroken sticks. Canes fed into the machine are subjected to impact load through pedal-activated nylon-roller against

protruded sharp edges of knife. Five to ten canes are fed into the machine, which has an extraction capacity of 25 kg of jute and 15 kg of mesta dry fibres in one hour.

The prototype of the machine has been developed, and it is being popularized now.

**Varieties released and notified of jute and allied fibres**

| Variety | Crop | Yield potential (tonnes/ha) | Salient features | Area of adoption |
|---|---|---|---|---|
| S 19 (Subala) | Jute | 3.6 | Fibre quality grade is $TD_2$, is tolerant to stem-rot, root-rot and anthracnose diseases | West Bengal, Assam, Bihar and Orissa |
| JRC 80 (Mitali white) | Jute | 3.0–3.5 | It is non-lodging type and is tolerant to waterlogging at later stage of growth | North Bengal, Assam, Uttar Pradesh |
| MT 150 (Nirmal) | Mesta | 2.56 (biomass) | It is suitable for paper pulp production | All mesta-growing areas |
| SH 4 (Sailesh) | Sunnhemp | 12 | - | All sunnhemp-growing areas |


*Jute JRC 80 (Mitali white).* It is a non-lodging type and is tolerant to waterlogging at later stage of growth

grouped with *C. trilocularis*; suggesting polyphyletic origin of two cultivated species. This study thus constitute the first report of use of STMS markers in jute and comparative analyses of three different molecular marker systems in intra and interspecific diversity analyses that suggests that germplasm of both species have a wider genetic variability; that can be used in the breeding programme. The varieties, particularly of *C. capsularis*, have a very narrow genetic base. JRO 3352 has been found a good donor for tolerance to *Macrophomina phaseolina*. Wild *Corchorus tridens* was found tolerant to *Macrophomina phaseolina* and *C. pseudo-capsularis* exhibited the finest fibres. National test guidelines for DUS testing of jute have been developed. Characterization of all notified varieties and varieties of common knowledge has been done following DUS test guidelines, and characterization digitalized online software has been developed by the NBPGR.

***Crop protection:*** A virus disease (named as yellow-vein mosaic) results in severe retardation in growth and yield in mesta. The disease is characterized by severe yellow vein mosaic symptoms on leaves of infected plants with reduction in photosynthetic area. Transmission electron microscopy from typical symptomatic leaves has revealed that the disease is associated with a geminivirus (20 nm × 30 nm). The disease is found to be transmitted by whitefly (*Bemisia tabaci*). And is transmitted by cleft grafting but not by sap and seeds of infected plant. The results indicate that associated geminivirus of yellow vein mosaic disease of mesta is a new record of a recombinant geminivirus.

In jute, the highest disease control as well as plant biomass increase was obtained with *Trichoderma. viride* + *Azotobacter*, and the highest fibre yield was obtained from *T. viride* alone, followed by *T. viride* and *Azotobacter*. In mesta, disease control was maximum with *T. viride* + *Azotobacter*, but highest biomass and fibre yield was obtained with *Pseudomonas fluorescens*. The pod formation stage has been identified as the most vulnerable stage of jute-seed infection by black-band pathogen *Botryodiplodia theobromae*.

**Tobacco**

***Crop improvement:*** Cy 135 line fared well with high cured leaf (1,590 kg/ha) with bright leaf (940 kg/ha) and grade index of 1,100 compared to check Hema and II-1624 with cured leaf yield of 1,550 and 1,480 kg/ha, and bright grade leaf of 760 and 710 kg/ha and grade index of 1040 and 780 in southern black soils of Andhra Pradesh.

Ninety lines including Island Gold and A 119 had low level of stem-borer infestation. Karedu was resistant to *Spodoptera litura*.

Genotypes/crosses CU 1097, C110, V 373 C110 × VT 1158, VT 1158 × V 373 and CU 1097 × VT 1158 were found resistant to tobacco aphid; C 110 × VT 1158 to whitefly/leaf curl, CU 1097, C 110, V 373, Hema × CU 1097, VT 1158 × V 373, CU 1097 × 1099/2/4 and C 110 × VT 1158 to budworm *Helicoverpa armigera*; CU 1097 × 1099/2/4, Hema × CU 1097 and VT 1158 × V373 to tobacco caterpillar *Spodoptera litura*.

***Crop production:*** Preparation and application of enriched organic matter utilizing high-grade phosphate rock (PR34/75) by vermicompost or biodynamic methods improved yields of FCV tobacco by 8.6% over control at Kandukur. At Vedasandur, chewing tobacco + Bellary onion intercropping increased net returns (Rs 68,859/ha), B:C ratio (2.53) and gave additional returns (Rs 24,527/ha) compared to sole chewing tobacco.

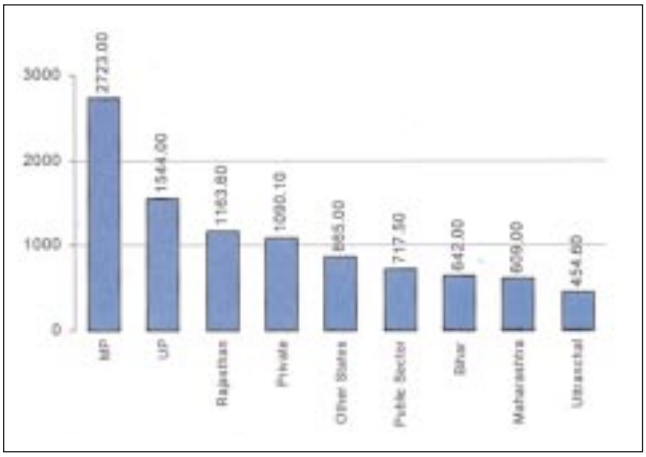
***Crop protection:*** Aqueous leaf extracts of neem, *Pongamia* and *Calotropis* at 4% on tobacco were found highly effective and were on a par with Chlorpyriphos 0.05% against *Spodoptera litura* and leaf curl virus.

*Nomurea rileyi* at $10^{13}$ spores/ha was effective in containing capsule damage (9.5%) caused by *Helicoverpa armigera* in the northern light soils tobacco and also found better than HA NPV 1.5 × $10^{12}$ PI B/ha (17.7%).

*Aspergillus niger* strain 27 ('Kalisena') and a bioagent enriched FYM to soil amended with neem-cake and soil solarization for 4–6 weeks managed soil-borne fungal diseases very well in flue-cured Virginia tobacco nursery; without any supportive fungicide in an eco-friendly way.

## Breeder seed production

In 2004–05, 4,341.21 tonnes of breeder seed were produced; major quantities belonged to oilseeds (1,855.90 tonnes) and cereals (1,701.52 tonnes), followed by pulses (712.09 tonnes), forages (51.53 tonnes) and fibre crops (20.17 tonnes). More than 1,500 tonnes of breeder seed have been produced for state released varieties directly by the centres as per the indent of the respective states.




Breeder seed indent of various indentors for *rabi* 2004–05

## Seed technology

***Seed storage:*** Seed treatment (at 10% seed-moisture content) of paddy hybrids and their parental lines with Thiram at 0.25% reduced fungal flora and maintained their germination above the Indian Minimum Seed Certification Standard (IMSCS) even after 14 months of storage in polylined bags.

Seed treatment of soybean (at 10% seed-moisture content) with Vitavax 200 at 0.25% or Thiram + Carbendazim (0.2% in 1.1 ratio) reduced fungal flora and maintained. Its germination above the IMSCS even after 7 months of storage in polylined bags.

Fabric - surface or soak treatment with Deltamethrin at 125 ppm or Bifenthrin at 125 ppm proved effective in protecting seed stored in it under ambient conditions for one sowing season (6–9 months).

For sorghum, groundnut and pearl millet, pre-sowing seed hydration (16–18 hr) and drying at room temperature to normal moisture content of seed, followed by dry dressing with Thiram at 0.2% was effective for their rapid and uniform field emergence and establishment.

***Seed health:*** In soybean, deep-freeze blotter method is recommended for detection of *Colletotrichum dematium* and *Macrophomina phaseolina* and standard blotter method for *Fusarium oxysporum*. Both the methods are in accordance with the International Seed Testing Association (ISTA) protocols.

## Seed processing

- Safflower (Bhima), sunflower (Morden, KBSH 1, its parental lines 6D 1 and CMS 234A), gram (Chaffa), mungbean (Asha, Muskan), paddy (Pusa 44, PNR 381) and maize (Early composite), must be processed through multi-stage seed

**Standardized sieve sizes for screen grading of different crop varieties**

| Crop | Genotype | Recommended screen size |
|---|---|---|
| Sunflower | KBSH 1 | 2.8 mm (s) |
| | RHA 6D1 | 1.85 mm (s) |
| Ragi | GPU 28 | *1.20 mm (r)* |
| Soybean | JS 335, MACS 13, PK 472 | |
| | MACS 124 | 3.6 mm |
| Safflower | Bhima, Girna, Tara, Sharda | 2.4 mm |
| Sunflower | CMS 2A, CMS 2B | 1.6 mm |
| | AK 1R | 1.4 mm |

processing comprising at least the seed cleaner-cum-grader and specific-gravity separator.

- Seed drying in the direct sunshine needs to be discouraged. Shade drying and mechanical drying below 40°C air temperature proved conducive in terms of reasonable drying rate, seed quality and storage performance in sunflower, groundnut-pods, paddy and pigeonpea.

***DUS project:*** National Test Guidelines for Distinctness, Uniformity and Stability (DUS) have been developed for 35 economically important crops. More than 1,000 crop varieties have been characterized as per the DUS test guidelines and the data of these crop varieties have been digitalized. The softwares for digital library and data analysis have been developed.

### *Puccinia spegazzinii*, a fungal biocontrol agent, ready for release in Kerala and Assam

Host-specificity tests involving 74 plant species have been completed for *Puccinia spegazzinii*, the rust pathogen of the weed *Mikania micrantha*. The permit was issued on 27-06-2005 for its limited field release in Kerala and Assam. The rust

*Mikania micrantha* infected with *Puccinia spegazzinii*

*Mikania micrantha* invading teak plantation in Kerala

has been bulked up on *M. micrantha* in quarantine, and is ready for transportation to Kerala and Assam. Once released, India would become the eighth country in the world to have released a fungus as a classical biological control agent against a weed.

- A website hosted on the Indian Coccinellidae and its natural enemies with image galleries of species
- Developed a computer-aided dichotomous key for 10 common Indian species of *Chilocorus*
- Recorded *Oenopia excellens* (crotch) and *Prototheа quadripunctata* (Mulsant) from north-eastern region and one new species of *Pseudoscymnus* from Bangalore
- Standardized a technique for shipping *Telenomus remus* cards
- Talc-based formulation of *Steinernema carpocapsae* found suitable and stable for surface transport
- Developed a simple magnetic stirrer technique for faster mass production of *Hirsutella thompsonii*
- Successfully produced Monocrotophos and Dicofol resistant strains of *Neoseilus longispinosus*
- Common myna, common swift and cattle egret reduced swarming caterpillar larvae, stem borers and grasshoppers by 20–30% in harvested paddy fields
- Developed a new formulation of bromadiolone that resulted 80% mortality of *Rattus rattus* within 5–10 days

### Indigenous Bt strain

A strain of *Bacillus thuringiensis* from Pantnagar among six samplex tested, has exhibited highest toxicity against *Plutella xylostella* in cabbage-leaf bioassay.

## Biological control

***Rearing and evaluation of natural enemies:*** A technique for shipping *Telenomus remus* cards in ventilated plastic boxes fixed with polystyrene strips with slits has been standardized. The total cost of 50 cards to be applied in a hectare would be Rs 200. The best parasitoid density for producing *Campoletis chlorideae* at 26–28°C and 70–80% relative humidity

### Predators of sugarcane woolly aphid *Ceratovacuna lanigera*

*Micromus igorotus* was recorded feeding on *Ceratovacuna lanigera* and could be bred on other aphid hosts. *Mallada desjardensi* (Chrysopidae), *Spalgis epeus* (Lycaenidae),

***Mass production of Cryptolaemus montrouzieri:*** *Cryptolaemus montrouzieri* could be mass reared successfully on *Sitotroga cerealella* eggs with a mean percentage pupation of 67.57% and adult emergence of 84%.

*Cryptolaemus montrouzieri* and *Synonycha grandis* (Coccinellidae) were found as other predators of sugarcane woolly aphid (SWA) recorded in sugarcane fields of Karnataka. Field multiplication technique to produce *Dipha aphidivora* has also been standardized and extensively recommended.

in cages measuring 1.7' × 1.7' × 2.5' was 5–8 with an yield of five females/female. Anthocorid *Orius tantillus* could be best reared at 24°C with a progeny production of 28.8 per female. Releases of *Trichogramma embryophagum* and *Trichogramma chilonis* against *Opisina arenosella* at 1,000 to 4,000/palm reduced larval population by 77.8 to 100%. *Trichogramma brasiliense* and *Trichogramma chilonis* evaluated against *Earias vittella* have revealed that at 5 pairs each for 50 eggs caused 46.7 and 41.3% parasitism, respectively; showing their promise for field evaluation.

***Artificial diets for parasitoids, predators and host insects:*** The anthocorid *Orius tantillus* could be successfully reared on a combination of an artificial diet with maize pollen and beans. Toddy-palm-leaf powder-based artificial diet was suitable for rearing *Opisina arenosella* with 73.2% pupation and 66.2% adult emergence. Cabbage leaf powder and defatted soya-based artificial diet could be successfully used for rearing *Plutella xylostella*.

***Insect viruses in biological control:*** NPV at $10^5$–$10^9$ POBs/ml caused up to 90% mortality of late second instar larvae of *Crocidolomia binotalis*. The virus was not cross-infective to *Bombyx mori*, *Helicoverpa armigera*, *Spodoptera litura*, *Plutella xylostella*, *Hellula undalis*, *Trichoplusia ni*, *Spodoptera exigua*, *Chilo partellus*, *Galleria mellonella*, *Corcyra cephalonica*, and was also found safe to predators, *Chrysoperla carnea* and *Cryptolaemus montrouzieri*.

Starch (1%) and crude sugar (10%) could be used as adjuvants with Ha and Sl NPVs resulting in increased mortality of *Helicoverpa armigera* (87.6%) and *Spodoptera litura* (94.3%) respectively on the first day.

***Isolation of endophytic bacteria:*** *Bacillus megaterium*, *Bacillus circulans*, *Enterobacter agglomerans* and *Erwinia herbicola* isolated from atmosphere of the plants caused 8–16% enhanced growth in chickpea and pigeonpea and also showed inhibitory activity against root-rot pathogens.

***Antagonists against plant diseases:*** Among 28 isolates of *Trichoderma harzianum*, 6 have been found inhibitory for *Sclerotium rolfsii* and four for *Macrophomina phaseolina*.

Talc formulations of *Trichoderma harzianum* and *T. viride* with 2 or 5% pure chitin had higher number of viable colony forming units (CFU) than formulations without chitin for up to 3 months of storage.

Wider C : N ratios in production medium (10 : 1 and 15 : 1) resulted in good sporulation and viable propagules during storage in *Tricboderma harzianum* and *T. viride*. Addition of glycerol in production medium at 3–9% and or heat shock at 40°C for 30 minutes during stationary phase of growth also gave more CFU counts during storage for up to 2–3 months.

Cow-dung was found ideal for multiplying *Pseudomonas fluorescens* at 32°C and 40% (w/w) moisture level. Biopriming of pea-seeds with PBA 3 improved seedling stand and increased yield of organically grown pea when applied as foliar spray. Seed treatment with different isolates of *Pseudomonas*, *Trichoderma harzianum* and *T. virens* resulted in 13.9–72.2, 4.7–52.2 and 15.5–41.3% suppression in sheath blight of rice.

***Entomopathogenic nematodes:*** Higher yield of 2.50 lakh was obtained at 1,000 ijs of *Steinernema carpocapsae* per larva of *Galleria mellonella* within 6 days, and 300 ijs of *Heterorhabditis indica* gave maximum yield of 6.50 lakh within 10 days. Two isolates of *Steinernema carpocapsae* and *Heterorhabditis indica* tested for shelf-life have been found viable for 3 months. Talc-based formulation of *Steinernema carpocapsae* was found suitable and stable for surface transport.

***Pathogens for biological suppression of phytophagous mites:*** Oatmeal agar (OMA mycelial) discs were found best inoculum in Sabouraud dextrose broth (SDB) continuous shake culture for production of *Hirsutella thompsonii*. A simple magnetic stirrer technique for faster mass production of *Hirsutella thompsonii* has been developed. Mycohit (50 g/litre) at 14 days after first and second sprays reduced population of *Tetranychus urticae* on *bhindi* by 45.65–62.72%.

***Biological suppression of plant-parasitic nematodes:*** *Pochonia chlamydosporia* from the grape vineyards around Bangalore effectively controlled reniform and root-knot nematodes.

***Biological suppression of crop pests:*** *Food crops: Trichogramma japonicum* (1 lakh/ha) was as effective as *Trichogramma chilonis* in controlling leaf folder, and so could be used both for stem borer and leaf folder in rice. Seven combined releases of *Trichogramma chilonis* and *Trichogramma japonicum* each at 100,000 per hectare at weekly interval, starting

*Encarsia flavoscutellum* has been observed as a parasitoid of sugarcane woolly aphid at Jorhat

at 30 days after transplanting proved effective against leaf folder and stem borer in organically-grown rice.

*Commercial crops: Encarsia flavoscutellum* was observed as a parasitoid of sugarcane woolly aphid (SWA) at Jorhat. *Dipha aphidivora* was predominant in parts of Andhra Pradesh, where no insecticides were used. Two releases of *Micromus igorotus* (100 pupae/release) were found sufficient in bringing down population of SWA within 45 days.

At PAU, 8 releases of *Trichogramma chilonis* at 50,000/ha at 10 days interval during mid-April to end-June, 6 of *Trichogramma japonicum* during May–June at 50,000/ha and 12–14 releases of *Trichogramma chilonis* at 7–10 days interval during July–October at 50,000/ha proved effective against sugarcane borers *Chilo infuscatellus*, *Scirpophaga excerptalis* and *Chilo auricillus* respectively.

At Rajahmundry, sequential releases of *Telenomus remus* at 50 per two square metres and *Chelonus formosanus* at 10 per two square metres resulted in higher parasitization of *Spodoptera exigua* and lesser seedling damage in tobacco nurseries.

*Pulse crops: Heterorhabditis* sp. at 1.5 billion nematodes/ha was found best in managing *Helicoverpa armigera* and blister beetle on pigeonpea. A BIPM package consisting of release of *Telenomus remus* and sprays of SlNPV against *Spodoptera litura* in soybean resulted in 17% more yield than chemical control at Rajahmundry.

*Oilseed crops: Ischiodon scutellaris* at 1,000 adults/ha (50,000 larvae/ha) reduced *Lipaphis erysimi* population on mustard and gave higher yield at Anand.

**Honeybee research**

In sesame cv. Uma, the activity of forager, *A. cerana indica*, predominated despite incessant rains during flowering stage (270.3 mm), and constituted the major proportion (11.0%) among foragers. A carpenter bee *Xylocopa fenestrata* constituted 9.0% of the total flower visitors.

***Queen rearing:*** Cells grafted in *A. mellifera* colonies, for their requeening, using vertical queen excluders, yielded 19.35% success. Half of these colonies superseded the older queen bees.

***Bee toxicity:*** Toxicity of recommended insecticides to *Apis mellifera* in *Brassica* is in the following order Imidacloprid > Chlorpyriphos > Quinalphos > Monocrotophos > Metasystox > Endosulfan.

***Studies on Trigona:*** The colonies of *Trigona irridipennis* in small wooden-box and earthern-pot were found developing appreciably than in bamboo. Foraging by bees was conspicuous between April–May in colonies hived in small wooden-box, which was found better than earthern-pot.

**Agricultural acarology**

*Polyphagotarsonemus latus* (yellow mite) severely damaged sesame in Gujarat and Punjab, and *Oligonychus oryzae* and *Stenotarsonemus spinki* were severe on rice in Tamil Nadu, Uttar Pradesh and Gujarat.

Among chilli varieties, KA 2 in Karnataka, Jwala, RHRC Erect and AEG 77 in Gujarat and Indam 10 in West Bengal have showed less susceptibility to yellow mite.

Studies on the role of plant architecture on the predatory efficiency of *Neoseilus longispinosus* revealed that bushy nature of plants aid in faster suppression of spidermites. Efforts to produce Monocrotophos and Dicofol resistant strains of *Neoseilus longispinosus* have been successful; strains resistant to recommended concentrations of pesticides have been developed.

**Nematode management**

***Hot spots of major nematode diseases:*** Hot spots for white-tip nematode, *Aphelenchoides besseyi*, infesting paddy, a seed-borne nematode in Gujarat and West Bengal; *Pratylenchus thornei* in chickpea in Uttar Pradesh; root-knot nematode infecting citrus and cotton in Gujarat and Haryana respectively have been identified.

***Management technology of root-knot nematode:*** Root-knot nematode *Meloidogyne incognita* of tomato at farmer's

**SUCCESS STORY**

**Nematodes management in various crops**

**Cotton**

An ecofriendly and economically viable nematode management technology against root-knot nematode in cotton, devised by Hisar centre by using a rhizospheric rhizobacteriun *Gluconacetobector diazotrophicus* strain 35–47 as seed treatment at 200 g of wood charcoal-based bacterial culture having $1 \times 10^8$ bacterial cells/g of charcoal powder/4–5 cotton-seeds, was effectively demonstrated at the farmer's field (Shri Jit Ram, village, Gabipur Barwala, Distt. Hisar) for 3 consecutive years 2001–03. Seed treatment with bacterium led to 56.5% mean higher cotton yield in root-knot nematode affected fields over check, and was highly cost-effective with cost: benefit ratio of 1 : 191.2. This technology is simple to apply, and has been included in the package of practices of CCS HAU, Hisar, for adoption by the farmers.

**Pigeonpea**

To minimize losses caused by pigeonpea cyst nematode (*Heterodera cajani*) in Tamil Nadu, a management technology in the form of combined treatment of *Pseudomonas flourescens* + *Trichoderma viride* at 5 + 5 g/kg of seed was demonstrated which led to 32.5% decrease in *Heterodera cajani* population in the soil and 37.1% increase in the grain yield.

field located at Madampatti village of Tamil Nadu was managed by raising crop nursery in solarized beds treated with Carbofuran 3G at 10 g/m$^2$, followed by transplanting in the main field treated with neem-cake at 500 kg/ha. This resulted in significant increase in yield 46.4% and reduced nematode population up to 56% over control.

Chickpea genotypes C 24, C 42, C 49; rajmash genotype R 7; pea genotypes FP 2, FP 12, FP 13. FP 18, FP 21, FP 28, FP 29, FP 30, FP 36 and FP 37 and lentil genotypes LE 8, LE 15, LE 16, LE 17, LE 23, LE 32 confirmed resistance against *Meloidogyne incognita* and *M. Javanica*.

Plant-parasitic nematode infecting mung crop was managed with seed soaking in Carbofuran (25 EC) at 0.1% and seed dressing at 3% w/w with Carbosulfan (25 SD) that resulted in significantly higher yield over control. Maximum yield was recorded with higher dose of Carbosulfan as seed soaking treatment. Root-knot nematode in groundnut was managed by soil application of neem-cake at 1,000 kg/ha + neem oil at 5 litres/ha + Carbofuran at 1 kg a.i./ha that reduced root-knot nematode index and registered 42.9% increase in crop yield.

**Pesticide residues management**

Supervised field trials of Oberon 240 SC (Spiromesifen) a new non-systemic insecticide and acaricide were conducted on eggplant, chilli and tea at the recommended dose (96 g a.i./ha) and its residues were found below detectable limit (BDL) on 15, 15 and 7 days, respectively. Residues in cotton-lint and seed were non-detectable after 1 picking when sprayed at 120 g a.i./ha.

Confidor 350 SC and Confider 70 WG (Imidacloprid) were sprayed on paddy at of 26.25 and 24.50 g a.i./ha. No residues were found at harvest in rice-grain, husk, straw and soil. In cotton, no residues were detected in lint and seed at 1 picking when Confidor 70 WG was applied at 35 g a.i/ha.

Nurelle-D (505, EC), a combination product of Chlorpyriphos and Cypermethrin (50% + 5%), was evaluated on chilli in different agroclimatic conditions of the country. The residues of both were non-detectable after 15 days.

Tricontanol 0.05% EC was applied on potato at of 0.25 g a.i/ha and residues were not detected at harvest in potato as well as in soil. No residues of Tracer 45 SC (Spinosad) were detected at harvest on pigeonpea when applied at 73 g a.i./ha.

**Whitegrub management and other soil arthropods**

***Management of soil arthropods by chemicals:*** In soybean at Ranichauri, Imidacloprid 200 SL (60 g a.i./ha) was found promising against whitegrubs *Holotrichia longipennis*, when applied as the standing-crop treatment.

At Durgapura, in groundnut, seed treatment with Imidacloprid 70 WS at 1.4 g a.i./kg of seed and soil-furrow application of Imidacloprid 0.75% G at 56.25 g a.i./ha were found effective against whitegrubs *Holotrichia consanguinea*. Seed treatment with Quinalphos 25 EC (4 ml/kg of seed), Thiomethoxicam 70 WS (2.0 g/kg of seed) and Thiomethoxicam 25 WG (4.0 g/kg of seed) proved promising against whitegrubs *(Brahmina coriacea)*; resulting in reduced plant mortality in off-season pea in Sangla valley (Distt Kinnaur), Himachal Pradesh.

***Effect of pesticides on non-targeted soil microarthropods:*** Pesticide application causes harmful effects on the non-targeted soil arthropods like collembola (soil insect) and soil mites. Quinalphos, Chlorpyriphos and Imidacloprid as soil treatment for whitegrub management at Palampur declined collembolan population by 30, 42 and 9%. However, at harvest, population of these micro-arthropod recovered, and reduction in all these insecticidal treatments ranged between 4 and 12%.

Chlorpyriphos 20 EC at 800 g a.i./ha and Imidacloprid 200 SL at 60 g a.i./ha) were applied in the standing crop of barnyard millet in July against whitegrubs. Adverse effects of insecticides on soil mites and collembolans were observed only for two months.

**Agricultural ornithology**

At Ludhiana, bird damage to germinating late-sown wheat-crop in fields with preceding sesame crop was to extent of 38–95%. The rose-ringed parakeet and small green barbet caused 12% damage to maturing *bhindi* cultivated as intercrop in Kerala. Koel, bulbul and barbets caused damage to the extent of 16% in pepper crop during vulnerable berry stage.

***Ecofriendly birds management:*** In field experiment at Kerala, botanicals *Andrographis paniculata*, *Annona squamosa* and *Ipomoea cornea* at 10% concentration showed 78–91% reduction in depredation rate of birds in the rice nursery and main field. In Andhra pradesh, the main crop of maize could be protected from bird damage by using fodder maize (1,995 kg/ha) and fodder sorghum (1,452 kg/ha) as border screen crop, as compared to control (1,211 kg/ha). In Andhra Pradesh, the bird management modules such as net recorded higher yield (1,458 kg/ha), followed by ribbon (1,236 kg/ha), botanical sprays (990 kg/ha), and lowest yield of 540 kg/ha was recorded in untreated control; along with 48% reduction in depredatory birds' population.

***Beneficial birds in suppression of insect/rodent pests:*** In harvested paddy fields, common myna, common swift and cattle egret reduced 20 to 30% swarming caterpillar larvae, stem borer and grasshoppers. In pigeonpea, NPV + bird perches showed higher yield (1,542 kg/ha) than control (1,094 kg/ha) in Andhra Pradesh. In the food analysis of spotted owlet, for the first time has been identified appendages of scorpion *Bufo melanosticus* and remnants of bats. In Andhra Pradesh, for the first time, range

extension of Isabelline chat (*Oenanthe isabelline*) was recorded and found feeding voraciously on *Helicoverpa armigera* on pigeonpea.

***Location-specific studies:*** Piscivorous birds, little greeb, kingfisher, cormorants and little egrets caused 15–25% damage to fingerlings of prawns in Coastal aquaculture areas of Andhra Pradesh. In Gujarat, 19% Sarus-crane juveniles were recorded in the population, which indicate successful breeding in the preceding monsoon.

**Rodent control**

***Rodent ecology and behaviour:*** *Rattus rattus* (8.09%) *Golunda ellioti* (2.94%), *Mus booduga* (2.20%) and *Millardia meltada* (0.74%) were other prevalent rodent species besides *Tatera indica* (63.97%) and *Funambalus pennati* and *M. musculus* (11.03%) in a study on effect of land-use pattern on rodent species. The truly desertic rodent fauna, *M. hurrianae* and *Gerbillus gleadowi* were not reported during this year, indicating their total replacement by other species due to changes in land-use pattern and urbanization of the study area. The sex ratio of all the species trapped was in favour of males excepting for *M. booduga*. Like previous years, the fruit orchards recorded higher rodent population of 39.71%, followed by agri-pasture (32.35%) and silva-pasture fields (27.94%). Among these, *Funambalus pennanti* was mainly trapped from *ber* and pomegranate orchards and *Tatera indica* was trapped from all the three habitats almost uniformly.

***Rodent management:*** *Rodenticidal formulation:* Developed a new formulation of bromadiolone by adding plaster of paris, wheat, sugar, oil and bromadiolone BC in ratio of 20 : 68 : 4 : 4 : 4 that yielded 80% mortality of *Rattus rattus* within 5–10 days.

*Rodenticidal evaluations:* Pearl millet-based coumatetralyl baits (0.0375%) yielded cent percent mortality of *Bandicota bengalensis* after 3 days exposure in choice and nochoice tests. Cholecalciferol, a vitamin D3-based compound, at 40–60 mg/kg dosage caused 50% mortality of house-rats within a week's time.