2002-07

Research Achievements of AICRPs on Crop Sciences

Indian Council of Agricultural Research
Directorate of Information & Publications of Agriculture
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Contents

All India Coordinated Cotton Improvement Project

1.	**Title of the Project**	:	**All India Coordinated Cotton Improvement Project**
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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years):

Research Achievements (2002-2007)

Crop Improvement

- During the year 2002 to 2007, many high yielding cotton varieties and hybrids have been released for commercial cultivation catering to specific needs and possessing special characteristics. Most of these varieties/hybrids are capable of yielding 18-25q/ha.

- Development of new hybrids/ varieties for North zone viz: F-1861, LH-1556, RG 18, Vagad Kalyan, CISAA 2, CISA 310, HD 324, H 1226 , H 1117, H 1098 , HHH 223, AAH-1, RS 2013, RS 810

- Development of new hybrids/ varieties for Central zone viz: G.Cot.Hy-10, G.Cot.23, G Cot 21, Phule 492, Phule 388, JK-4, AKA-8, AKA-7, NH-545, NH-615, NH-630, PKV Hy.5, PH-348, PA-255, PA-402, Parbhani Turab

- Development of new hybrids/ varieties for South zone viz: MCU 13, Narasimha, Veena, DHH-11

The details of the some of the varieties/hybrids are presented below.

Name	**Species**	**Year**	**Institution**	Area Adopted
Bunny	*H x H*	2001	Nuzuvedu seeds	Private R & D
H 1117	*G. hirsutum*	2002	CCSHAU, Hisar	Haryana
HHH 223	*H x H*	2002	CCSHAU, Hisar	Haryana
RS 2013	*G. hirsutum*	2002	RAU,	Rajasthan
JK 4	*G. hirsutum*	2002	JNKVV, Khandwa	Madhya Pradesh
G. Cot.23	*G.*	2002	GAU, Surat	Gujarat
Phule 492	*H x H*	2002	MPKV, Rahuri	Maharashtra
Phule 388	*H x B*	2002	MPKV, Rahuri	Maharashtra
VICH 5	*H x H*	2002	Vikram Seeds	Private R & D
PHV DH 1	*G.arb x G.arb*	2004	Dr. PDKV, Akola	Maharashtra
Parbhani Turab	*G.arboreum*	2004	MAU, Nanded	Maharashtra
PA 141	*G.arboreum*	2004	MAU, Nanded	Maharashtra
Pratap Kapi	*G.herbaceum*	2004	MPKVV, Banswara	Rajasthan
Veena	G.arboreum	2004	ANGRAU, Mudhol	A.P.
CSHH-198 Shresth)	G.hir x G.hir	2004	CICR, Sirsa	North zone
CISAA-2 (CICR-2)	*G.arb x G.arb*	2004	CICR, Sirsa	North zone
PKV DH - 1	*G.arb x G.arb*	2004	Dr.PDKV, Akola	Maharashtra
PKV Hy.5	*G.hir x G.hir*	2004	Dr.PDKV, Akola	Maharashtra
NH.545	*G.hirsutum*	2004	MAU, Nanded	Maharashtra
Raj DH 9	*G.arb x G.arb*	2005	RAU,Sriganganagar	Rajasthan
HD 324	*G. arboreum*	2005	HAU, Hisar	Haryana
MCU 13	*G. hirsutum*	2005	TNAU, Coimbatore	Tamil Nadu
HHH 287	*Intra*	2005	CCSHAU, Hisar	Haryana
Dhruv	*G. hir x G. hir*	2006	Ms Zuari Seeds	Central Zone
CISA 310 (CICR 1)	*G. arboreum*	2006	CICR (RS), Sirsa	North Zone
CSHH 238 (Kalyan)	*G. hir x G. hir*	2006	CICR (RS), Sirsa	North Zone
CSHH 243	*G. hir x G. hir*	2007	CICR (RS), Sirsa	North Zone

Cotton Crop Production technologies by AICCIP:

- Use of *Azospirillum* and *Azotobacter* was found beneficial in supplementing nitrogen needs of the cotton crop by 20-30 Kg/ha

- In the insecticide seed treatment experiment the seed treatment either by imidacloprid or thiamethoxam both @ 7.5 g/ kg cotton seed supplemented with application of 75 kg N/ha produced maximum seed cotton yield under rainfed condition in central zone.
- Use of weedicides like fluchloralin @ 1 Kg a.i./ha, Pendimethalin @ 1.5 Kg a.i./ha with interculture at 35 days after sowing was seen at par with manual weeding practice
- Ridges and furrow system of sowing; Drip irrigation with fertigation for saving irrigation water and to improve seed cotton yield by 25% in southern zone
- Detopping of apical bud under irrigated conditions ensures better development and retention of late-formed bolls besides arresting further vegetative growth.

- High yielding *G.herbaceum* cotton genotypes RAHS14, G.Cot.21 and *desi* hybrids G.Cot DH 7 and G.Cot.DH 9 were seen well adapted to coastal areas of the country with yield levels ranging from 10- 25 q/ha due to better physiological and biochemical adaptability attributes.

Seed rate, spacing and plant population for different species of cotton in three zones identified under AICCIP.

Species	Growing condition	Cotton Zone	Seed rate (acid delinted) (kg/ha)	Spacing (cm)	Plant population (per ha)
G. hirsutum	Irrigated	Northern	8-10	75 x 15	88,900
		Southern	8-10	75 x 30	44,444
			8-10	75 x 45	33,000
	Rainfed	Central	8-10	60 x 30	55,600
		Southern	8-10	60 x 30	55,600
			8-10	45 x 30	74,000
G. arboreum and *G. herbaceum*	Irrigated	Northern	6-8	60 x 30	55,600
		Central	10-12	60 x 30	55,600
	Rainfed	Central	10-12	45 x 60	88,900
		Southern	10-12	60 x 30	55,600
G. barbadense	Irrigated	Southern	8-10	90 x 30	37,000
Hybrids (Intra and Inter specific)	Irrigated	Southern	2.0-2.5	90 x 30	37,000
				90 x 45	24,690
				90 x 60	18,518
		Central	2-3	120 x 40	20,883
				120 x 60	13,888
				90 x 30	37,000
				90 x 45	24,690
				90 x 60	18,518
				90 x 75	14,815
				150 x 60	11,111
				120 x 80	8,333
	Rainfed	Central	2.0–2.5	150 x 60	11,111
		Southern	2.0-2.5	120 x 60	13,900

Crop Protection

Thiodicarb 75 SP @ 750 gai/ha and lambdacyhalothrin 5 EC @25 gai/ha found most effective against the pink bollworm.

Different chemical insecticides were tested against the cotton pests. Among these seed treatment with imidacloprid 70 WS @ 7.5 gai/ha, thiamethoxam 70 WS, Poncho 600 FS, thiamethoxam 350 FS @ 3 g ai/kg seed were found effective in controlling the sucking pests whereas lambdacyhalothrin 5 % EC @20 g ai/ha, karate 5 % EC @15 and 20 g ai/ha, spinosad 45 SC @ 75 g ai/ha and indoxacarb 14.5 SC @ 75 g ai/ha etc were found best against the bollworms.

Diafenthuron (polo) 50 SC @ 400 g ai/ ha has been found effective in checking the incidence of whiteflies

Thiodicarb 70 SP (750 g ai/ ha) and Profenophos 50 EC (500 g ai/ ha) have been found most promising for pink bollworm management.

The main components of IPM technologies developed for cotton by AICCIP are:

- Deep summer ploughing to expose soil borne pests, pathogens and their destruction
- Avoiding monocropping and proper crop rotation, selection of pest resistant cultivars
- Using certified acid delinted seeds for good plant stand and preventing seed borne diseases causing organism and pink bollworm
- Seed treatment with Imidacloprid to prevent the early season sucking pests and Trichoderma to prevent seedling rot
- Monitoring with pheromone traps and assessment of pest population through scouting and ETL based application of appropriate technology to reduce the pest build up
- Application of biopesticides (Trichogramma, neem, NPV) in the early phase of the crop growth. Phased application of proper pesticides ensuring correct dosage and coverage depending upon the pest and age of the crop
- Adoption of recommended agronomic practices ; Avoiding closer spacing, high dose of nitrogenous fertilizers and excess irrigation
- Inter cropping with cowpea/sorghum/soybean to enhance the natural enemy population of cotton pests and to diversify the cropping system
- Trap cropping of castor for Spodoptera and okra/pigeon pea for Helicoverpa
- Hand collection and destruction of grown up larvae and damaged plant parts etc
- Cotton leaf curl virus disease has been introduced from the neighbouring cotton growing country into western part of Punjab and Rajasthan few years ago
- IPM strategy consisted of Sex pheromone, release of Trichogramma and spraying of neem based insecticides and need based synthetic insecticides. This proved to be effective in managing cotton pest complex
- Basal application of neem cake at 150 kg/ha coupled with drenching 1% neem oil helped in minimising stem weevil damage
- Major emphasis is given for developing varieties/hybrids resistant to key pests
- Role of egg larval parasite- Chelonus blackburni- in control of bollworms was established
- Growing of intercrops like cluster bean and Maize reduced pest infestation in Andhra Pradesh
- Cotton intercropped with cowpea blackgram and greengram had lesser incidence of jassids and bollworms
- *Flavobacterium* sp. was found effective in control of bacterial blight

Following genotypes have been identified for their pest and disease tolerance and have been appropriately deployed in the resistance breeding programme for development of multi adversity resistance lines with better yielding ability for different regions

Biotic Stress	Variety	Zone
White fly	Abadhita, LK 861, Kanchana, Supriya	South zone
Boll worm	Abadhita	South zone
Cotton leaf curl virus disease	LHH 144, CSHH 198,RS 810, RS 875, RS 2013, F 1861, H1117	North zone

Fusarium wilt	G Cot 13, Eknath, Rohini	Central zone
Bacterial Blight	Arogya	Central zone
Verticillium wilt	MCU 5 VT, Surabhi	South zone

Recommendations for the Management of Diseases

Disease	Recommended fungicide/bactericide/bioagents
Root rot	Seed treatment with carboxin 200 wp @3 g/kg seed Trichoderma viride talc formulation-seed treatment @ 10g/kg seed plus soil amendment @ 2.5 kg/ha
Bacterial blight	Strepto cycline (100 ppm) + copper oxychloride (0.3%) as foliar spray at an interval of 10 days
Alternaria leaf spot	Dithane M 45 or copper oxychloride as foliar spray twice at an interval of 10 days
Grey mildew	Carbendazim/ Prochloraz/ Propiconazole 0.1% as foliar spray
Myrothecium leaf spot	Carbendazim/ Copper oxychloride as foliar spray

Biological control

Several antagonistic organisms were evaluated for the management of Root Rot and foliar diseases of cotton. *Trichoderma harzianum* has been found to control the root rot effectively in northern cotton growing states such as Rajasthan and Haryana. This species is also recommend as for seed and soil application just before sowing. Commercial formulations containing *Trichoderma* are readily available this purpose. *Flavobacterium* and *Pseudomonas fluorescence* have been found effective in the control of bacterial blight.

Location specific IPM modules were tested at different centres of AICCIP in all the three zones and indicated the following advantages of IPM Module.

- Incidence and damage of pest was less
- Activity of Natural enemies was more
- Number of sprays were reduced by 50 %
- The Net income and cost benefit ratio were higher in the range of 1:2.5
- Foliar application of Imidacloprid 35SC, Clothianidin 50WDG, diafenthiuroin (Polo 50SC) were found effective against Sap Sucking insect pests. Emamectin benzoate, KN 128, Spinosad, RIL 038 and Karate zion 5CS were all found effective in controlling boll worm complex.

All India Coordinated Small Millets Improvement Project

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Sl.No.	Crop	Name of the variety
1.	Finger millet	GPU 45, Chillika OEB 10, TNAU 946, VL 315 & GPU 48
2.	Foxtail millet	Meera (SR 16), Sri Lakshmi, Prathap kangni 1 (SR 1), SR 51, PRK 1 & TNAU 196
3.	Kodo millet	Jawahar kodo 48 (JK 48) & KK 2
4.	Barnyard millet	VL Madira 181
5.	Little millet	Tarini (OLM 203), Kolab (OLM 36) & OLM 20
6.	Proso millet	GPUP 8 & GPUP 21

Crop Production

- Double cropping of short duration finger millet in *kharif* followed by either horsegram/niger is a better option and remunerative for Jharkhand.
- Sequence cropping of finger millet and soybean in *kharif* followed by oats/wheat in rabi are profitable options for Uttaranchal.
- Pre emergence application of isoproturon @ 0.5kg a.i./ha for drilled ragi whereas oxyflurofen @ 0.1 kg a.i./ha for transplanted irrigated ragi is a better choice for controlling weeds effectively.
- Transplanting finger millet is more suitable and profitable under very delayed sowing conditions.
- Application of poultry manure to supply 100 % recommended nitrogen is a remunerative practice at Bangalore whereas pine needle compost (3.75 t/ha) along with rock phosphate and gypsum were a better choice for maximizing productivity.

- Application of 7.5 t FYM/ha and rotating either with ground nut or maize with recommended inorganic fertilizers is remunerative practice for targeting higher production in ragi based cropping system at Bangalore.
- Intercropping of medium duration compact erect types of pigeon pea was an ideal choice and remunerative for growing ragi in Karnataka, Tamil Nadu and coastal Andhra Pradesh. Whereas, short duration pigeon pea with medium duration finger millet was a better option for Orissa.
- Inter cropping field bean in finger millet (1:8) was a remunerative practice for Karnataka, adjoining areas of Tamil Nadu. Whereas, cluster bean as an inter crop in finger millet was a better choice for coastal Andhra Pradesh and Orissa.
- Strip cropping of finger millet 2/3rd and pulses 1/3rd is a better option at Bangalore, whereas inter cropping of finger millet and pigeon pea (8:2) is an alternative choice at coastal Andhra Pradesh, northern Bihar and parts of Tamil Nadu.
- Inter cropping foxtail millet and redgram/cotton/vegetable cowpea is a remunerative system for Rayalaseema regions of Andhra Pradesh and northern Karnataka.
- Pre emergence application of isoproturon @ 0.5 kg a.i./ha was found effective both in controlling weeds and enhancing productivity of foxtail millet.
- Integrated nutrient supply of organics and inorganics (25 per cent each) along with bio fertilizer seed inoculation is a remunerative practice under low fertility conditions.
- Niger – soybean – kodo or kodo – soybean – kodo are remunerative crop rotations for skeletal soils of Dindori.
- Pre emergence application of Isoproturon @ 0.5 kg a.i./ha was found ideal and effective for maximizing productivity and weed control in kodo millet.
- Inter cropping of little millet and cowpea either in 1:2 or 2:1 is profitable both at Kanke and Rewa centres.
- Harvesting little millet at physiological maturity was found to minimise yield loss.
- Sixty kilo gram nitrogen per hectare was found to be remunerative for maximizing productivity of proso millet under irrigated conditions.
- Sowing during first fortnight of May was remunerative besides maintaining higher productivity in barnyard millet.
- Pre emergence application of isoproturon @ 0.5 kg a.i./ha mixed with sand combined with two inter cultivations and one hand weeding was effective in providing good weed control and maintaining higher productivity.
- Forty-kilo gram nitrogen per hectare was found to be optimum and economical for barnyard millet.
- Integrated nutrient supply of organics and inorganics (25 per cent each) along with bio fertilizer seed inoculation was a remunerative practice under low fertility conditions for barnyard millet.
- Application of 3.75 t FYM/ha along with rock phosphate and gypsum gave comparable yields on par with recommended nutrient supply through organics and inorganics in barnyard millet.

Crop Protection

- Finger millet genotypes highly resistant to both neck and finger blast were identified.
- In all the breeding and pathological studies through screening of germplasm accessions / lines, varieties were identified for further use in the crop improvement programmes.
- Hot spots of different diseases- blast and cercospora leaf spot of finger millet, head smut of kodo millet, downy mildew of foxtail millet and grain smut were identified.
- Spraying of SAAF @ 0.2 % at 50% flowering and one more need based spray after 10 days was effective in controlling neck and finger blast.

- Choosing resistant variety and treating seeds with carbendazim @ 2 g/kg seed with recommended inputs effectively controlled the blast incidence and resulted in higher yield of finger millet; next best was selection of resistant variety for sowing.
- In foxtail millet sowing early in July minimized the incidence of blast and rust.
- Isolation, purification and characterization of phytotoxin and phytoalexin was helped in rapid diagnostic methods for resistance evaluation.
- The roles of phenols, PAL, PPO, Chitinase, β-13-gluconase activities has been established in disease resistance.
- Varieties resistant to insect pests were identified in all the small millets.
- Intercropping/sprinkling of Niger/mustard helps in enhancing the population of parasites and predators in small millets.
- A grain storage pest *Rhyzopertha dominica* was found for the first time feeding on stored ragi.

Crop Physiology

- Screening of finger millet germplasm for higher water use efficiency, root traits has shown that AKP 2, A 404 are superior types.
- Finger millet varieties Co 12, Paiyur 1 and GPU 28 were found tolerant to salinity.
- Exogenously supplied calcium was able to partially nullify the adverse effect of sodium stress.
- Processing and Value Addition
- Decortication of finger millet has opened many ways of making new products from finger millet.
- Par boiling of small millets also provided the opportunities for food and industrial utilization.

TECHNOLOGY TRANSFER

- Recommendations on package of practices formulated based on three to four years of research and having impact on the production have been taken to farmers field for demonstration these technologies small millets production could be enhanced to meet the projected requirements at the National level. During the last five years viz., 2000-04, 2285 farmers were involved in the conduct of Frontline demonstrations representing different socio-economic strata in an area of 865 ha in the country**.**
- The impact of these demonstrations indicated vast potential for increase in yield due to new recommended technology. The yield level and income of farmers could be substantially increased by the adoption of recommended technology. Enhancement in yield was around 82 % in finger millet, 95% in little millet, 83% in kodo millet, 43% in foxtail millet, 76% in proso millet & 82 % in barnyard millet.
- Small millets despite low genetic potential, are grown because of socio-economic conditions of the farmers and assured income under low input conditions. Inclusion of legumes as component crops helped in additional legume yield leading to nutritional security of the family and improved soil productivity and health. Similarly the adoption of other key components like use of new high yielding variety, application of fertilizers etc. showed significant influence on the yield of the crop.
- All centres have met the indented requirements of the Department of Agriculture and Cooperation, Government of India, to produce breeder seed particularly in finger millet, kodo millet and little millet. As much as 110 q of breeder seed have been produced and supplied against the target of 90 q.

All India Coordinated Research Project on Linseed

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

I BREEDING

GENETIC RESOURCE MANAGEMENT

- A total of 2806 germplasm comprising 2250 indegenous collections, 552 exotic collections and 4 wild spp. maintained under NAGS system.
- 609 accessions deposited to NBPGR, for long term conservation.
- Ist catalogue of 1980 germplasm documented for 29 descriptors was published in 1987.
- IInd catalogue of 2053 germplasm documented for 22 descriptors was published in 2002.
- 19 improved varieties were developed using potential germplasm identified for different special traits.

CROP IMPROVEMENT

51 improved varieties have been released and notified for general cultivation in different agro-climatic conditions by CVRC and States Variety Release Committee as per details enumerated below :-

Seed type varieties :

For Irrigated Condition : K-2, Mukta, Type 397, Neelum, Himalini, Triveni, Chambal, LC-54, Pusa-2, Pusa-3, Janki, Jawahar-23, Garima, Shubhra, Shekhar, RL-914, Suyog, Binwa, Him Alsi-1 and Deepika.

For Rainfed Cultivation : Hira, Jawahar-1, Jawahar-7, Jawahar-17, Neela, C-429, R-552, S-36, Sweta, Laxmi-27, Kiran, Padmini, JLS-9, Sheetal, NL 97, Sheela, Kartika, Indira Alsi-32 and Sharda.

For *Utera* Situation : LC 185, Surabhi, Baner.

Double purpose varieties : Gaurav, Jeevan, Nagarkot, Shikha, Rashmi, Meera, Parvati, Him Alsi-2 and RLU-6.

II. PRODUCTION TECHNOLOGY :

- Under utera system of linseed cultivation, farmers are sowing linseed by broadcasting 30-40 kg/ha seed in Madhya Pradesh, Maharashtra, Orissa, Chhatishgarh and Jharkhand states and 60-70 kg/ha seed in Himachal Pradesh at dough stage of paddy upto last week of October.

- Farmers are getting more benefits with linseed + gram/lentil (3 : 1 or 1 : 3) intercropping system under rainfed situation and linseed + mustard (5:1) under irrigated situation as compared to sole croppings.
- Farmers are getting higher net monetary return per unit area by adopting paddy – linseed (U.P., Bihar, Jharkhand), black gram – linseed (Jharkhand), soybean – linseed (MP, Chhatisgarh, Maharashtra), maize – linseed and Til – linseed crop rotation as compared to after rotations involving linseed

III. PROTECTION TECHNOLOGY :

DISEASES :

Linseed crop is attacked by a number of pathogens but four diseases *viz*., Alternaria blight and rust in northern India and wilt & powdery mildew in central and peninsular regions are most damaging. The main research was focused on the management of these diseases and salient achievements are given as under :

HOST RESISTANCE

More than 2045 germplasm, breeding material and varieties were screened against major diseases and the material found resistant/tolerant are given disease wise as under-

Wilt (*Fusarium oxysporum* f. sp. *lini*.)

Varieties : Kiran, R-552, J-23, Jeevan, LC-54, Nagarkot, Padmini, Surabhi, T-397.

Germplasm : 12 Jabalpur 1986, H-22, NP-47, NP(RR)-65.

Alternaria leaf and bud blight (*Alternaria lini*)

Varieties : K-2, Himalini, Jeevan, Gaurav, Nagarkot, Meera, Parvati, Rashmi, Sheela and Surabhi

Germplasm : Ayogi, BAU-610 A, ES-44, H-34, H-43, Polf-19, Polf-22.

Powdery mildew (*Oidium lini*)

Varieties : Himalini, J-23, Kiran, R-552, Nagarkot, Meera, Padmini, Parvati, Sheela and Surabhi

Germplasm : A-127, ES-44, H-34, KL-2045, KL-2057, LCK-8776, LCK-8722, LCK-89512, NHPY-10, NP(RR)-412, LH-1, Mahoba local, Mayurbhanj local.

Rust (*Melampsora lini*)

Varieties : LC-185, J-23, Himalini, Him-Alsi, Jeevan, Meera, Nagarkot, Sheela and Surabhi

Germplasm : 9x11, 5/47-2-2/10, Ayogi, ES-44, KL-178, Polf -5, Polf-19, RLC-73.

CHEMICAL CONTROL : The salient results are given as under **–**

Wilt : Seed treatment with Thiram (3g/kg seed) or Bavistin (1 g/kg seed) or Topsin M (2-3 g/kg seed) has been found effective.

Alternaria blight : Seed treatment before sowing with Topsin M (2.5g/kg seed) and 2-3 sprays of Indofil M-45 (0.25%) or Rovral (0.2%) after onset of disease at 10-15 days interval.

Powdery mildew : Three sprays of wettable sulphur (0.3%) or calixin (0.1%) on disease appearance at 10-15 days interval.

Rust : Seed treatment with Oxycarboxin (0.2%) before sowing and 2-3 sprays of calixin (0.1%) or mancozeb (0.25%) on disease appearance at 10-15 days interval

BIOLOGICAL CONTROL

Seed treatment with *Trichoderma viride* or *T. harzianum* alone or in combination with Thiram, sown in fields amended with FYM (@ 5 t/ha) have been found very effective in management of disease.

INTEGRATED DISEASE MANAGEMENT OF ALTERNARIA BLIGHT

Sowing of resistant/tolerant varieties, seed treated with Topsin-M (2.0g/kg seed), in the first fortnight of November with recommended doses of fertilizers and irrigation and one spray of Indofil M-45 (0.25%) on disease initiation resulted in yield increment upto 7.0 q/ha and Rs.8.373 incremental return in disease prone areas.

LINSEED BUD FLY RESISTANT/TOLERANT VARIETIES AND HOST PLANT SOURCES :

Bud fly (*D. lini*) is the key pest in Gangetic plains, control and peninsular regions of the country**.**

Variety : Neela

Germplasm :A-95B, EC-1392, EC-1424, GS-234, IC-15888, JRF-5, LCK-88062, LMS-109-2K

Chemical control of bud fly : Two fortnight sprays of monocrotophas 36 SL (0.04%) or imidacloprid 200 SL (100 ml/ha) can reduce the bud fly infestation significantly.

Biological control of bud fly : Sowing of linseed with recommendation agronomic practices and application of imidacloprid 200 SL (100ml/ha) followed by tobacco leaf extract (0.5%) reduce bud fly infestation with maximum economic return.

V BIOCHEMISTRY

HCN, polyphenol, sugar content were analysed and found that resistant genotypes against diseases contained higher amount of HCN and polyphenol and low in sugar content. Entries TL-11, TL-26, TL-27, TL-37 and TL-43 were observed as edible purpose having less than 3% lenolenic acid content in linseed seed with the potential of more than 18 q/ha.

FRONT LINE DEMONSTRATION

Front line demonstrations conducted during last five years (2001-02 to 2005-06) concluded that improved technologies applied in whole package increased the linseed yield on an average by 198% under irrigated, 83% under rainfed and 114% under *utera* conditions as compared to local practices.

All India Coordinated Research Project on Rapeseed-Mustard

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Crop Improvement

- 25 rapeseed-mustard varieties (19 Indian Mustard; 2 Gobhi Sarson and 1 each of Karan Rai, Toria, Yellow Sarson and Black Mustard) were released.
- Twenty-three mori based experimental hybrids have been tested under multi-location programme.
- 462.14 q breeder seed have also been produced against the indent of 110.69 q.

Crop Production

- Basal application of 40 kg S/ha+thiourea(0.1%) spray at pre-flowering stage has recorded maximum seed yield of mustard in zone II (North-Eastern parts of Rajasthan) and zone III (in tarai region of Uttaranchal) and hence recommended for getting remunerative yield of mustard in these zones.
- Integrated nutrient management practices i.e. RF+2t FYM (in seed furrows)+40 kg S+25 kg ZnSO4+1 kg boron + Azotobactor (seed treatment) should be followed for achieving higher seed yield of mustard over recommended fertility level at Shillongani in Zone V.
- Application of 2 to FYM/ha (in furrows)+40 kg S/ha (through gypsum) over 75% of recommended fertility was found more remunerative in moong-mustard cropping sequence and is recommended for North Gujarat condition.

Crop Protection

- Bulb extract of Allium sativum 1%(w/v) and Eucalyptus globosus 1%(w/v) individually has been found to be at par ($P<0.05$) with fungicidal check mancozeb in disease reduction and in increasing yield and hence either of them may be recommended for the control of Alternaria blight and white rust disease management.

Front line demonstrations

- A total of 1480 frontline demonstrations on improved production and protection technologies were conducted in 13 states of India during 2002-03 to 2004-05. The productivity improvement varied form 13-106. The productivity, which was 902 kg/ha in 2002-03, increased to 1117 kg/ha in 2005-06.

All India Network Project on Arid Legumes

1. **Title of the Project** : **All India Network Project on Arid Legumes**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Release of varieties:

Crop	No. of varieties	Name of varieties	Year of release
Guar	4	RGC-1017 RGM-112 RGC-1038 HGS-884	2002 2005 2006 2007
Moth bean	4	CAZRI Moth-2 CAZRI Moth-3	2003 2005
Cow pea	1	Co(CP-7)	2005
Horse gram	2	AK-42 CRIDA-18-R-1	2005 2007

Breeder Seed Production (total of 5 years)

Production status	Guar(q)	Cow pea(q)	Moth bean(q)	Horse gram (q)
Indent (q)	250.0	146.99	336.14	Very poor or almost no indent inspite of repeated requests
Production (q)	1027.27	169.45	941.1	
+/-	+777.27	+22.46	+604.94	
Revenue(Rs)	359450.0	67780.0	376440.0	
Total Rs.				803670.0

Identification quality rich lines

- High gum content guar varieties: HG-563(31-32%)
- High protein cow pea varieties:Co (CP-7) 28.0%, low tannin content (0.75 mg g^{-1})
- High protein moth bean: CAZRI Moth-(25%)

Plant Protection:

- Soil amendment with mustard residue (2.5 t/ha) along with seed treatment with Bacillus thuringensis (4 g/kg seed) and one summer irrigation effectively controlled mortality of pre and post emergence of guar seedlings.
- For effective control of cow pea and pod borer (A.vitrata) two sprays @ 0.15% with Cartap have proved effective.
- Seed treatment of cow pea with thiram (3 g/kg) followed by 2-3 sprays, of Carbendazim @ 0.1% at 15 and 45 DAS effectively managed Anthracnose disease in Southern states.
- The bruchids incidence of stored arid pulses was effectively controlled at least up to 200 days following seed treatment with 8 ml/kg of mustard seasame or groundnut oil.

Agronomy

- Two years study revealed that grain yield of guar (1184 kg/ha) and cow pea (1217 kg ha-1) increased by about 23.0 and 9.72%, over control values of 900.0 and 1110.0 kg ha-1, respectively following spray of ZnSO4 @ 0.5% at 25 and 45 days after sowing.
- Guar-guar cropping system earned maximum net return (Rs 12660/ha) followed by cow pea (Rs 9814/ha) under rainfed conditions.
- Grain yield of arid legumes could be increased by about 25% by keeping the crops weed free up to 25-30 days of sowing at the farmers fields.

Specific

Development of Neno-cultivars

- In case of cow pea and horse gram maturity has been curtailed from almost 90-95 days to 60 days with grain yield peaking almost up to 700-800 and 900-1000 kg, respectively, without fertility, irrigation and plant protection measures.

Diversification of agriculture:

- Cow pea genotypes for summer season for Uttranchal, and Punjab have been identified.
- Guar has been introduced in Anantpur and Chittoor districts to supplement poor yielding groundnuts, under rainfed conditions.

Increased export:

- Export of guar gum is increasing and peaking $ 459 m in 2006-07.
- No. of voluntary centers joined this project was 30 (against only 9 regular centers) during Xth Plan period, which itself proves its popularity.

All India Coordinated Research Project on Castor

1. **Title of the Project** : **All India Co-ordinated Research Project on Castor**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

A. Varieties/ Hybrids developed

The state-wise varieties/hybrids recommended during last five years

State		Recommended varieties/hybrids
Andhra Pradesh	Varieties	Kranti, Kiran, Haritha, 48-1(Jwala)*
	Hybrids	DCH-177, PCH-1, DCH 519
Gujarat	Varieties	48-1
	Hybrids	GCH-6, GCH-7, DCH-519
Karnataka	Varieties	RHC-1, RC-8, 48-1
	Hybrids	DCH-177, DCH-519
Maharashtra	Varieties	AKC-1, 48-1
	Hybrids	DCH-177, DCH-519
Rajasthan	Varieties	48-1
	Hybrids	RHC-1, DCH-177, DCH-519
Tamil Nadu	Varieties	48-1
	Hybrids	TMVCH-1, DCH-177, DCH 519
Uttar Pradesh	Varieties	48-1
Haryana & Punjab	Varieties	48-1
	Hybrids	DCH-177, DCH-519
Others	Varieties	48-1
	Hybrids	GCH-6, DCH-177, DCH 519

Salient features of hybrids/varieties recommended

Hybrid	Duration	Oil content (%)	Average yield (kg/ha)		Recommended for
			Rainfed	Irrigated	
Hybrids					
GCH-6	210	48	1400	2300	Irrigated castor growing areas of Gujarat, Maharashtra and Rajasthan
TMVCH 1	160-170	52	1200		Both pure and inter cropping situations of Tamil Nadu
DCH-177	90-100	49	1800	2500	Rainfed areas of hot semi-arid Deccan plateau (A.P., T.N. and Karnataka) and irrigated areas of Maharashtra
RHC-1		49.3	900-1200	2500-3000	Rainfed areas of A.P, Tamilnadu, Orissa, irrigated areas of Rajasthan and Maharashtra
PCH 1	150		1500	2000	Rainfed areas of A.P.
DCH-519	140-150	49.0	1500	2200	Both rainfed and irrigated castor growing areas of the country
GCH-7	140-150	-	2450	-	Irrigated areas of Gujarat
Varieties					
Jwala (48-1)	130-220	50	1000	1800	All castor growing areas under both rainfed and irrigated conditions
Kranti (PCS 4)	90-150	48-50	1200	-	Rainfed areas of Andhra Pradesh
Kiran (PCS 136)	90-180	48-51	1200-1500	-	Rainfed areas of A.P. and also late sown *kharif* conditions with one or two irrigations
Harita (PCS 124)	90-180	48-51	1400-1600	-	Light soils of Southern Telangana, Rayalaseema and Prakasam district

B. Remunerative Intercropping System

State	Intercropping	Row proportion
Andhra Pradesh	Castor + Pigeonpea	1:1
	Castor + Cowpea	1:2
	Castor + Urdbean	1:2
	Castor + Mungbean	1:2
	Castor + Clustebean (vegetable)	1:1
	Castor + Groundnut	1:5-7
	Castor + Turmeric/Ginger	1:5
	Castor + Horsegram (relay)	1:6-8
Gujarat	Castor + Pigeonpea/Clusterbean	1:1
	Castor + Cowpea	1:2
	Castor + Urdbean	1:2
	Castor + Mungbean	1:2
	Castor + Bunch groundnut	1:3
	Castor + Pearlmillet	1:2
	Castor + Sesame	1:1
Karnataka	Castor + Groundnut	1:5-7
	Castor + Horsegram (relay)	1.6-8
	Castor + Pigeonpea	2:1
Tamil Nadu	Castor + Groundnut	1:5-7
	Castor + Chillies	1:8
	Castor + Urdbean	1:2
Bihar	Castor + Soybean	1:1
	Castor + Lathyrus	1:5
	Castor + Turmeric/Ginger	1:5
	Castor + Chillies	1:8
Rajasthan	Castor + Mungbean	1:2
	Castor + Mothbean	1:2

C. State-wise intercropping systems recommended

State	Crop sequence	One year/two year	Irrigated/ rainfed
Andhra Pradesh	Castor-groundnut	One year	Irrigated
	Castor-sunflower	One year	Irrigated
	Castor-pearlmillet	Two year	Rainfed
	Castor-fingermillet	Two year	Rainfed
	Castor - pigeonpea	Two year	Rainfed
	Castor - groundnut	Two year	Rainfed
	Castor-sorghum	Two year	Rainfed
Gujarat	Pearlmillet-castor	One year	Irrigated
	Sorghum-castor	One year	Irrigated
	Castor-mungbean	One year	Irrigated
	Castor-groundnut	One year	Irrigated
	Castor-sesame	One year	Irrigated
	Castor-sunflower	One year	Irrigated
	Mustard-castor	Two year	Irrigated
	Castor-pearlmillet-mungbean	Two year	Irrigated
	Castor-pearlmillet-chickpea	Two year	Irrigated
Karnataka	Castor-fingermillet	Two year	Rainfed
	Castor-groundnut	Two year	Rainfed
Tamil Nadu	Castor-fingermillet	Two year	Rainfed
	Castor-groundnut	Two year	Rainfed
Rajasthan	Castor-pearlmillet	Two year	Irrigated

D. Agronomic Management

Spacing and plant population

A plant population of 18,500/ha and 14,000/ha was found to be optimum for rainfed and irrigated areas respectively. About 5 kg seeds/ha is adequate for obtaining the desired plant population.

Square planting at 75 x 75 cm for rainfed conditions and 90 x 90 cm for irrigated conditions would help in running the blade harrow both ways and reduce the cost of intra-row manual weeding. It also helps in controlling the excess vegetative growth and prevents lanky growth of the plants

Seed treatment

Seeds may be treated with thiram or captan @ 3g/kg seed or carbendazim 2 g/kg to protect plants from seed borne diseases like *Alternaria* leaf blight, seedling blight and wilt. Treat the seed with *Trichoderma viride* @ 10 g/kg seed and soil application of 2.5 kg incubated in 125 kg FYM/ha for managing wilt.

Fertiliser application

State/Region-wise recommendations of fertilizer (kg/ha) for castor in different regions and situations

Region	Situation	N	P_2O_5	K_2O	S
Andhra Pradesh	Rainfed	60	40	30	
	Irrigated	120	40	30	
Tamil Nadu	Rainfed	30	15	15	
	Irrigated	80	30	30	
Karnataka	Irrigated	75	50	25	
	Rainfed	40	40	20	
Maharashtra	Rainfed	60	30	0	
	Irrigated	120	30	30	
Rajasthan	Irrigated	80	50	0	20
North Gujarat	Irrigated	120	25	0	20
	Rabi castor	80	50	0	
Saurashtra (Gujarat)	Rainfed	120	50	0	

The recommended dose of phosphorus as well as potassium has to be applied as basal dose in the form of single super phosphate and muriate of potash respectively before sowing.

For rainfed castor, apart from application of basal dose of 20 kg N fertilizer, top dressing with 20 kg N/ha each at 35-40 and 65-70 days after sowing depending upon the moisture availability in the soil provides reasonable economic returns. In the event of a dry spell during 50-55 days, first top dressing with 20 kg N/ha has to be done at the time of initiation of secondaries with the receipt of rain. In case of rainfed castor grown in Saurashtra region of Gujarat, nitrogen has to be supplied to the crop in 3 splits and the entire dose of phosphorus and potassium has to be applied as basal dose.

For irrigated castor in Gujarat, nitrogen has to be given in 5 splits, 40 kg each at sowing, 40, 70, 100 and 130 days after sowing. In soils deficient in Zn and Fe, 10 kg Zn $S0_4$ and 30 kg Fe $S0_4$/ha, respectively has to be applied to obtain enhanced yields. For irrigated castor in Rajasthan, nitrogen should be applied in 3 splits, 40 N as basal and 20 kg N/ha each at 35 and 80 days after sowing.

In saline/sodic soils, spot application of 2 t/ha FYM and sowing the crop on the side of the ridge has been found beneficial. Besides, adoption of salinity tolerant varieties like GCH-5, 48-1, GC-2 also helps in combating salinity/sodicity problem.

For integrated nutrient management in irrigated castor in Rajasthan, application of 20 kg N through castor cake, 20 kg N through FYM, 20 kg N through *in situ* green manuring together with 20 kg N/ha through inorganic fertilizer has been recommended. For irrigated castor in North Gujarat and Saurashtra region of Gujarat, it has been recommended to apply 30 kg N in the form of FYM, 30 kg N through castor cake, 30 kg N through green manure and 30 kg N/ha through inorganic fertilizer for reaping higher yields.

In light soils of Gujarat, seed treatment with *Azospirillum* or phosphorus solubilizing bacteria (PSB) @ 50 g/kg seed, apart from application of 75-50-0 NPK/ha in conjunction with castor cake (1t/ha) or FYM (5t/ha) is advocated.

For groundnut + castor (3:1) intercropping system followed in Saurashtra region of Gujarat, application of recommended dose of fertilizer to both groundnut and castor on area basis is recommended to obtain higher returns.

Weeding and interculture

Castor is very sensitive to weed competition. In rainfed areas, 2 or 3 intercultures with the help of bullock drawn blade harrows starting from 25-30 days after planting combined with one manual intra-row weeding after first interculture effectively checks weed growth. A dicot weed, *Celosia argentia* appears in very large numbers during the months of September to January and it is not possible to use any implements due to coverage of plant canopy. Manual uprooting of the weeds before flowering is recommended.

In rainfed areas with undulated topography, proper preparation of land, sowing the crop across the slope, 2-3 intercultures and tieing ridges along the rows after the last interculture (40 DAS) helps in conservation of soil moisture apart from controlling weeds, thereby resulting in increased seed yields.

Weeds are more serious problem even in irrigated castor. Hence, the crop may need 2 or 3 hand weedings at intervals of 15-20 days in order to keep weeds under check. Alternatively pre-plant application of herbicides such as fluchloralin or trifluralin @ 1.0 kg a.i./ha or pre-emergence application of alachlor @ 1.25 kg a.i./ha is equally effective under irrigation.

E. Important insect pests of castor and their management

Insect	Nature of damage	Period of activity	Cultural management	Chemical control
Red hairy caterpillar (*Amsacta albistriga* Wlk.)	Larvae defoliate the crop. Major damage is caused by migrating caterpillars. More destruction to young crop.	Active during June to August.	Setting of light traps on community basis with the first monsoon rains to attract the moths and kill them, sowing cucumber along with castor. Placing the twigs of *Ipomoea, Jatropha* or *Calotropis* to attract the migrating caterpillars & kill them mechanically, opening deep furrows around field area and dusting methyl parathion/ quinalphos/endosulfan	Spray of monocrotophos (0.05%) fenvalerate (0.02%), quinalphos (0.05%), or methyl parathion (0.05%).
Semi-looper (*Achoea janata* L.)	Damages crop by defoliation. Older larvae are voracious feeders and leave bare stems and veins.	July to September	Hand picking of older larvae during early stages of crop growth, avoid chemical spray when 1-2 larval parasitoids (*Microplitis* sp.) are observed per plant.	Spray monocrotophos (0.05%) or endosulphan (0.07%), if more than 25% defoliation is observed.
Tobacco caterpillar (*Spodoptera litura* F.)	Damage is mostly by defoliation.	Active during August to October.	Collect and destroy egg masses and gregarious stages of the larvae along with damaged leaves.	Spray chlorpyrifos (0.05%) or monocrotophos (0.05%) if defoliation is above 25%
Hairy caterpillar (*Euproctis sp. Spilosoma obliqua* Wlk.)	Damage is mostly by defoliation, often capsules get damaged.	Active during October to December.	Collect & destroy egg masses and gregarious stages of the larvae along with damaged leaves.	Spray chlorpyrifos (0.05%) or monocrotophos(0.05%) if defolition is exceeding 25%
Capsule borer (Conogethes (Dicho-crosis) *punctiferalis* Guenee)	Larvae bore the capsules & chara-cteristic webbing of capsules along with excreta is seen.	Infestation starts from flowering stage. Usually active during Nov. to March	Good agronomic management with no or less use of insecticides on the crop usually keeps the borer at low level.	Spray monocrotophos (0.05%) or endosulfan (0.07%) or dust the spikes with quinalphos (1.5%) or methyl parathion (2%) if at least 10% capsules are damaged. If the damage is severe, spray delta methrin (0.03%) or acephate (0.075%). Repeat the spray after 2-3 weeks if required.
Leaf hopper (*Empoasca flavescens* Distant)	Both nymphs and adults suck sap from plants. Hopper burn symptoms are noticed if Jassid infestation is severe.	Peak infestation is during November to January.	Growing double/ triple bloom genotypes like GCH-4, DCS-9, GCH-5, 48-1, DCH-32 etc. which usually do not express damage symptoms.	Spray monocrotophos (0.05%) or dimethoate (0.05%). Repeat spray if required after a fortnight.
Thrips (*Retithrips syriacus*)	Both nymphs and adults suck sap resulting in characteristic wrinkling of plants and withering of developing spikes.	Throughout crop season	Varieties resistant to leaf hopper are also tolerant to thrips damage.	Spray monocrotophos (0.05%) or dimethoate (0.05%) if damage symptoms appear.
Whitefly (*Trialeurodes ricini*)	Crop presents a sick appearance and sooty mould develops when whitefly infestation is severe.	High infestation during summer on irrigated castor	Double and triple bloom genotypes are susceptible. Usually does not warrant any control.	Spray monocrotophos (0.05%) or dimethoate (0.05%). Repeat spray if required after a fortnight

Red spider mite (*Tetran-ychus telarius* L.)	Suck sap from leaves. Plants show characteristic yellowing.	Serious during summer on irrigated castor (March to May).		Spray dicofol (0.05%)

F. Important diseases of castor and their management

Seedling blight (*Phytophthora parasitica* (Dastur) Waterhouse	Dull green roundish patches develop on both the surfaces of cotyledonary leaves, infection spreads to form alternate light and dark brown concentric zones. Cotyledonary leaves rot and hang down. Infection spreads to the base of the petiole, point of attachment and stem. Seedlings wither and dry.	▪ Avoid sowing in low lying areas. ▪ Provide proper field drainage to avoid water-logged conditions. ▪ Treat the seeds with thiram or captan 3g/kg seed. ▪ Give need based spray of copper oxychloride 3g/l to avoid further spread of the disease.
Fusarial Wilt (*Fusarium oxysporum* f. sp. *ricini* Nanda & Prasad)	Discolouration of hypocotyls, loss of turgidity of top leaves and marginal necrosis at the seedling stage. On adult plants, gradual yellowing and sickly appearance of leaves followed by necrosis, browning of xylem tissues, formation of a dark stripe and pinkish overgrowth on the entire stem up to the infected leaves. Irreversible wilting with bending of apical leaves and branches.	▪ Cultivate disease tolerant/resistant varieties, *viz.*, DCS-9, 48-1 (Jwala), Harita, GCH-4, GCH-5 and DCH-177. ▪ Seed treatment with carbendazim (slurry 2g/Kg or seed soak 1g/l for 12 hrs)/ *Tricho-derma viride* 10g/kg and soil application 2.5 kg/ha incubated in 125 kg FYM. ▪ Avoid continuous cultivation. ▪ Crop rotation with pearlmillet/ fingermillet or cereals
Root rot/Die back (*Macrophomina phaseolina* (Tassi) Goid)	Plants show signs of water shortage. Dark black lesions develop on the stem near ground level. The taproot shows signs of drying and root bark shreds off easily. In severe infection entire branch or top of the branch withers away. Aerial infection in the form of small brown depressed lesions on or around the nodes. Wilting of leaves start from the apex and proceeds downwards. Pycnidia develop on woody tissue and in the pith region.	▪ Burning and destruction of crop debris. ▪ Crop rotation with cereal crops. ▪ Use resistant varieties like Jwala (48-1) and GCH-6. ▪ Seed treatment with *T. viride* 4g/kg or thiram/captan 3g/kg seed.
Alternaria Blight (*Alternaria ricini* (Yoshii) Hansford)	Light brown circular spots appear on cotyledonary leaves and irregular spots with concentric rings surrounded by yellow halos appear on mature leaves. Spots coalesce and cause foliage blight. Immature capsules wilt suddenly turn brown and due to collapse of pedicel fall or hang down. Sunken spots develop on mature capsules and gradually enlarge to cover the whole capsule with black sooty fungal growth.	▪ Seed treatment with thiram/captan 2-3 g/kg seed. ▪ Spray manocozeb 2.5g/l or copper oxychloride 3g/l 2-3 times at 15 day interval starting from 90 days of crop growth.
Cercospora leaf spot (*Cercospora ricinella* Sace.)	Minute circular to angular pale yellow watery lesions with pale green halo appear on the mature leaves which later turn into circular to irregular in shape with dark brown borders and greyish-white centres. The fructifications of the fungus are visible as tiny black dots in the white cen-tral region. When the spots coalesce, the intervening leaf tissue withers and large brown patches of dried leaf result.	▪ Teat the seeds with thiram/captan 3g/kg seed. ▪ Need based sprays of copper oxychloride 0.3% or mancozeb 0.25% two to three times at 10-15 days interval.
Bacterial leaf spot (*Xanthomonas compe*stris Pv.*ricini* Yos. & Tak)	Circular water soaked spots with pale green center and dark margin appear on the leaves, which later become angular and turn dark brown. Leaves become brittle and dry up. Dark elongated lesions develop on stem and petioles.	▪ Remove and destroy infected crop debris. ▪ Hot water seed treatment at 50-60^{0}C for 10 min. ▪ Spray streptocycline 1g/ 10 l of water or a combination of paushamycin 0.025% + copper oxychloride 0.3%.

Powdery mildew (*Leveillula taurica* (Lev) Arm)	Leaves turn pale yellow with whitish superficial powdery masses on the under surface. Light green patches corresponding to diseased areas on the under surface are visible on the upper side when the leaves held against light. Leaves turn brown and drop off prematurely.	▪ Spray wettable sulphur 0.2% twice at 15 days interval starting from 3 months after sowing.
Grey rot/grey mould (*Botrytis ricini* Godfrey)	Initially pale the blotch-like spots are formed on capsules/flowers from which drops of yellow liquid exude. Later fungal threads grow from these spots and transform into dense wooly growth. The growth may vary from pale to olive grey in colour. Severely infected capsules rot and fall. The immature seeds become soft and mature ones hollow, exhibiting discoloured seed coat. Black sclerotia develop on infected seeds. Circular to sub-circular or irregular lesions develop on leaves. Water soaked blackish lesions develop on tender shoots usually when infected spikes fall on them leading to rot and breakage.	▪ Use tolerant variety 48-1 (Jwala) ▪ Adopt wider spacing (90 x 60 cm) between rows. ▪ Give prophylactic spray with carbendazim or thiophanate methyl 1 g/l and one more spray soon after disease appearance. ▪ Prophylactic spray with *T.viride + Pseudomonas fluoresencs* 3 g/l. ▪ Remove infected spikes/capsules & destroy. ▪ Top dress with Urea 20 kg/ha after cessation of rains for the formation of new spikes.
Cladosporium *capsule rot (Cladosporium oxysporum* Berk and Cart.)	Dark green lesions develop towards the base of the capsules at the time of maturity, particularly when the capsules start developing cracks/fissures. Capsules rot, shrivel; depress and turn olive black. Infection spreads to the inner sides the seeds exhibiting blackish green sooty growth.	▪ Spray Dithane-Z-78 or mancozeb. Harvest at right time when the spikes turn lemon yellow.

All India Coordinated Research Project on Chickpea

1. Title of the Project : **All India Coordinated Research Project on Chickpea**

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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

3a. Newly released chickpea varieties for various states during this period through CVRC

SNo.	Name Of variety	Year Of release	Av.yield (q/ha)	Duration (days)	Special features	Area of Adoption
1	RSG 888	2002	21	130-135	Semi-spreading, small seeded, Drought tolerant, twin podded, tolerant to dry root rot	Haryana, Punjab, Rajasthan, Jammu, Western UP, Uttranchal, Delhi
2	JGK 1	2002	15-18	100-110	Bold seeded kabuli, Wilt resistant, semi-spreading, Early flowering	Bundelkhand region Of Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Parts of Rajasthan
3	Phule G 95311	2002	18	90	Bold seeded kabuli, Wilt resistant	Andhra Pradesh, Karnataka, Tamil Nadu, Orissa
4	RSG 963	2004	19-20	125-130	Medium bold seed,Suitable for late sown conditions	Haryana, Punjab, Rajasthan, Jammu,

						Western UP, Uttranchal, Delhi
5	BGM547	2005	18.0	135	Semi-erect plant bold and Golden brown seeds	Haryana, Punjab, Rajasthan, Jammu, Western Uttar Pradesh, Uttranchal, Delhi
6	Phule G 9425-9	2005	18.6	136	Semi-erect plant with profuse fruiting branch,yellowish brown seeds	Haryana, Punjab, Rajasthan, Jammu, Western Uttar Pradesh, Uttranchal, Delhi
7.	BGD128	2005	19.0	110-115	Plant semi-erect with more secondary branches, seed, wt277g/100 seeds and moderately Resistant to wilt /dry root rot	Bundelkhand region Of Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Parts of Rajasthan

3 b. Production Technologies:

• Foliar application of 2% urea/DAP at the time of flowering and 10 days there after significantly increased the grain yield of chickpea.

• Use of 2 ton of vermi-compost significantly improved the grain yield of chickpea (NWPZ, CZ and SZ).

• In bold seeded Kabuli chickpea, application of 60 kg P20s/ha was recommended when available P was less than 15 kg/ha in the soil.

• Rice-chickpea (Kabuli) system is gaining popularity because of higher economic returns as compared to Rice- wheat system.

• For bold seeded Kabuli, 100kg seed/ha proved beneficial to obtain higher grain yield.

• Sowing of two rows at 30 cm apart on 67.5 cm wide raised beds proved highly productive than the flat bed sowing in heavy soils.

• Combined application of biofertilizers consisting of Rhizobium + PSB + *Trichoderma, Pseudomonas* + PGPR and Vitavax was more beneficial as compared to inoculation with *Rhizobium* only.

• Highly efficient *Rhizobium* strains G567 SMR and GHUR 15 were recommended for commercialization.

• Micronutrient application of Molybdenum, Iron, Boron and Zinc enhanced the nitrogen fixation and resulted higher grain yields.

• Delivery of Rhizobium + PSB biofertilizers in a single packet is feasible in Alginate (2%) beads with self life up to 510 days.

• For drought tolerance the donor identified was Phule G 96006 where as donors for cold tolerance were PDG 84 16 and Phule G 96006.

• Higher total dry matter production with more partitioning into the economic sink, lower SLA or higher SLW particularly at podding stage, more number of effective nodes per plant and deep rooting system are recorded as important traits for higher grain yield under moisture stress.

3 c. Protection Technologies:

• Eco friendly management of Wilt and Dry Root Rot (DRR) in chickpea was evolved and validation of the technology was done:

- Wilt Resistant varieties such as JG315, Vijay, Vishal, KWR108, HC1 and GG1 were identified.

- Seed treatment with 4 g of *Trichoderma* + 1 g of Vitavax per kg of seed was recommended

- Deep summer ploughing was suggested to control soil born pathogen.

• Two insecticides - Betacyfluthrin 18.75 g ailha and Koranda showed superiority over endosulphan in controlling *H. armigera.*

• Among newer insecticides, Novaluron 10 EC 100 g and Proclaim 5 SC, 11 g gave 78.3% and 71.9% reduction in pod damage over control, respectively.

• Intercropping of chickpea having normal planting protected with NSKE-NPV and Profenofos was found comparable to 3 sprays of Profenofos for management of *H. armigera.*

• Seed treatment with Carbosulfan 25ST 3% was found effective in reducing 40% Root Knot nematode population.

Donors Identified

• Wilt : IPC 97-1, FG 712, IPC 97-7, Phule G 9425-9, IPC 97-29
• Wilt + Stunt IPC 2000-52, PSG 1, H 82-2
• Collar Rot + ORR : MPJGK 3
• Drought Tolerance : Phule G 96006
• Cold Tolerance: hule G 96006, PDG 84-16

All India Coordinated Research Project on Forage Crops

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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

3 (A) Newly developed forage crops varieties

Table : Forage Crops Varieties Released / Notified During Last Five Year (2002-2007)

No.	Name of crop	Name of Variety	Year of release	Breeding Institution	Adaptability (region / area)	Greenfodder yield (t/ha)	Specific characteristics
(A) Kharif : Annual Crops							
1.	Sorghum (Sorghum bicolor L.)	Pusa Chari Hybrid 109 (PCH 109)	2005	IARI, New Delhi	All Irrigated/ rain fed areas of the country	75-80	Resistant to major pests (Shoot fly and stem borer)
2.	Pearl millet (Pennisetum americanum L.)	AVKB-19	2007	IGFRI, RRS Avikanagar	North-West zone comprising Western UP, Raj. Haryana & Tarai region of Uttaranchal	35-38 (Seed yield-1.02)	Resistant to downy mildew and blast
3.	Cowpea (Vigna unguiculata L.)	UPC 607	2004	GBPUAT, Pantnagar	North-Western zone comprising states of Punjab, Haryana, U.P., Tarai and Rajasthan	30-35	Suitable for cultivation under irrigated summer
		UPC 618	2004	GBPUAT, Pantnagar	Northwest, Northeast and Central zones	30-35	Suitable for cultivation under irrigated summer and rain fed Kharif season
		UPC-622	2006	GBPUAT, Pantnagar	Northwest, Northeast and Hill Zones	26-28	Tolerant to yellow mosaic virus, root rot

							and anthracnose diseases
4.	Rice bean (Vigna umbellata T.)	Bidhan Rice bean-2 (KRB-4)	2005	BCKV, Kalyani	Eastern and NE region	25-30	High crude protein and resistant to major insects-pests
5.	Coix (Coix lachryma Jobi.)	Bidhan Coix-1 (KCA-3)	2005	BCKVV, Kalyani	North- east region	30-35	Supplement 60-90kg N/ha
Perennial grass							
6.	Guinea grass (Panicum maximum Jacq.)	Bundel Guinea - 1 (JHGG 96-5)	2005	IGFRI, Jhansi	Rain-fed areas of UP, MP, Maharashtra, Andhra Pradesh, Gujarat, Rajasthan Punjab	30-40	Apomictic, perennial, multi-cut, resistant to insect-pests
		Bundel Guinea-2 (JHGG - 04-1)	2007	IGFRI, Jhansi	Humid, Arid,& Sub-tropical areas of H.P., U.P., Gujarat, Maharashtra, Karnataka, Tamil Nadu & Kerala	55-60	Drought tolerant, resistant to lodging
7.	Buffel grass (Cenchrus ciliaris L.)	Bundel Anjan-3 (IGFRI-727)	2006	IGFRI, Jhansi	Arid & semiarid tracts of Western UP, HP, Uttarakhand, Rajasthan. AP, Punjab, Haryana, Maharashtra.	28-30	Superior in dry matter yield
8.	Black spear grass (Heteropogon contortous)	Bundel Lampaghas-1 (IGHCO3-4)	2007	IGFRI, Jhansi	Semi arid, tropical and sub tropical regions of UP, Gujarat, HP, Tamilnadu, Karnataka & Maharashtra states	25-27	Resistant to lodging
9.	Sen grass (Sehima nervosum)	Bundel Sen -1 (IGS-9901	2007	IGFRI, Jhansi	Central & western MP, Southern part of UP, North-west Karnataka, Rayalseema region of AP, south &	18-20	First released variety in this range grass and higher green fodder & Dry matter

					central Maharashtra and Rajasthan		
10.	Dhraf grass (Chrysopogon fulvus)	Bundel Phulkara -1(IGC-9903)	2007	IGFRI, Jhansi	Central & western MP, Southern part of UP, North-west Karnataka, Rayalseema region of AP, south & central Maharashtra and Rajasthan	25-28	First released variety in this range grass
11.	Setaria grass (Setaria anceps)	Setaria – 92	2005	CSK HPKV, Palampur	Hill zone comprising HP and Uttaranchal	30-35	Highly tolerant to pests and diseases
12.	Tall Fescue (Festuca arundinacea)	Hima-4	2005	CSK HPKV, Palampur	Hill zone comprising HP and Uttaranchal (Temperate region)	10-15	Highly tolerant to pests and diseases
13.	Stylosanthes spp.	Phule Krant (RSS-2000-95)	2005	MPKV Rahuri	Western Maharashtra	45-50	High yielding, good establishment in first year and easy seed collection
(B) Rabi crops							
14.	Oats (Avena sativa L.)	JHO-99-1	2005	IGFRI, Jhansi	Hill region of the country	40-42	Suitable for single cut in hill zone
		Bundel Jai 2001-3(JHO-2001-3)	2005	IGFRI, Jhansi	Tropical and subtropical areas in NW and South zones comprising states of UP, HP, Uttranchal, Rajasthan, Andhra Pradesh, Punjab, Haryana, Maharashtra, Tamilnadu and Karnatka	48-53	Suitable for cultivation in rabi season as a single cut crop
		JHO-99-2	2006	IGFRI, Jhansi	NE,NW and central zones	50-60	Multicut(2-4 cuts), resistant to major pests and diseases
		Bundel Jai 2000-4(JHO-2000-4)	2006	IGFRI, Jhansi	Entire country except central zone	35-38	Single cut variety and resistant to root rot, crown

							rust and powdery mildew
		Phule Harita (RO-19)	2007	MPKV, Rahuri	All oats growing areas of the country	40-45	Broad leaves, high tillering more CP, and multicut (2-4 cuts)
15.	Berseem (Trifolium alexandrinum L.)	BL-180	2006	PAU, Ludhiana	NW and Hill zones	65-75	High green fodder, profuse tillering and seed yield

3 (B) Forage Production Technology

1. Diversification of exiting cropping systems through remunerative forage crops

Remunerative forage based crop sequences

(A) Hill zone : In mid Himalayan hill zone, Maize (Fodder) – Wheat realizes significantly higher net monetary return which is 85 % higher than the most adopted sequence (Maize – wheat).

(B) North –West zone :

I. In Tarai area of Uttarancahal and West UP, Paddy – Wheat – Maize (Fodder) + Cowpea(Fodder) realizes highest net monetary return and superiority of 29 % over Paddy –Wheat.

II. In semiarid situation of Haryana, Pearl millet (Fodder) – Wheat – Greengram realizes 40 % higher net monetary return than Cotton – Wheat.

III. In arid region of Rajasthan, Guar (F) + Pearl millet(F) – Oat(F) – Cowpea(F) realizes significantly higher net monetary return which is 99 percent higher than the most adopted (Guar(G) – Wheat(G) – Fallow).

(C) Central zone :

I. In semi arid situation of bundelkhand, Groundnut – Berseem – Maize (Fodder) realizes 44% higher net monetary return than Groundnut – Greengram.

II. In Kaimur plateau region of Madhya Pradesh, Sorghum (F) – Berseem – Maize (F) + Cowpea (F) realizes 94% higher net monetary return than Rice – Wheat – Green gram.

III. In central zone under Vidarbha region of Maharashtra, Lucerne (Perennial) realizes 84 % higher net monetary return than Soybean – Wheat – Greengram. However, Maize (Fodder) – Berseem – Sorghum (Fodder) realizes 54 % higher net monetary return than Soybean (Grain) – Wheat(Grain) – Cowpea (Grain).

IV. In irrigated situation in Gujrat, NB hybrid + Cowpea/ Lucerne realizes 58 percent higher net monetary return than Maize(F) – Potato(T) – Pearlmillet(G).

(D) North east zone :

I. In Eastern zone of UP , significantly higher net monetary return was realized with NB hybrid (Perennial) + berseem which was 48.0 percent higher than Rice – Wheat – Green gram.

II. In subhumid situation of Orissa, Pearl millet(F) – Oat Maize(F) + Cowpea(F) realizes highest net monetary return with the superiority of 80 percent over Groundnut – Mustard – Greengram.

III. In NEH plain region under Jorhat(Assam) situations, NB hybrid (Perennial) realizes 120 percent higher net monetary return than Sesamum(G) – Rapseed – Greengram(G).

IV. In Jharkhand under Ranchi situations, NB hybrid + Berseem realizes 1770 percent higher net monetary return than Fallow – Rice.

V. Under Indo- gangetic plains of West Bengal , Rice – Oat – Sesame was superior for net monetary return with percent increase of 63 percent over Rice – Mustard – Groundnut.

(E) South zone :

I. Under semiarid situation of Andhra Pradesh, NB hybrid + Cowpea / Berseem was superior for net monetary return with percent increase of 10 percent over Red gram- Tomato-Sorghum + Red gram.

II. In rain shadow area and moderate rainfall situation (600-700mm) of Tamil Nadu, NB hybrid perennial realizes 300 percent higher net monetary return than Maize(F) + Cowpea(F) – Cowpea(F) + Maize(F) – Sorghum(F) + Cowpea(F).

III. In Coastal western ghats, NB hybrid perennial realizes 180 percent higher net monetary return than Upland rice(G) – Cowpea (vegetable) – Okra.

IV. In semiarid region of Karnataka under Tiptur situation, NB hybrid perennial realizes 142 percent higher net monetary return than Maize+ Cowpea - Maize+ Cowpea.

Intercropping : Under agro-climatic situations of north and central zone, the intercropping of 2 rows of forage sorghum / pearl millet (25 cm row to row spacing) in pigeonpea planted at 75 cm realizes significantly higher (40-45 percent) fodder equivalent yield and net monetary return than sole stands.

2. Nutrient management in forage crops and forage based crop sequences

- In south zone, the inoculation of *Azospirillum* to forage maize increases green fodder (2.0%) and dry matter yield (2.8%) and net monetary return (29.4%) over control (no fertilizer).
- Application of molybdenum (Mo) @ 0.5 kg/ha and boron (B) @ 2.0 kg/ha to Berseem increase the seed yield by 20-23 per cent over control in the deficient soils during initial years in North west zone.
- In Lucerne growing areas of western region, the supplementation of molybdenum (Mo) @ 1.0 kg/ha and boron (B) @ 2.0 kg/ha to lucerne increase the seed yield by 15-25 per cent over control in the deficient soils during initial years.
- At Bikaner, Pearl millet-oat-cowpea fertilized with 75% recommended dose of NPK+10 t/ha FYM in kharif season was best in terms of forage yield (Green fodder-624.9 q/ha and dry matter-146.2 q/ha) and net monetary return (Rs. 31288/ha/year).

3. Weed control in forages

- Application of Fluchloralin @ 0.90 kg a.i./ha PPI produced highest green fodder (658.5 q/ha) and dry matter (84.8 q/ha) of shaftal dominated with *Poa annua* and recorded remarkable weed control efficiency (65.9%) in north-west region.

4. Forage production from problem soils

- In acidic soil, the application of 40 kg P/ha as single super phosphate (SSP) enhances the green fodder yield of cowpea and ricebean by 26.2 and 45.3 per cent, respectively over control. It shows equal effect with the application of 20 kg P/ha + FYM @ 0.5 t/ha.
- In alkali soil, application of gypsum to rice and 90 kg P_2O_5 /ha to berseem yielded significantly higher green fodder (885 q/ha) and dry matter (146 q/ha) of berseem than the other treatments, closely followed by pyrite application.
- In acidic soil , application of lime + recommended dose of P & K + VAM to Kharif & Rabi in Rice bean-Oats sequence produced highest forage yield (green fodder-541.9 q/ha & dry matter-114.6 q/ha) and realized highest net monetary return (Rs. 13905/ha/year).
- In acidic soil (p^H < 5.5) at Bhubaneswar, intercropping of Ricebean (Fodder) + Maize (Grain) in row ratio of 2:2 after liming (100% LR) realizes higher forage equivalent yield (467.5 q/ha) with percentage increase of 275 over rice bean without liming.

5. Intensification of forages after rice

- In central and North West Zone, Berseem sown after rice with optimum tillage produces superior forage yield than no tillage. However, in North East Zone, Berseem sown in standing rice crop with no tillage and 50 kg seed/ha produces 15.0 per cent higher forage yield.In west-coast region, the performance of forage maize + cowpea was superior (65-136 %) in terms of green forage yield (198 q/ha) in rice fallow than sorghum and pearlmillet in sole stands and intercropping with cowpea.

6. Forage seed production

- In arid region, the spray of Thiourea @ 0.05% to *Lasiurus sindicus* increases the seed yield by 13-15 per cent over Gibberelic acid (10 ppm) and control.
- The semi spreading type forage cowpea cv. Bundel Lobia-1 with narrow spacing of 30 cm produces 17 per cent higher seed yield as compared to other popular cultivars of cowpea viz., IGFRI-95(erect type), UPC-9202 & UPC-4200 (spreading type). Location wise, forage cowpea varieties like Bundel Lobia -1 at Rahuri, Jhansi and Hisar; UPC-9202 at Pantnagar and Hyderabad; UPC-4200 at Jabalpur and Bhubaneswar were superior for seed yield.

7. Forage production under plantation crops

- In South zone, Guinea grass + Desmenthus (3:1) intercropped in Banana plantation produces higher green fodder (1984.3 q/ha) and realizes highest net monetary return (Rs. 93558/ha/yr) than other combinations of forages in banana orchard. Similarly, coconut +

Guinea grass + Desmenthus (3:1) in intercropping system realizes highest net monetary return (Rs. 55612/ha/yr) in this agro climatic situations**.**

- Production potential of guinea grass under shade was also promising at Coimbatore and Vellayani (under coconut) and Jorhat (under *Machilis bombycina*). The reduction in green forage yield was 17.4, 15.9 and 15.9 per cent only over open at Coimbatore, Vellayani and Jorhat, respectively. However, at Bhubaneswar condition, the forage yield of guinea grass increased by 6 % under coconut than open.

3 (C) Forage Protection Technology

- In cowpea, seed treatment with carbendazim @ 2g/kg, followed by two sprays of neem seed kernal extract @ 3% in 30 and 45 days crop is the most economical and productive measure for managing pests in an integrated manner.
- In Lucerne, soil treatment with carbofuran 3G @1g/m row along with seed treatment of carbendazim @ 1.0 g/kg and spray with neem seed kernal extract @ 3% , 15 days after each cut provides maximum fodder yield (381.9 q/ha) but economically seed treatment with carbendazim @1g/kg has been found most viable (C:B 53.43) than the other treatments studied.
- In Berseem, soil treatment with carbofuran @ 3G@1g/m row along with seed treatment with carbendazim @ 1g/kg provides maximum forage yield (518.89 q/ha) but economically seed treatment with neem seed powder@ 50g/ kg has been found most viable (C:B 50.95) than the other treatments studied.
- For white clover disease management, seed treatment with *Trichoderma* @5g/kg and alternate spray of cantaf and karathane @ 0.05% at 15 days and 7 days was economical.

All India Coordinated Research Project on Groundnut

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

..

• Demonstrate proven agro-production and protection technologies including improved varieties, cost effective production and protection technologies including IPM and Aflatoxin management through Front Line Demonstrations.

• Produce, monitor and supply of groundnut Nucleus and Breeder seeds as per Govt. of India indent / allocation.

• Identify constraints to groundnut production in non-traditional areas, particularly in Northeast and evolve technologies to overcome them.

• Formulate pragmatic and mission mode approaches, to improve groundnut productivity, especially under dry lands and thereby making this unpredictable legume more predictive, productive and remunerative.

• Exploit further scope for horizontal expansion of groundnut in rabi-rice fallow situation of Eastern and N.E. India and develop programmes under food security /bio-diversity.

• Provide scientific leadership and co-coordinating network researches with different SAUs and State Dept. of Agriculture for solving area specific problems in groundnut production.

• Finally, planning, implementation and monitoring of the AICRP-Groundnut activities spread over 14 states in the country under diverse production system in rainy and post-rainy seasons.

Salient Achievements of AICRP-G during X plan period (2002-03 to 2006-07)

I. Crop Improvement

• About eight groundnut germplasm accessions under four different habit groups were evaluated for various morphological, biotic and abiotic stresses and conserved at different AICRP-G centers

• One thousand four hundred and thirty seven new crosses were effected to develop high yielding groundnut varieties with resistance to biotic and abiotic stresses for both kharif and rabi/summer seasons

• From the crosses made earlier 23767 single plants and 6351 line bulks were selected for high yield, oil content, earliness, fresh seed dormancy, resistance to drought, diseases (rust, ELS, LLS, PBND, stem rot, collar rot), insect pests (Spodoptera, leaf miner, thrips) and other attributes at different generations and advanced to their respective filial generations.

• In addition, backcrosses of different breeding lines selected from crosses involving cultivarsl released varieties with different diploid wild species and several inter specific hybrid derivatives were also made. The interspecific hybrid derivatives included amphidiploids, triploid, tetraploid and hexaploids. 200 single line and bulk selections having high yield combined with resistance/tolerance to foliar diseases were made at different levels of back crossing

• 17 high yielding groundnut varieties (15 erect and 2 spreading) under- three different habit groups were released for *kharif* and *rabi/summer* cultivation for different states of India

• An early maturing, high yielding, sucking pets tolerant variety suitable for rice fallow situation, Dh 86 has been released for Orissa, West Bengal and Manipur

• An early maturing and high yielding stem rot tolerant y ray induced mutant derived groundnut variety, TG 38 B has been released for *rabi/summer* cultivation for Orissa, Bihar, West Bengal and Manipur .

• A high yielding and early maturing variety, GG 6 has been released for summer cultivation in Gujarat

• A high yielding foliar diseases (rust, leaf spots) and sucking pests tolerant varieties, ICUG 92195 and ICUG 92035 have been released for Rajasthan

• A high yielding early maturing variety, TG 37 A has been released for *kharif* cultivation in the states of Rajasthan, UP, Haryana and Punjab and for summer cultivation in Gujarat

• Two early maturing and high yielding erect type varieties, Sneha and Snigdha have been released for the state of Kerala for *kharif*cultivation for the first time

• One interspecific (KRG 1 x *A. cardinasii)* hybrid derivative GPBD 4 tolerant of rust and leaf spot diseases has been released for rainfed cultivation in the peninsular states

• A high yielding, bold seeded (>60g/100 kernel) variety, TPG 41 with *OIL* ratio and suitable for confectionery purposes has been released for All India for summer cultivation

• A high oil (51%) yielding and early maturing erect variety, AK 159 has been released for *kharif*cultivation in Maharashtra and Madhya Pradesh

• A high yielding, bud necrosis and root rot tolerant spreading variety, GG 16 has been released for peninsular India for rainfed cultivation.

• Root and collar rot tolerant, early maturing erect variety, GG 8 has bee released for *kharif* cultivation in Maharashtra and Madhya Pradesh

• A high yielding (2490 kg/ha), disease (stem rot, dry root rot) resistant and insect pests (Thrips, *Heliothis armigera)* tolerant Spanish groundnut variety, Dh 101 has been released for Jharkhand, Orissa, West Bengal and North-Eastern states for *Rabi/Summer* cultivation.

• A high yielding (1716 kg/ha of pod yield) and early (106 days) maturing erect groundnut variety, GG 8 has been released for the states of Maharastra and Madhya Pradesh for rainfed *kharif*situation.

• A high yielding (> 2.5 tonnes/ha of pod yield) and high oil content (>50%) erect groundnut variety, ANDG 50 has been identified (2005) for Zone IV comprising Jharkhand, Orissa, West Bengal and North-Eastern states for Rabi/Summer cultivation. This cultivar had high shelling out tum and tolerance to thrips.

• JSP 39, a high yielding (2.0 tonnes/ha of pod), early maturing (119 days) and medium bold seeded (43 *gl100* kernel) spreading groundnut variety has been identified (2005) for kharif rainfed situations of southern peninsular states namely, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala in addition to southern Maharashtra

• A high yielding, semi-spreading bold seeded high oil yielding variety, PBS 24030 has been identified for kharif situation for Rajasthan, UP, Punjab

• A high yielding, erect variety, JL 501 has been identified for kharif situation for Gujarat and Southern Rajasthan

• 900 q of groundnut breeder seeds of 45 improved groundnut varieties were produced during the period under report

II. Crop Production

• Irrigation applied at 50% of available soil moisture with water deficit imposed in between 10-40 days after sowing combined with FYM 10 t Iha and RDF resulted in highest pod yield at Digraj.

• Flat bed with polythene mulch produced higher pod yield as compared to BBF and without mulch at Dharwad. At Vriddhachalam, polythene mulch on paired row system gave the highest pod yield (2407 kg/ha) and BCR (2.21). Irrigation applied at 0.6 CPE and recommended dose of fertiliser along with Rhizobium and PSM gave the highest yield and also BCR.

• Seed inoculation with Plant Growth Promoting Rhizobia 2, 4 or mixture of strains (1 +2+4) provided the highest pod and the yield increase was in the range of 12.2 to 34.4% over the control at most AICRP-G centres

• Inter row water harvesting technique gave the highest pod yield (2665 kg/ha); 53.9% higher than the control. Broad bed and furrow method found effective in conserving soil moisture and increasing pod yield. This technology was also found remunerative and recorded higher Net returns (Rs. 17,553) as compared to the control (Rs. 16,459/-)

• In Groundnut + Pigeon pea inter cropping system, maintaining plant density of 100% in groundnut and 75% in pigeon pea or 75% of groundnut and pigeon pea, and fertilizing with 50% of to both the crops found most optimal combination and remunerative at Dharwad Jalgaon and Junagadh

• In groundnut + cluster bean intercropping, application of 100% recommended dose of fertilizer to groundnut and 50% to cluster bean, and maintaining 75% and 100% plant density, respectively, recorded maximum gross returns (Rs 41,343/as against Rs.37934) over control

• Soil of $ZnSo_4$ @ 30 kglha to *kharif* groundnut and no application of $ZnSo_4$ to succeeding wheat crop increased pod yield of groundnut by 27% and grain yield of wheat by 18.3% over no applicatic'll of $ZnS0_4$ to *kharif* groundnut. The BCR realized through this treatment was to the tune of 9.93.

• During *rabi/summer,* irrigation applied at 50% depletion of available soil moisture with water deficits imposed between 10-40 days, combined with FYM @ 10 tlha and recommended dose of fertilizer resulted in the highest pod and kernel yield 4566 and 3006 kglha, respectively at Dharwad and Digraj.

• Integrated weed management in groundnut based intercropping system revealed that pre-emergent application of pendimethalin (1 kg ailha) or oxyfluorfen (0.12 kg ai/ha) along with 1 hand weeding at 25-30 DAS at Kadiri effectively controlled the weeds in groundnut + pigeon pea intercropping system. While in groundnut + black gram intercropping, pre emergent application of pendimethalin @ 1.0 kg ai/ha as along with 1 hand weeding at 25-30 DAS effectively controlled the weeds at Vriddhachalam.

• In groundnut-wheat crop sequence, pre emergence application of fluchloralin 1 kg ai/ha in groundnut and 2-4 D sodium salt 500 ml/ha as post emergence in wheat at Durgapura and fluchloralin 1 kg ai/ha in groundnut and pre emergence application offluchloralin 1 kg ai/ha in blackgram at Vriddhachalam was found optimum.

• Adoption of in-situ moisture conservation increased pod yield by 11.1-17.7 % over control at Aliyarnagar, Chintamani, Durgapura & Jhargram. The results indicated that there is a possibility of reducing plant population and fertilizer dose (up to 25%) when in-situ moisture conservation technique is adopted.

• In groundnut + pigeon pea intercropping, irrigating pigeonpea at 0.5 IW/CPE at Aliyarnagar, Durgapura and 0.75 IW/CPE at Junagadh gave maximum net returns and BCR of the system. In groundnut + castor intercropping, irrigation to castor at 0.75 IW/CPE at Junagadh gave maximum net returns and BCR of the system

III. Crop Protection

• Germplasm evaluation against major diseases revealed that four genotypes *viz;* ICGV-91167, Y-I024, CSMG-84-1 and JL -80 appeared to be promising against stem rot «10% as against 48% in TG-26) at Jalgaon. Three genotypes, M-95-71, No. 1040 and PI-158853 were found to be promising against PBND «5% as against 38% in other genotype) at Raichur.

• Three entries, R 2001-1, VG 9816 and PBS 29017 at Aliyarnagar and six entries, JALW 26, TG 51, TG 52 and TKG 19A at Vriddhachalam showed resistant reaction against LLS and rust.

• Four genotypes, Dh-lOl, BSG 9802, GG 2 and Dh-106 at Dharwad and four entries, ICGS 44, R 2001-1, AK 159 and TG 50 at Jalgaon showed promise against stem rot.

• Five genotype, ICUG 92195, CSMG 9884, DSGl, TG17 and RG 141 showed promise against dry root rot at Kadiri.

• R 2001-1 showed multiple disease resistance (LLS, rust, stem rot)

• At Raichur, RS-l a released variety showed lowest foliage damage (15.5%) as against 67(Yo in TPT-l and four germplasm lines viz., Go-103. MK-374, VRIGJARlJL fmd NCAC-60 caused lowest damage « 10~/'O) as against 76% in lCG-7237 and 49 % in KRG-l.

• At Raichur, one gernlplasm line, NRCG-2323 recorded minimum damage (23~/o) due to GLM as against 80-85% in other genotypes.

• The genotypes, .lB-1101 (21% damage) and A1S-2003-5. (25<)/0 damage) showed less foliage damage of thrips (c. *indicus)* as against 85% damage in ICGV-86590 at Junagadh.

• At Junagadh genotypes *viz.,* INS-l-2004-1, 4, 8, 9, 12, AIS-(R)-2004-2 recorded <30% damage of thrips as against more than 70% in other genotypes and six genotypes viz; INS-I-2004-2, 7. AIS(R)-2004-1, 4, 5, 8 showed less than 10(% damage of *Helicoverpa armigera* as against 40-46% in other genotypes.

• Propiconazole (0.1%) and Difenaconazole (0.1 %) were found to be most effective and economical against LLS and rust for 3-4 years at Aliyamagar and Vriddhachalam.

• Integration of components *viz.* resistant variety (R 8808), spacing of 20 x 10 cm, groundnut + bajra intercropping (4:1), two foliar spray each of Phosphomidon (0.05%) and aqueous leaf extract of Sorghum (l 0%) at 20 and 30 DAS was found most effective in managing PBND at Kadiri and Raichur during three years of experimentation. This module was also found effective in managing PSND at Kadiri.

• The genotypes, JB 1101 (21% damage) and VG 9816 (32.5% damage) showed less foliage damage by thrips (c. *indicus)* as against 85% damage in ICGV 86590

• For the control of major seed and seedling diseases, integration of deep tillage during summer and/or crop rotation with wheat and seed treatment with *Trichoderma harzianum* @ 4g/kg seed was found most effective and economical (BCR 1:1.58-1 :1.79).

• For control of stem rot, seed treatment with Captan (2 g / kg) followed by soil solarization + seed treatment with *Trichoderma harzianum* @4 g/kg of seed was found to be effective.

• The cultures, CS-168, CS 86, PBS 29058, CS 19 and CS-160 possessed 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. The two genotypes, CS 168 and ICR 12 possessed promising multiple disease resistance. Six

NRCG breeding lines (NRCG 1 to 6) exhibited resistance to LLS and rust at the hotspot location (A1iyarnagar) of both these diseases

• The genotypes PBS-29071 and PBS-14010 have shown high level of resistance to leaf hopper, and genotypes NRCG-10628, 12698, 10818, ICG- 12367,12620,12621,9981,7846, 15119, 11721,2462,3037,4032,5403,9889,2701, 2748 and 4248 are found to be resistant to groundnut leaf miner under filed conditions under optimum disease pressure during the rainy season of 2004

• Based on three years data (2003, 2004, 2005) at Vriddhachalam, Hanumangarh, Latur and two years data at Raichur, soil application of FYM enriched formulation of *Trichoderma* sp. *(T viride IT harzianum)* was found most economical in managing the soil-borne diseases (collar rot, stem rot, root rot, pod rot) in groundnut. At Dharwad, based on 3 years data, seed treatment with *Trichoderma* sp. @4g/kg seed was found most economical with CBR of 1:2.48.

• At Jalgaon, based on 3 years data, it was revealed that the seed treatment with captan @ 3 g/kg seed gave highest ICBR of 56.39 in managing collar rot and stem rot.

• At Junagadh, the seed treatment with mancozeb @ 3 g/kg seed was found most effective in managing collar rot disease.

• At Dharwad, significantly low severity of rust was noticed in seed treatment with *P. jluorescens@* 10 g/kg seed. However, at Jalgaon, need based foliar application of NSKE @ 5% and seed treatment with mancozeb @ 3 g/kg seed significantly reduced the incidence of collar rot and stem rot followed by seed treatment with P. fluorescence @ 10 g/kg seed + soil application of P. fluorescence @ 2.5 kg/ha at 30 and 45 DAS. This treatment also gave highest pod yield of 1780 kg/ha.

• At Latur, seed treatment with *T harzianum* @2 g/kg seed + seed treatment with *Pseudomonas* spp. @2 g/kg seed significantly reduced the incidence of stem rot and gave highest pod yield of 1092 kg/ha.

• Based on three years data (2001, 2002 and 20(3) at Vriddhachalam and Jagtial it was revealed that integration of 2 foliar sprays of NSKE @ 5 % J()llowed by Quinalphos *Ci!:}* 0.05% and groundnut intercropped with castor (l 0: 1) was found most effective against *Spodoptera lilura* and realizing higher pod yield with CBR ofl:1.76.

• At Vriddhachalam, integration of foliar application of *NOn1uraea rileyi* (@ 2 g/ lit and the foliar spray of 5% NSKE was found most economical (CBR 1: 1.45 1:1.79) for the management of *51', litura* dming 2003-04 and 2004-05.

• Three years data at Kadiri showed that integration of components viz., groundnut + bajra intercropping (8: 1) + one spray of Dimethoate 0.03% at 30 DAS significantly reduced the damage caused by thlips and realized higher pod yield (1825 kg/ha) and haulm yield (2408 kg/ha) and CBR of 1: 2.47.

• Evaluation of IPM Module on Farmers' Field Under Micro-Mission-I of TMOP was allotted to 5 main centres of AICRPG (Dharwad, Jalgaon, Junagadh (JAU),Kadiri and Vriddhachalam) for 3 years (2003-2005) to assess and refine IPM technology along with farmers' practice on farmers' fields.

• Based on the information generated at 5 locations, it is suggested that the IPM technology with the main components of (i) soil application of Castor Cake @ 500 kg/ha (ii) seed treatment with *Trichoderma* sp (locally available formulation)

(iii) 'intercropping with locally recommended intercrops (iv) need based

application of crude neem oil (2%) and/or 5% NSKE, (v) erecting of pheromone traps @ 10/ha and (vi) if necessary, one spray of locally recommended chemical,may be adopted in groundnut based cropping system in the country.

IV. New initiatives and future thrusts

• Developing cultivars with tolerance/resistance/adapted to moisture deficit stress (early season / mid season and late season)/ major insects/diseases/cold and high temperature /acid soil!Al-toxicity/aflat.oxin

• Development of early Virginia cultivars and Spanish cultivars with fresh seed dormancy and cultivars with better confectionery traits.

• Development of suitable groundnut based cropping systems for enhancing input (including water) use efficiency and development of suitable agronomic packages for paddy fallow situation

• Development of integrated nutrient, insect and dis~ase management packages for the existing and emerging problems

• Conservation and utilization of new groundnut germplasm to introduce novel genetic variability

V. Approach to the XI five year plan

The present National Agriculture Policy spells out the new priorities to enable the farm sector to face the challenges arising out of economic liberalization and globalisation. During XI plan period special effort will be made to raise the productivity and production of groundnut at a globally competitive cost of production to meet the increasing domestic demand for edible oil generated by unabated demographic pressures and exploit the potential of groundnut for export and for value added products. To achieve this goal, a very high priority will be accorded to evolving new location specific and economically viable improved groundnut varieties and eco-friendly system oriented and integrated production and protection technologies. High input use efficiency, more and more dependence on non-synthetic inputs, reducing the risk associated with groundnut cultivation will be the important plans of action.Exploitation of the lower risk and high potential of rabi/ summer groundnut will be expedited. Technologies for slowly developing niches of paddy fallow, residual moisture and spring groundnut will be strengthened. Re-introduction of groundnut in those areas of rice - wheat system of northern India where groundnut used to be an important crop will be attempted.

All India Coordinated Research Project on Honey Bees and Pollinators

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Royal Jelly Production:

It has been observed that royal jelly production can be optimized by the use of 150 grafts in PVC Cell cups per bee colony of European honey bee.

Harvesting of Extra Pollen: It has been established that the harvesting of extra pollen as bee food by the use of *Apis mellifera* bee is best done by the use of pollen traps with hole size of 5 mm. The traps should be used at an interval of 3 days to have the best result of pollen separation without having adverse effect on hive health and development. Pollen harvest at the rate of over 2.5 kg/colony/year is possible for *A.mellifera*.

Propolis harvesting:

- Propolis is a natural gum of medicinal value that honey bees collect from plants and use them to fill up the cracks and gaps in the hives. This propolis is in demand in export market.
- Propolis can be scrapped by knife from wooden parts of the hives. Now plastic screens of 5 meshes may in addition be used inside the hives. Bees will fill up the gaps with propolis that can be extracted and purified. Over 7 grams of propolis/month/colony could be harvested.

Pollination of Litchi Crops:

For obtaining best result in Litchi plantation, it has been observed that the deployment of 25 standard *Apis mellifera* colony per ha results in maximum, best quality harvest of litchi crop because of effective pollination by the honey bees employed.

Pollination in Assam Lemon (Citrus) Crop:

- In Assam conditions, use of four standard(15,000 bees) *Apis cerana* hives have been found effective in pollination of 1 ha of Assam Lemon crops and yields 48.99 t/ha.

Bee pollination in Cherry and other Fruit Crops:

- The optimum pollination of cherry is achieved by the maintenance of two *Apis mellifera* hives of 6 to 8 frame strengths per hectare bee pollination results in the production of large berries. Similar results are obtained in Strawberry and Peach orchards.

Hybrid Seed Production in Cauliflower:

- *Apis mellifera* bees in cage condition of crop proved useful in hybrid seed production. Per plant the seed production due to honey bees was about 7 gms. Bees visitation rate was 7.6 bees/plant/5 minute of fertile line and 5.4 bees/plant/5 minute on CMS lines. So, European honey bee is no doubt one of the best tools in hybrid seed production and research.

Monitoring of bee management:

- Regular surveys and monitoring of the bee management methods and pest and disease status is being monitored for further improvement in the beekeeping development in India via nine centres of AICRP on honey bees located in State Agricultural Universities in Assam, H.P., Uttarakhand, Punjab, Haryana, Bihar, Orissa, A.P. and in Kerala.

Video Film on Beekeeping:

- Video Film on Beekeeping has been made by P.C. (Honey bee) for effective and interesting presentation of the scientific beekeeping. Video Films can be an effective tool for communication and hence needs more and more Video films on beekeeping including in regional languages.

Control of European foul brood disease in honey bees:

- It has been proved that the European foul brood disease of *Apis mellifera* is manageable by the application of a single dose of Oxytetracycline @ 200 mg/affected colony of bees/300 ml. of sugar syrup (50%) as and where the infection is noticed.
- In case of *Apis cerana* bees infested with European foul brood disease it is possible to have effective treatment by the use of a single dose of Tetracycline @ 200 mg/affected colony/300 ml. sugar syrup (50%) as and where the infection is noticed.

Mite Problem in Beekeeping:

- A large array of parasites mites are reported to be associated with honey bees and solitary bees the world over including in India. But the most important of them are *Varroa* spp. *Tropilaelaps* spp. and *Acarapis* spp. that are now a serious pest the world over. Use of white sheet method for detection and control of mites are possible by placing paper on bottom board at night and taking it out the next day; detecting the mites as reddish brown spots and burning the paper alongwith the mites. Repeating the system for 7 days will bring down the mite population. It should be essentially associated with the cleaning of

the bottom board of debris and burning the debris in all the colonies on every 7 to 10 days interval.

- Sulphur dust may be applied on the upper parts of wooden frames very lightly. One must avoid use of chemicals as the chemicals will contaminate the honey and pollen (bee food).

Mass scale queen production and Queen Bank:

- Technology is available to produce bee Queens in large number for commercial sale. Establishment of Queen Banks is possible by maintaining individual queens in small cages in a queenless strong bee colonies.

All India Coordinated Maize Improvement Project

1. **Title of the Project** : **All India Coordinated Maize Improvement Project**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Varietal improvement and production technologies developed under the DMR and its AICRP centers have resulted in an overall increase in area, production and productivity of maize in the country. Productivity increased from 0.5 tonnes in 1950's to about 2 tonnes per hectare during 2006-07. In the same period, production increased from 1.73 million tonnes to 14.98 million tonnes while the area increased from 3.1 million hectares to 7.8 million hectares. This 4 fold increase in the productivity, 8 fold increase in production and 2½ time increase in area that showed highest growth rate of area, production and productivity of maize among the cereals that has been possible mainly by virtue of technological advancement by the Directorate of Maize Research and its Coordinated Centers.

Achievements of the Directorate of Maize Research and AICRP centers located in different parts of the country, during last five years (2002-2007) are given briefly as follows:

Varieties developed

During last five year period 35 Hybrids and 12 Composite/Varieties were released/ identified for commercial cultivation in the country. A list is given below **(Annexure-I):**

Hybrids:- High yielding hybrids have been developed for conventional as well as non-traditional cropping systems, viz., Buland, Sheetal, HM-5, JH 10655, Malvya Makka Hybrid 2, COH(M)-4, HM-8, HM-9, NECH-128, HM-4 (medium maturity), PEH-5, DH 115, Vivek-15, Vivek-17, Vivek 25, Vivek 27. Medium and late maturity hybrids have also proved highly successfully for cultivation during rabi season. Early and extra early maturing hybrids are good for spring season.

HM – 9

HM - 8

A major breakthrough has been achieved by developing high quality protein maize (QPM) hybrids which have covered large area throughout the country viz., HQPM-1, HQPM-5 across the country, Shaktiman 3, Shaktiman 4 for Bihar and BQPH 12 for Andhra Pradesh.

HQPM - 5

HM-4 has excelled as the best hybrid for baby corn production throughout the country. VL78 for baby corn and Win yellow sweet corn varieties are also popular.

HM 4 (Baby Corn)

Composites:- Gujrat Makka-6, Narmada Moti, Javahar Makka 216, PratapMakka4, Pragati, Azad Kamal, Shalimar -1, Shalimar-2, Birsa Vikas Makka-2 have been released for various agro climatic conditions where hybrid seed is not available easily.

Germplasm lines registered

Thirty four Inbreds and two gene-pools for different favorable traits like productivity, disease resistance, drought / cold tolerance and good combining ability, have been registered in NBPGR for their use in hybrid breeding program as follows **(Annexure-II**):

BPTTI-28, BPTTI-32, BPTTI-34, BPTTI-35, BPTTI-37, BPTTI-38, BPTTI-44, BML-2, BML-3, BML-5, BML-6, BML-7, BML-8, BML-11, BML-14, BML15, BML-20, BML-22, HKI- 209, HKI-335, HKI-1025, HKI-323-8, HKI-1040-7, HKI-1105, HKI-1348-2, HKI-1352-58-9, HKI-1354, HKI-295, HKI-586, HKI-1344, HKI-1332, MS Pool C-4, Tux Pool C-4. H

HKI - 1105

Heterotic pools developed: 12 Heterotic Pool were developed as a long-term strategy to extract inbred lines

Disease resistance Sources: Apart from the lines registered with NBPGR, 33 multiple disease resistant inbred lines were also identified. Sources of resistance to major diseases were identified for their use in resistant cultivar development program as per the number in parentheses: TLB (53), *Polysora* rust (49), PFSR (5), BLSB (3), MLB, SDM

Package of practices for different maize-growing regions have been developed. These include production technologies for cultivation of baby corn, sweet corn and maize based cropping system.

Technology for transplanting during winter has been developed. This has been profitably adopted by farmers after harvest of late-sown paddy and early sugarcane crops. Winter maize cultivation in rice wheat cropping system to help eradicate *Phalaris minor*, and in eastern states to replace wheat crop which suffers due to rising temperature.

Exotic and indigenous materials are being regularly screened against important pests and diseases under artificial conditions or at hot spots. It has resulted in identification of sources of resistance to specific diseases and pests. Many of these materials have been used for developing maize cultivars resistant to diseases and pests.

Chemical and biological control measures have been devised to combat pests and diseases.

A technique for clipping infected basal leaves of maize has been developed to control banded leaf and sheath blight disease.

Post-flowering stalk rots management has been developed through manipulation of cultural practices (higher dose of potash) and by using bio-control agents (*Trichoderma* formulation after mixing with FYM 10 days before sowing and seed treatment with carbendazim).

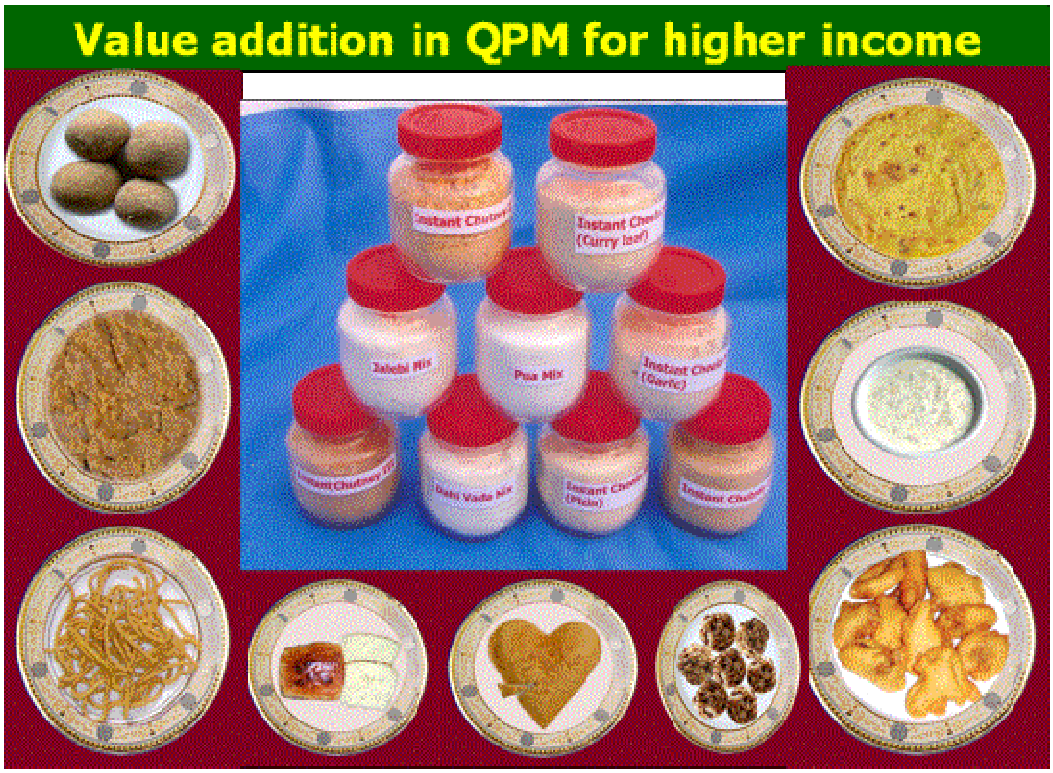
Integrated Pest Management strategies have been developed to minimize yield losses. Refinement in mass-rearing technique of stalk-borers has been made.

The shelf life of maize flour has been improved by kernel heat treatment at 80 ^{o}C for three hours before grinding.

Value Addition

A series of products from QPM and baby corn have been developed. Pickles, Murrabba, Halwa, Soup, Pakora etc. from baby corn and Dalia, Suji, different kinds of baby foods have been developed for nutritional security from QPM.

Significant efforts has been made for acceleration of adoption of maize production technologies in different parts of country




Value addition in Baby Corn for higher income and employment generation

Annexure-I: Hybrids and Composites released during 2002-2007

S. No.	Hybrids/ Composites	Year of release	AREA OF ADAPTION	Duration	Yield range (Kg/ha)
Quality Protein Maize (QPM) Hybrids					
1	SHAKTIMAN-2	2002	U.P., Bihar	Late maturity (Rabi)	7500-9500
2	SHAKTIMAN-3		U.P., Bihar	Late	6000-6500
3	SHAKTIMAN-4		U.P., Bihar	Late	6000-6500
4	BQPH-12	2004	Single cross hybrids for the states of H.P., Uttranchal , Bihar, Haryana, Karnataka, Rajasthan and A.P.	LATE MATURITY (KHARIF)	4500-5000
5	HQPM-1	2006	Across the country	Late Maturity	4500-6500
6	HQPM-5	2007	Across the country	Late Maturity	
NORMAL MAIZE HYBRIDS					
1	SHEETAL	2003	Punjab	Late maturity (Rabi)	7000-9000
2	PRO 339	2003	Andhra Pradesh, Maharashtra, Karnataka	Medium	4500-5000
3	DK-701 (F7001)	2003	Punjab, Haryana, Delhi, U.P., Bihar, Assam, Orissa, W.B.	Medium	4500-5000
4	PUSA EARLY HYBRID -5	2004	Punjab, Haryana, Delhi, Western U.P.	Early	4000-5000
5	DECCAN HYBRID 115	2004	Eastern U.P., Bihar, Assam, Orissa, Jharkhand, Chhatisgarh, A.P., Karnataka, Maharashtra, Tamilnadu	Early	4500-5500
6	JKMH 68-2	2004	A.P., Maharashtra, Tamilnadu, Karnataka	Early	4500-5000
7	PRO 345	2004	Eastern U.P., Bihar, Assam, Orissa, Jharkhand, Chhatisgarh	Medium	5000-6500
8	BIO 9862	2004	Punjab, Haryana, Delhi, Western U.P.	Medium	5000-6500
9	BULAND	2004	Single cross hybrids for the states of A.P., Maharahtra, Tamil Nadu, Karnataka for rabi cultivation	Late maturity	5000-9000

10	VIVEK-15	2004	Single cross hybrids for the states of Jammu & Kashmir, Himachal Pradesh, Hills of Uttranchal, Hills of West Bengal.	Early (Kharif)	3000-3500
11	VIVEK-17	2004	Single cross hybrids for the states of Delhi, Haryana, Punjab, A.P., Maharashtra, Karnataka and Tamil Nadu	Early (Kharif)	3000-3500
12	PMH19	2004	Maharashtra	Early (Kharif)	4500-5000
13	HM4	2005	Haryana (Baby corn)	Late maturity	4500-7000
14	HM5	2005	Haryana	Late maturity	4500-7000
15	COH (M)-4	2005	Tamil Nadu	Late maturity	4500-7000
16	JKMH-1701	2006	J&K, H.P., Uttranchal, NEH region , A.P., Maharashtra, Tamil Nadu and Karnataka	Early (Kharif)	3500-4500
17	JH 10655	2006	Delhi, Haryana, Punjab & West U.P.	Late Maturity	4500-6000
18	FH3211	2006	J&K, H.P., Uttranchal, NEH region , Delhi, Haryana, Punjab, A.P., Maharashtra, Tamil Nadu and Karnataka	Extra early (Kharif)	3000-4000
19	X1280	2006	A.P., Maharashtra, Tamil Nadu and Karnataka	Late maturity	5500-8000
20	VIVEK MAIZE HYBRID 21	2007	Uttaranchal, Punjab, Haryana, UP, J&K, Delhi	Extra Early	4500-5000
21	VIVEK MAIZE HYBRID 23	2007	Uttranchal hills	Early	4500-5000
22	VIVEK MAIZE HYBRID 25	2007	Uttaranchal, Himachal Pradesh and J&K	Extra Early	5000-5500
23	VIVEK MAIZE HYBRID 27	2007	Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Bihar, Orissa, Chattisgarh, West Bengal, Eastern UP	Early	5000-5500
24	COH(M) 5	2007	Tamil Nadu	Late	5000-5500
25	PMH-I	2007	Punjab	Early	5000-5300
26	MAIZE PAU 352	2007	Punjab, Delhi, Haryana, UP	Medium	5500-6000
27	HM 8	2007	AP, Karnataka, Tamil Nadu, Maharashtra	Medium	6000-6200
28	HM 9	2007	Eastern UP, Bihar, Orissa, Jharkhand, Chattisgarh	Medium	6000-6100

29	MALVYA MAKKA HYBRID2	2007	Eastern UP, Bihar, Orissa, Jharkhand, Chattisgarh	Medium	5000-5500
Composites					
1	Narmada Moti	2002	Western U.P., Punjab, Haryana, Delhi, Andhra Pradesh, Maharashtra, Karnataka, Tamilnadu, Rajasthan, Gujarat, Madhya Pradesh	Early	3500-4000
2	Gujarat Makka-6	2003	Gujarat	Early	3500-4000
3	Jawahar Makka-216	2003	M.P.	Medium	4000-5000
4	Pratap Makka 4	2004	Jammu & Kashmir, Uttaranchal, H.P., NEH region	Early	3500-4000
5	Pragati	2004	Eastern U.P., Bihar, Assam, Orissa, Jharkhand, Chhatisgarh	Early	3500-4000
6	r 9803 (Azad Kamal)	2004	Rajasthan, Gujrat, Madhya Pradesh	Early	3000-3500
7	Win yellow sweet Corn	2004	Himalayan region H.P., J&K, Uttaranchal	Early (Kharif)	2500-3000
8	vl 78 (baby vl 78)	2004	Across the zone for cultivation as baby corn	Kharif & Rabi	-------
9	Birsa Makka-2	2005	Jharkhand	Early	3000-3500
10	Shalimar kg maize-1	2005	Jammu And Kashmir	Early	3500-4000
11	Shalimar kg maize-2	2005	Jammu And Kashmir	Early	3500-4000
12	Birsa Vikas Makka-2	2005	Jharkhand	Early	3000-3500

All India Coordinated Research Project on MULLaRP

1. **Title of the Project** : **All India Coordinated Research Project of MULLaRP (Mungbean, Urdbean, Lentil, Lathyrus, Rajmash and Pea)**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Total 26 varieties of different crops (8 in mungbean, 3 in urdbean, 6 in fieldpea, 4 in lentil and 5 in rajmash) were identified during last five years.

1. Crop Improvement

• Large number of wide crosses, (mungbean x urdbean) were attempted for transfer of plant type traits. A variety IPM 99-125 (Meha) of mungbean has been released.

• Short duration and MYMV resistant mungbean varieties Meha, TM 99-37, HUM-12 and HUM 16 and urdbean variety WBU 109 were released for summer/spring cultivation under rice-wheat system of northern plains.

• High yielding varieties COGG 912, OUM 11-5 (SZ), and NDM 97-1 (NEPZ) of mungbean for kharif cultivation were developed.

• Donors for CLS resistance in mungbean (ML 515, PM 4, PDM 262) and urdbean (K 11-68, T 65) were identified which are being used in breeding programme

• Short duration, heat tolerant and powdery mildew resistant fieldpea varieties (Adarsh, Vikas, Prakash) were released for central zone.

• Several high yielding and powdery mildew resistant varieties of fieldpea (HFP 9907 B, VL 42) were also developed for cultivation in northern plains.

• Rust resistant lentil varieties KLS 218, HUL 57, VL 507 and IPL 406 were released for North India.

• Rajmash varieties Amber, Utkarsh (NEPZ), IPR 98-3 and HUR 203 (CZ) with BCMV tolerance were developed for rabi cultivation.

2. Crop Production

Lentil

• Sprouted seeds 0 f lentil sown 1 5 days before the harvest 0 f rice crop increase the lentil yield by 30 percent.

• Utera lentil yield increased by 9% due to two hours seed soaking in 2% KH_2P0_4 .

Urdbean

• Soil mulch and 2% KCL spray was found effective in urdbean
• 2% urea spray at flowering was found effective in urdbean.

• Urdbean strains CRU 7 recorded the highest yield across the centers in different years.

• Urdbean + Ragi at 2: 1 or 1: 1 row ratio and pre - emergence application of Alachlor @ 2 kg a.i./ha increased the yield in urdbean + ragi intercropping at Pantnagar.

• PUR 34 and VRU 7 were promising urdbean Rhizobium strains.

• 2% foliar spray of urea at pre-flowering, flowering and pod development stages increased yield by 28%.

Mungbean

• Among the mid season drought management practices, mixed spray of 2% KCL+O.l ppm Boron (891 kg/ha) was most effective in mungbean.

• Under rainfed situation, addition of 5t/ha FYM increased yield by 35.45% over 40 kg P20s/ha alone in mungbean.

• Irrespective of the sources of phosphorus, 40 kg P20Slha produced higher grain yield (17.34%) than 20 k P20 siha in mungbean.

• Intercropping of sorghum with mungbean and pigeonpea with urdbean produced highest respective equivalent yields (6065 kg/ha and 970 kg/ha). 2/3 rd dose of fertilizer saved in mungbean and urdbean.

• Combined application ofNPKS + 10 kg Borax/ha produced higher yield by 49.22 per cent. NPKS + Molybdate @ 2 kg/ha (48.33%) and NPKS + ZnS04 produced 41.43 per cent higher yields than NPKS alone application.

• Higher plant density of 4 lakh planslha proved superior to 3.3 lakh planting density of mungbean.

• Mungbean Strain CRM 6 was found superior under testing across the centers for consecutive four years.

• Under late planted (August sown), application ofN @ 20 kg/ha as basal + 10 kg N as foliar proved beneficial and resulted into higher into higher yield at higher planting densities (4 lakh & 5 lakh per ha) in mungbean.

• The multilocation testing of rhizobium strains revealed that strain CRM 6 (check) recorded the highest yield followed by PMR 2001 strain in mungbean.

• Ridge planting of mungbean increased the yield by 20% over flat planning.

Rajmash

• Two sprays of 2% urea at pre-flowering and pod development stages increased the yield significantly in raj mash.

Fieldpea

3. Crop Protection

Lentil

• Lentil genotypes PL 01 and PL 02 showed multiple disease resistance to rust, wilt, stem rot and ascochyta blight.

Urdbean

• Seed treatment with thiomethoxam (2gm/kg seed) followed by foliar spray of triazophos (0.04%) or Lambda cyhalothrin spray (0.04%) alone found highly effective against stemfly, whitefly and pod borer damage in urdbean.

• Treatments with NSKE + karate and NSKE + Dichlorovos gave maximum control against pest in urdbean.

• Urdbean entries OBG 19, TU 99-843 were recorded tolerant to both the species of root - knot nematode, M. incognita and M. javanica.

• Urdbean line KU 96-3 was found to show broad - based resistance to YMV.

• TPU 4 was found resistant to both the species of root - knot nematode *Meloidogyne incognita* and *M. javanica.*

• Foliar spray of Lambdacyhalohrin, thiodicarb (0.04%) and heir half dose in combination with NSKE 5% proved highly effective against *Maruca* damage in rabi urdbean.

Mungbean

• Intercropping of sorghum, finger millet or maize intercropping in mungbean (1 :2) lowered CLS and leaf curl disease.

• Seed treatment with neem seed kernel powder, neem oil, mahua oil, karanj oil gave minimum seed damage due to bruchid in mungbean.

• Mungbean HUM 7 was found resistant of both the species of the root – knot nematodes, *Meloidogyne incognita* and *M. javanica.*

• Mungbean ML 131 was recorded tolerant to three nematode species *M. incognita, M. javanica* and *Rotylenchulus reniformis.*

• Neem product, Numbicidine @ 0.03% was found effective in managing root – knot nematode population infesting mungbean.

• TM 99-50 and BPMR 145 were most promising entries against powdery mildew.

• Lamda Cyhalothrin (Karate 0.04%) alone and in combination with NSKE 5% (with half dose of Karate 0.02%) and Thiodicarb 0.04% proved higher effective against sucking pests and pod borer in mungbean.

• IPM 99-125 recorded resistance to both species of root - knot nematode *Meloidogyne incognita* and *M. javanica.*

• IPM module involving seed treatment with Dimethoate (5 ml/ha seed) + Carbendazim (2 gm/kg seed) + Removal of virus infested plant at 30 DAS + Foliar application of Chlorpyriphos (2.5 ml) + DDVP (1 ml) during flowering and pod stage was effective against pod borer complex and proved economical.

• ML 1108 and Pusa bold 1 showed multiple disease resistance against YMV, leaf curl and CLS diseases.

• SML 746 and TM 99-37 of mungbean were found resistant to both the species of root knot nematode *(Mjavanica* and *M. incognita).*

• Genotype TM 2000-02 showed broad based resistance against powdery mildew.

Rajmash

• Foliar spray of acephate 0.04%, profenophos + cypermethrin 44 EC (1 lit.lba) or Endosulphan 0.07% proved effective against stemfly and pod borer damage in rajmash.

Fieldpea

• Seed treatment with *Trichoderma viride* has reduced wilt incidence in fieldpea by 50%.

• Pea genotypes KPMR 640, DMR 47, IPF 2-19 and KPMR 615showed multilocational resistance against powdery mildew.

All India Coordinated Pearl Millet Improvement Project

1. **Title of the Project** : **All India Coordinated Pearl Millet Improvement Project**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

1. Breeding of new hybrids and varieties A. New disease resistant, high yielding released

S. No.	Hybrids/ Varieties	Year of release	Area of adaptation
1	GHB 558	2002	All India
2	HHB 146	2002	Rajasthan, Haryana, Gujarat, MP, UP
3	PB 172	2002	Summer growing areas of the country
4	GHB 526	2002	Summer growing areas of the country
5	SAMH 166	2003	Maharastra, Karnataka, AP, TN
6	RHB 127	2003	All India
7	GHB 577	2003	Rajasthan, Haryana, Gujarat, MP, UP
8	HHB 117	2003	Haryana
9	NMH 45	2004	Rajasthan, Haryana, MP, UP, Punjab, Delhi
10	KBH 3	2004	Rajasthan, Haryana, MP, UP, Punjab, Delhi
11	PB 180	2004	Rajasthan, Haryana, MP, UP, Punjab, Delhi
12	GHB 538	2004	Rajasthan, Gujarat, Haryana,
13	Sagar 205	2005	Maharahtra, Karnataka, AP, Tamil Nadu
14	HHB 67 Improved	2005	Western Rajasthan and drier part of Gujarat and Haryana
15	GHB 715	2006	Zone A1 (<400mm rainfall areas of Rajasthan, Haryana and Gujarat
16	GHB 719	2006	Zone A1 (<400mm rainfall areas of Rajasthan, Haryana and Gujarat
17	B 2301	2006	Maharahtra, Karnataka, AP, Tamil Nadu
18	86 M 52	2006	Summer areas of Rajasthan, Haryana, Gujarat, MP, UP, AP, TN, Maharashtra, Karnataka

B. New disease resistant, high yielding varieties released

S. No.	Hybrids/ Varieties	Year of release	Area of adaptation
1.	HC 20	2002	Haryana
2.	CZP 9802	2002	Rajasthan, Gujarat, Haryana
3.	PPC 6	2003	Maharashtra
4.	CoCu-9	2004	Tamil Nadu
5.	PCB 164	2004	Punjab
6.	FBC-16	2004	Punjab

C. Agronomically superior new hybrids and varieties identified

(i) Hybrid/ Varieties identified in 2002-03

Trial	Zone	Hybrid(s)/ variety(s) better than superior check	Grain yield (kg/ha) (Range)	Best check	Best check yield (kg/ha)
IHT-I	A	MH1143, MH1139, MH1144	1973-3099	PB 106	2954
	B	MH1139, MH1133, MH1165	2026-3548	Shraddha	3052
AHT	A	MH 1001, MH 1021, MH1079	2699-3418	7686	2491
	B	MH1079, MH 1010, MH 1073	2810-3150	PB106	2919
IPT	A	MP426	1526-2518	JBV 2	2254
	B	MP429, MP 426, MP 427	2174-2673	ICMV 155	2546
APT-V	A	MP 413	2313-2690	Raj 171	2664
AHPT	A1	MH1049, MH1109, MP414	1937-2716 1645-2249	HHB 67 RCB 2	2219 1957
PHT (NATP)		MH 1171, MH 1182, MH 1172	1730-2568	RHB 121	2351
IHT Summer		MSH 142 & MSH 148	3114-4031	Pusa 23	3577
AHT Summer		MSH118, MSH120, MSH 124	3682-4054	Pusa 23	3150

(ii) Hybrid/ Varieties identified in 2003-04

Trial	Zone	Hybrid(s)/ variety(s) better than superior check	Grain yield (kg/ha) (Range)	Best check	Best check yield (kg/ha)
IHT-I	A	MH 1219, MH 1213	1160-3171	Pb 106	2726
	B	MH1192, MH1189, MH1213, MH1196	1701-3792	GHB 558	3459
AHT-II	A	MH 1144, MH 1001, MH 1079	2114-3227	GHB 558	2800
	B	MH 1079	3013-3299	GHB 558	3300
IPT IV	A	MP 445, MP 444	1327-2063	Raj 171	1850
	B	MP 445, MP 444, MP 446	2179-3042	ICMV 155	2775

APT-V	A	MP 430	1838-2053	Raj 171	2044
	B	MP 426, MP 427	2316-2526	Raj 171	2441
AHPT	-	MH 1049, MH 1109, MH 1097	1576-2714	ICMH 356	2234
PHT (NATP)	-	MH 1236, MH 1234, MH 1230	2014-3422	RHB 121	3100
IHT Summer	-	MSH 155	3619-4784	GHB 526	4302
AHT Summer	-	MH 148, MSH 147	4024-4357	GHB 526	4235

(iii) Hybrid/ Varieties identified in 2004-05

Trial	Zone	Hybrid(s)/ variety(s) better than superior check	Grain yield (kg/ha) (Range)	Best check	Best check yield (kg/ha)
IHT-I (1)	A	None	-	GHB 538	3053
	B	MH 1242	3366	GHB 538	3281
IHT-1 (2)	A	MH 1264, MH 1274, MH 1276, MH 1272, MH 1271, MH 1267, MH 1249, MH 1263, MH 1280, MH 1266, MH 1262	2956-3293	ICMH 356	2899
Trial	Zone	Hybrid(s)/ variety(s) better than superior check	Grain yield (kg/ha) (Range)	Best check	Best check yield (kg/ha)
	B	MH 1264, MH 1280, MH 1277	3674-3932	PB 106	3546
IHT-1 (3)	A	MH 1308, MH 1299, MH 1307, MH 1302, MH 1306, MH 1291, MH 1295, MH 1309	3185-3610	GHB 558	3168
	B	MH 1290, MH 1283, MH 1291, MH 1284	3889-4389	GHB 558	3812
AHT	A	None	-	PB 106	2924
	B	MH 1196, MH 1190	3275-3337	GHB 558	3188
IPT	A	MP 454, MP 450, MP 456, MP 458, MP 453, MP 449	2655-2952	State Check	2648
	B	None	-	State Check	2695
APT	A	MP 445	2334	State Check	2323
	B	None	-	Raj 171	2947
AHPT	-	MH 1234, MH 1236, MH 1094, MH 1218, MH 1231	1905-1994	ICMH 356	1882
		MP 443, MP 433		Pusa 266	1385
PHT (NATP)	-	None	-	ICMH 356	2945
IHT Summer		MSH 173, MSH 184, MSH 167, MSH 175, MSH 183, MSH 185, MSH 166,	4167-4594	GHB 526	4163

		MSH 182, MSH 179			
AHT Summer		MSH 162, MSH 147, MSH 152, MSH 152	4262-4662	GHB 526	4099

(iv) Hybrid/ Varieties identified in 2005-06

Trial	Zone	Hybrid (s) / variety (s) better than superior check	Grain yield (kg/ha) (Range)	Best check	Best check yield (kg)
IHT-I	A	MH 1340	1850-2890	RHB 121	2510
IHT-II	A	MH 1384, MH 1369	1921-2882	PB 106	2809
	B	MH 1351, MH 1385, MH 1364,	1573-3156	GHB 558	2894
IHT-III	A	MH 1390, MH 1397	1819-2496	Pusa 23	2459
	B	MH 1404, MH 1391, MH 1392, MH 1405	1851-3656	GHB 558	3533
AHT-II	A	MH 1257, MH 1274	2307-2645	RHB 121	2509
	B	MH 1257	2687-3443	GHB 558	2978
AHT-III	A	MH 1295, MH 1291, MH 1306, MH 1302	2068-2632	GHB 558	2539
	B	MH 1192, MH 1196	3005-3917	GHB 558	3116
IPT	A	None	885-1700	Raj 171	1704
	B	None	1713-2846	Raj 171	2848
APT	A	MP 450, MP 444, MP 449	1450-1582	Pusa 383	1556
AHPT	A1	MH 1234, MH 1236, MP 443	1905-1994	GHB 538, CZP 9802	1883 1505
Summer Trial		MSH 155, MSH 187, MSH 175	3384-4360	GHB 526	3447

D. Development of new hybrid parents - CMS lines

- During 2002-06, concerted efforts on development of new diversified CMS lines under AICPMIP and the Mission Mode Project funded by NATP led in developing as many as 86 new CMS lines on A1 source (19 CMS lines developed at Delhi, 13 at Hisar, 28 at Jamnagar and 26 at Rahuri centres). Many of the CMS lines were found good general combiner and promising hybrids with new restorer lines were developed under the projects. AICPMIP attained the status from deficit to surplus in the development of new CMS lines. Development of diversified CMS lines on A4 cytoplamsic source is in progress

E. Pearl millet germplasm

- In collaboration with NBPGR, New Delhi seed of 93 germplasm accessions was multiplied in *kharif* 2002 and summer 2003 and deposited with NBPGR Hyderabad. Seed of 190 accessions received from NBPGR, Regional Station, Hyderabad were evaluated during *kharif* 2004. Seeds of 1930 germplasm accessions were also planted and multiplied during kharif 2004 and seed of 1845 accessions were deposited with NBPGR, Regional Station, Jodhpur. In addition 91 accessions were collected from Jalore, Rajasthan for high fodder yield. The same were evaluated at ICRISAT Hyderabad during summer 2005.

- Seed of 329 and 270 germplasm accessions were planted at 9 different locations viz. Hisar, Durgapura, Mandor, Jamnagar, Gwalior, Dhule, Aurangabad, Coimbatore and Palem during *kharif* 2003 and 2005, respectively. The accessions were evaluated for morphological characters and the trait specific agronomically superior lines were identified for distribution at the national level.

F. Grain quality

- During 2003-06, entries in different multilocation trials (IHT, AHT, IPT, AHPT, RHVT, PHT-NATP) were tested for protein (% dry weight) and fat (% dry weight). Protein ranged from 8.05 to 11.97 in IHT, 7.43 to 11.11 in ATH, 7.08 to 9.62 in IPT, 10.58 to 11.19 in APT, 9.62 to 12.33 in AHPT, 8.66 to 13.30 in RHVT and 9.45 to 13.12 in PHT-NATP.
- Varieties or hybrids with more than 13% protein included GHB 558, PB 106 and MH 1222. Fat per cent ranged from 4.65 to 7.65. Approximately 18 hybrids or varieties had more than 7.0 per cent fat during 2003-04. During 2004-05, varieties or hybrids had more than 13% protein included Pusa 23, PB 106, MH 1097, MH 1152, MH 1153. Hybrids MH 1244 and HHB 94 had more than 7% fat. A few hybrids/ varieties (MH 1280, MH 1304, Raj 171, Pusa 383) having more than 12 per cent protein have been identified during 2005-06

G. Breeder seed production

- During 2002-2003, breeder seed production programme was organized to meet the indent of DAC for supply of 12.62 q breeder seed of 30 parental lines and 10 varieties.
- Approximately 39.12 q breeder seed of 26 parental lines of hybrids and 9 varieties was produced during kharif 2003 for supply in the year 2004-05 as against a total indent of 11.65 q of the Department of Agriculture & Cooperation, Ministry of Agriculture, New Delhi.
- Thirty one quintal breeder seed of 39 parental lines of hybrids and 12 varieties were produced during 2004 for supply in the year 2005-06 as against a total indent of 13.17 q.
- Approximately 34.0 quintal breeder seed of 36 parental lines of hybrids and 10 varieties were produced during 2005 for supply in the year 2006-07 as against a total indent of 13 q.

2. Crop production

- Field studies were carried out on various agronomical aspects viz. response of new genotypes to nitrogen application, integrated nutrient management in pearl millet based cropping system, residue management to sustained the productivity of pearl millet, crop establishment under sub-optimum conditions, amelioration of drought stress, response of pearl millet to zinc application, effect of fertilizer and bio-fertilizer on pearl millet with and without intercropping under rainfed conditions, irrigation management in summer pearl millet and local specific problems.
- Application of 60 kg N/ha increased 21.64 and 7.58 per cent grain and 17.39 and 6.29 per cent fodder yield over 20 and 40 kg N/ha respectively in zone A1. Similarly in zone A, application of 90 and 60 kg N/ha increased 25.5 and 11.4 per cent grain and 18.9 and 10.7 per cent fodder yield over 30 kg N/ha. Also in zone B application of 90 kg N/ha increased 17.65 and 4.82 per cent grain and 21.97 and 4.93 per cent fodder yield over 30 and 60 kg N/ha.
- Grain and fodder yields increased significantly in summer pearl millet advance hybrids by application of 120 and 90 kg/ha over the 60 kg N/ha. MSH 155 responded more than MSH 162. Spreading of 5 t FYM over planted rows in A1 and A zone provided better

establishment of the crop and produced maximum grain and fodder yields as well as net return.

- Application of 20 kg $ZnSO_4$/ha enhanced grain and fodder yields. Also foliar application of $ZnSO_4$ at tillering and pre-flowering stage slightly increased grain and fodder yield.
- Optimum management of the crop produced 38-42% more grain and 15-20% more fodder as compared low management practices in zone A1 and A while only 8% increase in grain yield and 10% increase in fodder yield were observed with optimum management practices in zone B.
- Maximum grain yield was recorded in plots of dust mulching when trial was conducted to mitigate the adverse effect of drought stress under rainfed condition. Spray of 0.1% thiourea at tillering and flowering also helped to mitigate drought stress. Pearl millet crop irrigated at an interval of 1.00 IW/CPE ratio produced 12% and 17% more grain and fodder compared to when the crop was irrigated at critical stages.

Transfer of technology

- Large number of frontline demonstrations on newly developed hybrids/ varieties and on agronomic practices was planned in different states during summer and kharif 2002. Hybrid GHB 526 in summer and hybrid GHB 558 during kharif showed substantial superiority over the check hybrid. A new hybrid CoH(Cu8) showed more than 20 per cent superiority over local.
- Frontline demonstrations on 1500 ha were allotted on pearl millet crop during 2003-04 and these were taken up by different SAUs, ICAR institutions and NGO's on 1254.80 ha. Of these, 1870 FLDs on 1140.15 ha were successfully harvested. The FLDs were conducted to popularise improved production technology of pearl millet of inclusion of improved hybrids/ populations in package of practices and evaluating improved agronomic practices as against farmers practices. ICMH 356, RHB 121, RHB 90, Raj 171, HHB 67, ICTP 8203, CZP 9802 & Pusa 605 in Rajasthan, GHB 558 in Gujarat, PPC 6 in Maharashtra, HHB 94 in Haryana, JBV 3 in Madhya Pradesh, 9330, 9444 & 7688 in Uttar Pradesh, ICTP 8203, ICMV 221 & Mahalaxmi Seed in Maharashtra, COH(Cu)8 & Co7 in Tamil Nadu alongwith recommended package of practices considerably increased grain yield of pearl millet over the prevalent hybrids/ varieties in the states. Basal application of nitrogen increased grain yield by 20.14 per cent over no basal application in Sikar district of Rajasthan. The increases in grain yield by 53.85 and 7.0 per cent through herbicidal control and biofertlization were demonstrated in Rajasthan. Wider row spacing of 60 cm increased grain yield by 70.21 per cent over closer row spacing of 30 cm. Intercropping of pearl millet with clusterbean and mothbean in Rajasthan moong bean and clusterbean in Haryana and pigeonpea in South India were found beneficial as compared to sole pearl millet.
- Frontline demonstrations under integrated cereal development programme were conducted at Jamnagar and Coimbatore center in late rabi 2004 and *kharif* 2005. In 40 frontline demonstration conducted at Jamnagar revealed that improved practices gave 14.34 and 10.72 per cent higher grain and fodder yield than farmers practices. In *kharif* 2005 at Coimbatore, in comparison to local cultivars, Co(Cu)9 gave 31.30, 17.54 and 47.35 per cent higher grain fodder and net return respectively.

3. Crop Protection – Drought

Evaluation of hybrids or varieties for their response to terminal drought stress, the following pearl millet material is found tolerant to terminal drought in *kharif* 2005.

Material	Drought tolerance
Hybrid(s)	MH 1234 (GHB 715),
	MH 1307, MH 1272
Variety(ies)	Raj 171, MP 445

GHB 538, GHB 715 & GHB 720 among hybrids, 841A & 88004A among MS lines, and J 2244 and J 2405 among inbred at Jamnagar, while at Jaipur, 93333A x 191-200S/ 05, 843A x 14-15 S/04 and 843A x 20-24 S/04 among hybrids, and 14-15 S/04 and 20-24 S/04 among parents performed better for seedling establishment.

4. Management of diseases

2002-03

- Eighty seven hybrids and varieties in initial trial and 51 advance hybrids and varieties were screened in downy mildew sick plot nursery and for smut under artificial inoculation conditions. Seventeen hybrids and two varieties in zone A and 30 hybrids and one variety in zone B showed highly resistant (<1%) reaction to downy mildew disease. Hybrid MH 1021(GHB577) showed complete resistance (0.0%) in zone A and highly resistant reaction (0.5%) in zone B. Four hybrids MH 1001, MH 1109, MH 1169 & MH 1179 exhibited multiple disease resistance against downy mildew and smut diseases at all India level.
- Among released hybrids PB 106, 7688 and Shradha and variety JBV 2 have continued to exhibit high downy mildew disease resistance (<1%) across zones in the country.

2003-04

- Of the 94 entries screened for downy mildew in IHT, 26 entries in zone A and two entries in zone B represented highly resistant category (0-5%) and of the 56 entries tested in AHT, 21 entries in zone A and a entry in zone B showed highly resistant reaction to downy mildew. While monitoring of downy mildew resistance stability of released hybrids and varieties Pusa 605, ICMH 356, RHB 121, PB 106, 7688, HHB 94, Saburi and HC 10 represented highly resistant category in zone A but none of the entry showed highly resistant reaction in zone B.
- In pearl millet disease nursery A, B and R lines, NMS 20A and J 2440 exhibited highly resistant category with 0-5% disease reaction in zone A. Three lines NMS 20A, ICMB 95444 and ICMB 93222 with 0-5% disease incidence were observed in zone B. At both zones, NMS 20A showed same trend of highly resistant reaction.
- The entries represented highly resistant incidence to downy mildew were also screened for smut, rust, ergot and blast diseases. In PMPT 1, MH 1172, MH 1193, MH 1202, PB 106 (IHT 139). PB 106 (IHT 146) and MH 1228 were highly resistant to smut (0-10%). None of the above entries showed highly resistant reaction to rust disease. Fourteen and eight entries were highly resistant to ergot and blast.
- In PMPT-II five entries MH 1001, MH 1078, MH 1070, MH 1085 and JBV 2 showed highly resistant reaction to smut. Sixteen entries each for ergot and blast showed highly resistant reaction but none of the entry was found highly resistant to rust.
- Of the eight entries highly resistant to downy mildew in PMPT-III, PB 106 for smut, Sardha and Pusa 383 for ergot, ICMH 356, PB 106 and Pusa 383 for blast were highly resistant but none of the entry showed high resistant incidence to rust.

2004-05

- In zone A, 51 entries offered highly resistant category with 0-5% downy mildew disease incidence in PMPT –I. Interestingly, in zone B, 11 entries viz., MH1192, MH1194, MH1196, MH1201, MH1215, MH1219, MH1139, MH1187, MH1190, PB106 and MP444 recorded highly resistant reaction (0-5%) and the same entries offered similar reaction in zone A except MH1192 which offered resistant reaction with 7.7% downy mildew disease At 60 DAS, the mean disease incidence for the entries tested ranged between 0.4 to 16.3%. None of the entries showed 0% disease incidence. Hundred and four entries remained in the highly resistant (0-5%).
- In PMPT II, at 30 DAS, the mean performance in different entries for disease incidence ranged between 0.8 to 10.2%. Forty eight entries showed highly resistant reaction.
- Among the entries tested in PMPT III, six entries viz., ICMH 356, PB 106, SAMH 166, SABURI, SHARADA, RAJ 171 were highly resistant with the disease reaction of 4.00, 3.72, 4.13, 4.33, 2.91 and 4.18%.
- A total of nine hybrids and local cultivars were noticed during the farmer's field survey in Jaipur, Alwar, Sikar, Tonk Nagaur, Jodhpur, Pali, Barmer and Jalore districts of Rajasthan state. The maximum downy mildew incidence was noticed on hybrid cultivar JKBH26, Kanchan, Malav check311, Sriram and Pioneer 7686 recorded 2-3% disease incidence. For Smut disease the maximum incidence noticed in Bioseed8469 with disease incidence of 12.6% and the same hybrid recorded 3.4% ergot disease. In Alwar district maximum disease incidence was recorded in ICTP8203 followed by JKBH26 with disease incidence of 5% and remaining cultivars Pioneer 7688, Proagro9330 and Unknown hybrids were completely free form downy mildew disease, the maximum smut disease incidence of 10.6% was recorded in JKBH26, followed by unknown hybrid (7.2%). All the hybrids survey in Alwar district was completely free from ergot disease. In Sikar and Tonk district the maximum downy mildew incidence in local cultivars (6-7%) and Pioneer7686 (3-4%) in Sikar and Tonk respectively. Maximum smut incidence was recorded in Sikar with 6.2% disease in HHB67 and local cultivars in Sikar district and in Tonk the maximum smut disease was recorded in ICMH356 with 57% smut disease.
- In summer disease screening trial, At 60 DAS, seven entries viz., MSH165, MSH166, MSH171, MSH177, MSH178, MSH179, MSH184 and PUSA23 recorded disease incidence of 0.3, 0.2, 0.2, 0.3, 0.9, 0.5, 2.5 and 0.4% respectively. Only two entries MSH152 and MSH162 recorded disease incidence of 0.5 and 6.0%, respectively.

2005-06

- Thirty one entries were found resistant to downy mildew disease in PMPT-I. Among them four entries MH 1336, MH 1364, MH 1392 & Pusa 383 were also resistant to smut, ergot and blast. MH 1362 was resistant to smut, ergot and blast but recorded 23.59% rust. The entry MH 1351 was resistant to smut, ergot and rust but recorded 11.25% blast incidence
- Twenty eight entries were found highly resistant followed by 34 entries as resistant and six entries susceptible to downy mildew disease in PMPT-II
- In monitoring disease resistant stability of released popular hybrids, varieties, A, B and R lines in PMPT-III, none of the tested entries showed 0.0 per cent disease incidence in zone A. However in zone B, ICMH 356 recorded 0.0 per cent downy mildew incidence
- Studies on characterization of pathogen diversity in downy mildew of pearl millet included pathogenic diversity analysis by virulence nursery and genetic analysis through DNA marker. Biological pathotyping indicates variation in resistance in the pathogenic population of *S. graminicola* with reference to the host specificity, aggressiveness and virulence
- Some basic research on molecular characterization of R and AVR gene in pearl millet downy mildew system has been carried out at Mysore to explore the possibility of resistant

gene pyramiding/ stacking and other resistance gene deployment strategies to control downy mildew disease

- In PMPT-V, on-farm biological control of downy mildew using integrated disease management module suggested that smut, blast, rust diseases reduced considerably due to IDM module
- During *kharif*, 2005 field surveys were conducted to monitor occurrence of pearl millet diseases like downy mildew, smut and ergot in various districts of Rajasthan, Haryana, Gujarat, Madhya Pradesh, Karnataka, Tamil Nadu and Maharashtra and identified several hybrids/ varieties which are resistant to downy mildew disease
- Hybrids MSH 155, MSH 166, MSH 167, MSH 173, MSH 188, MSH 190 and MSH 191 were completely free from downy mildew diseases in summer disease screening trial involving initial and advance pearl millet hybrids and varieties

5. Management of insect pests

2002-03

- Fifty one advance entries of hybrids and varieties were evaluated for relative response to damage of different insect pests at Jamnagar and Delhi. For shootfly, response of entries to the damage at seedling stage and earhead stage varied at both locations. Percent shootfly damage was more at Jamnagar at seedling stage (7.8 to 18.9) and at earhead stage (5.5 to 33.2). Promising entries were identified at each location. Stem borer damage was observed more at Delhi and ranged from 1.7 to 12.9 per cent. Four hybrids and two varieties had less than 3.5 per cent damage. Damage to grey weevil was recorded at Delhi was high and damage grade ranged from 2.6 to 6.3.

2003-04

- Taking three component (14, 28 DAG and ear head stage) into consideration, entries MH 1078, MH 1099, MH 1139, MH 1079, Saburi, Raj 171, Pusa 383, ICTP 8203, MH 1038, MH 1049, MH 1109, and Pusa 266 were found promising against shoot fly. Over the locations the average stem borer damage per cent ranged from 3.71% (Saburi) to 29.78% (ICTP 8203). Eleven entries viz. MH 1140, Saburi, MP 430, Raj 171, ICMB 221, MH 1038, MH 1049, MH 1109, MH 1152, MP 414 and RCB 2 were found promising.

2004-05

- Four trials were conducted to confirm relative susceptibility of pearl millet lines from advanced and initial population and hybrid trials against key insect pests of pearl millet.
- The shoot fly damge (dead hearts %) was recorded at Delhi, Jamnagar and Jaipur on 14 DAG and 28 DAG and also at earhead stage. The average seedling deadheart % of all the three locations on 14 DAG ranged from 1.24 % (Raj-171) to 27.25% (MP429) and the damage at 28 DAG ranged from 2.95% (MH-1192) to 18.18% (MH-1097). Entries Raj-171, MH-1199, Pusa-23, RHB-121, MP-441 and Pusa-266 were found promising against shoot fly.
- Eleven entries viz., MH-1142, MH-1188, MH-1192, MH-1194, MH-1195, MH-1199, MH-1201, MH-1206, MH-1213, MH-1218 and MH-1139 were found promising against stem borer.
- Entries MH-1121, Saburi, CZP-9082 were found promising against *Pyrilla.*
- Six entries viz., MH-1187, MH-1153, MH-1205, MH-1231, MH-1236 and RHB-121 were found promising against grey weevil.
- Entry GHB-558 was found least susceptible to rice weevil and lesser grain borer at Delhi and Fatehpur Sekhawati.

2005-06

- Seed treatment with neem oil 5 ml/kg seed + spray of 5% N.S.K.E. (neem seed kernel extract) at 30 DAG and 50% flowering was found effective treatment in controlling pest complex of pearl millet
- Hybrid GHB 558 was found *least susceptible to rice weevil (Stiophilus oryzae) and lesser grain borer (Rhizopertha* dominica) at Delhi and Fatehpur Shekhawati

All India Coordinated Research Project on Pesticide Residues

1. Title of the Project : **All India Coordinated Research Project on Pesticide Residues**

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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

- AINP on Pesticide Residues has conducted a number of supervised field trials for the evaluation of safe waiting period and pre harvest interval for pesticide spray on important crops grown in different agro-climatic zones of the country. The residue data generated is also used for the risk assessment and fixation of MRL of pesticides on different crops.
- The persistence/dissipation of Spiromesifen was studied on a chilli, cotton, apple, tea and brinjal. Supervised field trial of spiromesifen was carried out at three centers YSPUH&F, Solan; PAU, Ludhiana and ANGRAU, Hyderabad. With each crop the trial was conducted at four locations and two dosages i.e. recommended and double the recommended dose of application (96 and 192 g a.i. ha^{-1}). The half-life of Spiromesifen was found to be 5.0-8.5 days in the tea leaves. The residues of Spiromesifen on brinjal fruits and soil were found non-detectable on the 15^{th} day of application at all the locations at both the dosages. The half life on chilli was found 2-2.5 days. In the chilli field soil no residues were detectable at harvest. Residues of Spiromesifen in cotton lint, seed and soil at the time of first picking were below detectable at all three locations.
- Supervised trial of Mancozeb75 % WP on cumin was carried out at four centers viz. Anand, Kalyani, Jaipur and Hyderabad at two dosages i.e. 1125 g a.i. /ha and 2250 g a.i./ha The mancozeb residues at harvest in cumin seeds were below its MRL of 3.0 CS_2 $\mu g\ g^{-1}$ at Anand and Jaipur and below detectable limit at the other two locations. The residues were not detected in soil samples at harvest at any of the four locations. Supervised trial of Tricontanol on potato was carried out at four centers viz. Anand, Kalyani, Solan and Ludhiana at two dosages i.e. 0.25 g a.i. /ha and 0.5 g a.i. /ha. Residues of tricontanol in potato tubers as well as soil at the time of harvest were Below Detectable limits (BDL) at all the four locations. Spinosad (45 % SC) persistence on red gram was carried out at Rahuri, Anand, Kalyani and Hyderabad centers at two dosage i.e. 73.0 and 146.0 g a.i. /ha. Spinosad residues in red gram as well as soil at harvest were below detectable limit at all the locations.
- The persistence of a number of pesticides was studied on apple crop by Solan center at four different locations of Himachal Pradesh, India *viz.* Solan, Mashobra, Matiana and Thanedhar. Spiromesifen was sprayed at two dosage i.e. 120 g a.i. /ha and 240 g a.i. /ha. The half-life of spiromesifen was found 5.47-6.24 days at the recommended dose. Bifenthrin (Brigade)® persistence was studied at 60.0 g a.i. /ha and 120.0 g a.i. /ha dosage.

Bifenthrin residues in apple fruits were below detectable limit at harvest i.e. 30 days after spray. Fenazaquin (Magister)® was sprayed in triplicate plot in two dosages i.e. 40 g a.i. /ha and 80 g a.i. /ha. Initial deposits of fenazaquin on apple fruits were 0.432-0.564 and 0.998-1.064 mg/kg due to application of 40 g a.i./ha and 80 g a.i./ha, which dissipate to below detectable limit in 30 days. Diniconazole (Sumi-8®, 25 WP) was applied at 500 and 1000 g a.i./ha dosages. Initial deposits of diniconazole on apple fruits were 0.55-1.34 mg/kg, which dissipate to below detectable limit in 30 days. The persistence and residues of imidacloprid was determined at two dosages 890 and 1780 g a.i. /ha. The residues of imidacloprid (Confidor 200 SL) become non-detectable on 30th days of sampling. Supervised trial of Fenpropathrin (Meothrin 30 EC) was carried out at 450 g a.i. /ha and 900 g a.i. /ha. Fenpropathrin residues in apple fruits and soil were non detectable at 30th day after spray.

- Supervised trial of Imidacloprid on cotton was carried out at college farm of Hyderabad center. The pesticide was applied twice first 60 days after sowing and then 75 DAS at two application rate i.e. 35 g ha^{-1} and 70 g ha^{-1}. None of the sample (soil, lint and seed) showed presence of imidacloprid residues in all treatments. Mixed formulation of acephate 50 % and imidacloprid 1.8 % SP (Lancer Gold)® on Cotton was evaluated at experimental field of PAU, Ludhiana. Residues of acephate dissipated to below detectable limit of 0.02 mg kg^{-1} after 15 days of its application and that of imidacloprid below detectable limit of 0.02 mg kg^{-1} after 7 days of application.
- Supervised trial of Imidacloprid (Confidor, 350 SC and 70 WG) on paddy was conducted at Hyderabad, Vellayani and Ludhiana at 75 and 150 ml ha^{-1} dosage. None of the sample (rice grain, husk, straw and soil) showed presence of imidacloprid residues in any treatments.
- Mixed formulation of chlorpyriphos 50% and cypermethrin 5% (Nurelle-D 55% EC) on chilli was evaluated at four centers Rahuri, Jaipur, Kalyani and Ludhiana at 1000 and 2000 ml ha^{-1} of the formulation. The residues of chlorpyriphos on chilli after 15 days of spray was in the range BDL- 0.08 μg g^{-1} at 500 g a.i. ha^{-1} application rate. The cypermethrin residues were below detectable limit after 15 days of spray. Supervised trial of Spiromesifen was carried out at three centers Solan, Ludhiana and Hyderabad at two dosage i.e. 96 g a.i. /ha and 192 g a.i. /ha. Tebuconazole (2 % DS) (Raxil)® on ground nut was evaluated at experimental fields of Agricultural Research Station, Durgapur, Jaipur at two dosages i.e. 0.025 and 0.05 g a.i. /kg seed. None of the sample of groundnut and soil showed presence of tebuconazole residues in any treatments.
- Persistence of Bifenthrin as termiticide in Building Soil was studied jointly by P.C. Cell, Delhi and CBRI, Roorkee. Field trial was laid at Indian Institute of Petroleum, Dehradoon. Residues of bifenthrin were detected up to 60 cm layer at 0.075 and 0.1 percent rate of application. Surface residues persist up to 37 months at lower dosage of application and even after 53 months at higher dosage of application (0.075 and 0.1%).
- The effect of processing/drying on the concentration of pesticide residues in spices was studied in field trials at different locations. The processing factor for endosulfan and chlorpyriphos in turmeric were found to be 4.67 and 0.640, respectively. Processing factors for chlorpyriphos in cardamom and pepper was found to be 0.2 and 0.38.
- Different centres collaborated with other ICAR projects for pesticide residue analysis study of omite 57 EC on brinjal and okra were conducted in collaboration with Acarology department of PAU, Ludhiana. In collaboration with CPRI, Shimla, Solan centre carried out the residues analysis of imidacloprid, EBDC, Phorate and chlorpyriphos in potato. IPM schedules developed by NCIPM have been evaluated in terms of residues left by pesticides used in the programme.
- For the generation of residue data, the method of residue extraction and clean-up was developed. The method developed was then validated in the laboratories of different centers. The analysis of residues was done on instruments like GC, HPLC. The instrumental conditions were standardized. For the authenticity and international acceptance of the

residue data generated, the laboratory should have NABL accreditation. All the centers of AINP on Pesticide Residues are upgrading their skills and infrastructure to get the NABL accreditation.

- For the benefit of residue research in the country, all the methods developed and validated in the AINP on Pesticide Residues has been compiled and published in the form of book "Pesticide Residues Analysis Manual" .
- The strengthening of residue research in the country is one of the main objectives of AINP on Pesticide Residues. Various training programmes on the techniques of pesticide residue analysis have been conducted at the project coordinating cell. The repository of certified reference material of pesticides is also maintained at the PC cell from where CRM are distributed to laboratories all over the country every year.
- This AINP is also enabling the National Pesticide Residue Monitoring Programme, undertaken by Department of Agriculture & Cooperation, Ministry of Agriculture, GOI.

All India Coordinated Research Project on Pigeonpea

1.	**Title of the Project**	:	**All India Co-ordinated Research Project on Pigeonpea**
2.	**Name and Address of the Project Coordinator**	:	**Dr. N.D. Majumder** **All India Co-ordinated Research Project on Pigeonpea** **Indian Institute of Pulses Research** **Kalyanpur, Kanpur - 280 024 (Uttar Pradesh)** **Telefax : 0512-2570145** **E-mail: ndmajumder@rediffmail.com**

3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

- During last five years seven high yielding varieties of pigeonpea namely MA 6, GAUT 001E, MAL 13, GTH 1, CORG 9701, NDA 98-1, NDA 99-6 and one CMS based hybrid (For Gujarat state) have been developed
- Application of 20 kg sulphur with 100 kg DAP/ha was beneficial to enhance the productivity of pigeonpea.
- Application of Pendimethalin @ 1.25 kg a.i./ha for weed control was found most effective.
- Production of Pigeonpea can be increased by 15% by inoculation with rhizobium culture.
- By ridge bed sowing production of pigeonpea can be increased by 15-20%.

All India Coordinated Research Project on Plant Parasitic Nematodes With Integrated Approach for Their Control

1. **Title of the Project** : **All India Coodinated Research Project on Plant Parasitic Nematodes with Integrated Approach for their Control**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

- Distribution of major nematode problems associated with different crops in the country with emphasis on identification of hot spots has been in progress and nematode distribution atlas has been prepared.
- Damage potential of economically important nematodes viz., root knot, cyst, ear cockle, reniform, burrowing, citrus and a few other agriculturally important nematodes has been established.
- Avoidable yield losses in a few crops up to 60% have been estimated due to high populations of plant parasitic nematodes through multi-location field experiments in crops depending upon initial nematode population and cropping systems followed under different agro-climatic zones of the country.
- More than 15,000 germplasms, accessions/varieties in rice, pulses, vegetables, cotton, groundnut, citrus, grapevine etc. have been screened for resistance against key nematode pests which has enabled to identify, develop and confirm a few sources of resistance in different crops.

CROP	NEMATODE	RESISTANT VARIETIES
Tomato	Root-knot nematodes (*Meloidogyne javanica/Meloidogyne incognita)*	PNR-7, NT-3, NT-12, Hisar Lalit
Chilli	Root-knot nematodes (*Meloidogyne javanica/Meloidogyne incognita)*	NP-46A, Pusa Jwala, Mohini
Cowpea	Root-knot nematodes (*Meloidogyne javanica/Meloidogyne incognita)*	GAU-1
Mungbean	Root-knot nematodes (*Meloidogyne javanica/Meloidogyne incognita)*	ML-30 and ML-62
Cotton	Meloidogyne incognita	Bikaneri nerma, Sharda, Paymaster
Grapevine	Root-knot nematodes (*Meloidogyne javanica/Meloidogyne incognita)*	Khalili, Kishmish Beli, Banquabad, Cardinal, Early Muscat, Loose Perlett
Potato	Potato cyst nematode (*Globodera rostochiensis*)	Kufri Swarna

CROP VARIETIES IDENTIFIED/DEVELOPED RESISTANT TO PLANT PARASITIC NEMATODES

- Inclusion of non-host/resistant varieties (viz. garlic, onion, Hisar Lalit variety of tomato and Sreebhadra of sweet potato etc. in vegetable based cropping systems has led to reduction in population of root-knot nematodes and enhancement of yield.
- Role of cropping systems and soil fertility on community structure, biodiversity and population dynamics of plant parasitic as well as other soil inhabiting nematodes under different agro-climatic conditions of the country has been investigated.
- Pest risk analysis for major nematode pests in Indian agricultural are investigated.
- Computerized databases of nematode resistance and distribution have been developed.

Technologies demonstrated:

- Low cost eco-friendly and practically feasible integrated nematode management technologies have been developed and demonstrated against economically important nematode pests at farmer's fields. These are:
- The rice root knot nematode (*Meloidogyne graminicola*) and rice root nematode (*Hirschmanniella* spp.) can be managed by treatment of nursery-beds with carbofuran @ 0.1 g a.i./ m^2 and field application of carbofuran @ 1 kg a.i./ha after 40 days of transplanting.
- Soil solarization of the nursery-bed area using a 100 gaze transparent polythene sheet for 2-4 weeks in summer and application of carbofuran @ 0.3 g a.i/ m^2 before sowing could provide nematode-free seedlings of transplanted crops like vegetables, fruits, and ornamentals etc. which perform better in field and reduce spread of nematodes.
- Deep summer ploughing in states having hot and dry summers helped in reducing infestation of root knot and cereal cyst nematodes.
- Methods have been developed for reducing the cost and dose of nematicides. Bare root-dip treatment of nursery seedlings with emulsifiable carbosulfan 25EC @ 500 ppm for 6 hours protected transplanted vegetables like tomato, brinjal, chilli, pointedgourd etc.
- Solarization of nematode infested field+Seed dressing of direct-seeded crops with carbosulfan 25 DS @ 3% a.i. (w\w) in mungbean, cowpea, blackgram, okra, cucurbits etc. reduced the attack of root knot, reniform and lesion nematodes.
- Use of organic amendments including neem and castor cakes @ 1 t/ha has been found to reduce root-knot nematode damage in vegetables and groundnut. Their combinations with seed treatment with carbosulfan 25 DS @ 3% a.i. (w/w) further improved efficacy in reducing the nematode population and enhancing the yield significantly.
- Paring and hot water treatment of banana suckers at 55^0 C for 20 minutes combined with application of neem cake @1kg\plant and carbofuran@ 0.5g\plant in the pit before planting was effective against nematode disease complex.

All India Coordinated Rice Improvement Project

1. **Title of the Project** : **All India Coordinated Rice Improvemen Project**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

SIGNIFICANT ACHIEVEMENTS (1997-2006)

The Directorate has grown over the years making significant contributions during the past five and a half decades. Directorate of Rice Research has become an example of

Power of Purposeful Collaborationand Partnership in Pubic sector Agriculture R & D and has become a model for other international programmes of similar nature. Salient research achievements over the past ten years have been presented here.

- Through AICRIP released 39 varieties by CSCSNRV and 180 varieties through state release
- Developed and released 10 varieties and one hybrid by DRR
- In all 20 hybrids were released. Area under rice hybrids touched one million ha/ during 2006.
- Multiple and durable pest resistant varieties like Triguna, Nidhi, Krishnahamsa developed.
- Developed DUS testing guidelines for rice
- A DNA based test for hybrid seed purity developed and commercialized
- About 1,300 tons of breeder seed of varieties and parental lines of hybrids developed and distributed.
- Cultures with high response to Nitrogen, low soil P and Zn tolerance were identified.
- Use of leaf color charts to save nitrogen fertilizer popularized.
- Agronomic management packages of practice developed for scented rice, hybrids, and direct seeded rice were developed.
- Integrated nutrient management involving organic and inorganic nutrients for sustaining rice based cropping system productivity and profitability was evolved.
- A eight row drum seeder for direct seeding of sprouted seed in puddle soil t save labour and water without sacrificing yield was developed and popularized.
- New sources of resistance to major insect pests and diseases were identified through germplasm evaluation.
- Variability in pest and pathogen population is being monitored to identify new races and biotypes being developed.
- New sage and effective chemicals for control of insect pests, diseases and weeds have been identified.

- Integrated pest management system for location and situation specific needs developed and evaluated.
- In all 128 training programmes were organized on need basis and about 2000 personnel trained in rice
- production technologies
- Frontlines demonstrations were organized on over 12,750 ha in 18 states coverin rice varieties, production and protection technologies thus carrying the proven technology to the door step of the end user clientale i.e.the rice farmer.

All India Coordinated Research Project on Safflower

1. **Title of the Project** : **All India Co-ordinated Research Project on Safflower**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

A. State-wise Varieties/Hybrids released (Last five years)

Andhra Pradesh	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Karnataka	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Maharashtra	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	Parbhani Kusum, Phule Kusuma, PBNS-40, AKS-207 (Vidarbha region)
Madhya Pradesh	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, JSI-97, JSI-99, PBNS-40
Orissa	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Bihar	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Chhattisgarh	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Uttar Pradesh	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Tamil Nadu	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40
Rajasthan	Hybrids	NARI-NH-1, NARI-H-15, MRSA- 521
	Varieties	NARI-6, Parbhani Kusum, Phule Kusuma, PBNS-40

Characteristics features of Varieties/Hybrids released

Hybrids						
NARI-NH-1 (PH-6)	2002	1936	140	31	All India	Non spiny hybrid, moderately resistant to Cercospora leaf spot, wilt; tolerant to *Alternaria* and aphids
NARI-H-15	2005	2200	129	29	All India	-
MRSA-521	2006	1000-1500 (R) 2200-2500 (I)	120-130	27	All India	Resistant to wilt; tolerant to *Alternaria* and aphids
Varieties						
NARI-6	2000	1500	137	31	All India	Non-spiny, tolerant to *Alternaria* and *Cercospora*
Parbhani Kusum	2001	1900	137	29	All India	Spiny
Phule Kusuma (JLSF-414)	2003	1200-1500 (R) 2000-2200 (I)	125-140	29	"	Spiny
PBNS-40	2006	1500	118-128	27	"	Non spiny
AKS-207	2006	1200-1400	120-135	27	Maharashtra	-
JSI-97	2004	1500-1600	130-135	30	Madhya Pradesh	Non-spiny, Moderately tolerant to *Alternaria,* wilt and aphids
JSI-99	2004	1100-1200	115-120	28-29	Madhya Pradesh	Semi-spiny, Moderately tolerant to *Alternaria,* wilt and aphids

B. Remunerative intercropping systems recommended

State/ Region	**Suggested intercropping system**	**Row proportion (Other crop : Safflower)**
Maharashtra	Chickpea + safflower	3:1 or 2:1
	Wheat + safflower	3:1 or 2:1
	Linseed + safflower	3:1 or 4:2
	Coriander + safflower	3:1
Karnataka	Chickpea + safflower	3:1
	Coriander + safflower	3:1 or 2:1
	Wheat + safflower	3:1 or 5:1
Andhra Pradesh	Chickpea + safflower	3:1 or 2:1
	Wheat + safflower	3:1 or 2:1
	Coriander + safflower	3:1 or 2:1
	Linseed + safflower	3:1 or 2:1

Madhya Pradesh	Mustard + safflower	6:2
	Toria + safflower	6:2
	Chickpea + safflower	2:1 or 6:2 or 4:2
	Linseed + safflower	2:1 or 6:2
	Amaranthus + safflower	6:2
Chhatisgarh	Chickpea + safflower	2:1 or 6:2 or 4:2
	Linseed + safflower	2:1 or 6:2
	Mustard + safflower	6:2
Eastern Uttar Pradesh and Bundelkhand region	Linseed + safflower	3:1
	Chickpea + safflower	3:1
	Barley + safflower	6:2
	Toria + safflower	1:2

C. Sustainable cropping sequences recommended

State	Suggested crop sequence
Transitional tract of Karnataka (Dharwad, Belgaum and adjoining areas)	Mungbean – safflower, Soybean – safflower Groundnut – safflower
Scanty rainfall areas of Karnataka (Medium deep black soils of Bijapur and western parts of Belary)	**Hybrid sorghum _ safflower*** **Mungbean – safflower***
Northern Telangana of Andhra Pradesh (parts of Ranga Reddy and Mahaboobnagar district, Adilabad, Medak and Nizamabad)	Mungbean – safflower **Maize – safflower** Hybrid sorghum – safflower* Sesame – safflower
Assured moisture areas of Maharashtra (Khandesh tract, parts of Marathwada and Vidarbha)	Mungbean – safflower, Urdbean – safflower, Sunflower – safflower Hybrid sorghum – safflower* Groundnut – safflower* Sesame – safflower
Drought prone areas of Maharashtra	Mungbean –safflower Urdbean – safflower
Malwa plateau of Madhya Pradesh	Soybean – safflower* , Maize – safflower Groundnut – safflower
Chhattisgarh	Upland rice – safflower
Bundelkhand region of Uttar Pradesh	Soybean – safflower Cowpea (fodder) – safflower Mungbean – safflower Hybrid sorghum – safflower
Eastern Uttar Pradesh	Upland rice – safflower **, Hybrid pearlmillet – safflower Mungbean – safflower, Urdbean – safflower, Sesame – safflower
Jharkhand	Upland rice – safflower*, Maize – safflower **
Medium and uplands of Orissa	Upland rice – safflower
South-eastern Rajasthan (Udaipur and adjoining areas)	Mungbean – safflower, Urdbean – safflower Maize (fodder) – safflower, Sorghum (fodder) – safflower Cowpea (fodder) – safflower, Cowpea (vegetable) – safflower

*As a contingent practice depending on timely receipt and/or availability of favourable soil moisture conditions.

**As a contingent practice or alternatively with pre-plant irrigation if conditions warrant

C. Agronomy Management

Seeds should be treated with Thiram, Captan or Carbendizim @ 3 g/kg seed before sowing to prevent losses from seed and soil borne diseases.

Manures and fertilizers

Manures and fertilizers recommended for different regions

Region		FYM (t/ha)	Fertilizer (kg/ha)		
			N	P_2O_5	K_2O
Andhra Pradesh	Rainfed	-	40	25	-
Maharashtra					
Western Maharashtra	Rainfed	-	50	25	-
	Normal				
	Scarcity zone	-	25	12.5	-
Marathwada	Rainfed	-	40	20	-
	Irrigated	-	60	40	-
Vidarbha	Rainfed	5-10	25	25	
	Irrigated	5-10	50	50	-
Karnataka	Rainfed	6	35	50	-25
	Irrigated	6	75	75	35
Gujarat	Rainfed	-	25	10	-
Orissa	Rainfed	6	25	25	-
Uttar Pradesh	Rainfed	-	40	30	20
	Irrigated	-	60	30	20
Madhya Pradesh					
Malwa tract	Rainfed	-	40	40	20
	Irrigated	-	60	40	30
Chhattisgarh	Rainfed	-	20-30	15-20	10-15
	Irrigated	-	50-60	20-30	20
All other areas	Rainfed	-	30	20	-

Others:

In scanty rainfall areas of Maharashtra, an additional top dressing of 20 to 25 kg N/ha should be given.

Under rainfed conditions, apply entire quantity of fertilizers as basal dose by drilling. Place the fertilizers deep in seed furrows (10 cm below the soil in traditional area and 10-15 cm in other areas). In the traditional single cropped rabi tracts of Maharashtra and Karnataka, application of fertilizers 2 to 3 weeks prior to optimum planting time is recommended for maximum efficiency under receding soil moisture.

Under irrigated conditions, apply 50% of N and 100% of P and K fertilizers at the time of seeding and top dress the remaining 50% N after 5 weeks at the time of first irrigation.

In drought prone areas of Maharashtra (Solapur), in chickpea-safflower rotation, 100% recommended P of any one of the crops in the rotation could be substituted by either with seed treatment (25 g/kg seed) or soil application (2.5 kg/ha) of PSB + 5 t FYM/ha without any adverse effect on system productivity.

Apply 15 kg Sulphur/ha in Satara district and 30 kg/ha in Parbhani district in Maharashtra and in Malwa plateau of Madhya Pradesh under irrigation and 45 kg/ha in Solapur district (Maharashtra) under rainfed conditions. Single super phophate in Satara, Solapur and Malwa plateau and gypsum in Parbhani were ideal sources of sulphur. In saline soils of Bhal region of Gujarat, 45 kg S/ha through ammonium sulphate and in Telangana region of Andhra Pradesh, 45 kg S/ha through single super phosphate is recommended.

Seed treatment with *Azotobacter* or mixed inoculation of *Azotobacter* and *Azospirillum* (25g/kg seed) could effectively substitute 50% of recommended needs of safflower amounting to 20 kg/ha under rainfed conditions in almost all the safflower growing regions of the country.

Thinning

Thin the excess seedlings within 10-15 days after emergence and maintain the desired plant to plant spacing. This practice increases the seed yield by 15 to 30% under rainfed conditions.

E. Important insect pests of safflower and their management

Insect	Nature of damage	Control method by agronomic management	Chemical control methods
Aphids (*Uroleucon compositae* Theobaid)	During pre-flowering stage both nymphs and adults suck the cell sap from shoot apices, peduncles, leaves and stem, secrete a honey dew like secretion on upper surface of the leaves and plant parts forming a black sooty mould which hinders photosynthetic activity resulting in stunted growth. Finally plants dry.	Avoid delayed planting	Spray dimethoate (0.05%) or Methyl parathion (0.05%) or monocrotophos (0.05%) or chloropyriphos or endosulfan (0.05%) or alternatively dust quinalphos (1.5%) or methyl parathion (2.5%) or malathion (5%) or endosulfan (4%) at 40 and 60 DAS. Use 500 litres of spray mixture and 20 kg dust formulation/ha. In transitional tract of Karnataka and scarcity zone of Maharashtra, one spray of NSKE (5%) a week after first incidence followed by the spray of recommended insecticide 15 days later gives good control of aphid
Capsule borer (*Helicoverpa armigera* Hubner)	During early stages of growth, it damages leaves and shoot apices. Then it is often noticed on capitula at later stage. Typical symptoms are perforated leaves and involucral bracts, partially or completely eaten capitula. Dried black excreted pellets are seen on the infested parts and the larva is seen on the holes of the capsule.	Avoid chickpea as intecrop. Hand pick and destroy caterpillars	Further spraying on the field borders (1.8 m around the field) is as effective as complete spray coverage of the field. Spray dimethoate (0.07%) or endosulfan (0.07%) at the rate of 500 litres of spray mixture/ha.

F. Important diseases of safflower and their management

Diseases	Nature of damage	Control method by agronomic management	Chemical control methods
Alternaria leaf spot (*Alternaria carthami* Chowdhary)	Severe in irrigated crop and in warmer areas particularly under frequent showers of cyclonic cloudy weather. Seed may rot and damping off of seedlings occur. Brown discolouration appears on the stem, dark brown spots with concentric rings upto 1 cm in dia-meter appear on the leaves which later develop into large lesions. Later hole is formed at the spotted patches.	Seed the crop at the recommended time.Avoid growing in low lying areas and flooding under irrigation. Avoid continuous growing of safflower. Remove and destroy the diseased plants. Do not delay irrigation until the crop exhibits moisture stress symptoms.	Spray mancozeb (0.25%) immediately after disease is noticed and repeat the spray 15 days later depending on the intensity of disease.
Cercospora leaf spot (*Cercospora carthami* (H. and P. Sydow) Sundararaman and Ramakrishnan)	Symptoms on leaves are charac-terized by formation of circular to irregular brown sunken spots measur-ing 3 to 20 mm in diameter. The spots have a yellowish tinge at the border and in advanced stages, the leaves turn brown and distorted. Under moist	Avoid safflower cultivation in low-lying water logged areas. Avoid conti-nuous cropping of safflower in the same plot and follow recommend-ed crop sequences and rotations. Plant crop as per the recommendation for each	Spray the crop with copper oxychloride (0.3%) or mancozeb (0.25%) to give satisfactory control of the disease.

	conditions, the spots have a velvety greyish-white appearance caused by sporulation of the fungus. All parts of plant are affected by the disease. Flower buds turn brown and dry. The entire capitulum may also be affected without formation of seed.	region.Late planting encourages spread of *Cerco-spora* leaf spot.	
Rust *(Puccinia carthami* Corda*)*	Seedling infection causes twisting towards one side. Chestnut brown pustules are formed on hypocotyls leading to collapse of seedling. On older plants girdling and hypertrophy of the stem base may occur. Small powdery chestnut brown pustules of 1-2 mm in size develop on leaf surface which later turn black.	Seed the crop at the recommended time. Avoid growing in low-lying areas and flooding under irrigation. Avoid continuous growing of safflower. Remove and destroy the diseased plants. Do not delay irrigation until the crop exhibits moisture stress symptoms.	One or two sprays of Calixin (0.050) or Dithane M-45 (0.25%) at 15 days interval.
Wilt *(Fusarium oxysporum* f.sp.*carthami)*	Yellowing of leaves on one side of plant starts particularly from lower leaves followed by wilting that progresses upwards. Lesion at soil line is the first symptom noticed which extends inside and affects the vascular system. Plant starts to wilt, drooping more often. Infected heads have aborted seeds.	Seed the crop at the recommended time. Avoid growing in low-lying areas and flooding under irrigation. Avoid continuous growing of safflower. Remove and destroy the diseased plants. Do not delay irrigation until the crop exhibits moisture stress symptoms	Treat the seed with Carbendazim @ 0.1-0.2%
Root rot (*Rhizoctonia bataticola*)	Dark cortical lesions occur slightly below or at the soil level on the stem, which later extend upwards. Lesions frequently girdle the stem. Root development is reduced and finally seedlings die.	Seed the crop at the recommended time. Avoid growing in low-lying areas and flooding under irrigation. Avoid continuous growing of safflower. Remove and destroy the diseased plants. Do not delay irrigation until the crop exhibits moisture stress symptoms.	Treat the seed with Thiram or Dithane M-45 @ 0.2%.

All India Coordinated Research Project on Seasame and Niger

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Crop improvement

Varieties identified/released

SESAME

Twelve high yielding improved varieties were developed and released for different agroclimatic regions/ area of adoption of the country

(i). JTS-8 (2002) resistant to Phytophthora blight and Alternaria Leaf spot, Moderate resistant to Phyllody, Antigastra for *kharif* season in MP, UP, AP, KK, Raj., Gujarat and Maharashtra;. (ii). AKT-64 (2002) tolerant to Macrophomina stem/root rot, Phytophthora blight and moderately resistant to phyllody for *kharif* season in Vidarbha region of Maharashtra; (iii). AKT-101 (2002) moderately resistant to phyllody, Macrophomina stem/root rot and bacterial blight for *rabi* season in Maharashtra states; (iv). Brijeshwari (2002) for *kharif* season in Himachal Pradesh (v). Pragati (2002) resistant to Phyllody, Leaf curl and Powdery mildew, MR-Phytophthora blight, Macrophomina stem/root rot, capsule borer for *kharif* season in UP, Haryana and Rajasthan;. (vi). Nirmala (2002) tolerant to phyllody and wilt, resistant to bacterial leaf spot and powdery mildew, moderately resistant to stem/ root rot, Alternaria leaf spot for *kharif* season in Coastal region of India; (vii). Prachi (2002) for *kharif* season in Orissa (viii). Chandan (2003) tolerant to phyllody, bacterial blight for *kharif* season in Andhra Pradesh; (ix). Gujrat Til-10 (2003) for *kharifseason* in Gujrat; (x). Thilarani (2003) for *rabi* season in Kerala, (xi).

VRI(SV)-2 (2006) resistant to phyllody and root rot for *kharif* / *rabi* season in Tamil Nadu; and (xii).Hima (2006) tolerant to capsule borer, field tolerance to phyllody, Alternaria leaf spot for *kharif /rabi* season in Andhra Pradesh.

NIGER

Varieties Identified/developed

Five high yielding improved composites were developed and released for different agroclimatic regions/ area of adoption of the country (i). JNC-6 (2002) for all niger growing areas, (ii). JNS-9

(2003) for all niger growing areas, (iii). Puja (2003) for all niger growing areas, (iv). NRS-961(2003) for all niger growing areas, (v). IGPN-2004-1 (2007) for Maharashtra and Karnataka.

Crop Production

Sesame

• Application of S @ 45 kg/ha along with RDF was found to give maximum seed and oil yield and Single Super Phosphate was the best source of its application followed by Gypsum.

• Intercropping combinations of sesame + blackgram (3:3), sesame + green gram (3:3), sesame + cotton (3:1), sesame + groundnut (2:2) and sesame + bajra (3: 1) were found to be most remunerative at different locations.

• Two hand weedings at 15 and 30 days after sowing were most effective in controlling weeds and increasing seed yield. However, integration of Alachlor @ 1.5 a.i. kg/ha or Quizalofop ethyl @ 50 g a.i. *Iha* followed by one hand hoeing at 30 days after sowing was equally effective and economic.

• The integrated nutrient supply and management with 50% N through urea + 50% N through oil cake or 50% N through urea + *Azospirillum* + *Azotobactor* + PSB + 50% P recorded the maximum seed yield.

• Supply of recommended dose of nutrients through organic natural sources [FYM (3.75 tlha) + neem cake (900 kg/ha) + Ash (75 kg/ha) + Bone meal (75 kg/ha) + ELS 20 kg/ha + PSB @ 5 kg/ha (soil application) + *Azotobacter* @ 5 kg/ha + *Trichoderma viride* (0.04%) seed treatment + neem oil spray thrice at 15, 30 and 45 DAS, *Azadrichitin* (0.03%) at 30 DAS] resulted higher seed yield and recommended for organic cultivation of sesame.

• Addition of micronutrients, zinc and iron @ 20 kg ZnS04 *Iha* + 25 kg FeS04 *Iha* and 2.5 tlha FYM + RDF resulted in higher seed yields of sesame.

• One hand weeding at 15 DAS + soil stirring up to 50 DAS (After each effective rain) + seed soaking in thio-urea (500 ppm) for 8 hrs was most effective *in-situ* moisture conservation practice for increasing sesame yields under scare moisture conditions.

Niger

• Fertilizer dose @ 40 kg N + 40 kg P/ha recorded maximum seed yields when phosphours was supplied half as DAP/SSP + half as rock phosphate enriched with FYM.

• Application of sulphur @ 30 kg *S/ha* with RDF and gypsum was the most suitable source of sulphur to enhance the seed yield.

• Sowing with onset of monsoon and two hand weedings or one hand weeding at 30 DAS + dust mulch within and between rows, after weeding was most effective for *in-situ* moisture conservation practice to get higher seed yields of niger under scare moisture conditions.

• The most appropriate sowing time for *pre-rabi* niger was 1st September with 3 irrigations.

• One hand weeding at 15 DAS + vegetative mulch @ 4 t *Iha* was most effective for *in-situ* moisture conservation practice to increase higher yield and GMR under rainfed conditions.

• Pre-emergence application of Pendimethalin + sieving was most effective for the management of *CusGuta* in niger to get highest seed yields and gross monitory return.

Crop Protection

Entomology

SESAME

• The IPM module - resistant variety + Seed treatment with *Trichoderma viride* (0.4%) + Intercropping with moong bean/pigeon pea/urid bean + two sprays of Azadirachitin (0.03%) minimized the incidence of *Antigastra* and *Dasyneura* as compared to farmer's practice.

• Combination of endosulfan 0.07% at 30 DAS + neem oil 10 ml/lit at 45 DAS was equally effective but economic and eco-friendly as compared to both the sprays of endosulfan 0.07%.

• Besides being economical and eco-friendly, the efficacy of ITK involving Garlic buds + Red pepper (1:1) @ 5g/lit or Neem leaf extract in cow urine (250g neem leaf/lit cow urine kept for 10-15 days) @ 30ml/lit or Cow butter milk @ 40 ml/lit (10-15 days old) were as effective as endosulfan 0.07% (@ 2 ml/lit) for the control of leaf roller/capsule borer and bud fly.

• Four sprays alternatively of NSKE 5% and endosulfan 0.07% or 3 sprays of NSKE 5% proved to be as effective as endosulfan 0.07% sprays to control leaf roller/capsule borer and bud fly.

• Sesame + green gram (3:3) and sesame + cluster bean (3:3) intercropping systems minimized the incidence of leaf roller/capsule borer and bud fly.

NIGER

• Niger is profusely flowering, self incompatible plant with 100% entomophilous crosspollination.

Very high seed yield of niger (1228 kg/ha) was recorded with one bee hive *(Apis mellifera)* per 600 sq. m in niger field. A yield reduction of 93 per cent was recorded in net covered control without any pollinators. An additional income of Rs. 252 to 2125 including Rs. 1015 /ha from honey was obtained through bee keeping with niger over open pollinated crop.

PATHOLOGY

SESAME

• Seed treatment with Carbendazim 50 WP (0.1%) + Thiram (0.4%) or *Trichoderma viride* (0.4%) or *T. harzianum* (0.4%) or cow dung ash (0.4%) reduced the incidence of Macrophomina stem/root rot.

• One spray of Mancozeb (0.2%) minimized the incidence of Alternaria leaf spot. Whereas one spray of Mancozeb (0.2%) + Methyldemeton (0.1%) minimized the incidence of Phytophthora

blight, Cercospora leaf spot, phyllody and leaf curl diseases and proved to be the most effective control measure against these diseases.

• Spray of *Trichoderma viride* (0.2%) was most effective in the management of Phytophthora blight.

• Seed treatment with *Trichoderma viride* 0.4 % + soil application of *Tviride* @ 2.5 kg/ha) minimized Phytophthora blight and Macrophomina stem/root rot and gave highest seed yield.

• One spray of Chlorothalonil (0.2%) minimized the incidence and proved to be most effective for the control of Cercospora leaf spot and Alternaria leaf spot and increased the grain yield.

• Two sprays of Propiconazol were most effective to minimize incidence of Alternaria leaf spot and powdery mildew, whereas Tridemorph was most effective to minimize Cercospora and Alternaria leaf spot. Chlorothalonil minimized the incidence of Alternaria leaf spot.

• IDM module comprising seed treatment with Thiram (0.2%) + Carbendazim 50 WP (0.1 %) + spray of Mancozeb (0.25%) + Endosulfan (0.07%) at 30-40 and 45-55 days after sowing minimized the incidence of powdery mildew, Alternaria leaf spot, Cercospora leaf spot, Phytophthora blight, phyllody and Macrophomina stem/root rot diseases and gave higher seed yield.

• Solarization + Mancozeb (0.25%) spray was most effective to manage of Phytophthora blight and yield increase.

• Soil incorporation of neem cake @ 500 kg/ha + seed treatment with *T viride* (0.4%) + soil application of *T viride* @ 2.5 kg/ha was most effective to reduce the incidence of Macrophomina stem/root rot and gave the highest seed yield.

All India Coordinated Research Project on Soybean

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

- Twenty soybean varieties viz. MAUS 71, MAUS 61-2, MAUS 61, RAUS 5, JS 93-05, MAUS 81, Palam Soya, PS 1241, TAMS 38, SL 525, DS 228, Co-3, PRS-1, DS 97-12, JS 75-60, PS 1347, DS 98-14, Himso 1588, RKS 18 and TAMS 98-21 were released/notified for different agro climatic regions. Two varieties viz. SL 688 for North Plain Zone and JS 97-52 for North Eastern Zone have been identified. So far, a total of 93 varieties of soybean have been developed under the AICRP on Soybean.
- Problem of pod shattering in soybean is largely solved by development of several shattering-resistant varieties.
- Early maturing varieties helped in increasing the system efficiency of soybean based cropping system and also in extending soybean to nontraditional areas.
- New location-specific biotic menaces viz. soybean rust and Yellow mosaic virus were successfully managed through recommendation of comprehensive integrated management schedule.
- Breeders seed was produced as per the DAC indent every year for the X plan period. In the year 2006-07 a total of 16814.00 quintal breeder seed was produced.
- Integrated pest management (IPM) for major insect-pests was standardized and successfully demonstrated in farmers' fields in different zones.
- Tank-mix combination of *Bacillus thuringiensis* based biopesticide with monocrotophos gave better pest complex management with higher yields.
- Integrated disease management for important diseases of soybean was developed and demonstrated in farmers fields in different zones.
- Neem products and ITK were recommended for effective management of diseases.
- Intercropping of soybean with pigeonpea (arhar) for rainfed situation and soybean with maize for irrigated situation was found highly beneficial. Farmers are increasingly adopting these intercropping systems.
- Soybean based cropping systems for different agro-ecological regions have been identified and recommended.
- Integrated use of crop residue @ 5 t/ha + FYM @ 5 t/ha + Zn @ 5 kg/ha along with RDF resulted in the maximum yield of soybean as well as wheat.
- Broad bed furrow and ridge sowing has been found promising in some regions over flat bed sowing.
- Varieties suitable under moisture stress conditions have been identified.
- Application of RDF + FYM @ 5 t + Zn @ 5 kg/ha gave promising results for soybean based intercropping system.

- Newly standardized post emergence herbicide such as Imaze thapyr, in contrast to the earlier recommended pre-emergence herbicides, facilitated the herbicide application at farm level. The recommendation of post-emergence herbicide also provided farmers an option to save on this input if they get time to use traditional 'dora'.
- Integrated nutrient management technology was standardized and recommended by suitably integrating organic and inorganic sources.
- Adoption of minimum tillage was found to reduce cost of cultivation in specific locations.
- *Bradyrhizobium* strains viz. Pantnagar 2 in combination with BJ 2 strain and others were identified for improving nitrogen fixation and productivity.
- Co-inoculation of *B. japonicum* either with VAM fungi or PGPR or 60 kg P_2O_5 or 60 kg K_2O + 5 kg boron gave promising results.

All India Coordinated Research Project on Sugarcane

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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

I. Sugarcane varieties identified :

During 2002-07, the following varieties were identified for cultivation in different agroclimatic zones of the country.

S.No.	Variety	Maturity	Agroclimatic zone
1.	Co 94008 (Shyama)	Early	Peninsular Zone
2.	Co 99004 (Damodaran)	Midlate	-do-
3.	Co 99006 (Neeruj)	Midlate	-do-
4.	CoC 01061	Early	East Coast Zone
5.	CoS 95255 (Rachna)	Early	North West Zone
6.	CoS 96268 (Mithas)	Early	-do-
7.	Co 98014 (Karan-1)	Early	-do-
8.	CoPant 93227	Midlate	-do-
9.	CoPant 97222	Midlata	-do-
10.	CoS 94270 (Sweta)	Midlate	-do-
11.	CoS 96275 (Sweety)	Midlate	-do-
12.	CoH 119	Midlate	-do-
13.	CoJ 20193	Midlate	-do-
14.	CoSe 96234 (Rashmi)	Early	-do-
15.	CoLk 94184 (Birendra)	Early	North Central Zone
16.	CoSe 96436	Midlate	-do-

II. Crop Production technology :

(i) Nutrient management :

In order to sustain the soil health and crop productivity, FYM (20 t/ha) or sulphitation press mud cake (SPMC)@10 t/ha + trash compost @ 5 t/ha to be applied before cane planting or green manuring once in the crop cycle with recommended dose of NPK to each crop may be adopted in the sugarcane based cropping system.

In order to sustain higher cane and sugar yield from sugarcane plant ratoon system, plant crop should be fertilized with 100% of the recommended NPK fertilizers + 25% N through FYM + biofertilizer (*Azotobacter* + PSB) and ratoon crop be fertilized with 100% of the recommended NPK through inorganics + trash incorporation with cellulytic culture + biofertilizer.

SSP and DAP are equally effective as sources of phosphorus. In north-west, north-east and east coast zones, sugarcane crop may be fertilized with 60 kg P_2O_5/ha. However, in peninsular zone, DAP is superior to SSP and sugarcane crop be fertilized with 60-80 kg P_2O_5/ha. As regards, zinc nutrition, 20-30 kg $ZnSO_4$/ha is sufficient.

New promising genotypes should be adopted to replace existing old/low yielding varieties. Sugarcane crop in peninsular and east coast zones may be fertilized with 25% more NPK over recommended dose of NPK. However, in north-west, north central and north east zones, recommended dose of NPK is adequate to meet nutritional requirement of promising sugarcane genotypes.

(ii) Management of sulphur deficiency in soil :

Sulphur @ 40-60 kg/ha in sugarcane plant crop needs to be applied in sulphur deficient soils. As regards source of sulphur, gypsum proved more effective and economical.

(iii) Ratoon management:

Under multiple ratooning, integration of agro-technologies viz., stubble shaving, gap filling, trash mulching and cultivation in alternate rows with the use of phorate (15 kg/ha) may be adopted to sustain higher ratoon cane yields. Keeping ratoon beyond third does not appear to be economical. As component technology, trash mulching and gap filling have been identified as critical technologies to sustain multiple ratoon productivity.

(iv) Conservation of tillage operation:

Pre-planting tillage operations can be economized to the extent of 50% by using rotavator twice over conventional tillage in late planted sugarcane crop following wheat crop in light soils.

(v) Management of weeds:

Metribuzin @ 1.0 kg a.i. or ametryn @ 2.0 kg a.i./ha as pre-emergence is as effective as earlier recommended pre-emergence herbicide atrazine @ 2.0 kg.a.i./ha. Either of these herbicides should be coupled with application of 2, 4-D @ 1.0 kg a.i./ha at 60 days after planting (DAP) and one hoeing at 90 DAP to sustain cane yield equivalent to three manual hoeings at 30, 60 & 90 DAP.

III. Crop Protection technology:

(i) Chemical control of smut disease :

Dipping of setts (10 minutes) in carbendazim (0.2%) and triademephon (0.2%) was found effective in the management of smut and increasing cane yield. However, taking into economic consideration, carbendazim (0.2%) sett treatment was recommended.

(ii) Integrated disease management (IDM) :

IDM practices, viz., use of resistant variety, healthy seed of crop raised from heat treated seed cane, sett treatment with a systemic fungicide (carbendazim @ 0.2%), roguing of diseased plants, foliar spray of copper oxychloride (0.25%) and dithiocarbamate fungicides (0.25%) against foliar diseases may be adopted for higher germination and cane yield

Chemical control of root borer:

Soil drenching of imidacloprid @ 0.1 kg a.i./ha during mid-August/120 days after planting be used for effective management of root borer.

Management of sugarcane woolly aphid:

For the effective management of sugarcane woolly aphid, the need based application of imidacloprid 17.8 SL @ 100 g a.i./ha and thiamethoxam 25 WG @ 50.0 g a.i./ha followed by release of *Dipha aphidivora* and *Micromus igorotus* @ 2000 larvae/ha 15 days after chemical treatment may be practiced.

Mass multiplication of *Dipha aphidivora*, the predator of sugarcane woolly aphid, may be carried out on sugarcane woolly aphid susceptible variety (e.g.,Co 86032, CoC 671) grown under green shade net. Woolly aphid may be released on the crop by continuous tagging of infested leaves till sizeable population is established. One hundred to two hundred larvae of *Dipha* may be released by tagging leaves. After 45-60 days, larvae of *Dipha* may be harvested for redistribution.

All India Coordinated Research Project on Sunflower

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

A. Varieties/ Hybrids developed (Last five years)

State-wise varieties/hybrids recommended during last five years

Karnataka	Hybrids	KBSH-41, KBSH-42, KBSH 44, RSFH-1, DRSH-1
	Varieties	DRSF-108
Maharashtra	Hybrids	LSFH-47, KBSH-44, DRSH-1
	Varieties	DRSF-108, TAS-82, AKSF-9
Andhra Pradesh	Hybrids	KBSH-44, NDSH-1, DRSH-1
	Varieties	DRSF-108
Tamil Nadu	Hybrids	KBSH-44, DRSH-1
	Varieties	DRSF-108, CO-5
Punjab	Hybrids	PSFH-118, KBSH-44, DRSH-1
Haryana	Hybrids	KBSH-44, DRSH-1, HSFH-848
Gujarat	Hybrids	KBSH-44, DRSH-1
	Varieties	DRSF-108.
Other states	Hybrids	KBSH-44, DRSH-1
	Varieties	DRSF-108

Characteristics features of varieties/hybrids released

S.No.	Varieties/ hybrids	Seed yield (kg/ha) under rainfed conditions*	Duration (days)	Oil content (%)	States for which recommended
Varieties					
1.	DRSF-108	800-1200	90-95	40-42	All States
2.	TAS-82	800-1200	90-95	40-42	Maharashtra
3.	CO-5	800-1200	90-95	40-42	Tamil Nadu
Hybrids					
1.	KBSH-41	1200-1500	90-95	40-44	Karnataka
2.	KBSH-42	1200-1500	90-95	40-42	Karnataka
3.	KBSH-44	1300-1600	95-100	38-40	All states
4.	PSFH-118	1200-1600	85-90	41-44	Punjab
5.	RSFH-1	1300-1600	95-100	40-43	Karnataka
6.	DRSH-1	1300-1600	92-98	42-44	All states

B. Remunerative Intercropping System

State	Soil type	Efficient intercropping	Row ratio
Karnataka	Alfisols	Grounndnut+Sunflower	4:2, 3:1
	Alfisols	Pigeonpea+Sunflower	1:2/1:1
	Vertisols	Pigeonpea+Sunflower	3:1
	Alfisols	Fingermillet+Sunflower	4:2
Maharashtra	Vertisols	Pigeonpea+Sunflower	3:3
	Vertisols	Soybean+Sunflower	2:1
	Vertisols	Groundnut+Sunflower	6:2
Andhra Pradesh	Alfisols	Groundnut+Sunflower	4:2
	Alfisols	Pigeonpea+Sunflower	1:2
	Alfisols	Castor+Sunflower	1:1
Tamil Nadu	Alfisols	Groundnut+Sunflower	3:1
	Alfisols	Castor+Sunflower	1:1
Gujarat	Vertisols	Groundnut+Sunflower	1:1
	Vertisols (irrigated)	Castor+Sunflower	1:1
Non-traditional areas	Inceptisols	Urdbean/Mungbean+ Sunflower	4:2/3:1

C. Suggested crop sequences involving sunflower for different states/regions of India

1.	**Karnataka**		
	Southern region	Rainfed	Sunflower-Fingermillet
		Irrigated	Rice-sunflower
			Groundnut-Sunflower
			Sorghum-soybean-sunflower
			Cotton-sunflower
			Maize-sunflower-groundnut
			Sunflower-groundnut
	North region	Rainfed	Fallow-sunflower
			Mungbean-sunflower
			Sunflower-chickpea
			Sunflower-safflower
		Irrigated	Cotton-sunflower
			Rice-sunflower
			Soybean-sunflower
			Maize-sunflower
			Sunflower-chickpea
			Sunflower-groundnut
2.	**Maharashtra**		
	Vidarbha	Rainfed	Sorghum-sunflower
			Kharif pulses-sunflower
			Sunflower-safflower
			Sunflower-chickpea
		Irrigated	Cotton-sunflower
			Sorghum-sunflower
			Groundnut-sunflower
	Marathwada	Rainfed	Soybean-sunflower
			Kharif pulses-sunflower
			Sunflower-chickpea
		Irrigated	Groundnut-sunflower-sesame
			Cotton-sunflower
			Sorghum+pigeonpea-sunflower
			Pigeonpea-sunflower
			Sorghum-sunflower
			Maize-Cowpea (F)
			Groundnut-sunflower-maize+Cowpea (F)
			Soybean-sunflower-maize+cowpea (F)
	Western Maharashtra	Rainfed	*Kharif* pulses-sunflower
			Soybean-sunflower
		Irrigated	Cotton-sunflower
			Sunflower-groundnut
3.	**Andhra Pradesh** (Telangana and Rayalaseema)		
		Rainfed	*Kharif* pulses-sunflower
			Millets-sunflower
			Groundnut-sunflower

			Sorghum-sunflower
		Irrigated	Rice-sunflower-mungbean
			Rice-sunflower
			Sesame-sunflower-groundnut
			Groundnut-sunflower
			Sorghum-sunflower
4.	**Tamil Nadu**	Irrigated	Groundnut-sunflower
			Mungbean-rice-sunflower
			Sunflower-rice-sesame
			Sunflower-rice
5.	**Non-traditional areas (Irrigated)**		
	Punjab, Haryana, Uttar Pradesh, Bihar		Maize-potato-sunflower-cotton-sunflower
			Fodder-potato-sunflower
			Fodder-mustard-sunflower
			Urdbean-mustard-sunflower
			Groundnut-mustard-sunflower
	Orissa, Chhattisgarh, West Bengal		Rice-sunflower
			Soybean-sunflower
			Rice-potato-sunflower

D. Agronomic Management

Suggested seed rates for different situations

	Rainfed	**Irrigated**
Varieties	6-7 (kg/ha)	5-6 (kg/ha)
Hybrids	5-6 (kg/ha)	4-5 (kg/ha)

Pre-soaking and seed treatment

For quick germination and better stand establishment in dryland conditions, soak the seed in fresh water (1:1 W/V) for about 14 hours and shade dry. Seed should be treated with thiram or captan @ 2-3 g/kg of seed to protect from seed-borne diseases. Seed treatment with metalaxyl @ 6 g/kg can protect the crop against downy mildew disease. Treat the seed with imidacloprid @ 5 or 6 g/kg seed before sowing against insect vectors for the necrosis management.

Spacing and plant population

In general, prefer wider spacing of 60 cm between rows and 30 cm within the row for hybrids and long duration populations. For short duration and dwarf varieties (Morden), follow 45 x 30 cm spacing.

State-wise fertiliser recommendations

State	Fertilizer (kg/ha)		
	N	P_2O_5	K_2O
Andhra Pradesh			
Rainfed (Rabi)	60	60	30
Irrigated	60	90	30
Karnataka			
Rainfed (Rabi)	50	25	25
Irrigated	60	75	60
Maharashtra			
Rainfed	40	60	0
Irrigated	60	95	60
Tamil Nadu			
Rainfed	40	20	20
Irrigated	60	90	60
Uttar Pradesh, Punjab, Bihar and Haryana	80	60	40
Rice fallow situation			
Irrigated	80	60	40
Rainfed	40	40	20
West Bengal, Bihar, Orissa, Chhattisgarh, Madhya Pradesh			
Irrigated	80	60	40

In Rayalaseema region of Andhra Pradesh (Nandyal), Vidarbha region of Maharashtra (Akola) and Tamil Nadu (Coimbatore), dual inoculation of *Azospirillum* and *Azatobactor* can save 50% recommended nitrogen for sunflower, resulting in economic gain of Rs. 200/- to 420/ha.

The fertilizer schedule may be decided based on the prevailing cropping systems of the region. For intercropping system of soybean + sunflower (2:1) in Vidarbha region of Maharashtra, application of 100% recommended dose of fertilizer (RDF) to soybean and 50% RDF to sunflower as basal on area basis and top dressing of 50% N to sunflower is advocated to get highest yield and returns. In Vertisols of Marathwada region of Maharashtra, fertilize pigeonpea + sunflower (1:1) intercropping system with RDF of pigeonpea on area basis along with 100% N (50% as basal and 50% as top dress) to sunflower component for higher productivity and profit. In groundnut + sunflower (3:1) intercropping system at Coimbatore and Raichur, it is suggested to apply recommended NPK to groundnut on area basis and recommended PK and 50% N as basal or top dress to sunflower for higher production and net returns. In Telangana region on Alfisols of Andhra Pradesh, for the intercropping systems of sunflower+groundnut (1:5) and sunflower + pigeonpea (2:1), it is desirable to apply RDF of sunflower to the intercropping systems for maximum returns under rainfed conditions. In Northern part of Karnataka for sunflower-chickpea sequence, it is possible to substitute 50% P needs of chickpea by seed treatment with PSB along with application of 5 t/ha FYM when sunflower is grown with recommended P. In Marathwada region of Maharashtra, in soybean-sunflower cropping system on Vertisols, it is profitable to substitute 50% P for sunflower by seed treatment with PSB and application of 5 t FYM/ha when the preceding soybean is supplied with recommended P. In the same region, in sunflower-chickpea sequence, incorporation of sunflower stalks treated with cellulotic micro-organisms can reduce fertilizer needs of chickpea by 25% besides increasing net returns.

Sulphur application

Sunflower has been found to respond to direct and residual sulphur fertilisation. In Vidarbha region of Maharashtra, application of sulphur @ 20 kg/ha through ammonium sulphate or single super phosphate significantly enhances the yield and returns from sunflower. In Vertisols of Marathwada region of Maharashtra 40 S/ha through single super phosphate gives higher seed yields and profit. In Telangana region of Andhra Pradesh, use of sulphur @ 45 kg/ha once in the cropping system (rice-sunflower and sunflower-groundnut) benefits the seed and oil yield besides maintaining soil fertility especially sulphur.

Boron application

Among different micronutrients, boron is the most important for sunflower. Providing directed spray of borax (0.2% i.e. 2 g/l of water) to capitulum at ray floret opening stage increases seed filling, yield and oil content. A spray mixture of 500 l/ha is required. Dissolve required quantity of borax (2 g/l) in small quantity of hot water and make up the required volume.

Irrigation management

Critical crop growth stages

Stage	Days after planting	
	Short duration varieties	**Long duration varieties**
Bud initiation	30-35	35-40
Flower opening	45-50	55-65
Seed filling	55-80	65-90

Supplemental pollination

Bees play a very important role in increasing seed set in sunflower more particularly in open-pollinated populations. Maintaining 5 hives/ha provides optimum requirement besides yielding valuable honey. Wherever bee activity is low, resort to supplemental hand pollination on alternate days preferably in the morning hours between 8 and 11 a.m. for about 2 weeks. For this purpose, cover the hands with muslin cloth and gently caress the heads with fingers and also touch the heads of neighbouring plants. Do not resort to insecticidal spray during the blooming period as it affects the visit of pollinators (bees). If absolutely essential, spray or dust in the evenings after 3 P.M. preferably with relatively safer insecticides like endosulfan or phosalone.

E. Important diseases and their control methods

Disease/causal organism		Management practice/Control
I.	Alternaria blight and leaf spot (*Alternaria helianthi*)	Treat the seed with Captan/Thiram @ 2.5 g or Carbendazim 1.0 g/kg seed. Early planting (*kharif*) escapes the disease. Spray with Mancozeb (0.3%), 3-4 times at 15 days interval or Rovral (0.05%) 2 times at 15 days interval.
II.	Rust (*Puccinia helianthi*)	Removal and destruction of crop residues, volunteer sunflower plants reduce the disease severity. Foliar spray with Mancozeb/Zineb 0.2% or calixin 0.1% at 30 days interval.
III.	Downy mildew (*Plasmopara halstedii*)	Use disease resistant hybrids i.e., LSH-1 and LSH-3 In endemic areas avoid continuous sunflower growing, follow 3-4 yearly crop rotation Early sowing, shallow planting escapes from the disease. Clean cultivation, roguing of infected plants reduces the disease incidence. Treat the seed with Metalaxyl 35 SD @ 6 g/kg of seed and followed by foliar spray of (Metalaxyl/Ridomyl).
IV.	Sclerotium wilt (*Sclerotium rolfisii*)	Seed dressing with captaf/carboxin 3-6 g/kg of seed. Adding of soil amendments and antagonistic fungi such as *Trichoderma harizanum* incorporated into soil reduces the disease incidence. Crop rotation for 3-4 years to be adopted. Avoid moisture stress/water logging conditions in the field.
V.	Charcoal rot (*Macrophomina phaseolina*)	Seed treatment with thiram 3 to 4 g/seed. Avoid moisture stress during high summer. Follow deep ploughing in summer and crop rotation.
VI.	Head rot (*Rhizopus arrhizus*)	Spray with Copper oxychloride @ 0.4% or Mancozeb 0.3% combined with Endosulfan (0.05%) at 50% flowering stage.
VII.	Sunflower Necrosis Disease	Follow clean cultivation and remove weeds specially *Parthenium, Commelina* etc. both from inside and neighbouring fields and also remove and destroy diseased plants. Seed treatment with Imidacloprid @ 5 g/kg of seed against insect vectors. Give prophylactic spray 2-4 times at 15-30 days interval with Imidacloprid (0.01%) for vectors control.

F. Important insect pests of sunflower and their management

Insect pests	Pest management practices
I. Seedling Pests	
Cut worm (*Agrotis* sp.)	Sow the seeds on slopes of ridges (6-8 cm height) Apply Chlorpyriphos (20 EC) @ 3.75 lit/ha to soil with irrigation water.
II. Sucking pests	
Leaf hopper (*Amrasca biguttula biguttula*) White fly (*Bemesia tabaci)* Thrips (*Scirtothrips dorsalis* and *Thrips* spp.)	Seed treatment with Imidacloprid 70 WS @ 5 g/kg of seed Apply Imidacloprid @ 0.1 ml/lit of water at 15-20 days interval Spray with Phosphamidon (0.03%) or Dimethoate (0.03%) or Monocrotophos (0.04%)
III. Foliage pests Tobacco caterpillar(*Spodoptera litura*) Bihar hairy caterpillar(*Spilosoma obliqua*) Green semilooper (*Thysanoplusia orichalcea* and *Trichoplusia ni*)	Collect and destroy egg masses and early stage larvae of *S.litura* and *S.obliqua* on damaged leaves. Spray neem seed kernel extract (NSKE) 5% or Endosulfan (0.07%) or Dichlorvos (0.05%) or Fenitrothion (0.05%) in 500-700 lit of spray solution/ha or dust Methyl parathion (2%) or Quinalphos (5%) @ 25 kg/ha.
IV. Capitulum borer (*Helicoverpa armigera)*	Spray *Bacillus thuringiensis* @ 2 lit/ha or *Helicoverpa* NPV @ 250 LE/ha or Endosulfan (0.07%) or Monocrotophos (0.05%) or Fenvalerate (0.005%) in 500-700 lit of spray solution/ha.

All India Coordinated Research Project on Wheat and Barley Improvement

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

New Wheat Varieties Released During the last Five Years

No.	Variety	Species	Released by	Recommended zone	Production conditions	Average yield (q/ha)
Year 2003						
1.	VL 832	*T.aestivum*	CVRC	NHZ	TS, RF HIGH ALT.	24.1
2.	PBW 502	*T aestivum*	CVRC	NWPZ	TS,IR	48.8
3.	HD 2824	*T aestivum*	CVRC	NEPZ	TS,IR	45.7
4.	HI 1500 (AMRITA)	*T aestivum*	CVRC	CZ	TS,RF	16.0
5.	MP 4010	*T aestivum*	CVRC	CZ	LS,IR	40.1
6.	RAJ 4037	*T aestivum*	CVRC	PZ	TS,IR	40.0
7.	UP 2565	*T aestivum*	SVRC	Tarai of Uttrakhand	TS,IR	41.8
8.	PBW 509	*T aestivum*	SVRC	Punjab	LS,IR	45.9
9.	TL 2908	*Triticale*	SVRC	Punjab	TS,IR	45.5
10.	WR 744	*T aestivum*	SVRC	Delhi	VLS,IR	33.5
11.	AKAW 3722	*T aestivum*	SVRC	Vidarbha	TS,IR	44.8
12.	NIDW 295	*T durum*	SVRC	Maharashtra	TS,IR	39.5
Year 2004						
13.	SKW 196	*Taestivum*	CVRC	NHZ	TS, RF, High Alt	22.9
14.	POW 291	*Tdurum*	CVRC	NWPZ	TS,IR	48.5
15.	MACS 6145	*Taestivum*	CVRC	NEPZ	TS,RF	25.5
16.	HD 2864 (URJA)	*Taestivum*	CVRC	CZ	LS,IR	41.8
17.	POW 274	*Tdurum*	SVRC	Punjab	TS,IR	52.0
18.	Pusa Vishesh	*Taestivum*	SVRC	Delhi	TS,IR	48.0

19.	K 9351	*Taestivum*	SVRC	U.P.	TS,RF	30.8
Year 2005						
20.	HI 8627	*Tdurum*	CVRC	CZ	TS, RIRIRF	31.0 (RIR) & 16.7 (RF)
21.	PBW 527	*Taestivum*	SVRC	Punjab	TS,RF	33.8
22.	NW 1067	*T.aestivum*	SVRC	EUP	TS,IR, Salt affeacted	35.0
23.	K 9423 (Unnat Halna)	*Taestivum*	SVRC	U.P.	LS,IR	35.4
24.	Raj6560	*T durum*	SVRC	Kota &	TS,IR	46.3
25.	MP 1142	*T.aestivum*	SVRC	MP	TS,IR	41.3
26.	MP 3020	*T.aestivum*	SVRC	MP	TS, RF / RI	Not tested in coord. trials
27.	COW (W)-1	*T.aestivum*	SVRC	Plains of TN	TS, RI	
Year 2006						
28.	DBW 16	*T.aestivum*	CVRC	NWPZ	LS,IR	38.8
29.	HD 2888 (Pusa wheat 107)	*T.aestivum*	CVRC	NEPZ	TS,RF	22.6
30.	HS 1531 (Harshita)	*T.aestivum*	CVRC	CZ	TS, RF/RI	24.8 (RF) & 27.2 (RI)
31.	NIAW 917 (Tapovan	*T.aestivum*	CVRC	PZ	TS,IR	43.4
32.	RAJ 4083	*T.aestivum*	CVRC	PZ	LS,IR	41.3
33.	HD 2833 (Pusa Wheat 105)	*T.aestivum*	CVRC	PZ	LS,IR	40.6
34.	PBW 533	*T.aestivum*	CVRC	PZ	LS,IR	37.2
35.	AKDW -2997 -16	*T. durum*	CVRC	PZ	TS,RF	11.6
36.	DDK 1025	*T. dicoccurti*	CVRC	PZ,SHZ	TS,IR	38.0
37.	DBW 17	*T.aestivum*	CVRC	NWPZ	TS,IR	48.3
38.	K307	*T.aestivum*	CVRC	NEPZ	TS,IR	45.6
39.	GW366	*T.aestivum*	CVRC	CZ	TS,IR	51.7
40.	TL 2942	Triticale	CVRC	NHZ	TS,RF	24.8
41.	PBW 550	*T.aestivum*	CVRC	NWPZ	TS,IR	46.9
Year 2007						
42.	VL 892	*T.aestivum*	CVRC	NHZ	LS, RIR	37.6
43.	HPW 251	*T.aestivum*	CVRC	NHZ	ES,RF	34.4
44.	PBW 550	*T.aestivum*	CVRC	NWPZ	TS,IR	47.7
45.	WH 1021	*T.aestivum*	CVRC	NEPZ	LS,IR	39.0
46.	HI 1544	*T.aestivum*	CVRC	CZ	TS,IR	51.4
47.	HD 2932	*T.aestivum*	CVRC	CZ,PZ	LS,IR	42.4 (CZ), 43.3 (PZ)
48.	HI 8663	*T. durum*	CVRC	PZ	TS,IR	40.1
49.	DDK 1029	*T. dicoccum*	CVRC	PZ	TS,IR	40.9

New Barley Varieties Released During the Last Five Years						
No.	**Variety**	**Species**	**Released by**	**Recommended zone**	**Production conditions**	**Average yield (q/ha)**
Year 2003						
1	**RD 2592**	*H. vulgare*	**SVRC**	Rajasthan	IR,TS	45.2
Year 2004						
2	RD2624	*H. vulgare*	**CVRC**	**NWPZ**	TS,RF	30.8
Year 2005						
3	NDB1173	*H. vulgare*	**CVRC**	Saline -alkaline soils of UP, Haryana, Rajasthan, Gujarat, Punjab, Bihar	TS,IR	35.2
4	Sindhu (NBL-11)	*H. vulgare*	SVRC	Leh & Laddakh area of J & K	TS,RF	35.0
5	Norboo	*H. vulgare*	SVRC	Leh & Laddakh area of J & K	TS,RF	39.0
6	JB58	*H. vulgare*	**SVRC**	Madhya Pradesh	TS,RF	35.0
7	VLB56	*H. vulgare*	**SVRC**	Uttarakhand	TS,RF	25.7
Year 2006						
8	RD2660	*H. vulgare*	**CVRC**	NWPZ	TS,RF	24.3
9	DWRUB52	*H. vulgare*	**CVRC**	NWPZ	TS,IR	45.1
10	RD2668	*H. vulgare*	**CVRC**	NWPZ	TS,IR	42.5
11	PL751	*H. vulgare*	**CVRC**	**CZ**	TS,IR	46.8

TS- Timely sown, LS - Late sown, ES -Early sown, IR - Irrigated, RF- Rainfed, RIR - restricted irrigation CVRC -Central Variety Release Committee, SVRC - State Variety Release Committee, NHZ - Northern Hill Zone, NWPZ - North Western Plains Zone, NEPZ - North Eastern Plains Zone, CZ- Central Zone, PZ - Peninsular Zone, SHZ - Southern Hills Zone

Technologies Developed and Validated During the last five years

- The ZT technology is the most widely adopted resource conservation technology (RCT) covering nearly 3 million hectares in rice-wheat system of Indo-Gangetic plains and has a potential to be extended to other areas, Zero tillage scores over conventional tillage by giving a net saving in cost of cultivation by around Rs. *3000/ha* through saving of diesel, advances the time of wheat sowing (4-5 days), requires less water for the first irrigation and results in less infestation of *Phalaris minor,* which is a serious problem in northwest India. Zero tillage produces similar wheat yield compared to conventional tillage at reduced cost. In situations where sowing of wheat is delayed, adoption of ZT can help earlier planting leading of higher yields. Nitrogen use efficiency was more where fertilizer was placed by drill compared to broadcasting in zero tilled wheat. Besides this, the technology is eco-friendly and reduces 192 kg CO~ha (assuming 2.6 kg CO_2 production *I* litre of diesel burnt), released during field preparation and seeding in conventional tillage.

- Rotary tillage technology is an RCT in which the field is completely pulverised with simultaneous placement of seed and fertiliser using a specially designed rotary till drill. The machine is suitable for sowing wheat both under normal and late sown conditions and economises on fuel and the all-important time especially when wheat sowing is delayed. This technology has an edge for productivity over other tillage options although the machine is comparatively costlier and also requires higher tractor power as well as maintenance compared to zero till drill. The added advantage is that the machine can be used for puddling for rice transplanting after removing the drilling mechanism where also a single tractor pass is sufficient to prepare the field.

- Bed planting of wheat is done by planting two to three rows of wheat on the top of bed, around 70 cm wide and irrigation is done through furrows. Bed planting is resource conservation technology, which saves 20-30% water and around 25% seed and fertilizer nitrogen. Farmers in north-west India generally skip the last irrigation under flat planting due to risk of lodging. FIRB (Furrow Irrigated Raised Bed) technology reduces lodging owing to lesser physical contact of the irrigation water with wheat culm and at the same time furrow providing easy air movement. This planting method also reduces the population of *Phalaris minor* on the top of bed due to faster drying. It also provides an opportunity of mechanical weeding in furrows and on the top of beds, if two rows are grown, during early stages. At later stages, if weeds are still left, then manual weeding is also easier. The crops susceptible to water logging and/or lodging, like maize, pigeon pea, soybean, green gram, vegetable pea, mustard etc, could be more beneficial under bed planting. In many cases same beds could be utilized for the succeeding crops without any tillage operations and thereby reducing the cost of cultivation.

- A machine named "Rotary Disc Drill" capable of seeding into loose crop residue has been developed and needs further refinement especially the front powered discs. This is the only machine which can also seed crops into sugarcane ratoons.

- Crop intensification/diversification- Continuously growing rice-wheat adversely affects the soil physico-chemical properties, decreases productivity and causes weed infestation. Intensification of rice-wheat system by introducing short duration legume crops for grains or green manuring in between rice and wheat helps in restoring soil health by enhancing the organic matter contents and improving the soil physico-chemical properties. Alternate cropping sequences like rice-potato-wheat, rice-pea-wheat, Rice-wheat-GM/moong, maize-wheat, cotton-wheat and sugarcane-wheat *etc.* are some of the options for the farmers depending upon the agro-situations to increase profitability and sustainability. This is applicable to North Western India covering rice-wheat growing areas of Punjab, Haryana, Northern Rajasthan and Western UP. Moong (SML 668) can be grown in between wheat and rice especially when wheat is grown on raised beds. One can harvest around 5 q/ha moong grains and its residues can be incorporated in the field as manure. The biomass added to the soil is around 100 q/ha on fresh weight basis and about 20 q/ha on dry weight basis, which adds around 50 kg N/ha, thus saving about 20% N for rice crop.

- Herbicides effective for the control of isoproturon resistant biotypes of *Phalaris minor* are

sulfosulfuron 25 g/ha, clodinafop 60g/ha fenoxaprop 100-120 g/ha and pinoxaden 35 g/ha. Sulfosulfuron is effective against both grassy and non-grassy weeds whereas, clodinafop, fenoxaprop and pinoxaden are specific to grasses. Metsulfuron @ 4.0 g/ha and Carfentrazone @ 20 g/ha were found effective against broadleaf weeds. For control of grassy weeds including isoproturon resistant *P. minor,* pinoxaden at 35 g/ha have also been found effective in barley. Multiple resistance in *P. minor* against isoproturon, c1odinafop and sulfosulfuron has been detected in some biotypes and for its management pendimethalin and triazines were found effective. In zero tillage less *P. minor* population were observed compared to conventional but *Rumex dentatus* was favoured by ZT system.

- In the termite prone areas, seed treatment with chlorpyriphos @ 0.9g a.i or endosulfan @ 2.4g a.i/kg seed, be taken up for their management. Termite control be given special attention under FIRBS in the termite prone area. Fipronil (Regent 5FS @ 0.3 g a.i./kg seed) is also very effective. In the standing crop, the broadcasting of the insecticide treated soil 15 DAS be practiced. For this, endosulfan 35EC @ 2.3 Lor chloropyriphos @ 3 L mixed in 50 Kg soil be used for one hectare field. Crop planted under FIRBS is more prone to termite

All India Network Project on Agricultural Acarlogy

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Assessment of loss due to mites

- Crop loss estimation studies indicated that the yellow mite of chilli *Polyphagotarsonemus latus* causes a yield loss of 28.6% a equivalent to monetary value of Rs. 3261 per hectare at Navsari, while in Byadagi Dabbi variety it is 41.81% loss in yield, in Karnataka, and 49% loss in yield of local chilli varieties like Suryamuki, Beldanga and Bullet in West Bengal. This mite has also been observed to cause a yield loss of 17.61% in Sesamum in Gujarat. Evaluation of yield loss due to the two spotted spider mite *Tetranychus urticae*, indicated that it causes 16.65% loss in yield in brinjal in Ludhiana and 14.03% loss in yield in Varanasi, 18.00% loss in yield in okra in Navsari. In cucumber it causes 52.63% loss in yield in Kalyani. Infestation of *Tetranychus* sp on marigold reduces the yield of flowers by 39%. In wheat the loss in yield caused by brown mite, *Petrobia latens* in Punjab is 14.85%.

Mite Vector management

- The role of eriophyid mite, *Aceria cajani* as a vector of the virus causing pigeonpea sterility mosaic disease was confirmed following successful transmission of the virus by stapling mite infested diseased leaflets on to the healthy seedlings. Studies on spatial distribution of vector mites on pigeonpea plant ascertained their preference for trifoliate leaves in the top canopy. Within a branch also, the trifoliate leaves at the tip harboured more number of mites. In a leaflet, basal half recorded relatively more number of vector mites. Application of profenophos 0.02% between 30 and 45 days after sowing effectively controlled the vector mite leading to significant reduction in the incidence of sterility mosaic disease.

Biological control using predatory mites and acaropathogens

- *Neoseiulus longispinosus* suppressed the population of *T. urticae* on rose in 2-3 weeks.Studies on the role of plant architecture on predatory efficiency of *Neoseiulus longispinosus* revealed that bushy nature of plants aid in faster suppression of spider

mites. Efforts to produce monocrotophos and dicofol resistant strains of *Neoseiulus longispinosus* has been successful, strains resistant to recommended concentrations of the pesticides have been developed.

- Virulent isolates of *Hirsutella thompsoni, Beauveria basssiana, Fusarium moniliforme, Paecilomyces fumosoroseus* infecting eriophyid and tetranychid mites, which can be possibly employed in the biological control of mites, have been collected.

Mite biodiversity and Taxonomy

- Efforts to document of mite biodiversity of different regions of the country have been undertaken by all the centres. As a result 24 new genera and 50 new species of Eriophyidae have been described mainly from tree species. In Phytoseiidae, fifty species including 10 species of *Amblyseius*, 5 species of *Typhlodromus*, 2 species of *Phytoseiulus* been recorded on shrubs and trees from different agro climatic regions of Karnataka. A predatory thrips, *Scolothrips rhagebianus* has been recorded, feeding on *Tetranychus* sp in Coimbatore.

Host plant resistance against mite pests

- Studies showed that the two-spotted spider mite, *Tetranychus urticae* prefers middle canopy leaves of tomato plant compared to top and bottom canopy leaves. Resistance to this mite in tomato genotypes likes LA 1740, LA 1777, LA 280 and LA 2963 is attributed to glandular trichomes and biochemicals like methyl ketones (2 tridecanones and 2 undecanone), phenols and acylsugars. In coconut, West Coast Tall X Choughat Orange Dwarf, West Coast Tall X Gangabondam, West Coast Tall X Malaysian Yellow Dwarf, Gangabondam X Fiji, Gangabondam X Philippine Ordinary, Gangabondam X Lakshadweep Ordinary have been found fairly tolerant to the perianth eriophyid mite showing lower mite damage.
- The sugarcane spider mite, *Oligonychus indicus,* was found to cause more damage, in Gujarat, on susceptible varieties like, CoN – 85134, CoN – 85132, 93078, CoN 91132,2001-7,CoJN-964, COVSI-9275, while varieties Co- 2001-8, Co-2001-10, C0-93337, Co-85004,403,336,23, Co- 99010 and Co-99012 were observed to be tolerant to the mite attack but the levels of phenols and acylsugars did not correlate with the intensity of resistance. Among chilli varieties, KA-2 in Karnataka, Jwala, RHRC Erect, CHI and MS-12 in Punjab and AEG-77 in Gujarat and Indam-10 in West Bengal have been found less susceptible to the yellow mite, *Polyphagotarsonemus latus,* whereas the chilli varieties CH-3, Punjab Gucchedar, S-2530 and bell pepper variety SPH-6 were found to be high susceptible to the damage by this mite.
- The okra varieties Punjab 7 and Punjab 8 have been assessed as tolerant to the attack of *Tetranychus* sp.

Ecology of mites

- Studies on seasonal activity of the yellow mite infesting chillies in Navsari indicated that the mite is present throughout the year but distinct peaks are reached during second

fortnight of October and first fortnight of January (causing 40% leaf curling). These peaks are associated with the vegetative growth stage of the chilli crop.

- *Oligonychus indicus* on sugarcane is active from beginning of January to third week of September, the peak activity periods are May and September.
- *T.urticae* on tomato starts two months after planting and reaches the peak when the crop is $3^1/_2$ – 4 months old. Its distribution is patchy. While population of nymphs and adults (17.7/cm^2 leaf area) will be more in the middle canopy, while that of the eggs is more (6.7/cm^2 leaf area) on top canopy leaves.
- In Punjab brown wheat mite's (*Petrobia latens*) population was monitored, it was observed that it reaches a peak of 154 mites/10cm^2 leaf area during March.
- The sheath mite of rice, *Steneotarsonemus spinki* was observed to reach high population causing severe damage (47 mites/leaf sheath) on variety Jaya and Gurjary in Navsari and the leaf mite, *Oligonychus oryzae,* population reached the peak 35 to 70 days after transplanting of rice.
- On cucumber, the two spotted spider mite's (*Tetranychus urticae*) population reaches a peak of 60 mites/leaf during April in Kalyani.

Management of mite pests

- A holistic package for the management of the coconut eriophyid mite has been developed by the Project which involves nutrient management (application of FYM, neem cake and recommended dosages of NPK and micronutrients like boron, magnesium, calcium *etc*) and spraying or root feeding of a neem based pesticide three times a year i.e., during May-June, September-October and January-February. This results in better retention of nut and overall increase of 34 to 53% in yield of nuts. This has been popularized in Karnataka and Tamil Nadu. The state Agriculture/Horticultural departments have adopted this package in their large scale demonstration.
- Managing mites infesting roses is a problem since these have developed resistance to conventional acaricides, in this regard fenpyroximate, bifenthrin diafenthiuron and buprofezin have been able to cause 76-93% mortality.
- Studies on residues of acaricides indicated that dicofol and ethion residues on brinjal fruits reached below the prescribed MRL values in 2 and 7 days, respectively.
- Studies on causes of resurgence of mite pests indicated that monocrotophos, cypermethrin, fenvalerate and deltamethrin are responsible for the high incidence of the yellow mite on chillies.
- Propargite (200ml/acre) and dicofol (300ml/acre) were found effective against the spider mites infesting bell pepper grown under protected condition, on okra the mites could be controlled using fenazaquin @ 0.25 to 0.5 ml per litre of water which causes 70-78% mortality of the mites.

Evaluation of newer molecules

- Flufenzin @ 80 and 100 g ai/ha and Clofentezine @ 300 g ai/ha caused significant
- (>60%) reduction in the population of coconut eriophyid mites. But these were highly toxic to the predatory mite, *Neoseiulus paspalivorus.*

- Fenpyroximate @ 15-30 g ai/ha, flufenzin @ 80-100 g ai/ha, milbemectin @ 3-4 g ai/ha and clofentezine @ 250-300 g ai/ha, were able to cause 70% reduction of *Tetranychus urticae* infesting tomato. Similarly diafenthiuron has also been effective at 300-600 g ai/ha against this mite infesting tomato and rose and at 200 g ai/per ha on brinjal diafenthiuron @ 0.08% was also able to control *T.urticae* infesting rose.
- Chlorfenapyr (75 g ai/ha) Bifenthrin (80 g ai/ha), fenpropathrin (45 g ai/ha), milbemectin (4-5 g ai/ha), clofentezine (250-300 g ai/ha), flufenzin (80-100 g ai/ha) and fenazaquin (125 g ai/ha) were found to be effective against *Polyphagotarsonemus latus* infesting chillies but the effectiveness lasted for seven days only, compared to 10-14 days in dicofol (0.05%). Diafenthiuron at 300 g ai /ha can reduce the population of this mite by 93% in 15 days, similarly fenpyroximate (0.006%) and buprofezin (0.03%) were also highly effective.
- Propargite @ 570 g ai/ha was effective in controlling *Tetranychus* sp on cowpea, okra, cucumber and brinjal by causing almost 80% mortality. Spiromesifen @ 96 g ai/ha and Fenazaquin @ 125 g.a.i per ha were also effective against the brinjal mite, causing 75% mortality.
- Propargite, dicofol or ethion caused 78% mortality of the spider mite infesting mung bean and continued to be effective for two weeks.
- To control *Steneotarsonemus spinki* on rice, application of fenazaquin @ 125 gai/hectare or diafenthiuron @ 300-600 g ai/ha or propargite 0.05% or dicofol @0.05% were effective. Whereas abamectin @ 0.5ml/ltr of water and fenazaquin @ 1ml/litre of water were found effective against *Oligonychus oryzae,* the rice leaf mite.

All India Network Project on Agricultural Ornithology

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

- Developed the low cost technology of protecting the crop with Reflective Ribbon
- Standardized the technique of wrapping maize leaves around cobs at the grain maturity stage.
- Copper Oxycloride @ 3g/kg seed showed very effective in controlling bird damage during sprouting stage in maize & groundnut.
- Raising maize & Sorghum fodder as screen to the main crop (maize) showed significant reduction in the activity of depredatory birds.
- Wrapping along with reflective ribbon proved very effective in controlling bird damage in maize.
- Developed IBPM methods for the management of depredatory species at the vulnerable stage of the crop.
- Recommended block plantation of sunflower crop to avoid parakeet damage
- Evaluated & standardized 18 different ethnic practices of bird management strategies.
- Crude extract of botanicals viz. *Andrographis paniculata* and *Ipomea carnea* @ of 10 ml/lit. showed significant (60-85%) repellent action against depredatory birds both in captivity and field conditions on crops like paddy, sorghum, safflower, and sunflower.
- Planting of some fruit bearing trees like Manila tamarind, flame of the forest (*Butea mono sperma*) and mulberry and *Salvadora persica* attracts large number of insectivorous birds.
- Sowing tall crops among the shorter crops provides natural perches (Growing few maize or jowar plants).
- Implementation of IPM concept with the Ornithology as one of the potential component on the crops like Cotton, Red gram in checking the *Heliothis* population
- White grub prone areas were recommended three bullocks driven ploughing in three consecutive days and if the soil is dry one or more irrigation prior to ploughing is suggested. 70% of the white grubs population can be controlled before they go for pupation by this method.
- 60 cm row distance than 45 cm coupled with spraying of endosulphon 0.07% at the pod formation stage in chickpea will give more encouraging results.
- Providing 'T' shaped perches 20/acre or 50/ha proved more useful in reducing the *Helicoverpa* population.

- NPV (250 LE/ha) and Bird perches (@ 20/acre) proved very effective in controlling *Helicoverpa armigera* in Pigeon pea.
- Standardized the nest boxes design for cavity nesting birds in controlling insects & rodent's pests of various crops. These were validated in the field.
- Birds like small green barbet (*Megalaima viridis*) white checked bulbul (*Pycnotus jocosus*) and Tree pie (*Dendrocitta vagabunda*) were recorded to play a vital role in propagation of *Momordica dioica* a cucurbitaceous climber. It has been proved in the laboratory that the seed found in the excreta of these birds are readily germinated (100%) unlike in seeds harvested manually.
- Cattle egret (*Bubulus ibis*) is identified as potential bio-control agent and farmer's friend during all agricultural operations.
- Designed and developed agricultural ornithology website.
- Published various brochures, stickers, posters and bulletin's highlighting the role of bird both at regional and national level.
- Cattle egret is the best avian predator in the agricultural landscape and remains present during every agricultural operation to capture insect pests. Hence, it should be given due importance in the IPM programme. The species can be encouraged to breed on thorny trees at the edges of village ponds near human settlements.
- Developed habitat suitability index of key depredatory birds in relation to their spatial distribution and cropping pattern, which enable to evolve location specific technologies to minimize the crop damage.

All India Network Project on White Grubs and Other Soil Arthropods

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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

- Pheromone from whitegrub female adults of *Holotrichia consanguinea* was isolated and identified during the last plan period. During the present plan period refinement in the pheromone technique of whitegrub (*H. consanguinea*) management was done. On campus and off campus training programmes were organized for farmers and extension functionaries to educate them about pheromone technique of whitegrub management. Large-scale demonstrations/onfarm trials were conducted in several villages covering more than 900 ha.
- The pheromone technique of whitegrub management has reduced the pesticidal consumption by more than 60 per cent which ultimately reduced the cost of protection, labour and pesticidal load on the environment. The pest population and the crop damage in campaign area/demonstration villages was reduced by more than 80 per cent and increased the productivity of groundnut crop by more than 4 q/ha
- Under taxonomic studies work on identification of whitegrub species is continued at Bangalore centre. During the plan in 2002, 6 species; in 2003, 22 species; in 2004, 23 species and in 2005, 20 species were identified and added to database. Database on whitegrub for the entire country updated with 13435 specimens recorded from 1682 locations; about thirty crops/cropping systems and representing 268 species. The database provided information on present taxon status, distribution and host range of the whitegrubs
- In Rajasthan, Himachal Pradesh, Karnataka Uttaranchal and Assam states many species of whditegrubs i.e. *Holotrichia consanguinea, H. coriacae, Leucopholis lepidophora, Lepidiota stigma, Leucopholis burmeisteri, L. coneophora, Anomala rufiventris, H. longipennis, H. serrata and H. reynaudi* are causing severe damage during 2002-2006 to crops including groundnut, potato, palm, soyabean, maize, pea, arecanut, pulses, vegetables, apple, peach, pear, plum, millets, upland rice and off season vegetables. To overcome the menace due to this polyphagous scarabid number of new chemicals were tried along with the recommended pesticides (Chlorpyriphos and quinalphos) and among them imidacloprid 200 SL, imidacloprid 70 WS, thiamethoxam 70 WS, fipronil 5 FS as seed dressers and imidacloprid 200 SL, fipronil 5 FS and thiamethoxam 70 & 25 WS as standing crop treatment were found promising.

- Two entomophagous fungi, *Metarhizium anisopliae* and *Beauveria bassiana* and entomophilic nematodes were tested to control the whitegrubs in different agroecosystems. Several local strain of entomopathogenic nematodes have been isolated from different ecosystems with the objective of evolving their potential in whitegrub management.
- Itinerary of soil micro-arthropods in different regions of Rajasthan, Himachal Pradesh, Uttaranchal and Karnataka State have been prepared. It was also found that collembolans, soil mites and nematodes were found to be major groups of soil micro-arthropods.
- The population of soil micro-arthropods was comparatively higher in upper layer of soil (0-10 cm depth) as compared to lower layer of soil (10-20 cm depth). Further, it was noted that maximum number was present in the forest ecosystem followed by agro-ecosystem and fallow land. In trials to record the effect of pesticides on non-target organisms. It was noted that use of pesticides decreased, the population of collembola, soil mites and other soil micro arthropods. It was also observed that the population of collembola, soil mites and nematodes are restored after 1-3 months in quinalphos, chlorpyriphos and imidacloprid treated plots.

All India Network Project on Rodent Control

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3. Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):

(i) Rodent population survey and surveillance, eco-biology, and crop losses

- Changes in land use pattern and urbanization has affected the xeric rodents in arid zones, as these species are being replaced by sub-mesic /mesic/ commensal species. Intrusion of *Bandicota bengalensis* in arid zone is a recent change.
- Four species viz., *Niviventer niviventer*, *N. fluvescens, Rattus sikkimensis* and *R. nitidus* were identified as problem species showing upsurge in their population synchronizing with bamboo flowering in NEH region. Monitoring of rodent problem in NEH revealed population upsurge in parts of Manipur and Assam in 2003-04 and in Arunachal Pradesh in 2004-05 due to mass flowering of bamboos.
- In rice-rice system prevalence of pregnancy in lesser bandicoots was maximum in May with another small peak during March and October in Godawari delta, whereas in urban locales of Jodhpur it showed higher pregnancy rates during March and August.

(ii) Evaluation of rodent management techniques

(a) Non lethal methods

- Neem leaf powder (5%) showed antifeedant action on rodents, hence recommended as protectant in storage, whereas neem oil repelled the rats to the tune of 18-48%. Neem formulation BBR recorded a repellency index upto 87% at 3% conc. in baits against rodents.
- Jojoba seed cake powder (10-20%) recorded a repellency index of up to 90% in *Tatera indica.* The aversion through learning persited for a week. Among other botanicals kaner seeds, neem cake, castor seeds and jatropha seeds too showed anti rodent properties in preliminary trials. Crude cotton-seed oil (5%) showed anti fertility effects on bandicoots.
- Male urine was found to possess sex pheromonal properties as it was reported to accelerate puberty in females. Vaginal opening was advanced for three weeks. Addition of fresh burrow sand in baits increases the bait acceptance and consumption in bandicoots indicating that urinary pheromones are involved in intra specific communication.
- Alpha-chlorohydrin (0.5%) in baits was found to cause mortality, however, the dead rats were observed to indicate reduced male organs (testes, epididymis) and aspermia in epididymal fluid. Similarly epi chlorohydrin @ 50-100 mg/kg proved an effective male sterilant for lesser bandicoots.

- An ecofriendly mechanical device named as 'Burrow Fumigator' was developed and recommended for farmers' use in AP. For non chemical rodent control indigenous butta trap was found superior to Tanjore bow traps in trapping *B. bengalensis* and *M. booduga*

(b) Rodenticides

- The new Rodenticidal molecules evaluated against pest rodents included difethialone, coumatetralyl, cholecalciferol and alpha-chlorohydrin. A new relatively safer and ready to use formulation of bromadiolone (0.005%) containing denatonium benzoate was found effective in containing the rodent menace. Attempts were made to develop a new formulation of bromadiolone by adding plaster of paris in bromadiolone bait which yielded 80% mortality of *R. rattus* within 5-10 days.
- Difethialone (0.0025%) in fresh baits proved effective against baitshy rodents. Vitamin K1 supplementation @ twice the dosage intake of Difethialone for two weeks was sufficient to reverse the anticoagulation process in rodents.
- Reduction in dyke and regular weed management and anticoagulant baiting or AlP fumigation forms the package of rodent management in vegetable crops in hilly regions.

(iii) Action Plans for Rodent Management in NEH Region

Two pronged Action Plans (i) for researchers and (ii) for extension personnels was developed by AINP on Rodent Control for NEH region for effective management of Rodents during their upsurge synchronizing with bamboo flowering. Besides organizing a special Training on Rodent management in Arunachal Pradesh in association with CAU Imphal, the AINP has actively collaborated in imparting trainings in Manipur, Mizoram, Arunachal Pradesh and Meghalaya**.**

(iv) Technologies Developed for farmers

Punjab:

(i) Rodent control in fields of zero tillage wheat should be carried out by burrow baiting with freshly prepared zinc phosphide (2%) or bromadiolone (0.005%) baits before sowing of the crop in the months of October and November followed by crop period control operation in February. (ii) In fields of delayed harvesting of sugarcane, rodent control should be carried out with freshly prepared bait of bromadiolone (0.005%) @ 4 kg/ha bait placed at about 100 bait stations covering rodent activity damage sites.

Western Rajasthan*:*

In wheat-cumin-mustard cropping system application of zinc phosphide (2%) bait in pearl millet @ 10g/burrow followed by bromadiolone (0.005%) bait in pearl millet @ 20 g/burrow before sowing. If both these treatments are not done before sowing, then two baitings with bromadiolone (0.005%) baits prepared in pearl millet grains @ 20 g/burrow one at vegetative growth stage and another at flowering stage is recommended.

Andhra Pradesh:

(i) Summer ploughing and reduce the size and number of field bunds. (ii) Timely field operations pudding and transplantation and avoid staggered planting. (iii) Allow alleyways in transplanted rice 20 cm for every 2 meters crop. (iv) During the first month of transplanting keep bait stations made of coconut husks. Five bait stations/ha, four in four corners one meter inside the crop and one in the center of the field. Place bait material twice in a week (50 g/bait station) (v) Set bamboo traps @ 20/acre up to primordial initiation stage.(vi) Place bromadiolone bait (15 g/ burrow) inside the burrows. (vi) At grain formation stage kill burrow dwelling rats by natural smoke employing burrow fumigator.

Karnataka:

In dry land crops one chemical control using zinc phosphide (2%) in cereal-groundnut oil bait prior to sowing followed by bromadiolone baiting for surviving population. A second similar operation at grain/ fruit maturation stage.

(v) Transfer of Rodent Management Technologies

- Regular On and Off Campus Trainings on Rodent Control were organized by all centers of the Project. Collaboration with KVKs, State Deptts & other organizations are also sought.
- Apex Level Trainers Trainings on Rodent Control organized at ANGRAU, Maruteru in 2002, 04 and 06.
- Three Special training for State Officials of Arunachal Pradesh were organized at Seppa, Saglee and Ziro during 2005.
- Six Technical Bulletins and one Monograph were published during the Plan period.
- Publication of a Quarterly “Rodent Newsletter’ was continued.
- Consultancy and advisory services to clients mainly pesticide Industries was rendered and resources of over 5.0 lakhs were generated.
- Regional Meeting on Rodent Pest Management for NEH Region was organized at Aizawl during April 2006.

All India Coordinated Research Network on Underutilized Crops

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Eleven improved varieties have been released at national / regional level in different under utilized crops during the last five years by central variety release committee based on their performance at multi locations in various coordinated trials.

Varieties Released under All India Coordinated Research Network on Underutilized crops during 2001-2006

Crop	Variety	Yr. of release/ identifi-cation	Economic product	Yield potential (q/ha)	Characteristics	Areas for which recommended
GRAIN AMARANTH	PRA 9401	2003	Grain	25.00	High grain yield	Hilly region
	IC 35407 (Durga)	2004	Grain	21.50	High grain yield and Early maturing	North west hill zone
	BGA-2	2005	Grain	13.26	High grain yield and Early maturing	Karnataka, Orissa and Tamil Nadu
BUCKWHEAT	Shimla B-1	2005	Grain	11.12	Early maturing	Mid and high hills of Himachal Pradesh and Uttranchal
	Sangla B-1	2005	Grain	12.65	Early maturing and high yielding	Mid and high hills of Himachal Pradesh and Uttranchal
RICE BEAN	RBL 35	2003	Grain	14-16.00	Early maturing	Plains
	RBL 50	2003	Grain	15-16.00	Dark green seeds	Plains
	BRS 1	2003	Grain	16-18.00	Early maturing	Hills

					and high seed yield	
TUMBA	RMT 59 (Mansha Marudhara	2004	Seed/oil	2.38	High fruit and seed yield	Rajasthan and Gujarat
KANKODA	Indira Kankoda (RMF-37)	2006	Vegetable	15-20	High fruit yield	Chhatisgarh, Uttar Pradesh, Jharkhand, Orissa and Maharashtra
JATROPHA	Chhatrapati (SDAUJ-1)	2006	Oil	4.00 (Upto 3rd year)	High yield and oil percent	Gujarat, Orissa, Haryana and Maharashtra

Following agronomical practices have been recommended for economical cultivation and popularization of some of the important underutilized crops:

Amaranth:

- A dose of 100 kg N in hills and 60 kg N in plains results in higher grain yield of amaranth. Supplementation with FYM @ 5 t/ha further enhances the seed yield. Substitution of 25% N by FYM or Neem cake also enhances grain yield.
- In hills intercropping french bean and amaranth in 2:1 row ratio results in highest grain yield and gross income.
- In Tamil Nadu grain amaranth can profitably be intercropped by growing its one row in widely spaced (90 cm) pigeonpea. It gives B:C ratio of 1.89. As a pure crop also it gives higher yield than black gram. In this context TNAU and a private company has signed MOU for cultivation of amaranth at farmers fields.

Buckwheat:

- Pre-emergent application of alachlor @ 1.5 kg/ ha is effective to control weeds both in common and tatary buckwheats.

Rice bean:

- Pre-emergence application of pendimethelin gives almost similar results as that of weed free treatment
- In hills, intercropping rice bean with maize in 2:1 ratio resulted in highest rice bean equivalent yield, LER and B:C ratio.
- Rice bean out yielded green gram and black gram for seed production at all locations except S.K. Nagar. For fodder production rice bean performed better than cowpea at Ranichauri while cowpea gave better performance than rice bean at Bangalore.

- In peninsular India, growing pigeonpea and rice bean in 1: 2 row ratios resulted in highest rice bean equivalent yield , land equivalent ratio (1.34) and benefit cost ratio (2.10)

Jatropha

2 x 1 m spacing and a fertilizer dose of $N_{45}P_{30}K_{30}$ per ha resulted in highest seed yield

Paradise tree

Use of VAM culture @10g/poly bag helps to reduce nursery raising time from three months to one and a half month

All India Coordinated Sorghum Improvement Project

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

New varieties released during last five years

A) GRAIN SORGHUMS

Name of cultivar	Tested number	Notification Number	Year of release	Originating centre	Area of adaptation	Salient feature
Hybrids						
CSH 19R	SPH 1010R	821(E) dt.13.9.2000	2000	PDKV, Akola	All rabi sorghum growing areas of the country, suitable to medium to deep soils	Non tan, juicy stem, broad leaves, semi compact panicle, pearly white, slightly flat medium size seed
CSH 23	SPH 1290	SO1566(E) 05.11.2005	2005	NRCS	Kharif sorghum growing areas of AP, Gujarat, Karnataka, M.P. Maharashtra, Rajasthan and UP	Tan, Tall (180 cm), dull green midrib, medium bold, white seed. Early maturity (103 days) avoid terminal drought
Varieties						
CSV 216 (Phule Yashoda)	SPV 1359	821(E) dt. 13.09.2000	2000	MPKV Rahuri	Recommended for cultivation during rabi viz., AP, Gujarat,	Plants non-tan tpe, grains bold, slightly flat

					Karnataka, parts of MP, Maharashtra & TN	and creamy. Highly fertilizer responsive under deep soils/irrigated conditions
CSV 17	SPV 1489	Notification awaited	2002	MPUA&T Udaipur	All kharif sorghum growing areas of the country	Early maturing tan, dark green leaves, white dull midrib colour, moderately resistant to shootfly and stem borer.
CSV 18 (Parbhani Jyothi)	SPV 1595	Notification awaited	2005	Parbhani	Maharashtra, Karnataka, AP under irrigated conditions	Tall (227 cm), thin stem with non-senescence habit, dull midrib, Non lodging and aphid tolerant.

B) FORAGE SORGHUM

Name of cultivar	Tested number	Notification Number	Year of release	Originating centre	Area of adaptation	Salient feature
CSH 20 MF	UPMCH 1101	SO 1177(E) 25.8.2005	2005	Pantnagar	All forage sorghum growing areas of the country	Tan, dark green heavy foliage with green midrib. Medium thick juicy stem, resistant to foliar diseases

C) SWEET SORGHUM

Name of cultivar	Tested number	Notification Number	Year of release	Originating centre	Area of adaptation	Salient feature
CSH 19SS (Variety)	RSSV 9	SO 1177(E) 25.8.2005	2005	Rahuri	All sorghum growing of the country	Tan, purple coleoptiles, dull green midrib, pearly white medium seed, high green cane yield, juice yield and tolerant to shootfly.
CSH 22 SS(Hybrid)	NSSH 104	SO 1566(E) 05.11.2005	2005	NRCS	All sorghum growing of the country	Yellowish green stem has one visible long notch at bud initiation site. Good cane and juice yield. Moderately tolerant to shoot fly.

New technologies developed during last 5 years

- Technology of harvesting at Physiological maturity and artificial drying Application/Use: By harvesting at physiological maturity and artificial drying,farmers double the profit. If harvested and stored by conventional means, the produce gets deteriorated
- Description/Features of the technology developed: Crops from the fields in sorghum growing 4 districts were selected for harvesting. One- half of the crop was harvested at physiological maturity and artificially dried in order to prevent the grain deterioration; the other half was harvested at the normal maturity and sun-dried (farmers' practice). Market price was ascertained for the produce from both the treatments. Significant improvement in grain quality (grain deterioration score was reduced to 2.1 from 4.0) and also the market price of the produce (on an average 55% increase in market price) were observed by the use of this technology.

Description of the Equipment:

- Equipment: Low cost community drier (steel fabricated structure)
- Raw material: 5 tonnes sorghum crop/ batch for (3 hours/batch).
- Land: 50 x 40 x 20 feet
- Cost of instrument: 2 lakhs/drier.
- Man power: 2 labor / batch.

Commercialization status

- 3 numbers of such community driers are under fabrication, one number in each of the districts of Mahabubnagar, Parbhani and Dharwad.

All India Network Project on Jute and Allied Fibres

1. **Title of the Project** : **All India Network Project on Jute & Allied Fibres**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Variety released during 2002-2007 :

Crop	Variety	Developed at	Year of release	Remarks
Jute (*C. olitorius*)	JRO-128 (Surya)	CRIJAF	2002	Suitable for *olitorius* jute growing areas of India
Jute (*C. olitorius*)	S-19 (SUBALA)	CRIJAF	2004	Suitable for *olitorius* jute growing areas of India
Jute (*C. capsularis*)	JRC-80 (MITALI)	CRIJAF	2004	Suitable for *capsularis* jute growing areas of India
Hibiuscus cannabinus (kenaf)	MT-150 (NIRMAL)	CRIJAF	2005	Suitable for paper pulp production
Hibiuscus sabdariffa (roslle)	AMV-5 (DURGA)	ANGRAU A.P.	2005	Suitable for mesta growing states of India
Sunnhemp	SH-4 (SAILESH)	-do-	2005	Suitable for *sunnhemp* growing areas of India
Hibiuscus sabdariffa (roslle)	GR-27 (MADHURI)	CRIJAF	2006	Suitable for mesta growing states of India
C. olitorius (Jute)	JBO-2003-H (IRA)	CRIJAF	2007	Suitable for *olitorius* jute growing areas of India
C. olitorius (Jute)	JRO-204 (SUREN)	CRIJAF	2007	Suitable for *olitorius* jute growing areas of India
C. olitorius (Jute)	OJ-1 (Tarun)	Nagaon AAU, Assam	2007	Suitable for *olitorius* jute growing areas of India

- Jute – rice – potato/mustard/lentil were found to the higher yielding and remunerative cropping sequence under irrigated condition.
- Substitution of the recommended fertilizer dose with locally available organics like water hyacinth, *S. rostrata* compost or green manures of Dhaincha was possible upto 25% without affecting yield of jute and mesta (18.4 q/ha) and soil available nutrient status also improved.
- Pre-emergence application of Trifluralin @ 0.75-1.00 kg/ha or post-emergence application of Quizalophop ethyl (5% EC) @ 1.5-2.0 ml/l controlled grassy weeds significantly in olitorius jute and mesta.
- Intercropping jute with red amaranth / cowpea recorded significantly higher fibre yield of jute and also controlled the weed population successfully.

- Mid-June was found optimum sowing time for seed jute and topping at 45 DAS significantly increase seed yield.
- Soil application of *Trichoderma viride* thrice at 7, 15 and 30 DAS gave best control to *Macrophomina* diseases.
- Practice of IPM modules developed at CRIJAF recorded significantly higher yield and better pest control under different agro-climatic conditions.

All India Network Research Project on Tobacco

1. **Title of the Project** : **All India Network Research Project on Tobacco**

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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

New varieties released and used by the farmers during the last five years

Variety	Year of release	Cured leaf Yield (kg/ha)	Developed by	Area of adaptation	Remarks
FCV tobacco					
Kanthi (Cy 79)	2006	1600-2000	CTRI RS, Kandukur	SLS & SBS	Withstands moisture stress to certain extent
Hemadri (II-1624)	2006	2500	CTRI RS, Guntur	CBS and SBS	-
Siri (Cy 135)	2006	2900	CTRI, Rajahmundry	NBS, CBS and SBS	-
Bidi tobacco					
MR GTH 1	2005	3700	BTRS, Anand	Irrigated areas of Gujarat	Tolerant to root-knot, resistant to TMV; Contains high nicotine
NBD 43	2005	1742	ARS, Nipani	Karnataka	-* Yet to be released by Karnataka State
Chewing & *Rustica* tobacco					
Abirami	2006	4000	CTRI RS, Vedasandur	For Southern, Central and Western Zones of Tamil Nadu	Rich in solanesol

				except coastal belt	
Kaviri	2006	3130	CTRI RS, Vedasandur	Coastal belt of Vedaranyam and Chidambaram areas of T.N.	Good chewing score of 60.2 out of 80.0
Meenkshi (CR)	2007	3500	CTRI RS, Vedasandur	Inland chewing tobacco tract of Tamil Nadu under irrigated conditions	Resistant to caterpillar
Natu tobacco					
Gajapati	2004	1774	AINRPT, Berhampur	Pikka tobacco growing areas of Orissa	Moderately tolerant to frog-eye spot, black shank, TMV and leaf curl
Bhairavi (NG-73)	2006	2600	CTRI RS, Guntur	Suitable to Cigarette Natu areas of A.P.	-

Technologies developed and recommended to the farmers in the last five years

FCV tobacco: Andhra Pradesh state - Northern Black Soils

- Okra– FCV tobacco realized highest net returns among the tobacco based cropping systems evaluated in northern black soils of Andhra Pradesh and recommended to the farmers.
- Maize + soybean (1:1) during *kharif* and bengal gram in *rabi* recorded the highest net return among the non-tobacco based cropping systems evaluated in northern black soils of Andhra Pradesh and recommended to the farmers.
- Sorghum as a border crop with one spray of imidacloprid was effective in aphid management in FCV tobacco in northern black soil areas of Andhra Pradesh.

FCV tobacco: Andhra Pradesh state - Southern and Central Black Soils

- Agronomic practices for the newly released variety, Siri have been developed under SBS and CBS conditions and recommended to the farmers.

FCV tobacco: Andhra Pradesh state - Northern Light Soils

- Maize - FCV tobacco - groundnut sequence and maize – FCV tobacco –watermelon as relay crop sequence realized higher net returns among the tobacco based cropping systems evaluated in northern light soils of Andhra Pradesh.

FCV tobacco: Karnataka state - Karnataka Light Soils – Shimoga area

- Paired row of hybrid cotton + chilli + French bean (3 rows) was found more profitable among the non-tobacco based cropping systems evaluated at Shimoga in Karnataka.
- FCV tobacco – horse gram sequence gave highest net return among various tobacco based cropping systems evaluated at Shimoga in Karnataka.
- Application of Alachlor @ 0.75 kg a.i./ha two weeks before sowing followed by one hand weeding at 25 days after sowing is recommended for effective control of weeds in FCV tobacco nursery in Shimoga area of Karnataka.
- Application of 75% recommended N + 2.5 kg *Azotobacter* + 2.5 kg *Azospirillum* + 2.5 t FYM/ha to FCV tobacco is recommended for higher yields and net returns to the farmers of Shimoga region in Karnataka.
- Application of 30 kg P_2O_5/ha once in three years is recommended for FCV tobacco in Shimoga area of Karnataka light soils for soils testing high for P as against the earlier general recommendation of 60 kg P_2O_5/ha every year.
- Application of zinc sulphate @ 2 g/m^2 in tobacco nursery of light soil area of Karnataka enhanced the cured leaf yields of FCV tobacco.
- Significant improvement in seed yield, oil content and oil yield of chewing tobacco variety, A 145 was observed due to S application at Shimoga.
- *Campoletis chloridae* is the key mortality factor for lepidopterous pests in tobacco at Shimoga in Karnataka light soils.

FCV tobacco: Karnataka state - Karnataka Light Soils - Hunsur area

- Growing finger millet or castor in *rabi* season preceded by FCV tobacco in *kharif* was found to be more remunerative at Hunsur in Karnataka.
- The present recommendation of 120 kg K_2O/ha to FCV tobacco will continue under Mysore conditions in KLS as the K content of cured leaf and burn related K were not significantly increased due to application of potassium at higher doses of 140 & 180 kg K_2O /ha.
- Border crop of bajra with one spray of imidacloprid was effective in reducing aphid infestation in FCV tobacco in Karnataka light soil area and recommended for aphid management in Karnataka light soil area.