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Research Achievements of AICRPs on Horticulture

Indian Council of Agricultural Research
Directorate of Information & Publications of Agriculture
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All India Coordinated Research Project on Floriculture

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

1. ROSE

- A total of 780 accessions of varieties belonging to various classes of roses i.e. Hybrid Tea, Floribunda, Miniature and Climbing groups were collected and maintained at Delhi, Bhubaneswar, Ludhiana, Hessaraghatta, Ranchi, Pantnagar and Udaipur centers
- Rose cv. Pusa Gauvav' (developed by IARI, New Delhi) was found to be suitable for cut flower production under Bhubaneswar conditions.
- For loose flower production rose cvs. 'Neelambari' and 'Arunima' were found promising whereas 'Banjaran' proved to be the best for garden display under Bhubaneswar agroclimatic conditions.
- The exotic varieties of rose namely 'Skyline', 'Nobelesse' and 'Golden Gate' under Pune conditions performed better than the other exotic varieties.
- HT rose Pusa Gaurav and Floribunda rose Arunima have been found performing well at most of the centers.
- For commercial cultivation of rose, 400:200:200 ppm NPK/plant/week were recommended.
- Application of 300-400 ppm nitrogen, 200 ppm each of phosphorus and potash per week to the plants of rose cv. 'Montezuma' growing under protected conditions was found to be best with regard to number of flowers per plant (56.80) as well as size of flowers under Bhubaneswar conditions.
- Application of 400:200 ppm NPK in rose cv. 'First Red' growing under polyhouse recorded maximum plant height, number of flowers per plant (40.55) and stem length (80-50 cm).
- Pulsing the cut flowers of rose with aluminium sulphate (300 ppm) + sucrose (3%) followed by the treatment with a holding solution consisting of aluminium suplhate (300 ppm) and sucrose (1.5%) increased the postharvest life under Ludhiana, Pune and Lucknow conditions.
- For the control of powdery mildew disease of rose, spraying the plants with Difencanozole (0.05%), Hexaconozole (0.05%), Pencanozole (0.05%) or Tridemorph (0.05%) significantly controlled the disease under Pune agro-climatic conditions.
- Three applications of monocrotophos and phosphomidon effectively controlled the aphid population in roses at Pantnagar centre.
- Kavach (0.2 %) against *Botrytis* grey mould of rose is very promising.

2. GLADIOLUS

- In gladiolus, 637 accessions of varieties were maintained at Ludhiana, Yercaud, Srinagar, Hessaraghatta, Udaipur, Solan, Katrain, Hyderabad, Delhi, Kahikuchi, Lucknow, Ranchi, Pantnagar, Shillong and Kalimpong.
- In gladiolus, Arka Kesar, 87-22-1, hybrid 84-7-11, 86-3-4, 84-4-8, Swarnima and Shagun have been found performing better.
- Cut spikes of gladiolus treated with a solution consisting of sucrose (4%), aluminium suplhate (300 ppm) and sodium hypochloride (25 ppm), stored at 4^0C for 0 to 3 days and subjected to simulated transit for 48 hours either unwrapped or after wrapping with polyethylene or cellophane or polypropylene sleeves recorded the highest post-harvest life at Ludhiana (cv. 'Jacksonille Gold'), Pune (cv. Sancerre), Udaipur (cvs Sancerre, 'Punjab Dawn' and 'White Prosperity'), Srinagar (cvs 'White Prosperity' and 'Priscilla'), 'Pantnagar (cvs Nova Lux' and 'American Beauty'), Solan (cvs 'White Prosperity' and 'Trader's Horn') and Hyderabad (cvs. 'Trader's Horn', 'Yellow Frill' and Arun').
- $Al_2(SO_4)_3$ (300 ppm) + sucrose (4 %) + NaOCl (bleach solution, 25 ppm) for gladiolus were recommended as best solution.
- Application of Captaf (0.03%) significantly controlled the corm rot disease of gladiolus cvs 'Melody' and 'Sancerre' at Ludhiana and similarly, under Pune conditions, Captan (0.03%) was found very effective in controlling the disease.
- The bio-agent *Trichoderma harzianum* used for the treatment of corms controlled corm rot disease effectively at Pune and Kahikuchi centres.
- For the chemical control of *Fusarium* wilt disease of gladiolus, Benomyl (0.02%) at Pune, Carbendazim at Kahikuchi and Bangalore were found to be most effective fungicides.
- Spraying the gladiolus plants with Kavach (Chorothalonil) @ (0.02%) recorded lowest disease incidence with maximum disease control.
- Kavach (0.2 %) and Dithane M-45 (0.2 %) are highly promising against *Botrytis* grey mould of gladiolus.

3. CARNATION

- In carnation, 121 accessions were collected and maintained at Solan, Yercaud, Srinagar, Ludhiana, Katrain, Kalimpong and UAS Bangalore.
- Pinching of carnation cv. 'Impala' growing under protected conditions with pinch and a half method and foliar feeding of nitrogen (150 ppm) at fortnight interval enhanced plant height, flower size, stem length, number of flowers per plant and vase life under Solan like conditions of Himachal Pradesh.
- Carnation cvs Impala' 'Super Star', 'Veleta' and 'Fantasia' supplied with 4 hours extended lighting resulted in maximum flowering stem length and induced early flowering under polyhouse at Solan.
- In carnation, April planting with double pinching in Srinagar, in tuberose, March planting in West Bengal, March – April and Oct-Nov. at Vellanikkara and July-Aug. in and around Heyderabad is most suitable.
- In carnation 200 ppm N are recommended for commercial cultivation.

- $Al_2(SO_4)_3$ (300 ppm) + sucrose (10%) for 8h pulsing of carnation and STS (50 ppm) + 8-HQC (50 ppm) + sucrose (2 %) as holding solution in carnation have good promise.
- Application of Bordeaux mixture followed by a mixture of Benomyl + Captaf and Bavistin + Captaf showed promising results in controlloing the Fusarium wilt disease in carnation at Kalyani. Mancozeb (0.025%) and carbendazim (0.01%) significantly controlled the disease at Katrain.

3. CHRYSANTHEMUM

- In chrysanthemum, a total of 1115 accessions of varieties are maintained at Hessaraghatta, Ludhiana, Pune, Solan, Coimbatore, Bhubaneswar, Hyderabad, Udaipur, Lucknow, Srinagar, UAS Bangalore, Ranchi and Pantnagar centres.
- Newly developed varieties of chrysanthemum viz., 'Arka Ravi' (at Hessaraghatta, Solan, Udaipur and UAS Bangalore), 'Punjab Gold' (at Hessaraghatta and Pune), Mother Teresa' (at Hessaraghatta), 'CO.2' and Indira (at Coimbatore), 'Yellow Gold' (at Solan), 'Ratlam Selection' and 'Basanti Local' (at Hyderabad), 'Sonali Tara', 'Sunil' 'Baggi' and 'IIHR Hybrid-11 (at Pune) were found to be very promising.
- Baggi in chrysanthemum was recorded outstanding.
- Under Ludhiana conditions, the flowers can be produced in chrysanthemum cv. ' Punjab Anuradha' during May by maintaining the plants under natural short day conditions from December to February and artifical short days from March.
- Rooted cuttings of chrysanthemum cv. 'Sonali Tara' planted during April to June and given 15 hours short day treatment enhanced duration of flowering (28 days), maximum number of flowers per plant (65), size of flower (5-5.2 cm) and yield of flowers per plant (97.5 g) under Pune conditions.
- The plants of chrysanthemum cv. 'CO-1 subjected to the exposure of day light for 10 hours (14 hours shade treatment) and an extended period for 2 hours were found to be best in respect of vegetative growth and flower yield under Coimbatore conditions.
- Covering the plants of chrysanthemum with black polythene for 14 hours daily at night till 60-70 % buds show their colour induced early flowering in cvs 'Birbal Sahani' and 'Jubilee' by 21 days; 'Flirt' by 16 days; 'Sunil', 'Jayanti; and 'Vijay' by 14 days as compared to their natural blooming under Lucknow like agro-climatic conditions of Uttar Pradesh.
- In case of artifical long day conditions (16 h) provided the plants for 4 weeks daily, the blooming dates could be delayed by 49 days in cv. 'Sharad Bahar' and 24 days in 'Pin Gin' whereas artificial light (16 h) provided to the plants for 2 weeks daily, delayed blooming by 28 days in 'White Prolific', 21 days in 'Kundan' and 14 days in 'Flirt' as compared to the control plants growing in natural day length conditions of Lucknow.
- Citric acid (75 ppm) + $AgNO_3$ (25 ppm) as best holding solution in chrysanthemum, BA (50 ppm) or sucrose (10 %) or Triadimefon (20 ppm) as best pulsing treatment of orchid flowers and 8-HQC (200 ppm) + sucrose (6 %) $AgNO_3$ (25 ppm) + HQ (400 ppm) + sucrose (5%) as best holding solution for orchids.
- Among the different fungicides tested against the leaf spot disease of chrysanthemum, Cuman (0.02%) and Dithane M 45 (0.02%) economically controlled the disease under Ludhiana conditions.

- Pune centre has recommended that six sprays of Chlorothalonil @ 0.02% or Mancozeb (0.02%) at 15 days interval starting from the first spray immediately at the disease appearance, were effective in controlling the leaf spot disease of chrysanthemum

4. ORCHIDS

- The centres namely Vellanikkara, Yercaud, Kalyani, Bhubaneswar, Kahikuchi, Shillong, Kalimpong and UAS Bangalore collected and maintained 165 accessions of various genera, species and hybrids of orchids.
- Cocunut husk was found as the best suitable medium for *Dendrobium* cv. 'Sonia' at Kalyani.
- In D*endrobium* orchid Sonia – 17, NPK 20:30:30, 10:30:30 or 10:20:20 at 0.2 % spraying twice weekly were recommended for commercial cultivation.
- The foliar application of N:P:K (10:5:10) @ 0.2% and VAM applied near root zone at the time of planting resulted in best growth and flowering in *Epidendrum radicans* and *Coelogyne* species under Yercaud conditions.
- BA 100 ppm and GA_3 50 ppm in *Dendrobium* cv. Sonia 17 bring about good spike length.
- 75 % shadenet for *Dendrobium* cv. Sonia-17, 2 h extended light in chrysanthemum, and low-cost polyhouse for Srinagar for gerbera growing are best.
- 75 % shadenet for *Dendrobium* cv. Sonia-17, 2 h extended light in chrysanthemum, and low-cost polyhouse for Srinagar for gerbera growing are best.
- Tile bits + coconut fibre for *Dendrobium* and river sand + leaf mould + cocopeat medium for anthurium are recommended for better growth and development.

4. ANTHURIUM

- In anthurium, 206 varieties were collected, maintained and evaluated at Hessaraghatta Coimbatore, Yercaud, Kalimpong, Kahikuchi, Shillong, Kalyani and Vellanikkara.
- Spadix explant of anthurium could successfully be established after surface sterilization with mercuric chloride (0.1%) for 10 min., culturing on MS medium supplemented with 2,4-D (2 mg/l) and Kinetin(0.3 mg/l) was found optimum for obtaining orgarogenesis from the explant at Vellanikkara.
- Top cuttings, nodal cuttings and suckers of anthurium can be propagated successfully on 100% cocopeat under Hessaraghatta like conditions.
- The plants of anthurium provided with 80% and 75% shade performed better than other shade levels under Vellanikkara, Yercaud and Hessaraghatta conditions.
- For commercial cultivation of anthurium, 30:10:10 or 30:20:20 NPK at 0.2 % + GA_3 200 ppm + *Azospirillum* + VAM were recommended.
- Maximum vase life of 15.6 days was obtained when the spikes of anthurium were held for 24 hrs and 48 hrs by covering the base of spikes with cotton dipped in a solution having BA (50 ppm) + Bavistin (0.2%) as compared to those spikes which were covered with cotton dipped in another solution containing $AgNO_3$ (30 ppm) + sucrose (2%) for 24 hrs and 48 hrs over the other treatments.
- HQ (500 ppm) + sucrose (5 %) for 6h or BA (25 ppm) + carbendazim (0.2 %) for 24h or $Al_2(SO_4)_3$ (300 ppm) for pulsing of anthurium flowers and $AgNO_3$ (25 ppm) + sucrose (5%) or $Al_2(SO_4)_3$ (300 ppm) + kinetin (25 ppm) + sucrose (5%) as holding solution for anthurium flowers.

5. TUBEROSE

- In tuberose, more than 50 accessions were collected, maintained and evaluated at Hessaraghatta, Coimbatore, Kahikuchi, Kalyani, Hyderabad, Lucknow, Ludhiana, Pune, Delhi and Vellanikkara.
- In tuberose, Prajwal and Vaibhav had been recorded outstanding.
- In tuberose, 200:200:200 kg NPK/ha were recommended for commercial cultivation.
- In tuberose, citric acid (300 ppm) + sucrose (2%) at pH 3.6 had been the best pulsing treatments.
- For the control of *Sclerotium* wilt disease of tuberose, treatment of *Trichoderma viride* @ 20g/m2 followed by carbendazim (0.01%) + Captan (0.02%) were found to be effective at Pune. The applications of carbendazim (0.01 %) + Captan (0.02 %) and Basamid G (40g/m^2) significantly reduced the disease incidence under Kahikuchi conditions.
- Leaf blight disease of tuberose could be controlled effectively by spraying the plants with Iprodone (0.025%) followed by Difencanozole (0.05%) under Pune conditions.
- Bulb treatment with monocrotophos 36 EC proved to be the best treatment in controlling the nematode population in tuberose at Kalyani.

6. GERBERA

- A total of 286 accessions of gerbera were collected, maintained and evaluated at Shillong, Pune, Yercud, Hessaraghatta, Kahikuchi, Ranchi, Srinagar, Kalyani, Ludhiana and Vellanikkara.
- Gerbera cultivars grown under low cost polyhouse performed better than those grown under shadenet and open field conditions at Yercaud, Kalyani and Srinagar.
- In gerbera 20g P_2O_5 + 10g N/m^2 are recommended for commercial cultivation.
- $AgNO_3$ $(SO_4)_3$ @ 25 ppm was found to be the best for increasing vase life of cut gerbera varieties 'Thalasa' and 'Lyonella' as reported by IIHR, Bangalore.
- In gerbera, $Al_2(SO_4)_3$ (300 ppm) + sucrose (2 %) had been the best pulsing treatments.
- The leaf spot/blight disease of gerbera could be controlled by treating the plants with Benomyl (0.01%) followed by Kavach (0.02%) and difencanazole (0.05%) at Pune, whereas Benomyl (0.02%) was found to be more effective at Ludhiana. Spraying the gerbera plants with copper oxychloride (0.03%) followed by Mancozeb (0.02%) was found superior than other fungicides in reducing the leaf spot/blight disease in gerbera under Kahikuchi conditions.
- For the control of foot rot/root rot disease of gerbera, the treatment of plants with Benomyl (0.01 %) + Captan (0.02%) followed by Benomyl (0.01%) and *Trichoderma viride* (20 g/m2) was found to be very effective under Pune agro-climatic conditions.
- Foliar application of Difencanozole (0.05%) and Panchanozole(0.05%) controlled the disease effectively under Pune conditions.
- During 2004-05, four new crops were included. About five cultivars of tulip were collected, maintained and evaluated at Srinagar, Solan and Katrain. In daffodils, five cultivars were maintained at Katrain , Srinagar and Solan. 17 varieties of Lilium were collected, maintained and evaluated at Solan, Srinagar and Katrain. In alstroemeria, 15 varieties were maintained at four centres viz., Kalimpong, Srinagar, Katrain and Solan

All India Coordinated Research Project on Potato

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

New varieties

Six hybrids following multilocation testing under AICRP (Potato) were recommended for release as new potato varieties for different regions/purposes. Salient features of these hybrids under new varietal names are given below:

Hybrid	Variety name	Salient features	Areas of adaptability
JW-160	Kufri Pushkar (2003)	High yielding medium maturing hybrid having field resistance to late blight and excellent keeping quality	Plains and plateau regions of the country
MS/92-2105	Kufri Arun (2003)	A red skinned high yielding hybrid having field resistance to late blight	Indo-Gangetic plains
SM/87-185	Kufri Shailja (2003)	A late blight resistant hybrid having higher tuber dry matter and better keeping quality	Hilly regions of the country
HT/92-621	Kufri Surya (2005)	A heat tolerant hybrid suitable for early planting conditions and having high dry matter is also suitable for processing into French fries	Northern plains and warmer areas of the country.
MP/97-583	Kufri Chipsona-3 (2005)	Produces high yield, high tuber dry matter and excellent chip color. It produces more processable grade tubers and acceptable quality chips after storage at 10-12°C upto 180 days.	Indo-Gangetic plains, Kota and Indore region
SM/91-1515	Kufri Himalini (2005)	Better resistance to late blight than all available varieties, good tuber shape and no tuber cracking.	North western and north-eastern hills of the country.

Agro-techniques

Potato based intensive cropping systems

- Suitable varieties of rice, potato and wheat were identified for rice-potato-wheat cropping system in Punjab, Haryana, Uttar Pradesh and Bihar.

- Potato-groundnut-til was economically viable crop sequence in Gujarat.
- Paddy-potato-okra gave higher production and net returns in West Bengal and Orissa.
- Blackgram-potato-okra gave higher production and net returns in Assam.
- Potato-garlic in ratio of 1:1 in hills of J&K and Uttrakhand and in the ratio of 1:2 in Karnataka was found profitable.

Yield maximization

- Maximum tuber yields and net returns were obtained by fertilizing the crop with 275 kg N, 137.5 kg P_2O_5, 275 kg K_2O and 25 t/ha FYM in Gujarat (as against earlier recommended dose of 240 : 100 : 150 NPK).
- Maximum tuber yields and net returns were obtained by fertilizing the crop with 187.5 kg N, 125 kg P_2O_5, 125 kg K_2O and 25 t/ha FYM in Rajasthan (as against earlier recommended dose of 120 : 100 : 100 NPK).
- Similarly, doses of NPK need to be revised upwardly by 50% in the states of Punjab, Haryana, Bihar, Uttar Pradesh and Madhya Pradesh for maximizing potato yields and net returns.

Fertilizer economy

- In potato-onion-groundnut and potato-wheat-cowpea systems in Punjab, residue incorporation of each crop could economize on NPK by 50% in succeeding crops after potato.
- For economizing 25% N and P, it was recommended to soak tubers in a solution containing 1% each of urea and sodium bicarbonate along with seed treatment with Azatobacter + Phosphobacteria.

Seed research

- For maximizing the number of seed sized tubers (upto 50 g), crop should be planted at 60 x 10/15 cm spacing and fertilized with 150 kg N, 150 kg P_2O_5 and 80 kg K_2O/ha and haulms be cut at 80 days at most of the seed producing areas.

Management of diseases and insect pests

Eco-friendly management of diseases and insect pests

- Effective strains of bio-control agents viz., *Trichoderma viride* and *Bacillus subtilis* were submitted to IMTECH, Chandigarh for registration.
- Field use of *Bacillus cereus* and *B. subtilis* for control of bacterial wilt was recommended in Karnataka.
- *Trichoderma viride* was recommended for control of black scurf.
- Trap crops like marigold and castor were recommended for management of *Agrotis* sp., jassids, etc.
- Eco-friendly treatment (3% boric acid) of seed tubers was developed for the control of tuber borne fungal/bacterial diseases.

- Safer pesticides like imidacloprid identified for replacing methyl-demeton/ monocrotophos/ phorate for control of insect pests.

IPM schedules for potato diseases

Haryana	: Black scurf, viruses and sooty mould
Uttrakhand, Eastern Uttar Pradesh and Bihar	: Black scurf, late blight, viruses and common scab
West Bengal and Gujarat	: Late blight, early blight, common scab and viruses
Orissa and Assam	: Black scurf, viruses and bacterial wilt
Rajasthan	: Stem necrosis and black scurf
Madhya Pradesh	: Early blight, brown rot and viruses

IPM schedules for major insect pests

West Bengal	: Cut-worms, mole cricket and epilachna beetle
Punjab, Bihar & Gujarat	: Defoliating caterpillars and cut-worms
Haryana	: Leaf hoppers and mites

Transfer of technology activities:

CPRI/ AICRP training programmes (04); training programmes for farmers and extension workers (149); demonstrations on farmers' fields (101); Farmers' Days (91); Radio/ TV programmes (45).

All India Coordinated Research Project on Subtropical Fruits

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

Crops	Location	Variety	Features
Mango	IARI, New Delhi	Pusa Surya	Fruit medium to large, (234.7g), golden yellow with attractive red coloration on ventral shoulder, pulp firm, TSS (17.25^0 B), highly juicy, pleasantly flavored and shelf life excellent at room temperature (11-14 days) and suits long distance transport.
Mango	IARI, New Delhi	Pusa Arunima (Amrapali x Sensation)	Fruit medium to large, and have red peel colour and late maturity with good yield and quality and suitable for export.
Guava	CISH, Lucknow	Shweta	Medium size, globes fruits, pulp snow white with red blush, high TSS content (13.20^0 B) and vitamin `C' (300mg $100g^{-1}$ edible portion) with good keeping quality.

Technologies developed

Mango

- Mango cultivars Pusa Arunima and Pusa Surya released by IARI, New Delhi are recommended for commercial cultivation.
- Cv. Mallika is recommended for commercial cultivaation in south and east Indian region.
- Application of Paclobutrazol @ 3ml/m canopy diameter at 90-120 days before bud brust is recommended for increasing the yield and to control alternate bearing in mango cultivars.
- Heading back of crowded branches and centre opening with use of Paclobutrazol is over crowded mango orchard is recommended for commercial adoption.
- One spray of Imidacloprid (0.005%) is recommended for spraying at Panicle emergence stage to control mango hopper and other pests.
- Cultivar Dahiyar and Meghlantan were found resistant to malformation for several years and can be recommended for cultivation and use for breading programme.

- Cultivar Ellaichi is recommended as resistant donor for mango malformation while cultivars Neelgoa reported susceptible and its propagation may be discouraged in hot spot areas.
- Carbendazim (0.1%) can be recommended for the control of anthracnose of mango.

Guava

- Cultivar Chittidar is being recommended for cultivation in M.P. State.
- Double hedgerow system of planting is recommended for getting maximum yield and quality fruits.
- *Aspergillus niger* mixed in FYM and applied in root zone is recommended for control of diseases.

Litchi

- For control of fruit borer in litchi first spray should be given with endosulphon (0.07%) at red colour initiation stage followed by Azadiractin 1500ppm (0.2%) spray after 10 days of first spray.
- Double hedgerow system of planting is recommended for getting maximum yield and quality fruits.

All India Coordinated Research Project on Tuber Crops

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

3.1 Recommended Varieties

Sl.No.	Crop/variety identified	Centres responsible	State for release
Cassava			
1	Sree Prakash	ANGRAU, Rajendranagar	AP
2	Sree Jaya	ANGRAU, Rajendranagar	AP
3	Sree Vijaya	AAU, Jorhat	Assam
Taro			
4	Ahina Kachu	AAU, Jorhat	Assam
5	Bhavpuri(KCS-2)	ANGRAU, Rajendranagar	AP
6	RNArvi-1	ANGRAU, Rajendranagar	AP
7	Narendra Arvi - 3	NDUAT , Faizabad	UP
8	BKCol-2 (Indira arvi-1)	AAU, Jorhat, IGAU, Raipur	Assam, Chhattisgarh
9	Sonajuli	CTCRI, RC, Bhubaneswar	Orissa
10	Jhankri	CTCRI, RC , Bhubaneswar	Orissa
11	Birsa Arvi-1	BAU, Ranchi	Jharkhand
12	Sree Kiran	CTCRI, TVM	Kerala
Bunda			
13	Narendra Bunda-3	NDUAT, Faizabad	UP
14	Narendra Bunda-4	NDUAT, Faizabad	UP
Elephant foot yam			
15	Narendra Asha	NDUAT, Faizabad	UP
Sweet Potato			
16	Indira Naveen(IGSP-4)	BSKKV, Dapoli ;	Maharashtra,

	(short duration)	IGAU, Raipur	Chhattisgarh
17	Indira Nandhini(IGSP-17)	IGAU, Raipur	Chattisgarh
18	RNSakharkand-3	ANGRAU, Rajendranagar	AP
19	NDSP-10	NDUAT, Faizabad	UP
20	Sree Arun(RS-III-3)	CTCRI,TVM	Kerala
21	Sree Varun (56-2)	CTCRI,TVM	Kerala
22	Sree Kanaka	CTCRI,TVM	Kerala
23	Indira Madhur	IGAU, Raipur	Chattisgarh
24	Bidhan Jagannath	BCKV, Kalyani	West Bengal
25	Birsa Sakharkand-1	BAU, Ranchi	Jharkhand
Yams			
26	Sree Karthika	CTCRI, Thiruvananthapuram	Kerala
27	Orissa elite	CTCRI, RC, Bhubaneswar	Orissa

3.2 Significant Research Achievements :

3.2.A. Genetic resources of Root and Tuber Crops

- A total of 4350 accessions were being maintained at various centres apart from CTCRI. The centre at Dholi maintained the largest collection (1489 accessions) followed by Coimbatore, Jagdalpur, Kalyani and Rajendranagar. There were about 24 species of tuber crops in the collection. There was an increase of 286 accessions compared to 2002-2003 where in a total of 4069accessions was reported. Maximum collections were in sweet potato followed by *Colocasia,* cassava, yam bean and yams. At Yethapur 363 accessions of cassava were maintained and evaluated. The evaluation of entries for starch content revealed that 67 accessions recorded more than 25 per cent starch content.
- At Jorhat twelve accessions of greater yam were characterized and catalogued. 113 collections of Dioscorea were made from 30 blocks of Chattisgarh state including Bastar and Dandiwada districts.
- At Kovvur, the germplasm of *Colocasia* was maintained in three groups *viz.,* short duration (less than 6 months), medium duration (6 months to 7 months), long duration (7 months and above) and was evaluated for the various morphological characters and yield. Plant height, number of tillers, number of leaves, single plant yield in number as well as by weight and cormel yield per hectare of short, medium and long duration germplasm entries were recorded. A total of 92 germplasm was characterised and classified morphologically. Among the 28 short duration entries , CA 7, CA 18 and CA 44 had recorded the maximum cormel yield of 37.0 t ha^{-1} . Among the 34 medium duration entries, CA 42 recorded maximum yield of 48.8 t ha^{-1} followed by CA 57 (34.4 t ha^{-1}). Out of 30 long duration entries KCS 2 recorded maximum yield of 48.5 t ha^{-1} followed by Panchamukhi (45.9 t ha^{-1}).
- Among the elephant foot yam accessions maintained at Kovvur, 20 non-irritant types and 12 irritant types were evaluated along with a local for their yield and other characters like plant height, pseudostem girth, leaf canopy spread, single tuber weight and yield per hectare. Among the non irritant types , AC- 25 recorded a maximum yield of 81.40 t ha^{-1} followed by accession AC- 3 (80.48 t ha^{-1}), AC-6 and AC-26 (77.70 t ha^{-1} each). Among the irritant types AC - 36 had recorded maximum yield of 48.10 t ha^{-1} followed by NDA- 4 (43.00 t ha^{-1}).

3.2.B Recommended Production Technologies:Crop- wise

Cassava

- A spacing of 90x90cm and 100:50:100 kg ha^{-1} of NPK gave maximum tuber yield in cassava at Navasari
- Half the recommended dose of P_2O_5 with full dose N and K and FYM(12.5 t ha^{-1}) along with combined application AM Fungi and Phosphobacteria(10kg ha^{-1}) recorded 28.03 t ha^{-1} cassava tuber and it was comparable to that of recommended dose of NPK and FYM both at Yethapur, Salem of Tamil Nadu and at Peddapuram of Andhra Pradesh.

Sweet potato

- In Kalyani, Dholi, Jorhat and Thiruvananthapuram, the experiment on biofertilizers in sweet potato revealed that application of $1/3^{rd}$ or $2/3^{rd}$ recommended N (60 kg N ha^{-1}) + 2 kg *Azospirillum* ha^{-1} as vine dipping + 10 kg *Azospirillum* ha^{-1} as soil application increased the marketable tuber yield as well as dry matter of tuber.
- At Faizabad 30:40:60 NPK kg ha^{-1} with 30 kg N by vermicompost and 45:40:60 NPK kg ha^{-1} with 15 kg N by vermicompost gave maximum tuber yield
- In an on farm trial of sweet potato based cropping system at Jagdalpur at four locations revealed that the treatment cowpea – sweet potato was found ideal sequence which produced 24.00 t ha^{-1} tuber yield of sweet potato and 5.73 t ha^{-1} green pod yield of cowpea. Sweet potato based cropping system research indicated that the vegetable cowpea and sweet potato gave maximum net return both at Faizabad and at Dapoli.

Colocasia

- Twenty to thirty grams of the seed size was found ideal yielding the maximum at all levels of nitrogen except the lower dose of 80 kg ha^{-1} in Colocasia (bunda)in Faizabad.
- Half the recommended doze of P_2O_5 (30 kg) and full dose of N and K (120:120 kg ha^{-1})with FYM (15 t ha^{-1}) and AM fungi (10 kg ha^{-1}) with or without Phosphobacteria(10 kg ha^{-1})at Rajendranagar gave maximum cormel yield (17.75 t ha^{-1}) in taro.

Colocasia –swamp taro

- Application of Mahua cake (50kg N)+225 kg ha^{-1}N produced significantly higher stolon production of 20.86 t ha^{-1} in swamp taro in Kalyani .

Elephant foot yam

- Vegetable cowpea + Elephant foot yam cropping system was found profitable in Faizabad , Jorhat, Coimbatore and Kalyani

- Application of karanj cake @500g plant -1 was found equally effective as that of 80:40:80 kg NPK ha-1 in producing maximum corm yield at Ranchi
- The fertilizer dose for intercropped EFY in coconut gardens was found to be optimum for maximum yield at 80:60:100 kg NPK ha-1 at Port Blair
- In Elephant foot yam application of 125:60:100 kg NPK ha-1 with 50 kg N by FYM or vermicompost gave maximum corm yield (50.87 and 45.92 t ha-1 respectively) at Faizabad. Vermicompost application was found to enhance the corm yield at Faizabad as well as at Kalyani.
- A fertilizer dose of 120:60:60 kg NPK t ha-1 with 5 kg FYM per pit of elephant foot yam gave maximum corm yield (35.8 t ha-1) at Ranchi
- At Navasari 150:60:150 kg NPK ha-1 applied half as basal and the half at 60 DAP resulted in maximum corm yield (32.4 t ha-1).
- At Navasari 75 x 50 cm spacing and seed tuber size of one kg gave maximum yield (68 to 96 t ha-1) when planted during early March.
- At Faizabad 60 x 45 or 60 x 30 cm spacing and 175 or 200 g seed tuber size were found to be optimum for elephant foot yam cultivation.
- In the trial on intercropping tuber crops in orchards, elephant foot yam was identified as an ideal intercrop in litchi orchards at Dholi. In mango orchards of Raipur, arrowroot performed well with higher tuber yield. Sweet potato was found to be a good intercrop in cashew plantation at Dapoli.

3.2.C. Recommended /Validated Protection Technologies

- In Cassava,MNga-1 showed no incidence of mosaic at Yethapur, Salem, Tamil Nadu where as the disease prevalence was 21-56% in other varieties.
- IPM package against SP weevil revealed superiority over control and chemical treatments in Coimbatore, Rajendranagar, Faizabad, Dapoli, Dholi, Ranchi and Kalyani. The IPM package with mass trapping (using BARC sex pheromone)component against SPW was found effective in reducing the weevil damage on tubers and at the same time increased the marketable tubers at Kalyani, Dholi and Coimbatore. On farm trials also gave the same result
- IDM against taro leaf blight conducted at Dapoli, Rajendranagar, Dholi and Kalyani revealed that the IDM package was effective in containing the leaf blight and enhancing the cormel yield in all the centres.
- In the screening of taro for leaf blight resistance, Kadma local had less susceptibility to leaf blight (3.41% PDI) at Ranchi. Muktakeshi showed high degree of resistance of the disease at Dholi, Rajendranagar and Kalyani; while it was RCM-4-11 at Dapoli. RNCA-1 at Rajendranagar and BCC-1 at Kalyani were also found to have leaf blight tolerance with high yield .
- In EFY cultivation straw mulching the crop was found to be effective in the weed management with enhanced corm yield at Kalyani, Thiruvananthapuram and Rajendranagar. At Dholi sesame leaf mulching or black polythene mulching was effective.
- In Elephant foot yam, the trial on management of diseases on elephant foot yam showed that the hexaconazole + mancozeb spray contained the disease incidence and enhanced the corm yield both at Kalyani and Rajendranagar. Trichoderma and Pseudomonas fluorescence were found to be effective in containing the disease and it could be compared to the synthetic fungicides.

- Snails were a menace on tuber crops at Dapoli, Maharashtra. Yam bean as a border crop to elephant foot yam reduced the snail damage on the crop. Spraying of 5% yam bean seed and soap nut seed extracts were effective in checking the snail population. Waste leaves of cauliflower acted as a trap by luring them.

3.2.D. Seed tuber/planting material Distribution

- Cassava stems 33,000,sweet potato vines 25,000,elephant foot yam 15tonnes,taroand bunda 4 tonnes, yams 2 tonnes and yambean seeds 500kg were distributed to progressive farmers /NGOs and SAUs etc

3.2.E. Extension Activities

Dapoli

- Tuber samples were displayed and the information on cultivation practices and varieties were disseminated to about 1250 farmers and 100 College and school students. In the exhibition organized by the University , the AICRPTC centre displayed tuber crops specimens along with the information.
- Krishi Vigyan Kendra, Baramati organized a visit to cassava cultivation at Kini Vathar, Tal. Hatkangale, Dist. Kolhapur. The Asst. Horticulturist of the AIRCPTC appraised the farmer's group and the Krishi Sevak, Wakawali regarding tuber crop cultivation, under programme organized by the Sub Divisional Agriculture Officer, Dapoli. Dr. P.V. Salvi, Dr. S.B. Kadrekar, Former Vice Chancellors, Dr B.S. Konkan Krishi Vidyapeeth, Dapoli, Mr. M.K. Moghe and S.P. Pakhre, Horticulturists, Indian Petro Chemicals, Nagothane, Raigud Dist., Mr. Ashok Lokhande, Superintendent Agriculture Officer, Thane and Mr. Satpal Singh, D.I.G. Konkan Division, Navi, Mumbai visited the tuber crops centre to know the tuber crops and their technologies.
- Radio/T.V talks were made on different tuber crops and their pests/diseases `1by the Scientists of the centre to popularize tuber crops.

Dholi

- The Scientists of AICRP(TC) participated in three Kisan Melas at Headquarter, Research Centre and KVK's during 2004-05 and 2005-06. The live specimens of high yielding varieties of sweet potato, yambean, *Colocasia*, elephant foot yam, cassava and *Dioscorea* were exhibited. Leaflets/folders describing details about production and protection technologies were distributed to the farmers. The Scientists also participated in Kisan Gosthi and replied the questions of the farmers related to tuber crops and delivered two separate sessions on cultivation of yam bean and improved package of practices of taro through Doordarshan Kendra, Patna.

Ranchi

- Varieties of tuber crops viz. elephant foot yam, sweet potato, cassava, *colocasia* (Arvi & Bunda) were exhibited in Agrotech Kisan Mela and Horticultural show organized at Birsa Agricultural University campus, Ranchi. Improved technologies in tuber crop cultivation were demonstrated through charts, posters and photographs. Large number of farmers from the different districts of Jharkhand visited the stall. TV/Radio talks, Phone-in programme on tuber crops etc. were made by different Scientists to popularize tuber crops.

Kalyani

- One day farmers' Training on Tuber Crops was organized on 18th March 2005. A folder in Bengali (Regional language) on agrotechniques and crop protection of important tuber crops in West Bengal was released during the Farmers' Training. Other extension and social activities including distribution /selling of planting materials to the progressive farmers have been going on. Two training programmes were organised in Howrah district on taro, EFY cultivation and sweet potato vine production. Udainarayanpur was identified as a very potential zone for taro cultivation. Agricultural fair was held in Howrah district from 15th to 17th December 05 and Kalyani Centre actively participated in the programme and arranged interaction with farmers. All the materials were exhibited and farmers expressed high interest in EFY seed corm production. The cultivars also have been provided to 'Ashalaya' Don Bosco, Nadia. The Tuber Crops Kalyani Centre opened a display stall of the produce in Eastern Zone Agricultural Fair organised by BCKV during 30th January to 2nd February 2006.The seed corm of Bidhan Kusum (BCA-1) was distributed to KVK, Ramkrishna Ashram, Nimpith, W.B., and others for wide coverage of EFY.

Jorhat

- Radio talk on "Improved cultivation practices on *Colocasia* and greater yam" in Assamese broadcasted by AIR, Dibrugarh (Assam), on 19th December, 2004 and participated in phone-in-line Programme, AIR, Dibrugrah, Assam, on 18th August, 2004. were made by the Scientists of the centre to popularize tuber crops.

Faizabad

- AICRPTC, Faizabad arranged a tuber crops exhibition stall in the Gauri Ganj Kisan Mela in 2005 and Sri. Rahul Gandhi, Honourable Member of Parliament visited .A group of Journalist trainees from Lucknow visited the AICRPTC centre at Faizabad.

Coimbatore

- Thirteen farmers'meetings were conducted at Yethapur in Salem of Tamilnadu in which a total of 2153 farmers participated. Three farmers' day were conducted at TCRS, Yethapur, Thammapatti, Ayothiapattinam in which a total of 1037 farmers participated. AIR messages were broadcasted weekly. Newsletters were published monthly and Zonal workshops were

conducted monthly. In addition to these, Scientists imparted trainings to KVK farmers on tuber crops cultivation and information on tuber crops cultivation was disseminated through Kissan call centre.

Rajendranagar

- Fifty training programmes on the latest technology of tuber crops were imparted to the officers of Dept of Agriculture and Horticulture and 25 training programmes to farmers. Ten press notes were released on package of practices of tuber crops. Fourteen radio talks and 12 TV programmes were broadcasted on package of practices of tuber crops. The Scientists participated in 9 Kisan Melas. Three leaflets were published in Telugu. Farmers from Maharashtra, Orissa and different parts of AP visited the Centre.

3.2.F. Group meeting and farmers' day

- The sixth group meeting of the project was held at the College of Agriculture and Research Station (IGAU),Jagdalpur during 3-5 Oct 2001. The entries RS-III-3 and 56-2 were recommended for release in Kerala based on its performance. A farmers day was also organized on the 5th Oct,2001 along with group meeting.
- The VII group meeting of AICRPTC was held during 24-25 May, 2004 at the Central Tuber Crops Research Institute, Thiruvananthapuram. Four sweet potato entries *viz.,* 90/704 form Ranchi, 90/101 from Kalyani, IB-90-15-9 from Raipur and NDSP-10 from Faizabad ; four taro entries *viz.,* Kadma local from Ranchi, BCC-1 from Kalyani, Ahina Katchu from Jorhat and BK Col-2 from Raipur were recommended for release in their respective states. *Colocasia* varieties Sree Kripa and Sree Kiran, sweet potato variety Sree Kanaka and yam varieties Sree Karthika and 'Orissa elite' all from CTCRI were recommended for release in Kerala except the last one which was meant for Orissa state.
- The VIII biennial Group meeting was held at Narendra Dev University of Agriculture and Technology (NDUAT), Kumarganj, Faizabad during 4th - 6th May, 2006. Cassava varieties Sree Jaya and Sree Prakash were recommended for release in Andhra Pradesh and Sree Vijaya was released for Assam and Jharkand. Sweet potato varieties IGSP-4 was recommended for release in Konkan region of Maharashtra and Chattisgarh. And IGSP-17 was recommended for Chattisgarh. Colocasia (Arvi) varieties RNCA -1 was recommended for Andhra Pradesh, PKS-1 for Uttar Pradesh, BK Col-2 for Jorhat and Sonanjuli and Jhankri for Orissa. Colocasia bunda varieties NDB-3 and NDB-21 was recommended for release in Uttar Pradesh. Elephant foot yam variety NDA-9 was recommended for Uttar Pradesh.
- The IX biennial group meeting of AICRPTC was held during 21-23 December, 2007 at Navsari Agricultural University, Navsari. Nine varieties were recommended for seven states.

All India Coordinated Research Project on Vegetable Crops

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

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

New varieties/hybrids developed

TOMATO

Open pollinated

S.No.	Variety	. Remark	Developing centre	Recommended zone	Year of identification
1.	BT-116-3-2	Det.	QUAT	V, VI	2001
2.	NDT-3	Det.	NDUA&T	IV, VII	2001
3.	KS-118	Det.		IV	2001
4.	DVRT-2	Det.	IIVR	VI	2001
5.	BT-20-2-1	Indet.	QUAT	IV, VII	2001
6.	NDT-9	Indet.	NDUA&T	IV	2001
7.	NDTS-2001-3	Det	NDUA&T, Faizabad	IV	2004
8.	Mani Laima	Det	ICAR Res Com.for NEH Barapani	III	. 2004
9.	IIVR Sel-l	Det.	IIVR	V, VII	2005
10.	IIVR Sel-2	Indet	IIVR	IV	2005
11.	BT-136		Bhubaneswar	II,IV	2005
12.	VLT-32	VPKAS, Almora		IV	2005

Hybrid

S.No.	Hybrid	Growth habit	Developing centre	Recommended zone	Year of identification
1.	BSS-20	Indet.	Beejo Sheetal	All	2001
2.	DTH-8	Det.	IARI	IV	2001
3.	CHTH-l	Det.	IARI	IV	2001
4.	ARTH-128	Indet.	Ankur	VII	2001
5.	KTH-2	Indet.	CSAUAT	IV, V	2002
6.	JKTH-3055	Determinate	J.K. Seeds	I, IV	2004
7.	KTH-l		CSAUAT	IV	2004
8.	Nun-7730	Indeterminate	NunHems	I, IV	2004
9.	TH01462	Determinate	Syngenta	I, II, IV, VI,VII	2005

Resistant

S.No	Variety	Resistant against	Developing centre	Recommended zone	Year of identification
1.	LE-415	Bacterial wilt	KAU,	I, V, VIII	2004
2.	H86	TLCV	IIVR	I,IV,V,VIII	2005

BRINJAL

Open pollinated

S.No	Variety	Fruiting type	Developing centre	Recommended zone	Year of identification
1.	PunjabSadabahar	Long	PAU	IVVI	2001
2.	NDB-28-2	Long	NDUA&T	IV	2001
3.	DBL-21	Long	IARI, New Delhi	IV	2004
4.	KS-235	Round	CSAUA&T,	IVVVII	2004
5.	ABSR-2	SmallLong	GAUAnand	VII	2004
6.	HABR-4	Round	HARPRanchi	IV	2005
7.	IVBR-1	Round	IIVR	IV	2005
8.	HABL-1	Long	HARPRanchi	I	2006
9.	PB-66	Long	GBPUA&TPantnagar,	VII,IV	2007

Hybrid

S.No.	Hybrid	Fruiting type	Developing centre	Recommended zone	Year of identification
1	ARBH-541	Long	Ankur Seeds	All	2001
2.	PBH-6	Long	Pandey Beej	All	2001
3.	JBH-l	Round	Junagadh	All	2001
4.	BH-l	Round	Ludhiana	IV	2001
5.	BH-2	Round	PAU,Ludhiana,	IV,V	2002
6.	VRBHR-I	Round	IIVR,Varanasi	IV,VI	2002
7.	IVBHL-54	Long fruited	IIVR	IV	2004
8.	ARBH-786	Long fruited	Ankurseeds	IV	2004
9.	VNR-51	Small round	VNR,Seed	IV,VI	2005
10	Navina	Long	VNRSeeds	IV	2007
11	HABH-17	Round	HARP,Ranchi	IV	2007

Resistant

S. No	Variety	Developing centre	Recommended zone	Year of identification
1	CHES-309	HARP	I,VII	2001
2	BB-64	QUAT	IV,V,VII,VIII	2004

CHILLI & CAPSICUM

Open pollinated

S. No	Variety	Developing centre	Recommended zone	Year of identification
1	AKC-86-39	Akola	VII	2001
2	BC-14-2	QUA&T	V,VI	2001
3	RHRC-ClusterErect	MPKV	VII	2001
4	PMR-57/88-K	IIHR	VII	2002
5	LCA334	LAM	III,IV,V,VII	2002
6.	ASC-2000-02	GAU,Anand	VII	2004
7	KA-2	IIVR	IV	2005
8	LCA-353	RARS,Lam	V,VIII,IV	2007
9.	BC-25	OUA&T,Bhubaneshwar	VI,VII,V	2007

Hybrid

S. No.	Vegetable	Hybrid	Developing centre	Recommended zone	Year of identification
1	Capsicum	Lario	Syngenta	I	2001
2.	Chilli	ARCH-228	AnkurSeeds	IV,V,VI	2002
3	Capsicum	DARL-202	DARL	I,IV	2002
4.	Chilli	CCH-2	IIVR	II,IV,V,VI	2005
5	Sweetpepper	KTCPH-3	Katrain	I,VI,VII	2005

GARDEN PEA

Open pollinated

S. No.	Variety	Maturity group	Developing centre	Recommended zone	Year of identification
1	VRP-2	EarlySeason	IIVR	VI	2001
2	NDVP-12	EarlySeason	NDUA&T	IV	2001
3	VRP-3	MidSeason	IIVR	I	2001
4.	OrganPodded	EdiblePodded	PAU	VI	2001
5.	VRP-5	Early	IIVR	I,IV,VIII	2005
6	CHP-2	Midseason	HARP,Ranchi	IV,VI	2005
7.	VP-101	(Early)	VPKAS,Almora	IV,I	2007
8.	PC-531	(Mid)	PAU,Ludhiana	VI,VII,I	2007

Resistant variety

S. No.	Variety	Developing centre	Recommended zone	Year of identification
1.	DPP-68	Palampur		2001
2.	KS-245	CSAUA&T		2001
3.	NDVP-250	Faizabad	V	2001
4.	DPP-9411	HPKV	I	2002
5.	KTP-8	Katrain	I,IV,V	2005

COWPEA

Open pollinated

S. No.	Variety	Developing centre	Recommended zone	Year of identification
1.	NDCP-13	NDUAT,Faizabad	II,III,IV,VII	2002
2.	IVRCP-I	IIVR	IV	2004
3.	CHCP-2	HARP, Ranchi	VIII	2005
4.	IIVRCP-4	IIVR,Varanasi	IV,V,VII	2007

FRENCH BEAN

Open pollinated

SNo.	Variety	Developing centre	Recommended zone	Year of identification
1.	CH-812	CHES	VII,III	2001
2.	CH-819	CHES	I	2001
3.	IVFB-I	IIVR	I,VII	2005

DOLICHOS BEAN

Open pollinated

Sr No	Variety	Developingcentre	Recommendedzone	Yearofidentification
1	CHDB-1	HARP	IV	2004

OKRA.

Hybrid

SrNo	Variety	Developingcentre	Recommendedzone	Yearofidentification
1	1DVR-3	I1VR	All	2001
2.	DVR-4	I1VR	IV,V,VII	2001
3.	HBH-142	HAU	IV,V,VII	2005
4.	SOH-152	Syngenta	IV,VII,VII	2005
5.	SOH-10I6	Syngenta	IV,VII	2007
6.	NBH-180	NuziVedu	VII	2007

Resistant

S. No.	Resistant/tolerant Variety	Developing centre	Recommended Zone	Year of identification
1	VRO-3	IIVR		2001
2.	VRO-4	IIVR	IV,V	2001
3.	VRO-5	I1VR	VI	2002
4.	VRO-6	IIVR	IV,V	2002
5.	NDO-10	Faizabad	IV	2005
6.	HRB-107-4	Hisar	VI,VIII	2005
7.	I1VR-11	IIVR	VI,VII	2005
8.	JNDOL-03-I	Junagarh	VII,VIII	2007

ONION

Open pollinated

S. No	Name of variety	Remark	Developing centre	Recommended Zone	Year of identification
I.	L-28	Rabiseason	NHRDF,Nashik	IV,VII	2006
2.	HOS-1	Rabiseason	HAU,Hisar,	VI	2006
3.	B-780-5-2-2		NRCO&G	VI	2007

GARLIC

Open pollinated

S. No	Variety	Developing centre	Recommended Zone	Year of identification
1.	VLG-7	Almora	I	2001
2.	DARL-52	DARL,Pithoragarh,	I	2002
3.	G-323	NHRDF,Nasik	VI	2002

CAULIFLOWER

Open pollinated variety

S. No.	Variety	Maturity group	Developing centre	Recommended zone	Year of identification
1.	KT-25	Snowballgroup	IARI,(Katrain)	I	2001
2.	IVREC-2	Early	IIVR	IV	2005

Hybrid

Sno	Hybrid	Maturity	Developing centre	Recommendedzones	Yearofidentification
1.	DCH-541	IARI		II,IV	2002
2.	SYCFH-202	Earlygroup	Syngenta	IV,VII	2004
3.	SummerKing	Earlygroup	Sungro	I,IV	2004
4.	SYCFH-203	Earlygroup	Syngenta	IV,V,VII	2005

CABBAGE

Hybrid

Sno	Hybrid	Developing centre	Recommended zones	Year of identification
1	KGMR-l	Katrain	I,IV	2005

CARROT

Open pollinated

Sno	Hybrid	Developingcentre	Recommended zones	Yearofidentification
1.	SKAUC-50	SKUA&T,Srinagar	I	2006

MUSKMELON

Open pollinated

Sno	Hybrid	Developingcentre	Recommendedzones	Yearofidentification
1	NDM-15	NDUAT,Faizabad	IV	2002
2.	IVMM-3	IIVR, Varanasi	IV	2006

Hybrid

SNo.	Variety	Developingcentre	Source	Yearofidentification
1.	MHY-5	Durgapura	VII	2001

Resistant

Sno	Variety	Developingcentre	Source	Yearofidentification
1.	DMDR-l	IARI	CGMV	2001
2.	DMDR-l	IARI	CGMV	2001
3.	DMDR-2	IARI	Downy mildew+CGMV	2001

BITTER GOURD

Open pollinated

Sno	Variety	Developing centre	Recommended zones	Year of identification
1	PBIG-l	GBPU&T	IV	2001

Hybrid

Sno	Variety	Developing centre	Recommendedzones	Yearofidentification
1.	PusaHybrid-2	IARI	IV,V,VI	2002
2	NBGH-167	Nirmal Seeds	IV	2004

PUMPKIN

Open Pollinated

SNo.	Variety	Developing centre	Recommended zone	Yearofidentification
1.	CM-350	KAU	VII, VIII	2001
2.	NDPK-24	NDUA&T	IV,VI	2001

CUCUMBER

Open Pollinated

SNo.	Variety	Developing centre	Recommended zone	Year of identification
1.	CHC-2	HAFRP	IV	2001
2.	CH-20	HAFRP	IV	2001
3.	PCUC-28	Pantnagar	I,VII,VIII	2001

Hybrid

SNo.	Variety	Developing centre	Recommended zone	Year of identification
1.	PCUCH-I	GBPU&T	All	2001
2.	HybridNo1	Century Seeds	I,IV,VII	2004
3.	PCUCH-3	GBPU&T	I,IV	2005

RIDGE GOURD

Open Pollinated

SNo.	Variety	Developing centre	Recommended zone	Year of identification
1.	CHRG-I	CHES	IV	2001
2.	PRG-7	GBPU&T	VII	2001
3.	IIHR-7	IIHR	VIII	2001

BOTTLE GOURD

Open Pollinated

SNo.	Variety	Developingcentre	Recommendedzone	Yearofidentification
1.	OBOG-61	GBPU&T	IV,VI	2001
2.	NDBG-I04	Faizabad	IV	2002
3.	NDBG-132	Faizabad	VI	2004

Hybrid

SNo.	Variety	Developingcentre	Recommendedzone	Yearofidentification
1.	PBOG-2	GBPU&T	VII	2001
2.	PBOG-I	GBPU&T		2001
3.	NDBH-4	NDUA&T	All	2001

SPONGE GOURD-Open Pollinated

SNo.	Variety	Developingcentre	Recommendedzone	Yearofidentification
1.	CHSG-I	HARP,Ranchi	IV	2005
2.	JSGL	GAU,Junagarh	VII	2005
3.	KSG-14	CSAUA&T,Kanpur	IV	2006
4.	PSG-40	GBPUA&T,Pantnagar	VII,I	2007

ASHGOURD-open pollinated

SNo.	Variety	Developing centre	Recommended zone	Year of identification
1.	IVAG-90	IIVR,Varanasi,	IV,VIII	2006
2.	PAG-72	GBPUA&T,Pantnagar	VIII	2006
3.	Pusa Ujwal	IARI,NewDelhi	VIII	2007

Production technologies developed:

Recommendations for 2002-03

Use of biofertilizers

- Maximum yield (86.39 q/ha) and C:B ratio (1: 2.82) were recorded with the application of *Azospirillum* along with 100% recommended dose of nitrogen in chillies cv.Azad Mirch-I. Hence, it is recommended for Kanpur conditions.
- The maximum yield of cauliflower cv. Pusa Snowball K-I (304.5 q/ha) and C:B ratio (1 :3.88) were recorded with the application of PSB @ 500 g/ha as seedlings root dip along with recommended dose of NPK through fertilizers. Hence, it is recommended for Pantnagar conditions.

Use of liquid fertilizers

- At Hyderabad, maximum yield of brinjal (365.6 q/ha) with C:B ratio (1 :3.8) were obtained with 5 sprays of water soluble fertilizer having the combination ofNPK 15 : 15 :30. Hence, it is recommended for Hyderabad conditions.
- At Kalyanpur 5 foliar applications of water soluble fertilizer NPK (17: 10:27) at 10 days interval resulted in maximum yield (241.5 q/ha) and C:B ratio (1: 2.97) in tomato cv. Type -1. Hence, it is recommended for Kanpur conditions.
- At Jabalpur, the maximum yield of tomato (269.28 q/ha) along with the C:B ratio (1 :2.08) were obtained with 5 sprays of Multi K 13:0:45 applied at 10 days interval after 40 days transplanting. Hence, it is recommended for Satpura hills and Kaymore plateau region of M.P.
- At Coimbatore foliar application of water soluble fertilizer NPK (19 :19: 19) 5 times at 10 days interval starting from 40 days after transplanting resulted in maximum yield (556 q/ha) and C:B ratio (1 :5.05) in Brinjal Hybrid -1 (COBH-I). Hence, it is recommended for Coimbatore conditions.

Use of micronutrients

- At Pantnagar, maximum yield (314 q/ha) and C:B ratio (1 :2.15) along with high TSS (5.7%) and shelf life (7.6 days) were recorded in Pusa Hybrid -1 tomato with three foliar sprays ofmicronutient mixture (B, Zn, Cu, Fe, Mn, each @ 100 ppm and Mo @ 50 ppm) at 10 days interval starting from 40 days after transplanting. Hence, it is recommended for Tarai conditions of Pantnagar.

- At Jabalpur, the maximum yield (360.40 q/ha) and C:B ratio (1: 2.75) of hybrid cabbage Krishna were recorded with 3 foliar sprays of ZnS04 at 100 ppm concentration. Hence it is recommended for Satpura hills and Kaymore plateau region of M.P.
- At Kalyanpur three foliar sprays of mixture of micronutrients (B, Zn, Cu, Fe, Mn each @ 100 ppm and Mo @ 50 ppm) at 10 days interval starting from 40 days after transplanting. resulted in maximum yield (83.89 q/ha) and C:B ratio (1 :3.43) in capsicum cv. California Wonder. Hence, it is recommended for Kanpur conditions.

Integrated Nutrient Management

- At Bhubaneswar the integrated application ofFYM @ 40 t/ha + half the dose of NPK through fertilizers resulted in maximum yield in tomato cv. Utkal Deepti with C:B ratio of I: 1.62. Hence, it is recommended for Bhubaneswar conditions.
- At Jabalpur, maximum yield (310.68 q/ha) and C:B ratio (1 :2.58)of cv. Jawahar Tomato-99 was obtained with the application of 20 t/ha FYM and full dose ofN:P:K (180: 120:80 kg/ha)through fertilizers. Hence, it is recommended for Satpura hills and Kaymore plateau region of M.P.

Irrigation trials

- At Bhubaneswar, application of irrigation at 50 mm CPE resulted in yield of 251.4 q/ha with the highest C:B ratio of 1: 1.81 in tomato. Hence, irrigation scheduling at 50 mm CPE in tomato is recommended under Bhubaneswar conditions.
- At Sabour, the highest yield (483.40 q/ha) and C:B ratio (1:4.65) were obtained with 75 mm CPE in tomato hybrid Avinash-2. Hence irrigation in tomato at 75 mm CPE is recommended under Sabour conditions.

Protected cultivation

- At IIHR, Bangalore, maximum yield of 1329.0 q/ha was obtained under protected cultivation of hybrid tomato cv. SH-7611 with a spacing of 50 x 20 cm by following double stem training, which is recommended for Bangalore conditions.

Recommendations for 2003-04

Use of bio-fertilizers

1. At Hyderabad, the maximum yield (226 q/ha) along with C:B ratio (1 :2.96) were obtained in late Cauliflower with the application of VAM @ 15kg/ha. + recommend dose ofNPK. Hence, this is recommended for Hyderabad conditions.

2. At Hisar, the highest yield (347.8q/ha) and C:B ratio (1 :5.53) were obtained with the application ofPSB +75% P and recommended dose of nitrogen and potassium in late cauliflower. Hence, it is recommended for Hisar conditions.

3. At Faizabad, the maximum yield (257.75 q/ha) and C;B ratio (1:3.19) were obtained in cauliflower cv. Snowball-16 with the application of *Azospirillum* plus recommended dose of NPK. Hence, it is recommended for Faizabad conditions.

4. At Kalyanpur, the application of *Azospirillum* with 75% ofN and full dose P and K gave the maximum yield (293.95 q/ha) and C:B ratio (1 :1.60) of cauliflower cv. Snowball-16. Hence, it is recommended for Kanpur conditions.

Use of liquid fertilizer

5. At Faizabad, in addition to the recommended dose of NPK (150:80:80) five foliar applications of water soluble NPK fertilizer (19: 10:27) after 30 days of transplanting at 10 days interval resulted in maximum yield (395 q/ha) and highest C;B ratio (1 :3.53) of brinjal hybrid Suchitra. Hence, it is recommended for Faizabad conditions.

6. The highest yield of capsicum hybrid Bharat (167.45 q/ha) along with C:B ratio (1 :1.52) were recorded with three foliar sprays of water soluble fertilizers (15:15:30 at 45x30 cm spacing on 30th October and C:B ratio (1:1.77). Hence, it is @0.5%) at 10 days interval starting from 30 days after transplanting. Hence, it is recommended for Pantnagar conditions.

Use of micro-nutrients

7. At Coimbatore, the foliar application of ZnSo4 at 100 ppm concentration thrice starting from 40 days after transplanting resulted in the maximum yield (645.6q/ha) along with C:B ratio (1 :4.86) in case of tomato hybrid - 1 (COTH-l). Hence, it is recommended for Coimbatore conditions.

8. At Bhubaneswar, the maximum yield (431.6q/ha) of hybrid cabbage along with C:B ratio (1: 1.83) were obtained with 3 sprays of 100 ppm ZnS04 at 10 days interval starting from 40 days after transplanting. Hence it is recommended for Bhubaneswar conditions. However, at Jorhat, application of boron at same concentration resulted in maximum yield (485 q/ha) and C:B ratio of (1 :2.76) which is recommended for Jorhat conditions.

Planting date cum spacing trial

9. At Jorhat, planting of broccoli cv.KTS-l resulted in maximum yield (158 q/ha) recommended for Jorhat conditions.

10. At Kalyanpur, maximum yield (315.52 q/ha) and C:B ratio (1:2.27) were obtained when broccoli hybrid Fiesta was planted on 15 October at 45X30 cm spacing. Hence, it is recommended for Kanpur conditions. However, at Durgapura, the maximum yield (310.4 q/ha) and C:B ratio (1 :8.5) were obtained at 45 x 45 cm spacing on the same date oftransplanting, which may be recommended for Durgapura conditions.

Recommendations for 2004 -2005

Tomato

- Based on the higher germination percentage, seedling vigour and economics (20 paise per seedling extra profit over control), seedling raising of hybrid tomato in 10x6 cm size polyethylene bags on raised bed with polyethylene layer is recommended under Pantnagar conditions of Tarai area.
- Planting of tomato indeterminate hybrid ARTH-4 at 80x60 cm spacing on raised beds along with staking is recommended for higher yield (334 q/ha) and C:B ration (1 :3 :41) under Pantnagar conditions. Planting at 80 x 45 cm spacing along with staking is recommended for maximum yield (439 q/ha) and C:B ratio (1 :4:52) under Coimbatore conditions. For Hisar and Durgapura conditions, planting of tomato hybrid ARTH-4 at 80x60 cm is recommended. Pinching of side shoots up to 30cm was not found economical at any ofthe above locations.
- Based on the highest yield (643 q/ha) and C:B ratio (1:10.33), application of nitrogen @240kgiha and P20S 120 kgiha is recommended for tomato hybrid ARTH-3 under Kanpur conditions. For Hisar conditions, application of nitrogen @180kgiha and P20S @60kgiha is recommended for obtaining highest yield (372q/ha) and C:B ratio (1 :4.9) in the same hybrid.

Capsicum

- Application of 120 kg nitrogen and 60 kg P20s/ha is recommended for getting maximum yield (136 q/ha) and C:B ratio (1: 1.50) under Tarai conditions of Pantnagar. For Faizabad conditions, application of 240 kg/ha nitrogen and 180 kg/ha P20S is recommended for obtaining the maximum yield (195.6 q/ha) and C:B ratio (1 :4.22), while for Coimbatore conditions, application of 180 kg/ha nitrogen and 120 kg/ha P20 Sis recommended for the highest yield (63.7 q/ha) and C:B ratio (1:3.98) in the same hybrid.

French bean

- Application of nitrogen @160 kg/ha and P20S @90 kg/ha is recommended for maximum green pod yield (65 q/ha) and C:B ratio (1 :2.95) in French bean variety Contender under Durgapura conditions. At Faizabad, application of 160 kg/ha nitrogen and 60 kg/ha P20S is recommended for highest yield (98 q/ha) and C:B ration (1 :2.44) in the French bean variety Patn Bean-2.

Okra

- Application of metolachior @0.75 kg ai/ha as pre-emergence spray followed by one hand weeding 45 days after sowing is recommended for effective weed management and obtain economic yield (63 q/ha and C:B ratio 1:3.67) under Coimbatore conditions.

Pointed gourd

- Application of paddy straw mulch is recommended for effective weed management, higher yield (127 q/ha) and C:B ratio (1: 1.99) under Faizabad conditions.

Pea

- For maximum yield (118.79 q/ha) and C:B ratio (1:2.73), 3 irrigations, i.e., at pre-bloom (30 days after sowing), at bloom (50% flowering) and at pod set stages are recommended for the variety Azad Pea-l under Faizabad conditions.

Garlic

- Application of 50 Kg, N and 60 Kg/ha K20 is recommended for highest yield (88.0 q/ha) and C:B ratio (1 :2.63) in garlic variety GG-2 under Junagadh conditions.

Recommendations for 2005-06

Integrated nutrient management

INM in brinjal- okra cropping sequence

- Application of neem cake @ 5 q/ha and rest of the recommended NPK through chemicals fertilizer gave the highest mean yield of 415.86 q/ha along with the maximum C:B ratio of 2.34 in brinjal. The residual effect of the same treatment was found to be the best for okra crop producing the highest mean yield of 133.71 q/ha with the maximum C:B ratio of 1: 1.82. Hence, it is recommended for Kalyanpur conditions.
- At Bhubaneswar, application of FYM @10 t/ha and recommended doses of NPK (125 : 50 : 75 kg/ha) gave the highest fruit yield of brinjal (229. 36 q/ha) along with the maximum C:B ratio of 1: 4.05. However the residual effects of treatment did not show significant improvements in succeeding okra yield. Hence it is recommended for Bhubaneswar conditions.
- Under brinjal- okra cropping sequence at Faizabad, the maximum mean yield of brinjal i.e., 269.55 q/ha and C:B ratio 1: 1.57 was recorded with the application of neem cake @ 5 q/ha + recommended dose of NPK through chemical fertilizers. The residual effect of same treatment gave the highest C:B ratio 1: 2.16 in Okra. Hence, this is recommended for Faizabad conditions.

Integrated Nutrient Management

Garden pea:

- At IIHR, Bangalore, the garden pea variety Arka Kartik recorded the highest yield 105.2 q/ha with the maximum C:B ratio of 1:2.78 with the application of 10 t/ha FYM plus half dose of N:P:K (20:30:25 kg / ha). Hence, it is recommended for Bangalore conditions.
- At Faizabad application of neem cake @2.5 q/ha plus half of the recommended dose ofNPK (15:30:20 kg / ha) recorded the highest mean yield of pod of in garden pea cv. Azad Pea-3 (102.10 q/ha) with the maximum C:B ratio of 1:2.98. Hence, it is recommended for Faizabad conditions.

Tomato:

- At IIVR, application of recommended doses of NPK (120:60:60)+ FYM @ 10 t/ha + Sulphur at the rate of 25 kg / ha + *Azotobacter* + mixture of all micronutritients (Zn, B, Mo, Fe, Cu and Mn) resulted in the best mean yield 413.83 q/ha along with highest C:B ratio 1:3.65 of tomato cultivar H-86. Hence it is recommended for Varanasi conditions.
- At IIHR Bangalore, cucumber hybrid Tripti recorded the highest yield of 269.2 q/ha with the C:B ratio 1:2.17 by application ofFYM @ 10 t/ha + halfNPK (30:25:40 kg/ha) + Biofertilizers. Hence it is recommended for Bangalore conditions. Cucumber:
- At Varanasi the maximum mean yield of cucumber 218.76 q/ha along with highest C:B ratio 1:2.13 has recorded with the application ofhalfNPK (60:30:30 kglha) + FYM @ 10 t/ha + Biofertilizer. Hence, it is recommended for Vamanasi region.

Carrot:

- At Hyderabad the maximum yield (316 q/ha) with C:B ratio 1:3.70 of carrot cv. improved Kuroda was obtained with the application of vermicompost @2 t/ha +biofertilizers + half recommended dose ofNPK (25 : 20 : 25 kg /ha). Hence, it is recommended for Hyderabad conditions.
- At Durgapura, the maximum yield of carrot i.e., 557.09 q/ha and C:B ratio 1:2.59 was obtained under half recommdned dose of NPK (30:20:60 kg/ha) + Vermicompost @ 2 tonnes /ha + biofertilizer. Hence, it is recommended for Jaipur conditions of Rajasthan.
- At Varanasi, the maximum yield (246.80 q/ha)of carrot cv. Early Nantes was obtained with the application of half dose of recommended NPK (60:30:30 kg/ha)+ vermin compost @ 2t /ha + biofertilizers. Hence, it is recommdned for Varanasi conditions.
- At Faizabad, the maximum yield (212.91 q/ha) and C:B ratio 1:2.98 of carrot cv. Nantes was obtained with the application of half NPK (40:30:30 kg/ha) +Legume green manure @2.5 t/ha + Biofertilizers. Hence, it is recommended for Faizabad conditions.
- At IIHR, Bangalore, the maximum yield (248.7 q/ha) and C:B ratio 1:2.0 of carrot cv. Early Nantes was recorded with the application of half NPK (40:30:25 kg/ha)+ FYM 10 t/ha + biofertilizers. Hence, it is recommended for Bangalore conditions.
- At Srinagar, the maximum yield (210.95 q/ha) and C.B. ratio 1: 4.11 was obtained with application of FYM @ 10t/ha + Vermicompost @ 2t /ha for organically produced of carrot var. Chamman. Hence it is recommended for Kashmir valley.

III. Use of biofertilizers :

- Under Pantnagar conditions, application of PSB + recommended dose of NPK (150:90:60 kg/ha) gave the highest average yield of tomato i.e., 653.4 q/ha along with the maximum C:B ratio 1:3.19. Hence, it is recommended for Tarai region of Pantnagar conditions.
- At Kalyanpur, application of *Azospirillum* with 75% N and 100% PK gave the highest average yield 267.44 q/ha of tomato var. TYPE-l with the maximum CB ratio 1:2.20. Hence it is recommended for Kanpur conditions.

IV. Foliar application of water soluble fertilizers:

- Trails conducted at Jabalpur on brinjal cv. Jawahar Brinjal 64, the maximum mean of yield 243.72 q/ha with highest C:B ratio i.e., 1:3.02 was obtained by five foliar sprays of NPK (19: 19: 19) @5 g/litre in addition to recommended dose of NPK. Hence, it is recommended for Kymore plateau and Satpura hills of M.P.
- At Sabour, the highest yield (494. llq/ha) and C:B ratio 1: 2.13 of tomato was recorded with the five foliar sprays ofNPK (15:15:15) @ 5g / litre in addition to recommended dose of NPK. Hence, it is recommended for Sabour conditions of Bihar.
- At Bhubaneshwar, the maximum curd yield (178.03 q/ha) and C:B ratio 1:2.11 of cauliflower was obtained with three foliar sprays ofNPK (19: 19: 19) in addition to recommended dose of NPK. Hence, it is recommended for Bhubaneshwar conditions.

V. Application of micronutrients:

- Under Durgapura conditions, three foliar applications of Ferrous sulphate @100 ppm at 40, 50 and 60 DAT gave the maximum mean yield of 454.11 q/ha along with highest C:B ratio 1:2.44 of tomato cv. Pusa Hybrid-2. Hence, it is recommended for Durgapur conditions of Rajasthan.
- At Faizabad, the maximum C:B ratio 1:3.15 and better yield of cauliflower cv. Pusa Snowball- K-l was obtained with the foliar application of boron @ 100 ppm + Molybdenum @ 50 ppm. Hence, it is recommended for Faizabad conditions.

VI. Protected cultivation of vegetables:

- In three years of experimentation at Pantnagar cucumber cv. Poinsettie recorded the maximum mean yield of 14.12 kg/m2 with the highest C:B ratio 1:31.01.Hence, this variety is recommended for protected cultivation.
- At Hisar, the highest yield (530.6 q/ha) and C:B ratio 1:2.19 tomato cv. ARTH128 was record under 50x40 cm spacing with double stem training.
- At Hisar, the maximum yield (570.5 q/ha) and C:B ratio 1:2.61 of cucumber Cv. Phule Prachi was recorded.

VII. Seed Pelleting and planting method:

- Trials conducted on seed pelleting and methods of planting on onion at NRC (O&G) showed that higher yield i.e., 25.6 t/ha with the maximum C:B ratio i.e.,1:2.40 was recorded with the pelleting of *Trichoderma viridae* @ 4g/kg seed under flat bed system in Kharif planting. The same treatment is recommended for rabi season also.

VIII. Planting date and spacing:

- At faizabad, the maximum ~ield (22.45 t/ha) and C:B ratio 1:4.89 of broccoli cv. Fiesta was obtained by 15t October planting at spacing of 45 x 30 cm. Hence, this date of planting and spacing is recommended for Faizabad conditions.

- At Ranchi, transplanting of broccoli in October from 15_30th at 45x30 cm spacing recorded the maximum mean yield and C:B ratio 1:4.89. Hence, this date of planting and spacing is recommended for Ranchi conditions.

IX. Fertilization studies:

- At NRC (OG), the application ofNPK @ 50:50:80 kglha as basal + 100 kg N in seven split through drip irrigation expressed better yield (29.6 t/ha) and highest C:B ratio i.e., 1: 1.63 in onion. Whereas for garlic application ofNPK @ 50:50:50 kglha as basal + 50 kg N in seven split through drip irrigation gave yield of 7.91 tonnes *I* ha with maximum C:B ratio 1:2.93. Hence, it is recommended for Pune conditions of Maharastra.

Recommendation for 2006-07

Protected cultivation

- Under polyhouse production of capsicum hybrid Indra, based on highest yield (9.64 kglm2) and cost: benefit ratio (1 :6.56); spacing of 60 X 30 cm without training is recommended under naturally ventilated polyhouse under terai conditions of Pantnagar.
- In naturally ventilated polyhouse, maximum yield (1399.64 qlha) along with highest C:B ratio 1:3.92 in hybrid tomato cv. Tolstoy was obtained with double stem training at 50 X 20 cm spacing. Hence it is recommended for Varanasi conditions.
- In naturally ventilated polyhouse, the maximum C:B ratio 1:2.27 along with higher yield 451.55 qlha was recorded in capsicum hybrid Indra with the treatment combination of 60 X 30 cm plant spacing without pruning. Hence, it is recommended for Varanasi conditions.

Weed Control

- For weed management in onion, application of oxyfluorfen @ 0.15 kg a:lha as PE resulted in highest yield (11.26 tlha) and C:B ratio (l :3.40). Hence, it is recommended for Coimbatore conditions.

Use of Biofertilizer

• Root dipping of tomato seedlings with Azotobactor along with 75 per cent N + 100 per cent PK recorded highest fruit yield (635.38 qlha) and C:B ratio (l :3:26). Hence it is recommended for Srinagar conditions.

• Under Coimbatore conditions, seedling root dip with the Azospirillum in addition to 75% N + 100% PK recommended resulted in highest yield 427.2 qlha along with the maximum C:B ratio of 1:4: 11 in tomato. Hence, it is recommended for Coimbatore conditions.

Integrated Nutrient Management

Tomato

• At Hisar, the maximum mean yield (432.3 qlha) and C: B ratio (l :2.66) were obtained in tomato on application of recommended NPK + FYM @ 10 tlha + S@25 kglha + Mixture of all micronutrients (Zn, B, Mo, Fe, Cu, Mn) + *Azotobactor.* Hence, it is recommended for Hisar conditions of Haryana. The same treatment also recorded the highest yield (336.20 qlha) along with the maximum C: B ratio of 1:2.63. Hence, it is recommended for Kalyanpur conditions.

• At Faizabad, the highest mean yield (368.35 q/ha) along with highest, C.B. ratio 1:3.02 was recorded in tomato var. Narendra Tomato-6 with the application of NPK @ 120:60:60 kg *I* ha + FYM 10 tlha + Sulphur 25 kglha + *Azotobactor* + MM (mixuture of all micronutrients, Zn, B, Mo,Fe, Cu, & Mn). Hence, it is recommended for Faizabad conditions.

Garden pea

- At Bhubaneswar, the integrated application of poultry manure @ 2.5 t/ha + half recommended NPK(25:37.5:25 kg/ha) resulted in 44.16 quintal per hectare pod yield and C:B ratio of 1: 1.49. Hence, it is recommended for Bhubaneswar conditions of Orissa.

Cucumber

• At Kalyanpur, the maximum mean yield (223.18 q/ha) along with the highest C: B ratio 1:3.68 has recorded in Cucumber with the application of half recommended NPK + FYM @ 10t/ha + biofertilizer. Hence, it is recommended for Kanpur conditions ofU.P.

• At Hyderabad, the maximum yield of fruit (111 q/ha) and C:B ratio (1 :2.10) were obtained in cucumber CV. Poinsette with the application of FYM @ 10 t/ha + biofertilizers in addition to recommended dose of NPK (100:50:50 kg/ha). Hence, it is recommended for Hyderabad conditions.

Broccoli

- At Srinagar, application of vermi compost @ 5t/ha recorded the maximum C:B ratio 1:4.7 with higher mean yield of 156.61 q/ha in broccoli. Hence, it is recommended for Srinagar conditions of J&K.

Water Soluble fertilizer

- At Coimbatore, the highest mean fruit yield 712.50 q/ha and the maximum C: B ratio 1: 4.78 were recorded in hybrid tomato with five foliar sprays of NPK (19:19:19).Hence, it is recommended for Coimbatore conditions of Tamil Nadu.

Studies on micronutrient:

Bitter gourd

- At Kalyanpur, the maximum mean yield(161.25 q/ha) of bitter gourd cv. Summer Green and highest C: B ratio 1:2.13 were recorded with the foliar application ofmixture of micronutrients (Zn, B, Mo, Cu, Fe, Mn). Hence, it is recommended for Kalyanpur (Kanpur) conditions.

Cauliflower

• At Bhubaneswar, the higher mean yield of cauliflower (166.6 q/ha) along with maximum C:B ratio 1:4.09 were obtained with the foliar sprays of boron @ 100 ppm in addition to recommended NPK. Hence, it is recommended for Bhubaneswar conditions of Orissa.

• At Kalyanpur, the higher curd yield of cauliflower (317.09 q/ha) along with the maximum C: B ratio 1:3.17 were recorded with the soil application of borax @ 10 kg/ha + Ammonium Molybdate @2.0 kg/ha. Hence, it is recommended for Kanpur conditions.

Cabbage

The highest mean yield (400.7 q/ha) along with the maximum C:B ratio (1:2.92) were obtained in cabbage hybrid cv. Meenakshi with the application of Ferrous sulfate @ 100 ppm in addition to recommended dose of NPK (180:60:60 kg/ha). Hence, it is recommended for Hyderabad conditions.

Insect Pest Management

• At Ludhiana, application ofFYM @ 10 t/ha and azotobacter @ 1.25 kg/ha followed by need based NSKE (4%) spray at 10 days interval is recommended for the management of pest complex on brinjal with highest C:B ratio

• At Rahuri, application ofNPK @ 100:50:50 along with 4 sprays NSKE (4%) was best in managing brinjal shoot and fruit borer with maximum C:B ratio (1 :4) followed by application of FYM 10 t/ha + Azospirillum @ 1.25 kg/ha along with 4 sprays of NSKE (4%) are recommended for BSFB management with the C:B ratio of 1:1.8.

• For effective and economical management of leaf miner in cucumber, erection of yellow sticky trap @ l/hill, clipping oflower 2-3 infested leaves followed by application of neem soap @ 109/lit or NSKE (4%) at cotyledonary leaf stage and two foliar sprays ofdeltamethrin (0.005%) along withjaggery (2%) at 50% flowering stage is recommended under Anand and Rahuri condition with maximum C:B ratio

Disease Management Survey and surveillance

1. Based on 3 years pooled data it has been concluded that average incidence of grey leaf spot *(Stemphyllium solani)* and early blight *(Alternaria solani)* in tomato was 66 and 39.7% respectively during November to February; in brinjal Phomopsis blight *(Phomopsis vexans)* accounted for 36%; with the incidence of 37.4% in powdery mildew *(Erysiphe polygonii)* in pea. *Alternaria brassicae* and

A.brassicicola with predominance of the later in cauliflower were severe and recommended to take control measures in the region.

2. In tomato, Alternaria blight *(A. solani)* and buckeye rot *(Phytophthora parasitica)*were graded serious having varied incidence of 28-39.4% and 21.6-29.2%. Fruit rot of capsicum *(Phytophthora capsici)* was predominantly serious over the years at Solan valley with 18.9-23.4% incidence. Suitable recommendations should be adopted in the region.

Integrated Disease Management

1. Green manuring along with *Trichoderma viride* @5 kg/ha alone or in combination with neem cake @ 10 q/ha has been found effective in minimizing tomato diseases viz. *Rhizoctonia solani, Sclerotium rolfsii, Pythium* and *Phytophthora* spp. Upto 50%. The treatment combination of green manuring + neem cake + bioagent was adjudged best in reducing Rhizoctonia/Fusarium root rot/wilt incidence thereby increasing the pea yield considerably and is recommended for Varanasi region.

2. Green manuring + neem cake @10 q/ha + antagonists *(Trichoderma viride)* 6 kg/ha recorded the minimum Fusarium wilt incidence and increased yield in chilli and okra. The highest C:B ratio 1.03 in chilli and 3.03 in okra was obtained in the treatment. This treatment combination is recommended for effective control of *Fusarium* wilt in chilli and okra in Rahuri conditions.

3. For the management of collar rot in cowpea in Vellanikkara region and tomato wilt in Junagadh region, application of green manuring (Sunhemp) and antagonists either with neem cake or without neem cake is recommended as the best treatment combination.

4. Green-mannuring *(Sesbania aculeta)* alone was found to be the most cost effective (C:B 1:6) in limiting the bean root rot and okra at Solan and Hessarghatta respectively apart from increasing yield.

5. Green manure + neem cake + *Trichorderma viride* lowered the wilt incidence and increased the yield in chilli at Hyderabad and seed treatment of pea gave excellent result against pea diseases at Kanpur.

Epidemiology

6. It was found that the incidence of buckeye rot of tomato in Solan region was positively correlated with rainfall and humidity. The multiple regression analysis revealed the significant effect of temp., rainfall and humidity.

7. It has been observed that the downy mildew in bitter gourd at Vellinikkara was positively correlated with RH, rainfall and no. of rainy days. The linear function so obtained is recommended for disease prediction.

Seed Pathology

1. Seed· treatment with *T viride* @5 g/kg was found effective to control seed borne fungi and increasing seed germination (91.3 %) in tomato as compared to control (54.3%) at Rahuri.

2. The increased germination (90.8%) and suppression of mycoflora over control was recorded in carbendazim (0.25%) at Parbhani.

Information related to National Seed Project on Vegetables (NSP)

Year	Vegetable Breeder Seed			
	Indent(kg)	Production(kg)	Surplus production	%increase over indent
2000-01	55799.6	60020.7	4221.1	7.56475
2001-02	37843.4	45102.8	7259.4	19.18274
2002-03	38666.6	54702	16035.4	41.47093
2003-04	41556.4	48381.8	6825.4	16.42443
2004-05	27073.3	39543.2	12469.9	46.05977
2005-06	15833	24682	8849	55.8896
2006-07	21062	Production figure awaited		

All India Coordinated Research Project on arid Zone Fruits

1. **Title of the Project** : **All India Coordinated Research Project on Arid Zone Fruits**

2. **Name and Address of the Project Coordinator** : **Dr. T. A. More**
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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Genetic Resources

1. In case of *ber* var. Gola has been found to be suitable for very dry areas, Kaithali for slightly higher rainfall areas and Umran for moderate arid and semi-arid areas.

2. Pomegranate variety Phule Arakta and Bhagawa have been reported as the most promising for Maharashtra and Andhra Pradesh and Karnataka (MPKV, Rahuri and ANGAU, Anantapur), Jalore Seedless and Jodhpur Red for Rajasthan (RAU).

3. *Aonla* varieties NA-7, Chakaiya, Kanchan and NA-6 have been found most promising uniformly all over the region. Date palm varieties Halawy, Barhee and Medjool are reported to be most suitable for date growing regions. Custard apple varieties Island Gem, Bullocks Heart and Mammoth are reported as suitable in Karnataka, Andhra Pradesh and Maharashtra. Fig varieties Condaria, Poona Fig and Dianna are reported as suitable for fig growing areas.

4. Date palm: Varieties Halawy and Barhee are reported as most suitable for desert, variety Medjool for making dry dates (*chhuhara*) at PAU - Abohar and RAU - Bikaner and varieties Zahidi and Hallawy for soft dates (pind khajoor) PAU - Abohar. SDAU - Mundra has located very high yielding, good quality clones from wild date palm groves of Kachchh area, which were supposedly developed by Middle East settlers a few centuries ago.

5. Custard apple: Variety Balanagar is suitable under very low rainfall situation (ANGAU - Anantapur) and Selection A.S.1 under moderate rainfall situation (TNAU - Aruppukottai).

6. Fig: Varieties Condario and Dianna are best selections for situations of minimum irrigation availability (MPKV-Rahuri).

7. *Bael*: NDUAT has selected two promising lines, NB 5 and NB 9, which possess salinity/sodicity tolerance. HAU (Bawal) has identified some promising germplasms having good plant characters.

Crop Improvement

1. IIHR has released Arka Sahan custard apple hybrid having smooth skin, attractive pulp colour and sweetness with less seeds. MPKV - Rahuri has released Hybrid 61 (Mridula) of pomegranate having red aril colour, very soft seed and other desirable characters.

2. Some centres have made promising selections to suit specific situations and purposes. Notable among these are:

Aonla: NDUAT has reported that selection NA-19, 20, 24 and 25 are found excellent with reaspect of fruit yield and quality characters.

Ber: NDUAT reported Narendra Ber Selection-1 & 2 have been recommended for commercial cultivation in Utter Pradesh.. HAU (Bawal) has observed field tolerance against powdery mildew and fruitfly under low inoculum pressure in variety B.S.1. 2.

Propagation Techniques

1. Custard apple: ANGAU - Anantapur centre has standardized softwood-grafting technique, which gave maximum success when done during January - March under local conditions. Patch budding has been recommended with good success at TNAU - Aruppukottai centre.

Plant Density

1. TNAU (Aruppukottai) centre reported planting at 8 x 3 m and 8 x 4 m spacing respectively for Banarasi and Kaithali varieties of *ber* for high-density plantation.

2. IIHR Bangalore reported 5 x 2 m as optimum spacing for high density planting of pomegranate. MPKV (Rahuri) reported 1000 plants per hectare as optimum in pomegranate.

Water Management

1. The highest fruit yield was obtained at 250% normal with 5% slope in ber (Arrupukottai). Application of water through drip significantly increased the yield and quality parameters up to 60% daily evaporation replenishment at Bawal while at Anantpur, plants irrigated with drip and mulch with irrigation schedule at IW/CPE ratio of 0.8 in pomegranate fruit crops. At Faizabad in aonla drip irrigation with 0.60 IW/CPE at 3rd day irrigation was found most effective.

Nutrition Management

1. 1 to 3 leaves can be used for N, P and K estimation and 3rd leaf from top can be used for micronutrient analysis for custard apple (Anantapur)

2. Under Bangalore condition, a fertilizer dose of 500 g N, 250 g P_2O_5 and 250 g K_2O per plant per year in two splits during May and another post monsoon along with 3-4 basket of FYM and 1 kg neem cake for each plant of pomegranate is recommended.

3. In aonla fertilizer dose with combination of 100 g N, 50 g P_2O_5, 50g K_2O per plant per year (1000 g N, 500g P_2O_5 and 500 g K_2O of 10 year old plant) is recommended for commercial cultivation in UP.

4. In fertilizer dose with combination of 100 g N, 50 g P_2O_5, 50 g K_2O per plant per year (800 g N, 400 g P_2O_5 and 400 g K_2O of 8 year old plant) is recommended for commercial cultivation of bael in UP. (Faizabad)

Flowering, Fruit Development and Ripening

1. NDUAT (Faizabad) has reported the phenomenon of self-incompatibility in most of the commercial varieties of *aonla* and need of proportionate planting of pollinizer varieties. NA-6 was found to be the best pollinizer for NA-7.

2. At Bangalore, hand pollination with Squamosa (Custard apple) pollen is recommended to achieve not only higher productivity, but also large sized symmetrical Arka Sahan fruits.

3. Pre-harvest application of ethrel @ 100 ppm at colour break stage was found to improve fruit weight and quality in date palm (RAU - Bikaner). Removal of 1/3rd strands from the centre of the bunch at the time of pollination induced early maturity and improved quality of dates. Spray of ethrel (1500 ppm) at colour break stage gave uniform ripening and higher TSS in *doka* and *dang* fruits of date palm (PAU - Abohar,). Application of 1000-ppm ethepon at colour turning stage induced early ripening by one week in Halawy variety of date palm.

4. Application of 750 ppm of ethephon at colour turning stage induced early ripening in *ber* (NDUAT - Faizabad). In pomegranate, 50 fruits / tree was found to be optimum for highest return per tree (MPKV - Rahuri). Kaolin (5.0 - 7.5%) and liquid paraffin (1%) have been found to improve yield and check fruit cracking in pomegranate and *ber*.

Pest and Disease Management

1. Fig rust can be controlled by 3-4 sprays of 0.2 per cent chlorothalonil or copper oxychloride (0.40%) during the crop susceptibility period.

2. For the control of *ber* fruit fly carbaryl 50 WP 0.1% has been found to be the best pesticide. Three to four sprays at 0.01% starting from peanut stage till maturity can check the fruit fly incidence effectively. Fenthion 100 EC 0.05% at an interval of 15 days checked the spread of disease. Other pesticides found effective are deltamethrin (0.002%) or fenvalerate (0.01%).

3. For *ber* powdery mildew, 2-4 sprays of dinocap or carbendazim or triedomorph or thiophenate methyl (0.1%) or wettable sulfur (0.2%) at 15-20 days interval were found as effective at during the most vulnerable period starting with the onset of the disease.

4. Pomegranate bark eating caterpillar can be effectively checked by spraying the infested bark with any of the pesticides like monocrotophos 36 WSC (0.08%), fenvalerate (20 EC (0.04%), quinalphos 25 EC (0.08%).

5. Rotational use of deltamelthrin 28 EC at 0.002% and carbaryl 50 WP at 21 days interval starting from fruit set has been found the most effective for the control of pomegranate fruit borer.

6. Black beetle (*Chilocerus nigritus*) has been identified as an effective predator of date palm scale.

Post-harvest Technology

1. Boiling of *doka* stage berries for 20 minutes followed by dehydration at 50^{o} C for 70 hours is recommended for preparation of good quality dry dates (*chhuhara*).

2. Half *dang* stage berries can be processed to prepare soft dates (*pind khajoor*) by dehydrating at 50^{o} C for 70 hours.

Khalal stage of cv. Halawy has been found appropriate for making best quality dry dates in Kutch region of India.

All India Coordinated Research Project on Cashew

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

- Local cashew germplasm material with desirable characters such as high yield, cluster bearing habit, bold sized nuts, short duration of flowering, off season flowering types from different cashew growing regions have been collected and clonally propagated and field planted in different centers. Number of cashew accessions so far collected and conserved by the Coordinating Centres in Regional Cashew Field Gene Banks is 1261
- A total of 27 high yielding cashew varieties have been developed and released for cultivation in different states by different centers of AICRP Cashew.
- Location specific package of practices has been developed to different cashew growing states by the corresponding centre of AICRP on Cashew.
- Intercrops such as ginger, turmeric, cluster bean, black gram, horse gram, ground nut, or vegetables, or medicinal plants along with cashew as main crop during the initial stage of orchard establishment have been identified for enhancing net returns by different centres of AICRP on Cashew.
- Effective spray schedule for the management of tea mosquito bug (TMB) and other minor pests of cashew with monocrotophos (0.05%) at flushing and carbaryl (0.1%) at flowering and fruiting were found effective in controlling these pests. Recently lambda cyhalothrin (0.003%) has been found to be effective and economical for management of TMB and other foliage pests.
- Most of the centres of AICRP on Cashew have established cashew nurseries under the Regional Nursery programme of Directorate of Cashewnut and Cocoa Development, (DCCD) Kochi and are producing large number of cashew grafts of improved and high yielding cashew varieties.

All India Network Research Project on Medicinal and Aromatic Plants

1. **Title of the Project** : **All India Network Research Project on Medicinal & Aromatic Plants**

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

Present status and benefited accrued to the beneficiaries

- This project has succeeded in creating awareness of the importance and the varieties play a key role in production. Over 90 improved varieties (vide list follows) were released for cultivation in different spices. Several promising accessions were identified, and some are in the pipeline for release and these varieties are to be tested in different agroclimatic zones. There is also need for laying out MLTs/CVTs in different spices and also screening of promising accessions to disease, pest and abiotic stress.
- This project has also formulated need based and action based new research programmes for meeting the future targets and challenges.
- The execution of improved production technologies are to be transferred to farmers by means of demonstration trial, field visits, training etc.

Germplasm maintained at different centres of AINRPMAP and are being used when required for experimentation purposes on sustainable basis.

Sl. No.	Crop	Centre	No. of Accessions
1	Aswagandha	Mandsaur Udaipur	31 13
2	Isabgol	Anand Hisar	47 48
3	Guggal	Anand Udaipur	33 16
4	Asparagus	Anand	9
5	Palmarosa	Indore	65

6	Patchouli	Bangalore Udaipur	4 3
7	Vetiver	Trichur	37
8	Safed musli	Anand Indore Mandsaur	20 29 21
9	Aloe	Anand Trichur Udaipur	21 6 5
10	Kalmegh	Trichur	6
11	Opium poppy	Faizabad Mandsaur Udaipur	58 90 80
12	Guduchi	Trichur	12
13	Ocimum	Hisar	12
14	Geranium	Bangalore Udaipur	13 6
15	Long pepper	Trichur	67
16	Kacholam	Trichur	12
17	Mucuna	Solan	7
18	Gentiana	Solan	11
19	Jasmine	Bangalore	104
20	Indigofera	Trichur	2
21	Matricaria	Solan	4
22	Melissa	Solan	-
23	Khasi kateri	Bangalore	7
24	Periwinkle	Bangalore	8
25	Coleus	Bangalore	13
26	Valeriana	Solan	40
27	Heracleum	Solan	10
28	Liquorice	Hisar Anand	5 5
29	Mentha	Solan	9
30	Henbane	Indore Solan	14 14
31	Lemon grass	Trichur	20
32	Silibum	Anand	10

Varieties released in the AINRP on MAP

Sl No	Variety	Crop	Developed by	Year of release
Medicinal plants				
1	Anand Late Selection	*Cassia angustifolia* Vahl. (Senna)	AICRP on M &AP, Gujarat Agricultural University, Anand	1989
2.	Prabhat	*Catharanthus roseus* (Periwinkle)	AINRP, Hisar	2002
3.	Jawahar Safed musli 405	*Chlorophytum borivilianum*	AINRP Mandsaur	2004
4.	FB(C)-1	*Diascoria floribunda* Mart. & Gal. (Yam)	Indian Institute of Horticulture Bangalore	1974
5.	Arka Upakar		Indian Institute of Horticulture, Bangalore	1980
6	D 76	*Digitalis lanata* Ehrh. (Foxglove)	AICRP on M&AP,Y.S.Parmar University of Horticulture and Forestry, Nauni Solan	1991
7	H 47-3	*Glaucium flavum* (Yellow Horned Poppy)	AICRP on M&AP,Y.S.Parmar University of Horticulture and Forestry, Nauni Solan	1991
8	Haryana Mulhatti-1	*Glycyrrhiza glabra* L. (Liquorice)	AICRP On M&AP, CCS Hariyana Agricultural University, Hisar	1989
9	HMI-80-1	*Hyoscyamus muticus* L. (Egyptian Henbane)	AICRP on M&AP, College of Agriculture, Indore	-
10	GA 1	*Lepidium sativum* L. (Cress)	AICRP M &AP, Center, Gujarat Agricultural University, Anand	1998
11	RI-1	*Rauvolfia serpentine* Benth. Ex Kurz. (Sarpagandha)	AICRP on M&AP, College of Agriculture, Indore	-
12	Jawahar Aphim 16	*Papaver somniferum* L. (Opium Poppy)	AICRP on M&AP, College of Agriculture, Mandsaur	1984
13	Kirtiman		AICRP on M&AP,ND University of Agriculture and Technology, Faizabad	1990
14	Jawahar Opium 539		AICRP on M&AP, College of Agriculture, Mandsaur	1997
15	Jawahar Opium 540		AICRP on M&AP, College of Agriculture, Mandsaur	1998
16	Chetak Aphim		AICRP on M&AP, Rajasthan Agricultural University, Udaipur	1994
17	Trishna		NBPGR, New Delhi	-

18	Viswam	*Piper longum* L. (Long Pepper)	AICRP on M& AP, College of Horticulture, Trichur	1996
19	Gujarat Isabgol- 1	*Plantago ovata* Forsk. (Isabgol)	AICRP on M &AP,Center, Gujarat Agricultural University, Anand	1976
20	Gujarat Isabgol-2		AICRP on M &AP,Center, Gujarat Agricultural University, Anand	1983
21	Haryana Isabgol-5		AICRP On M&AP,CCS Hariyana Agricultural University, Hisar	1989
22	Jawahar Isabgol-4		AICRP on M&AP, Mandsaur	1996
23	NH 88-12	*Solanum laciniatum* Act.	AICRP on M&AP,Y.S.Parmar University of Horticulture and Forestry, Nauni Solan	1991
24	Arka Sanjeevani	*Solanum viarum* Dunal Syn. *S. khasianum* Clarke. (Khasi Kateri)	Indian Institute of Horticulture, Bangalore	1989
25	Arka Mahima		Indian Institute of Horticulture, Bangalore	1992
26	Jawahar Asgand-20	*Withania somnifera* Dunal (Aswagandha	AICRP on M&AP, Mandsaur	1989
27	Jawahar Asgand-134		AICRP on M&AP, Mandsaur 458 001	1998
		Aromatic Plants		
1	NLG-84	*Cymbopogon flexuosus* Nees ex. Steud Wats. (Lemon Grass)	AICRP on M&AP,ND University of Agriculture and Technology, Faizabad	1994
2	Rosha Grass-49	*C. martinii* Stapf.Var. motia (Palmarosa)	AICRP On M&AP,CCS Haryana Agricultural University, Hisar	1989
3	CI-80-68		AICRP on M&AP, Indore 452 001	-
4	Arka Surabhi	*Jasminum grandiflorum* L. (Jasmine)	Indian Institute of Horticulture, Bangalore	1993
5	Punjab Spearmint-1	*Mentha spicata* L. (Spearmint)	AICRP on M&AP,Y.S.Parmar University of Horticulture and Forestry, Nauni Solan	1991
6	Dalhousi Clone	*Valeriana jatamansi* DC. (Mushakbala)	AICRP on M&AP,Y.S.Parmar University of Horticulture and Forestry, Nauni Solan	1994
7	Hyb-8	*Vetiveria zizanioides* (L) Nash. (Vetiver)	NBPGR, New Delhi	-

Research Achievements:

- Location specific varieties for 22 medicinal and aromatic plants with their package and practices have been developed.
- Package and practices and four varieties of Isabgol for different zones have been developed.
- Forecasting system for downy mildew of Isabgol has been developed (Crop Protection).
- In safed musli, it was established that harvesting should be done according to the usage of the fleshy root. And for drug purposes, early harvesting should be practised to avoid loss in active principle. Whereas, fleshy roots meant for propagation should be harvested later to avoid loss due to drying (Crop Production).
- In safed musli *(Chlorophytum borivilianum)*, a wide spectrum of variability was observed in terms of fasciculated root whose multiplication ratio was 1:14.
- Morphological and biochemical characterization have been done in two species of Safed musli viz. *Chlorophytum borivilianum*, and *Chlorophytum tuberosum. Chlorophytum borivilianum* contain higher amount of saponin (4%) and sapogenin (0.18%) as compared to *Chlorophytum tuberosum* (1.6% and 0.05%, respectively).
- In *Chlorophytum borivilianum,* in a study it has been established that elimination of inflorescence increased the number of fleshy root and as a result 41% increase in yield has been recorded compared to non-topped plants.
- In *Chlorophytum borivilianum,* chemical finger printing has been done to characterize qualitative comparison of the saponin profiles by HPTLC. It was found that two saponin fractions were prominent in two species of *Chlorophytum* (Quality Improvement).
- Cultivation of Kalmegh (*Andrographis paniculata*) has been successfully grown as rainfed crop in medium black soil of Indore region. (Location specific work).
- Cultivation of Kalmegh (*Andrographis paniculata*) has also been recommended during kharif as profitable crop which has yielded highest biomass (4017 kg/ha) of good quality (1.95% andrographoloid) at Anand condition. (Location specific work and Production).
- In Kalmegh (*Andrographis paniculata*), it has been established that application of castor cake to provide 40 kg /ha Nitrogen could produce highest herbage yield (3740 kg/ha) and 96.8 kg/ha of Andrographoloid yield. (Organic cultivation).
- Studies revealed that in *Gymnema sylvestre* (Madhunashini), semi hard wood laterals characterized by 50% browning of the stem, was excellent for vegetative propagation.
- Riboflavin, a cheap vitamine source was found to be effective in increasing rooting in cuttings of Gymnema.
- In *Gentiana kurroo* (Indian Gentian), commonly known as *karu* or *kutiki,* Solan centre of AINRPMAP has successfully domesticated and standardized propagation techniques for large scale cultivation (Productivity).
- Reproductive biology of Indian Gentian (Gentiana kurroo) in detail has been worked out. Higher fruit set has been observed in open pollination (80.57%) compared to the controlled selfing (7.25%).
- *In vitro* multiplication of Sarpagandha (*Rauvolfia serpentina*) has been developed by Hisar Centre of AINRPMAP for the micro-propagation and conservation of this valuable threatened plant species (Sustainability).
- Cultivation of Muskdana (*Abelmoschus moschatus*) proved to be a beeter option as rainfed crop in the shallow black soils of Malwa plateau of Madhya Pradesh. (Location specific work).

- In Sacred lotus, The National flower of India (*Nelumbo nucifera*), 42 accessions from different districts of Kerela and Tamil Nadu have been collected showing wide variability in flower colour, petal number, presence of transitional whorls, carpels in the torus.
- In Arjuna (*Terminilia arjuna*), an important medicinal tree, a successful air layering technique has been developed by application of IBA (6000 ppm) which has increased number of primary and secondary roots per layer as well as mean length of longest root.
- In Opium poppy, a study to determine the dynamics of morphine content in the flower petals of the variety Chetak revealed that petals contained lowest morphine (0.26%) at bud opening stage.
- In Opium poppy, Faizabad centre of AINRPMAP has shown about 104 % latex yield increase in hybrid opium poppy developed by crossing inbred lines (ND-20 x NOP-4) suggesting that the current yield barrier could be removed and making available hybrid varieties for cultivation. (Hybrid Production).
- In Ashwagandha (*Withania somnifera*), it has been established that inorganic fertilisers affect alkaloid content suggesting that to what extent application of inorganic fertilisers affect quality of the produce which is very important in medicinal plants.
- In Liquorice (*Glycyrrhiza glabra*), an introduced medicinal plant in India, it has been established that thin (0.1-0.5 cm dia) roots of two year old crop contained more than 9% glycyrrhizic acid compared to 5%, in such roots of one year old crop.
- In Liquorice (*Glycyrrhiza glabra*), it was further revealed that the thinner roots contained more glycyrrhizic acid compared to the thick roots of same age of crop.
- Extraction and estimation of podophyllotoxin (active principle of *Podophyllum*) has been done. It was separated from the mixture of lignans extracted by soxhelating the rootstock (roots and rhizomes) in methanol followed by acidification and TLC.
- In *Valeriana jatamansi*, the phenomenon of gynodioecium i.e. occurrence of hermaphrodite and female flowers on different plants have been observed.

All India Coordinated Mushroom Improvement Project

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

Maharana Pratap University of Agriculture and Technology, Udaipur

White button mushroom *Agaricus bisporus*:

In strain evaluation trial strains, CM-6 and C M -10 gave the highest yield. Compost prepared from sugarcane bagasse and wheat straw in the ratio of 1:1 w/w out yielded the compost prepared from wheat straw alone. The long method compost treated with DDVP + Bavistin gave highest mushroom yield over other chemical treatments and untreated compost. Farm Yard Manure (FYM) alone and its combinations with garden soil (1:1), spent mushroom compost gave higher yield. In Veradix, a root promoting hormone spraying trial on button mushroom beds of two different strains, the 0.10% solution treatment gave highest yield in S-11 and U-3 strains. In "Phosphotika" biofertilizer mixing in compost at spawning stage, 1.0% mixing gave highest yield of S-11 strain. Button mushroom when dipped in EDTA (75, 125, and 200 ppm) and KMS (0.05%), dipping treatment in 200 ppm was found best treatment for storage at ambient condition, while for storage under refrigerated conditions, 75 ppm EDTA treatment was best .

Oyster mushroom (*Pleurotus* spp.):

In Oyster mushroom, two experiments were conducted, one on different substrate sterilization treatments and another on supplementation. Chemical and hot water treatments were found better. In supplementation studies 2% neem cake and 4% rice bran gave superior mushroom yield than other supplements and unsupplemented substrate.

Other Mushrooms:

Cultivation and strain evaluation trials for speciality mushroom e.g. milky, jelly and shiitake were also conducted. In milky mushroom cultivation trials, substrate prepared from wheat straw alone and in

combination with paddy straw proved better than paddy straw. Strain C.i.-6 gave higher yield. Shiitake mushroom gave good yield on saw dust supplemented with 20% wheat bran. Highest yield of *Auricularica polytricha* was obtained on unsupplemented wheat straw and 4% wheat bran supplemented wheat straw.

Germplasm Collection and Survey & Surveillance of Diseases/Insect Pests:

Total of 400 different wild mushrooms were collected, identified, preserved and their data base were prepared and one set was deposited at NRC Mushroom, Solan and one set was kept at Center. Similarly work on surveys and surveillance of diseases and insect pests were also carried out and infection of *Trichoderma*, *Coprinus*, *Aspergillus*, *Penicillium* and *Papulospora byssina* and infestation from sciarid and phorid flies was also recorded along with fruiting body scaling, browning and gill opening as the abiotic disorders.

Transfer of Technology:

In transfer of technology, total of 60 training programme were conducted in which more than 800 participants participated. Twelve (12) farmers fair both on campus and off campus were organized. The Centre supplied more than 900kg of mushroom spawn to the farmers of the area in addition to the technical guidance to the mushroom growers. Published more than20 research papers and popular articles.

Punjab Agricultural University, Ludhiana

White Button Mushroom (*Agaricus bisporus*):

The yield performance of the strains was variable probably due to the impact of biotic and abiotic factors interaction in nature. Four strains CM1, CM5, CM7 and CM10 were found to grow well in Punjab during the last five years of experiments. Bavistin (Carbendazim), DDVP (Dichlorovos), and Formaldehyde were used in four combinations to treat the long method compost. Bavistin + DDVP were consistently found the best treatment to give high mushroom yield due to low initial microbial count in the base material. Five casing materials, namely, burnt rice husk (BRH), coir pith (CP), farm yard manure (FYM), spent compost (SC) and garden soil were tried in eleven combinations. CP + FYM (1:1 v/v) showed best yield followed by SC alone and FYM + SC (1:1). Coir pith used as supplement proved better during the crop due to improved water holding capacity and better air exchange. In Punjab, coir pith is not an easily available material to recommend it to the regional farmers.

Oyster Mushroom (*Pleurotus* ssp.):

Neem cake, wheat bran, rice bran and de-oiled soybean meal, were supplemented to wetted wheat straw in different concentrations (2-5%) to grow *P. florida* and *P. sajor caju*. The results indicated that wheat bran (2%) and rice bran (2%) as supplement have improved the yield potential of *P. florida*, while wheat bran (2% & 4%) and rice bran (4%) improved yield of *P. sajor caju* in comparison to the un-supplemented control.

Other Mushrooms:

Out of nine strains of *C. indica*, strain C.i.-3 was found to give maximum yield consistently for four years. *Calocybe indica* fruited best on wheat straw. Wheat straw sterilized with steam or in hot water was suitable for the growth of *C. indica*. Out of seven strains of *V. volvacea* (VV1-VV7) evaluated for mushroom yield, strain VV4 showed early fruiting and better biological efficiency under natural climatic conditions of Punjab. Paddy straw compost gave superior mushroom yield than cotton waste compost during the cultivation of *Volvariella volvacea*. Five different bed designs – hollow bed, compact bed (square), compact bed (round), hollow bundles (4x5+2) and compact bundles (5x4+2) were tried. Compact bed (round) gave highest mushroom yield along with early pinning. Out of four substrates tried namely, wheat straw, paddy straw, maize stalks/leaves and corn cobs, wheat straw was the most suitable for the cultivation of *A. polytricha*. Later on, supplementation of wheat straw with wheat bran @ 4% further improved the yield potential on steam sterilization of the substrate before inoculation of spawn.

Post Harvest Technology:

Mushrooms were dipped for 10 minutes in EDTA (75, 100, 125, 150, 200, 500 ppm), EDTA 100 ppm + KMS (0.02%) and KMS (0.05%) and stored at room temperature and in the refrigerator. The observations made after 48h indicated that *A. bisporus* U3 strain was at its best when treated with EDTA 100 ppm + KMS (0.02%) and EDTA 500 ppm stored in the refrigerator but the same was not true for the S11 strain. Mushrooms were harvested, washed with 0.05% KMS and packed in 75, 100, 125 gauge PP bags and 100 gauge PE bags as control. The bags were kept at RT (22 ± 2^{o}C) and in the refrigerator (5^{o}C) for 48h. .At room temperature, at 0h all mushrooms were white (3+) but after 24h, mushrooms in 100 PP and 125 PP maintained superior whiteness. After 48h, mushrooms in 125 PP bag were better to show highest whiteness with no weight loss. At refrigerated conditions, maximum whiteness of mushrooms was observed even after 24h in 75PP, 100PP and 125 PP bags but after 48h whiteness was best (+3) in mushrooms packed in 125 PP bags with no significant weight loss and veil opening.

Pleurotus florida fruiting bodies were blanched (dipped in boiling 0.2% NaCl + 0.1% Citric Acid solution for 2 min) and unblanched (washed with 0.2% NaCl + 0.1% Citric Acid for 2 min) and compared with unwashed fruiting bodies. The mushrooms were subjected to sun drying and cabinet drying (60^{o}C till 7-8% moisture using Kilburn oven Model 12E WQ148, Macnill & Macor Ltd, Calcutta). Whiteness was best (+4) when blanched mushrooms were sun dried/cabinet dried and stored upto 3 months. After 3 months, brittleness was maximum (+4) for sun dried blanched/unblanched mushrooms. For *Pleurotus florida*, best keeping quality was observed when sun dried unblanched mushrooms were stored. In all set of treatments, dried mushrooms showed no incidence of any disease/pest/off flavour.

Germplasm Collection and Survey & Surveillance for Diseases and Insect Pests:

During the period *Agaricus, Coprinus, Ganoderma, Pleurotus, Podaxis* and *Volvariella* spp. have been collected. During the survey of farms in Punjab, incidence of *Coprinus, Populaspora byssina,*

Scopulariopsis fimicola and *Trichoderma* was observed to cause less than 5% harm to the crop. At the verge of crop termination abiotic disorders like open veil, rose comb, scales, colour browning and stroma formation was observed along with the incidence of sciarid and phorid flies.

Transfer of Technology:

Forty (40) training courses were organized to educate farmers about the mushroom cultivation technology. Forty four (44) demonstrations and forty three (43) lectures were delivered. In addition, production linked activities and the facilities provided to the growers from the Centre were highlighted at Kisan Mela's organized at PAU campus and other regional research stations as well as KVK's in Punjab twice every year, one in September and other in the month of March. Four TV talks were delivered live at Doordarshan Kendra, Jalandhar. The staff was also actively engaged in conducting on site visits of the mushroom farms and active scientific interaction at workshops of Horticulture development officers and the mushroom scientists of India. Back up services for testing of compost and casing samples along with the supply of quality spawn was provided to the mushroom growers of Punjab and adjoining areas.

G.B. Pant University of Agriculture and Technology, Pantnagar:

White Button Mushroom (Agaricus bisporus):

Of the 15 strains of *Agaricus bisporus* evaluated during X Plan Period, the strains CM 1, 3 and 5 were the best yielders. Worked out chemical treatment of long method compost using formalin 15 ml + bavistin 0.5 gm per 10 kg compost to avoid the infestation of moulds in *Agaricus bisporus* cultivation. Spray of Veradix on the button mushroom crop beds @ 0.05% and mixing of 'Phosphotika' biofertilizer in the compost @ 1.0 and 1.5 % effectively increased the yield of *Agaricus bisporus*.

Oyster Mushroom (*Pleurotus* ssp.):

Sprays of 0.1M K_2HPO_4 and 0.1% urea resulted in higher yields of *Pleurotus sajor-caju* and *P. florida,* respectively. Standardized cultivation of *Pleurotus fossulatu* by using wheat straw as the substrate. Wheat straw supplemented with wheat bran and neem cake @ 2 & 4% significantly enhanced the yield of *Pleurotus sajor-caju*. Blue oyster mushroom (*Hypsizygus ulmarius*) was comparable with *P. florida* and *P. sajor-caju* in terms of yield. However, the pileus thickness of *H. ulmarius* was better and attractive.

Other Mushrooms:

Out of the 9 strains of *Calocybe indica* tested during X Plan Period, the strains CI 1, 7 and 2 were the best yielders. Cultivation of *Calocybe indica* was standardized using wheat straw as a substrate and FYM + spent compost + sand (2:1:1) as casing. Cultivation of *Auricularia polytricha* was standardized using sterilized rapeseed straw and wheat straw supplemented with 3% wheat bran. Standardized cultivation technology of shiitake mushroom (*Lentinula edodes*), using wheat straw supplemented with 20%saw dust and wheat bran.

Post harvest technology

Agaricus bisporus washed with potassium metabisulphite (0.02%) + EDTA (100 ppm) solution had much longer shelf life as compared to unwashed check.. The button mushroom stored using 125 gauge PP bags and kept at 5^0C temperature had no weight loss after 48 hrs.

Breeding (Station trial)

Intergeneric and interspecific hybrids (23 Nos.) of oyster and blue oyster mushrooms developed and evaluated for yield. Some of them are performing much better than respective parents.

Germplsam collection and identification

One hundred thirty nine (139) mushroom species from different locations of Uttarakhand have been collected and preserved. Out of this, 85 species were identified. Of the collected and identified mushroom isolates, five *Auricularia*, four *Pleurotus* and ten *Ganoderma* have been brought under cultivation level.

Survey and surveillance of disease and insects pest

More than 200 marginal and small scale mushroom farms located in the U.S. Nagar, Nianital and Almora districts of the Uttarakhand were surveyed and infestation of green mould (*Trichoderma*)*, Diehilomyces micosporus, Papulospera, bysinna, Verticillium fungicola*¸ Rose comb, brown discolouration have been observed. Infestation of sciarid and phorid flies was also observed in case of mushroom growing huts.

Transfer of Technology:

Seventy five (75) training programmes were organized during X Plan Period and total of 2040 trainees from Uttarakhand, U.P., M.P., Bihar etc. get trained on spawn preparation, composting, cultivation and processing of various mushrooms. Supplied 247.4 Metric Tones of compost, 351 numbers of mushroom culture tubes, 459 bottles of master spawn and 189 quintals. of commercial spawn. Organized mushroom field days and Front Line Demonstrations on Dhingri (*Pleurotus* spp.) and Milky mushroom (*Calocybe indica*) at 39 places in Nainital, U.S. Nagar and Almora districts of Uttarakhand.

N.D. University of Agriculture and Technology, Faizabad:

Cultivation Technology of White Button Mushroom (*Agaricus bisporus*), Oyster Mushroom (*Pleurotus* spp.), Milky mushroom (*Calocybe indica*) and Paddy Straw Mushroom (*Volvariella volvacea*):

We have been working for the improvements in cultivation technologies, especially on substrate capacity improvement for high productivity and casing mixture improvements for better pinhead initiation and yield. We have achieved biological efficiency up to 27.3 % in *Agaricus bisporus*, 17.8 % in *Volvariella*, 79.9 % in *Hypsizygus ulmarius*, 78.1 % in *Pleurotus florida* and 106.4 % in *Calocybe indica.* Some of these results are in the process of publication and others under further confirmation.

Post Harvest Technology:

We have been working for improvement in post harvest self life and biochemical changes during storage with especial concentration on milky mushroom. Some results are already published and others under further confirmation.

Germplasm Collection:

New records have been collected rom hills of Mirzapur and during last two years gardens, forest areas and hills of Faizabad, Sultanpur, Jaunpur, Varanasi, Mirzapur, Allahabad and Pratapgarh districts have been surveyed. A total of 106 samples were collected, out of which, 31 were *Volvariella* spp., 19 of *Termitomyces* spp., 23 of *Ganoderma* spp. 16 of *Calocybe indica* and 17 of unidentified edible mushrooms. Selected fruiting bodies were tissue cultured for further studies. It will take further few years time in the development of cultivation technologies of few identified species.

Survey and surveillance:

Cultivation of button mushroom has been influenced by the fungi like *Trichoderma viride*, *Penicillium* spp., *Coprinus* spp. and *Cladosporium cludosporioides.* Cultivation of oyster mushroom was affected by *Trichoderma* spp., *Aspergillus* spp. and *Coprinus* spp.; and bacterial infection in beds. Milky mushroom was affected by *Coprinus* spp. and *Trichoderma* spp. Occurrence of insects has although been recorded but with almost no effect on fruiting bodies.

Transfer of Technology:

Total of 15 on-campus and 15 off-campus training programs were organized in which total 760 participants participated. The mushroom cultivation technology was also demonstrated to 450 farmers of the area. Total 1845 kg of commercial mushroom spawn was supplied to the mushroom growers. Mushrooms (12.69quintal) were also sold. Seventeen (17) TV Talks were delivered. Participated in Kisan Melas organized by the University during both Kharif and Rabi seasons. Delivered lectures in Vocational Trainings for rural youth organized by KVKs.

Indira Gandhi Krishi Vishva Vidhalaya, Raipur (C.G.):

White Button Mushroom (*Agaricus bisporus*):

Strains, CM 3 and CM 7 of *Agaricus bisporus* were found superior with regards to economic yield in consecutive five years experiment trials under Chhattisgarh ecosystem.

Oyster Mushroom (*Pleurotus* spp.):

Pilot scale project on cultivation of *Pleurotus spp*. on Paddy/Wheat straw with hot water treatment produced higher yield of *P. florida.* Oyster mushroom cultivation was made popular and suitable for Chhattisgarh Region. A new variety “Indira Sweta” was identified and released by SVRC at this Centre.

Other Mushrooms: Wheat + Paddy straw substrate in ratio of 1:1 was found to be the best substrate for higher yield of *Calocybe indica* in five years study. Partially composed cotton waste was found to be the most suitable media for production of paddy straw mushroom based on consecutive five years experimentation. *Ganoderma lucidum* local strains, Chinese strains, and Udaipur strains were evaluated and attained good success.

Germplasm Collection and Survey & surveillance for diseases and Insect Pests:

Total 110 (One hundred and ten) wild fleshy fungi were collected form 16 districts of Chhattisgarh during monsoon season (2002-06) some of theme have already been deposited at gene bank, NRCM, Solan and most prominent fungi was *Termitomyces sp.* In Survey and surveillance for diseases and insects pests, *Trichoderma viride* was recorded to be the most predominant followed by *Coprinus* Sp. *Rhizoctonia solani* and *Sclerotium rolfsii* among competitors' molds of different mushroom growers and experiments.

Post Harvest Technology:

Loss in weight of fruit bodies of *Agaricus bisporus* cv CM I was considerably less when the fruiting bodies were dipped with EDTA, 500 & 200 ppm under both ambient and refrigerated conditions. *Agariucus bisporus* was preserved well for 8-10 days under refrigerated condition and only 1-2 days under ambient temperature when packed in 125 gauge thick polyethylene bags and 100 gauge thick polyethylene bags.

Transfer of Technology:

Twenty eight (28) training programs were organized (5 national & 23 state level) on Mushroom Spawn Production, Crop Production Technology, Processing Technology for the benefit of 1140 entrepreneurs, rural youths, students, farm foment/ men of Chhattisgarh during last five year. Centre participated in 24 Kisan mela/Kisan Sammelan /NSS camps. Fifty two lectures were delivered in different training programs on mushroom. Eighteen talks were delivered on Television / Radio. Two video films on different aspects of mushroom cultivation were prepared. One hundred three (103) Extension articles/News/leaf lets/folders/bulletins/compendiums were published. Mushroom pure culture/mother spawn/ pickles/fresh mushroom worth of Rs. 1, 83, 437 /- were sold from mushroom research lab during last five year. Thirty four (34) distinguished dignitaries of National and State, Governors, Council of Ministers, Officers from Central and State Government etc. visited and appreciated the activities. Seventy (70) groups of visitors visited the mushroom laboratory. Participated in exhibitions of students and farmers of different district of Chhattisgarh.

Publications: During the period 19 research articles were published, 45 research papers were presented, while a National Workshop on "Awareness Creation on Bio-diversity and Conservation of Mushrooms" from 1-2nd December, 2005 and X Biennial Workshop of AICMIP from 26-27th October, 2006 were organized. Eighteen PG Thesis were Guided. One ICAR Short course from 9-18th January, 2006 was successfully organized.

Mahatma Phule University of Agriculture and Technology, Pune:

White Button Mushroom (Agaricus bisporus):

The strain CM-7 and CM-9 recorded highest mushroom yield of 17.89 to 19.42 g/100 kg compost. In chemical pasteurization, significantly higher yield of 11.06 kg per 100 kg compost was obtained in the treatment of DDVP + Bavistin (@ 3ml+0.5 g/ 10 kg compost). Casing of button mushroom begs with Coir pith + FYM (1:1) as casing material recorded significantly higher mushroom yield of 14.56 g/100 kg compost The strain U-3 responded well to Veradix-2 (rooting hormone) spray and spray @ 0.15% gave highest button mushroom yield of 18.62g/100 kg compost The strain U-3 interacted well with Phosphotika biofertilizer and mixing of Phosphotika biofertilizer @ 1.0% in compost at the time of spawning gave significant increase in yield of button mushroom yield (15.54 g/100kg compost) over control.

Oyster Mushroom (*Pleurotus* spp.)

The supplementation treatment of Rice bran @ 4% of dry weight of substrate recorded significantly higher yield of 705 gm/kg of substrate of *P. sajor caju* and 742 gm/kg substrate of *P.florida*. Highest yield of 592g/Kg. dry straw of *P. sajor caju* and 552g/Kg dry straw of *P. florida* was recorded in control treatment i.e. water spray. Spray with 0.1M K_2HPO_4 performed well in *P. sajor caju* and gave superior mushroom yield. The blue oyster (*Hysizygus ulmarius*) yielded of 788 g/kg dry substrate and was statistically superior yielder over *P. sajor caju* (637 g/kg dry substrate) and *P. florida* (577g/kg dry substrate).

Other Mushrooms:

Out of 9 strains only 5 strains gave fruiting. Among the five fruiting strains, the strain CI-1 recorded maximum yield of 257 g/kg dry straw. Next best strain was CI-3 followed by CI-4 and CI-5. The highest fresh mushroom yield of Milky mushroom (*Calocybe indica*) was obtained in mixture of wheat + paddy straw (1:1) (i.e. 1361 g/kg dry substrate). Next best substrate treatment was paddy straw, showing 1344 g mushrooms/ kg dry substrate. The supplementation of sawdust with 20% wheat bran gave superior yield of shiitake mushroom (*Lentinula edodes*).

Post Harvest Technology:

The acceptable colour of white button mushroom was retained in treatment of 200 ppm and 75 ppm EDTA under ambient and refrigerated conditions, respectively. Both these treatment also recorded maximum reduction in weight of mushroom. At refrigerated condition treatment of 100 ppm EDTA and 100 ppm EDTA + 0.02 % KMS showed retention of good milky white colour of button up to 48 hrs. However, at ambient temperature desired colour was retained in 100 ppm EDTA +0.02% KMS treatment up to 24 hrs. Packaging of button mushroom in100 gauge PP bags with holes helped in maintaining good acceptable white colour up to 24 hrs. at ambient and refrigerated storage conditions.

Mushroom Germplasm Collection and Survey & Surveillance of Diseases and Insect Pests:

A total of 106 samples of wild fleshy fungi were collected. Out of these 35 cultures were successfully isolated in pure form. A total of 6 cultures isolated from wild fleshy fungi have been deposited to NRCM, Chambaghat, Solan (HP).The mushroom flora of Maharashtra State comprises nearly 232 species, which are distributed in 73 genera. Out of these 73 genera, 30 are reported to be edible while others are either toxic or the information regarding their edibility is not known at present. A total of 13 Button farms, 19 oyster farms and 2 Milky farms were surveyed for presence of insects and pests during the period under report.

Transfer of Technology:

Apart from basic and applied research this Centre has contributed enormously in popularization of mushroom production and consumption. The package of practices developed at the Centre have been communicated effectively to the mushroom growers through various media like extension bulletin, exhibitions, farmers rallies, visits and training. A total of 85 training's on Oyster mushroom cultivation were organized. Through this training's 1540 persons were trained. Five spawn production training's were also organized and 95 persons were trained. Under mass communication programme, 3 radio talks, 3 T.V. programs , 10 Popular articles, 12 Farmers rallies and exhibitions were arranged and published. In addition to this, this Centre has also organized five front line demonstration trials at four different places through which more than 300 poor families were benefited. During period under report 850 groups comprising of 13,000 farmers, students, scientists etc. visited this Centre. As per demand from growers good quality spawn of 5,438 Kg was supplied. As per demand from private spawn producers 80 pure culture tubes were supplied. . A core course on Mushroom production has been introduced at UG and PG levels in all Agricultural Universities in the state. Three P.G. thesis were submitted. A total of 15 research papers have been published in national level scientific journals.

Tamil Nadu Agricultural University, Coimbatore:

Tamil Nadu stands first in the total Indian mushroom production with an average annual production of more than 18,000Mt. With the sustained research, teaching and extension activities of the Department of Plant Pathology, TNAU, mushroom cultivation has become one of the promising agricultural enterprises in this state since 1983. The following varieties of tropical and temperate mushrooms, improved production techniques have been released for the farmers from time to time.

White Button mushroom (*Agaricus bisporus*):

- *Agaricus bisporus* – White – Ooty 1

Oyster mushroom (*Pleurotus* spp.):

In Oyster mushroom, *Pleurotus florida, P. eous* and *Hypsizygus ulmarius* are commercially grown in all parts of Tamil Nadu.

- *Pleurotus citrinopileatus* – Pure white - CO 1

- *P. eous* – Pink – A.P.K 1
- *P. djamor* – White – M.D.U 1
- *P. flabellatus* – White – M.D.U 2
- *P. ostreatus* – Ashy white – Ooty 1
- *P. sajor caju* – Ash – M 2
- *P. florida* – White - PF
- *Hypsizygus. ulmarius* – Bluish white – CO 2

Milky mushroom (*Calocybe indica*):

- *Calocybe indica* – Milky white – A.P.K 2

Transfer of Technology:

One day training programme was conducted (on 5th of every month) by this centre. Every month an average number of 40-50 participants attended the programme from different places of the state and even from other states also. So far 289 such programmes have been conducted and more than 20,000 people have participated in these programmes. About 620 spawn production units and more than 1400 mushroom entrepreneurs are distributed through out the state. The sustained efforts taken through All India Coordinated Mushroom Improvement Project for the production and supply of quality spawn, mother culture and stock cultures of various kinds of mushrooms and timely supply has created a strong impact on mushroom production in this state. During 2004-2005 more than 450 new entrepreneurs have been trained on small scale mushroom production. In addition intensive training on tissue culture, spawn production and large scale production of tropical mushrooms have been imparted to 37 unemployed graduates. Many satellite mushroom growing units, Self-help groups and spawn production centers have been established through out the state due to the efforts taken up by TNAU center.

Details of Extension activities (Trainings organized & Supply of Spawns)

No. of Spawn supplied : 98,095
No. of One day trainings : 289
No. of 5 days training : 28
No. of 10 days training : 2
No. of ODL trainings : 289
No. of visitors to MRTC : 2000
No of Publications :17
No of Books Published : 6

Kerala Agricultural University, Thrissur (Vellayani):

Oyster mushroom (*Pleurotus* spp.):

The experiments laid out with oyster mushrooms were fully successful. Both *Pleurotus sajor caju* and *Pleurotus florida* gave very good yield. Trials conducted with the blue oyster mushroom also gave good results but *Pleurotus sajor caju* and *Pleurotus florida* out yielded *Hypsizygus. Ulmarius,* the test species.

Milky mushroom (*Calocybe indica*):

Paddy straw alone was the substrate used for cultivation of *Calocybe indica* . C.i.– 3 strain provided by the Centre proved to be a promising variety in all the trials conducted . Nine native isolates of *Calocybe* were compared with the strains from Solan. All the local isolates proved to be better. The native isolates were also preferred because of better taste than the Solan isolates which had slight pungent taste.

Black Ear Mushroom (*Auricularia polytricha*):

After a series of attempts the Centre could standardize the cultivation of *Auricularia* on mango wood chips.

Paddy Straw Mushroom (*Volvariella volvacea*):

Trials with isolates from Solan gave poor results only except for one isolate.

Germplasm Collection and Survey & Surveillance of Diseases and Insect Pests:

Survey and collection of wild mushrooms were undertaken during the monsoon seasons in the forest areas and districts of the state. A total of 110 wild specimens have been collected and preserved in the museum. Attempts have been made to isolate pure culture from them and 21 cultures were deposited in the National Culture Bank at NRCM, Solan. These cultures are also maintained in the commercial AICRP lab. Commonly found pests were mushroom flies. Only mild to medium level infestation (5 to 20 %) were noticed. No disease could be noticed in any of the localities. The use of blue and yellow light traps in growing houses to ward off flies and observing complete hygienic conditions in and around the growing houses were recommended to tackle pest problem of the region.

Transfer of Technology: Two TOT seminars conducted in the Centre in which both beginners and progressive mushroom cultivators from all over the state participated and they have expressed their experiences in the field of mushroom production. Training on mushroom cultivation was given to VHSE students, unemployed men, women, senior citizens, residents association members etc. More 5000 participants have attended the regular training conducted in the department during the period. 25,000 spawn have been distributed to farmers. The staff of the Centre have actively participated in seminars, mushroom melas, workshops and won prize in the recipe competition. The staff of the Centre has participated in the biennial meeting held in 2002, 2004 and 2006 and presented the report of work conducted in the Centre. A book on “Mushroom recipes” authored by Dr. Lulu Das, a scientist of the Centre was released in the 2002 meeting. One book in regional language was published by the Mushroom Growers Association of Kerala authored by Dr. B. Balakrishnan and Dr. Lulu Das. The scientists of the Centre participated in more than 100 seminars organized by various agencies in the region and presented papers. The staff of the Centre participated in Mushroom Growers meet and Mushroom Mela at TBGRI and exhibition arranged by the Centre.

Technologies developed in the Centre:

Following technologies were developed at the Centre:

1) A suitable method of cultivation of *Calocybe* using the spent mushroom substrate of oyster mushroom has been developed in the Vellayani Centre.

2) A simple technique namely stapler method – a modified spawn production technique has been perfected.

3) A cultivation technique for *Auricularia polytricha* using mango wood chips as substrate has been standardized in the Centre.

Horticulture and Agro forestry Research Project: Ranchi:

Oyster mushroom (*Pleurotus* spp.):

- The experiment was conducted for two years (2003 and 2004) with three species of *Pleurotus* viz, *P. florida*, *P.sajor-caju* and *P.ostreatus* The data revealed that supplementation with wheat bran @2% enhanced the yield significantly in *P. florida* (48.3%), *P sajor-caju* (44.9%) and in *P. ostreatus* (48.1%) over control. Based on above result it is recommended that wheat bran @2% (w/w) supplementation in the paddy–straw substrate may be used in cultivation of oyster mushroom for higher yield and profit.
- Paddy Straw Mushroom (*Volvariella volvacea*): Based on 2005 and 2006, the mean five strains viz; VV1,VV 4, VV-6, VV-7 and OE 112 of paddy straw mushroom (*Volvariella volvacea*) were tested during April – May,2005 and 2006 The data revealed that the strain VV7,VV6 and OE112 were performing better than other strains which resulted in biological efficiency (BE) of 13.88%,11.29% and 8.06 %, respectively which indicated these strain can be cultivated successfully in summer and monsoon months.
- Strain evaluation of Milky mushroom (*Calocybe indica*): Based on 2005 and 2006, the mean BE of milky mushroom was 84.5%. The maximum BE was found in strain CI-6 (107%) followed by CI-7 (88.9%), CI-1 (80.2%), CI-3 (73.8%) and APK2 (72.8%). All strains performed better than others strains. However, the strain CI-6 and CI-7 were at par but significantly superior than other strains. Thus CI-6, CI-7 and APK-2 were better suited strains in respect to fruit quality and yield for cultivation of milky mushroom (*Calocybe indica*) in Jharkhand in summer months. Among them CI 6 was the best one.

Germplasm Collection:

The survey was done in the monsoon season of 2003 and 2004. The following fleshy fungi were collected and wet preserved.

Common Name	**Scientific Name**
Oyster mushroom	*Pleurotus* sp
Bada Khukhri	*Macrolapiota* sp Rugra *Lycoperdon* sp
Button mushroom	*Agaricus* spp Jamum Kukri *Boletus* spp

Milky mushroom	*Calocybe* spp
Reishi Mushroom	*Ganoderma* sp

Transfer of Technology: During five years (2002-03 to 2006-07) a total of 144.45 quintal of spawn for oyster mushroom was made available to interested mushroom growers of Jharkhand and other states. The 500 farmers are growing oyster mushroom in the state. Various training programmes were conducted by various organizations to popularize mushroom cultivation in the State. Holy Cross Krishi Vigyan Kendra, Hazaribagh conducted training and trained a total of 2448 number of farmers in Bihar (Anonymous, 2001-02 to 2004-05). After creation of Jharkhand in 2000 several other organizations have also trained the farmers. It has been reported by SAMETI (2004) that ATMA, Palamau trained several various tribal women and organized them in 10 groups. A number of farmers were trained by HARP (1860), SRI (152) (Anonymous, 2003-04) and RK Mission (357) (Anonymous, 2005). A mushroom Divas was organized by HARP on 24th Oct. 2003 to popularize mushroom cultivation in Jharkhand in which various interested mushroom growers participants.

ICAR Research Complex for NEH Region, Barapani (Meghalaya)

White Button Mushroom (*Agaricus bisporus*):

High yielding strain CM-14 of *Agaricus bisporus* was identified. Chemical pasteurization of long method compost with DDVP + Formalin gave excellent results with respect to button mushroom yield and diseases management.

Oyster Mushroom (*Pleurotus* spp.):

Supplementation of oyster mushroom substrate with organic Nitrogen rich supplements and supplementation with 5% rice bran promoted oyster mushroom yield by 40%. *Pleurotus florida* out yielded blue oyster mushroom *Hypsizygus ulmarius*. Spraying of *Pleurotus florida* bags with 0.1% urea gave higher mushroom yield. Blue oyster mushroom *Hypsizygus ulmarius* gave good mushroom yield.

Other Mushrooms:

Worked on strainal evaluation of paddy straw mushroom *Volvariella volvacea* and 4 high yielding strains were identified with more than 15% biological efficiency. Out of 7 strains strain VV-06 gave highest yield.

Germplasm Collection: Reported some new specimens of wild edible mushrooms.

Transfer of Technology: Organized training programmes for unemployment youths.

Dr. Y.S.Parmar Univ. of Horticulture and Forestry, Nauni, Solan (Cooperating Centre)

White Button Mushroom (*Agaricus bisporus*):

- Studies were carried out on microbial dynamics in supplemented substrate and its effect on mushroom yield. *Penicillium* spp. dominated in cotton seed meal, cotton seed cake and sesame meal supplemented substrates followed by *Rhizopus nigricans* and *Mucor racemosus*. Among bacteria *Pseudomonas* spp. dominated all the supplemented substrates. The microbial population increased gradually with time and was highest on 20th day of spawning. Higheast button mushroom yield of 21.64 kg/100kg compost was recorded in cotton seed meal supplemented substrate. Different supplements also stimulated the growth of different fungi in compost and affected the mushroom yield. Highest yield loss was recorded due to *Sepedonium chrysospermum* resulted because of addition of 2% peptone in the substrate.
- Inoculation of thermophilic fungi in compost at the time of spawning also enhanced the button mushroom yield and the combined inoculum of three fungi viz, *Scytalidium thermophilum*, *Gilmaniella Humicola* and *Thermomyces lanuginosus* gave highest mushroom yield of 22.75 kg/100kg compost about 21.30 % increase of the control. Different casing materials were also evaluated alone and in their different combinations. Among these the Farm Yard Manure alone and its combination with leached vermicompost and 3 years old spent compost gave highest mushroom yield. A new composting process was also developed which gave mushroom yield of 23.9 to 24.9 kg/100kg compost in 3 evaluation trails with a yield enhancement of about 19 to 24% over the traditional method.

All India Coordinated Research Project on Palms

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

2. **Name and Address of the Project Coordinator** : **Dr. S. Arulraj,**
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3. **Research Achievements (New varieties/Technologies Developed/validated and being practiced in the last five years) (2002-2007):**

Achievements at a glance

- In coconut, four cultivars and ten hybrids have been released based on their performance at different locations for commercial cultivation in the respective States.
- In addition to the released cultivars and hybrids, a few types are in the final stages of evaluation at different locations. In the East Coast of Tamil Nadu, the WCT and Andaman Ordinary are performing well. In the Maharashtra coast at Ratnagiri, Laccadive Ordinary, Pratap and Kerasankara have shown stable performance as suitable varieties of the tract. At Ambajipeta, Philippines Ordinary is performing well.
- In West Bengal, Jamaica Tall and in Assam, Assam Green Tall (Kamrupa) are suggested for commercial cultivation.
- The hybrids showing promise in different centres include WCT x GBGD, COD x WCT and WCT x COD.
- Three arecanut cultivars were released for cultivation based on multilocation trials.
- Nutritional requirements for D x T hybrids for each agro-climatic zone have been worked out.
- Recommendation on biomass recycling within the system and the use of low cost technologies on lignin degrading fungi/use of epigeic earthworms were offered for commercial exploitation.
- Nutrient management techniques for littoral sandy soils of West Coast region have been standardized.
- Irrigation schedule based on evaporation demand (Eo) has been standardized for interior and coastal regions of Tamil Nadu and Konkan coast of Maharashtra.
- Successful and economically viable coconut based cropping systems have been identified for different states. In general, nut yield increased in mixed cropping compared with monocrop of coconut. The net profit under Coconut Based Cropping Systems was reported between Rs.50,000 to Rs.1,65,000 per hectare.

- Plant protection packages for the management of basal stem rot, leaf eating caterpillar, red weevil and rhinoceros beetle have been developed.
- Fertilizer and irrigation requirements for oil palm in major states have been worked out.
- Promising germplasm types in palmyrah available in Andhra Pradesh and Tamil Nadu States were collected and a genebank has been established.
- Plant protection recommendation for the management of tuber rot disease of palmyrah has been developed.

New Varieties/Technologies Developed/Validated and being practiced in the Last Five Years.

1.Coconut varieties/hybrids recommended for large scale cultivation in the respective region

- Ratnagiri (Maharashtra): Laccadive Ordinary (LO)
- Veppankulam (Tamil Nadu) : COC x PHOT
- Aliyarnagar (Tamil Nadu): Philippines Ordinary, WCT x COD, WCT x GBGD, COD x WCT - These hybrids/varieties have already been released from CPCRI and hence these types can be recommended for the region.
- Kahikuchi (Assam): MYD x WCT

2. Crop Management recommendations

- A fertilizer dose of 500:500:2000 gm NPK/palm/year is recommended for DxT hybrids in Assam State.
- 500:250:1000 gm NPK/palm/year is recommended for hybrid coconut in West Bengal state.
- 1000:500:2000 gm NPK/palm/year is recommended for hybrid coconut in Maharashtra state.
- 1000:500:2000gm NPK/ palm/year is to be recommended for hybrid coconut in coastal Tamil Nadu.
- As a component of drip irrigation schedule, in summer months, 65 litres of water/ palm/ day may be recommended for interior region in Tamil Nadu.
- A combination of 50% composted coir pith along with 50% recommended dose of fertilizers could be recommended as the INM package for interior Tamil Nadu region, coastal Andhra Pradesh and maidan tract of Karnataka.

Crop Protection recommendations

- Seed nut soaking in *T. viride* combined with soil application of neem cake to be popularized as a tuber rot disease management practice in palmyrah.
- While taking prophylactic spraying for bud rot disease in coconut, it is essential that the palmyrah palms available near the coconut field also are to be treated to prevent the incidence of bud rot disease.

All India Coordinated Research Project on Spices

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

Improved varieties recommended through AICRPS

Spices	Total No.	Varieties
Black pepper	7	Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Panniyur-6, Panniyur-7
Cardamom	10	Mudigere 1, Mudigere 2, PV-1, ICRI-1, ICRI-2, ICRI-3, ICRI-4, PV-2, ICRI-5 (hybrid), ICRI-6
Ginger	4	Suprabha, Suruchi, Suravi, Himgiri
Mango ginger	1	Amba
Turmeric	8	CO-1, BSR-1, BSR-2, Roma, Suroma, Ranga, Rasmi, Suranjana
Cinnamon	3	YCD-1, PP(Ci) – 1, Konkan Tej
Nutmeg	1	Konkan Sugandha
Coriander	22	CO. 1, CO. 2, CO. 3, CS-287, Guj. Coriander-1, Guj. Coriander-2, Rajendra Swathi, RCr-41, Sadhana, Swathi, Sindhu, RCr-20, RCr-435, RCr-436, RCr-684, Hisar Anand, UD-446, Hisar Sugandh, Hisar Surabhi, RCr-480, Hisar Surabhi, Sudha
Cumin	9	Guj. Cumin-1, Guj. Cumin-2, Guj. Cumin-3, RZ-19, MC- 43, S-404, RZ-223, RZ-341, Gujarat Cumin - 4

Fennel	10	PF-35, Guj. Fennel-1, Guj. Fennel-2, CO.1, RF-101, Rajendra Sourabha, Gujarat Fennel-11, Hisar Swarup, RF- 143, RF-178
Fenugreek	15	CO. 1, CO. 2, Rajendra Kanti, RMt-1, Lam Sel. -1, Hisar Sonali, Guj. Methi-1, RMt-303, Rajendra Khushba, Hisar Suvarna, Hisar Madhavi, Hisar Mukta, RMt-305, RMt-351, Gujarat Methi -2
Total	90	

Improved technologies developed through AICRPS

Black Pepper

- The AICRPS centers holds 612 accessions in black pepper.
- Under inter-varietal hybridization programme the hybrid Karimunda x Panniyur-5 produced the highest yield of 4.2 kg berries/vine.
- In black pepper – arecanut mixed cropping system, irrigation with 20 l/ vine/day and fertilizer dose of NPK 100:40:140g/vine recorded highest yield (2.69 kg/vine).
- Under drip irrigation trial, irrigation at 2 l/day increased the yield and among the varieties, Panniyur-5 responded positively and recorded highest yield (2.08 kg/ha).
- Addition of traditional nutrient sources like burnt earth (10 kg) and wood ash (2 kg) along with FYM (10 kg) was promising in increasing black pepper yield (6.43 kg berries/vine).
- Inclusion of *Azospirillum* & Phosphobacteria separately or in combination with recommended inorganic fertilizer enhanced the yield in black pepper.
- Application of inorganic nitrogen 100% + *Azospirillum* (50g/vine)/ P-solubilizer (50g/vine) + 10kg FYM gave maximum yield of 4.84 kg/vine with *Azospirillum* application and 6.0 kg/ha. with P-solubilizers.
- Planting of black pepper cutting in solarized potting mixture fortified with *Trichoderma harzianum* @ 1 g/kg and VAM @ 100 cc/kg of soil was found effective for the management of *Phytophthora* infection and is ideal for production of healthy rooted cutting.
- Application of metalaxyl gold MZ (2.58/l) (2.5g/l) and *T. harzianum* (50g/vine) and neem cake (1 kg) was effective for controlling black pepper *Phytophthora* foot rot disease in the field.
- Spraying and drenching with Bordeaux mixture (1.0%) during May/June and July/August was also effective.
- The anthracnose disease in black pepper was maximum at higher elevations and could be controlled by spraying combination of fungicide containing both carbendazim & mancozeb @ 0.1% as foliar spray thrice during the last week of May, July and August.
- Spraying of monocrotophos (0.05%) was effective for the management of scale insects in black pepper at high altitudes.

Cardamom

- The centers hold 273 cardamom accessions.
- Two varieties in cardamom ICRI-5 (1543 kg/ha) and ICRI-6 (1200 kg/ha) have been identified for release from ICRI (Spices Board), Myladumpara.
- Studies on the possibility of supplementing the biofertilizer with inorganic fertilizer in cardamom production revealed that inclusion of *Azospirillum* & Phosphobacteria separately or in combination with recommended inorganic fertilizer enhanced the cardamom yield.
- Inorganic nitrogen (100%) + *Azospirillum* +FYM –5 kg/plant recorded maximum yield of 213.24 kg dry capsule /ha and inorganic P (100%) + P. solubilizers 50g +FYM 5 kg/plant gave higher yield of 220.32 kg dry capsule/ha.
- Cardamom root grub can be checked effectively by drenching with imidacloprid (0.75 ml/l) or chlorpyriphos (0.07%) and maximum yield 412 g/plant and highest B: C ratio (1:1.65) could be realized.

Ginger

- The centers maintain 603 accessions in ginger. Accessions V_1E_8-8, V_2E_5-2, & Turai local (Pottangi) Gorubathan (Pundibari) were found promising in respect of yield.
- Application of inorganic N 100% + *Azospirillum* 50g/bed +5kg FYM recorded maximum yield of 31.46 t/ha. in ginger.
- Application of *Azospirillum* (50g) along with recommended fertilizer schedule proved better in augmenting ginger yield.
- Application of zinc sulphate @ 25.0 kg/ha produced maximum ginger yield (20.27t/ha).
- Rhizome rot of ginger was controlled by pre-treating the seed rhizomes in hot water at 51^{o}C for 10 min. and *T. harzianum* mixed with neem cake for 30 minutes before planting the rhizomes.

Turmeric

- The centers hold 1332 germplasm accessions.
- Turmeric PTS-11, PTS-39 (Pottangi) NDH-18 (Kumarganj) RH-5, JTS-72, JTS-314, JTS-612 (Jagtial) T-1 (Raigarh) CL-101 (Coimbatore).
- R H 9190 (Dholi) TCP-11 (Pundibari) were promising.
- Application of NPK 125: 60:90 kg/ha +FYM 10t/ha +*T.viride* + *Pseudomonas fluorescens* @ 4g kg/ha as seed treatment and *T. viride + P. fluorescens* applied to soil (12.5kg & 25.0 kg/ha) as basal and top dressing respectively resulted in higher yield (28.60 t/ha) with lowest rhizome rot incidence .
- In turmeric higher yield could be obtained by applying inorganic nitrogen 75% +*Azospirillum* 5 kg/ha + FYM 5 t/ha.
- Application of organic inputs viz. FYM 10 kg, *Pongamia* cake 250 g, sterameal 250 g, rock phosphate 500g, wood ash 250g per 3 m^2 bed produced turmeric yield of 6.71 kg/3m^2 compared to 7.76 kg/3m^2 with application of inorganic materials.

- Foliar disease, *viz*. leaf spot and leaf blotch could be effectively controlled by application of mancozeb + carbendazim (0.2%) as seed treatment and 2-3 foliar sprays (0.3%).

Tree Spices

- The centers maintain a total of 202 tree spices accessions (in clove, nutmeg & cinnamon).
- Soft wood grafting techniques in nutmeg is successful. October-March was found to be most congenial particularly January month with highest success of 68.33%.

Seed Spices

Coriander

- The centers maintain 1736 coriander accessions including 128 exotic accessions.
- Coriander LCC-174, LCC-128 (Guntur) K. selection (Kumarganj) DH-205 (Hisar) were found promising.
- Coriander varieties Hisar Surabhi from HAU, Hisar which given an yield of 1800-2000 kg/ha; RCr-480 from Jobner yielding 1325 kg/ha; Sudha from Guntur yields 1200-1500 kg/ha (under irrigation) were identified for release.
- In coriander, micronutrient spray viz. Zn SO4 + FeSO4 + Cu SO4 +Mn SO4 (each at 0.5%) recorded higher yield (940 kg/ha).
- Application of 100 % inorganic nitrogen + *Azospirillum* @ 1.5 kg/ha + 5 t FYM /ha resulted in maximum seed yield (3.45 t/ha).
- Spraying of bioregulator Triacontanol @ 0.5% thrice at 40, 60 and 80 days after sowing significantly increased the yield 1.46 t/ha.
- Similarly spraying of NAA 10 ppm, twice at 40, & 60 days after sowing gave maximum yield.
- Application of *T. harzianum* as seed treatment as well as soil application recorded maximum yield and minimum incidence of wilt in coriander. Seed treatment with *P. fluorescens* @ 10 g/kg + soil application of *P. fluorescens* @ 5 kg /ha is an effective biocontrol agent for coriander wilt.
- Powdery mildew could be managed by applying carbendazim as soil drench and spray (0.01%) as well as spraying of neem seed kernel extract (NSKE 5%) thrice.

Cumin

- The centers hold 621 accessions including 13 exotic ones. In Cumin, UC-310, JC-2002-22 (Jobner) were identified as promising.
- Cumin varieties viz. RZ-223 (600 kg/ha) and RZ-341 (405 kg/ha) from Jobner, Gujarat cumin -4 from Jagudan which yields 1250 kg/ha were identified for release.
- Application of 100% in organic nitrogen + *Azospirillum* @ 1.5 kg/ha as seed treatment + 5 t FYM /ha resulted in maximum seed in cumin (320kg/ha) with maximum B: C ratio (1:39).
- In cumin maximum yield was obtained by controlling blight and wilt disease with application of mancozeb @ 0.25% at 40, 50,60 and 70 days after sowing.

- For the control of aphids in cumin two sprays of monocrotophos and acephate were found effective.
- Application of *Trichoderma* +FYM and spraying with Mancozeb @ 0.25% reduced wilt incidence to 5% and recorded seed yield of 308 kg/ha.
- Wilt resistant variety of cumin-GC-4 (Gujarat cumin-4) developed by AICRP Jagudan Centre has been identified for release.

Fennel

- Four hundred and eighty five accessions including 24 exotic accessions were maintained at centers.
- Fennel UF-177 (Jobner) J. Fen-210 (Kumarganj) HF-116 (Hisar) JF-332 (Jagudan) were identified as promising.
- Fennel varieties identified for release are RF-178 (1600 kg/ha) and RF-143 (1200 kg/ha) from Jobner, Gujarat Fennel-11 from Jagudan (2489 kg/ha). Hisar Swarup from Hisar (1600-1800 kg/ha).
- Application of 100% inorganic N + *Azospirillum* @ 1.5 kg/ha + 5t FYM/ha resulted in maximum yield in fennel (1.16 t/ha).

Fenugreek

- A total of 1119 fenugreek accessions including 12 exotic accessions were maintained at the centers.
- UF-351, UF-352 (Jobner) J.F-244 (Guntur) HM-114 (Kumarganj) HM-292 (Hisar) JF-270 (Coimbatore), HM-444 (Dholi) J.Fenu.239 (Jagudan) are identified for further testing.
- Fenugreek RMt-351 (1840 kg/ha) and RMt-305 (1300 kg/ha) from Jobner, Guj.Methi-2 (1920 kg/ha) from Jagudan were identified as promising varieties for release.
- Application of 100% inorganic N alone give the highest yield of 1. 256 t/ha in the inorganic fertilizer trial supplementing biofertilizer.
- Carbendazim as soil treatment alone or along with soil drenching proved highly effective against root rot in fenugreek.
- Soil application of *T. viride* (5 kg/ha) +neem cake (150 kg/ha) also recommend for checking the root rot disease incidence.

All India Coordinated Research Project on Tropical Fruits

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

NEW VARIETIES

- Khagzi lime clone-PDKV lime has been released by Akola centre.
- Balaji acid lime - released by Tirupati centre.
- The spindle shaped sapota identified at Periyakulam from an open pollinated progeny of PKM-1 has been released as PKM-4.

PROMISING GENOTYPES IDENTIFIED

CITRUS		
	Centre	*Promising genotypes*
Acid lime	Rahuri	RHR-L-124 and RHR-L-122
Khasi mandarin	Tinsukia	CRS – 4
Sweet orange	Rahuri	Selection-2, 4 and Nucellar mosambi
	Tirupati	Kodur Sathgudi and Himakuntla selection-1

BANANA	
Promising genotypes	*Characters (Name of the centre)*
Manjeri Nendran-II	Tolerant to Sigatoka and high yield (Kannara)

KBS-4	Dessert type selected from agency areas (hill tracts) of A.P. (Kovvur)
KBS-8	Kovvur selection from Dwarf Cavendish for heavy bunch weight (Kovvur)
Kanthali clone-1 & 2	Mohanpur selection
NPH-02-01	Hybrid tolerant to *Fusarium* and nematode (Coimbatore)
H-212 & H-96/1	Tolerant to nematode (Coimbatore)

JACKFRUIT	
Suitability	Number of clones
For all purposes (table purpose, chip making and culinary purpose)	Two clones
Table purpose	Nine clones
Chips	Four clones
Culinary purpose	Two clones

Technologies Developed/Validated and being Practiced in the Last Five Years

- Based on rootstock trial in sweet orange (or mosambi) at Rahuri, Rangapur lime strain Marmalade orange has been recommended as most suitable rootstock. At Tirupati also, Rangpur lime has been recommended as the most suitable rootstock for Sathgudi.
- In acid lime plant spacing of 6 x 6m is ideal for superior quality fruit production having less pest and disease problem though the yield was less than 6 x 3m spacing.
- Variety specific planting density has been developed for banana and sapota & is as under:

BANANA	
Variety	Planting Density
Nendran	2 x 3m with 3 suckers/pit (5000 plants/ha)
Robusta	1.8 x 3.6m with 3 suckers/pit (4630 plants/ha)
Grand Naine	2 x 3m with 3 suckers/pit (5000 plants/ha)
Basrai	2 x 3m with 3 suckers/pit (5000 plants/ha)
Tellachakkerakeli, Malbhog and Rasthali	1.2 x 1.2 x 2 (5208 plants/ha)

SAPOTA	
PKM-1 sapota at Periyakulam	8x4m (312 plants/ha)
Kalipatti at Kovvur	5.0 x 5.0m (400 plants/ha) young orchard

- Planting of banana from March to May, June and February were found ideal under Assam, Kovvur and Mohanpur conditions, respectively. While planting of Nendran is remunerative during all the seasons under Kannara conditions, however, planting during October is remunerative with an eye on production during off-season and exports.
- A fertilizer dose of 600g N, 225-300g P_2O_5, 450-600 g K_2O with 7.5 to 15kg neemcake in sweet orange at Tirupati and acid lime at Periyakulam, Rahuri and Tirupati and Khasi mandarin at Tinsukia has been recommended.
- For sweet orange at Tirupati, application of 800 g N (50% as urea, 25% as FYM and 25% as oil cakes) along with 200 g P_2O_5 and 400 K_2O / plant / year can also be recommended.
- Foliar application of 1 to 2% of 13: 0: 46 N: P_2O_5 : K_2O fertilizer mix or 2% potassium nitrate may be resorted to improve fruit size and yield of Kinnow mandarin at Ludhiana and Khasi mandarin at Tinsukia.
- At Arabhavi, application of N and K (200 g each) in 6 splits can be recommended for Rajapuri banana (AAB).
- In banana application of 75 per cent recommended dose of fertilizer (RDF-200g each of N and K_2O per plant per year) at Arabhavi (Robusta), Jalgaon (Grand Naine) and Kannara (Robusta) and 50 per cent RDF at Kovvur through drip was sufficient for Karpura Chakkerakeli (AAB, Mysore).
- In papaya application of 75 per cent recommended dose of fertilizer (RDF-50g each of N and K_2O per plant per year) at Coimbatore for CO.2 recorded higher yield.
- Application of copper oxychloride (0.3%) and 2, 4 – D (10 ppm) resulted in higher fruit retention and yield of Kinnow mandarin at Ludhiana over a two year period. This treatment also provided higher benefit: cost ratio and the technology could be passed on to the growers for adoption.
- Effective weed control in Rajapuri banana was observed by growing double crop of cowpea and its incorporation into the soil.
- The best crop sequence in banana as intercrops are onion at Arabhavi Knolkhol and elephant foot yam at Jorhat, cowpea at Jalgaon, *Amorphophallus* and Colocasia at Kovvur and cabbage at Mohanpur.
- Blackfly in citrus was effectively controlled by spray of acephate (0.1125%) or imidacloprid (0.005%) or releases of 4 to 6 eggs per shoot of *Mallada boninensis* during *Hasta bahar* under Maharashtra conditions has been found to be effective.
- Neem based insecticide azadirachtin 1% at 5 ml per litre spray on the pseudo stem + chopped pseudo stem is very effective for the IPM of pseudo stem borer of banana (*Odoiporus longicollis*).
- Application of carbosulfan (0.05%) or fenobucarb (0.1%) or Polytrin-C (0.044%) or profenophos (0.075%) or acephate (0.1125%) or endosulfan (0.07%) when sprayed three times at 15 days interval contributed maximum reduction of incidence of leaf webber, bud worm and fruit flies in sapota.
- For the nematode management in papaya combined application of neem cake (250g) + carbofuran 3G (1g ai/plant) + *Pseudomonas fluorescens* (4 g) has been recommended.

- Metalaxyl MZ as soil drench (0.2%) and Al Fosetyl (0.2%) as foliar spray can be recommended for management of *Phytothora* problem of citrus in existing orchards. Bordeaux paste applied to the trunk can be an additional measure.
- Pruning of dried twigs followed by three sprays of carbendazim (0.1%) and copper cxychloride (0.3%) has been recommended for the control of twig blight in citrus.
- For the control of stem end rot of citrus, three pre harvest sprays of carbendazim (0.1%) or thiophanate methyl (0.1%) was effective (last spray may be given 15 days before harvest).
- Sigatoka leaf spot of banana can be effectively controlled with sprays of mancozeb (0.2%) or tridemorph (0.1%) or tebuconazole (0.1%).

All India Coordinated Research Project on Betelvine

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

Present status and benefited accrued to the beneficiaries

- This project has succeeded in creating awareness among the betelvine growers/farmers with latest technologies in betelvine cultivation. Several promising accessions were identified, and some are in the pipeline for release and these varieties are to be tested in different agroclimatic zones.
- This project has also formulated need based and action based new research programmes for meeting the future targets and challenges.
- The execution of improved production technologies are to be transferred to farmers by means of demonstration trial, field visits, training etc.

Germplasm maintained at different centres of AINRP-B and are being used when required for experimentation purposes on sustainable basis.

i) Development of hybrids through traditional breeding technique

- Hybrid seeds are produced with 29 different cross combinations. Fruit set was observed in all crosses. Seeds are being collected after ripening of fruits.Field evaluation of hybrids at various centres showed that GN1 hybrid produced marketable leaves and other three hybrids showed hybrid depression.

ii) Development of suitable and cost effective eco-safe package of cultivation

a) Application of *Trichoderma viride* and its rhizosphere competence

- Rhizosphere survival of *T viride* was recorded with maximum population of approx. 80 x 10^3 cfu/g at 80 days after application.

b) Standardization of mass multiplication of *Trichoderma viride:*

- Fifty to sixty gram inoculums of *T. viride* was found to produce highest spore production. Ground nut oil cake/mustard oil cake was favorable for multiplication of the fungus.

c) Application of biofertilizers:

- Application of different biofertilizers did not significantly influence the growth and yield of betelvine. The soil nutrient status and nutrient uptake by betelvine improved significantly by the application of biofertilizers with organic manures.

iii) Optimising the plant population

- Results of experiment conducted under open system of cultivation showed that 1.25 lakh population at ANGRAU, 1.75 lakh at JNKV, 2 lakh at OUAT and 75000 per hactare at TNAU were optimum for higher leaf yield. Disease pressure was found increasing as poulation increased in almost all the centers.

iv) Drip irrigation in betelvine:

- Results showed that although 125% replenishment of pan evaporation rate through drip produced highest leaf yield (105.97 lakh/ha). The incidence of disease viz. foot rot was less observed in application of through drip irrigation treatment while in surface irrigation treatment incidence of foot rot was (46.55 %).

v) Epidemiological study and forecasting of major diseases

a) Epidemiology of phytophthora foot rot:

- The disease occurrence was at maximum from November to February at Bapatla (ANGARU), multiple regression analysis of weather data and *Phytophthora* foot rot disease indicated that all weather parameters could collectively influence the disease incidence to an extent of 61.11%. The effect of minimum temperature on the disease incidence to an extent of 47.78%
- The minimum temperature and relative humidity are positively correlated with the disease incidence at Sirughamani,(TNAU).

b) Phytophthora leaf rot disease

- The important contributing environmental components for disease incidence were maximum relative humidity above 90 per cent and minimum temperature 25.2 to 28.1^{0}C which prevailed during the period seems to have accounted for 18.3 and 10.3%, respectively of the total variation in disease incidence at Pusa (RAU)

C) Epidemiology of bacterial leaf Blight

- Minimum temperature and rainfall had positive correlation

d) Epidemiology of bacterial leaf spot

- The minimum temperature and relative humidity are positively correlated with the disease incidence.
- Epidemiology of anthracnose
- Minimum temperature, high relative humidity at evenings and more number of rainy days is positively correlated with disease incidence.

vi) Development of integrated package of crop management

- Integrated crop management (IPM+INM) package of betelvine
- The integrated crop management package has been developed by eight centres for their respective regions.
- Best plant population + 200 kg nitrogen in splits in organic form + 100 kg P_2O_5 + 100 kg K_2O + irrigation 100% replenishment of CPE + 4 application of Trichoderma + Sanitation has been found to show better growth, yield attributes and high organic carbon content in soil compared to other treatments.

vii) IPM of Root knot nematode

- The results revealed that the application of oil cakes + carbofuran + three or four inoculations of *P. lilacinus* inoculated oil cakes showed best control of root knot nematode and increased leaf yield compared to other treatments.

viii) Management of insect pests

- Application of NSKE 5% spray 3 times + NSKE 5% drench 3 times or application of *Beauveria bassiana* 5gms/lit containing 1.8 x 10^6 spores/gm recorded higher mean plan height, stem girth and lower number of grubs per plant there by effectively checking the incidence of stem weevil of live support of Betelvine (sesbania)