



## **SYMSAC-1**

*(Symposium on Spices and Aromatic Crops)*

# **COMMERCIALIZATION OF SPICES, MEDICINAL AND AROMATIC CROPS**

1-2 November 2004

## **Abstracts of Papers**



**Indian Society for Spices**

IISR, Calicut - 673 012, Kerala

**Indian Institute of Spices Research**

Calicut - 673 012, Kerala



*In collaboration with*  
**ICAR, New Delhi**

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#### Session 1

### BIODIVERSITY, CONVENTIONAL BREEDING AND BIOTECHNOLOGY

## Oral Presentations

### 1

#### Breeding minor group of seed spices - important milestones

S K Malhotra & B B Vashishtha

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The minor seed spice crops viz., ajowan (*Trachyspermum ammi* Sprague), dill (*Anethum graveolens* L., *Anethum sowa* Kurz.), nigella (*Nigella sativa* L.), celery (*Apium graveolens* L.), caraway (*Carum carvi* L.) and anise (*Pimpinella anisum* L.) have not received serious attention for crop improvement work in the past. Realizing the importance and strength of these seed spices, we initiated breeding work on these crops. The centre has developed five varieties consisting of two ajowan (NRCSS-AA-1, NRCSS-AA-2), two dill (NRCSS-AD-1, NRCSS-AD-2) and one nigella ((NRCSS-AN-1). All the five varieties were developed through selection and identified for release in XVII, Workshop of AICRP on Spices. The ajowan varieties, NRCSS-AA-1 and NRCSS-AA-2 are suitable for both irrigated and rainfed farming systems. The dill variety, NRCSS-AD-1 is the first European type apioleless variety of India, whereas, NRCSS-AD-2 is the first improved Indian type of variety with compact seeds identified for rainfed and limited available water conditions. The first approved nigella variety, NRCSS-AN-01 is suitable for cultivation under semi-arid conditions. Suitable selections A Cel-1-10 of celery, A Car-1-94 of caraway and A-An-01-2 of anise have also been developed and are progressively improved for their acclimatization in the semi-arid regions.



**Poster Presentations****4****Genetic variability in turmeric germplasm**

R Kumar, V P Pandey &amp; Anil Dwevedi

Department of Vegetable Science  
N.D. University of Agriculture and Technology  
Kumarganj, Faizabad-224 229 (UP)

Thirty-three accessions of turmeric (*Curcuma longa* L.) along with 'Rajendra Sonia' used as a local check were evaluated during 2003-04. Significant differences were observed for all the characters with high heritability. Rhizome yield, weight of fresh rhizome/ plant, plant height and days to maturity showed high heritability with high genetic advance, whereas, oleoresin, moisture & dry matter contents and plant girth exhibited high heritability along with low genetic advance. Therefore, the selection of parents on the basis of weight of fresh rhizome per plant, plant height and days to maturity will be more effective for crop improvement. However, path analysis indicated that weight of fresh rhizome per plant, length of secondary rhizome and number of leaves/ plant should be given more emphasis during selection for high rhizome yield.

**5****Comparative performance of turmeric genotypes in Eastern Uttar Pradesh**

V P Pandey, J Dixit, R P Saxena &amp; R K Gupta

Department of Vegetable Science  
N D University of Agriculture & Technology  
Kumarganj, Faizabad- 224 229 (UP)

Seventeen genotypes of turmeric received from different centers of AICRP on spices were evaluated during 2000-04. During the year 2003-

04, maximum fresh rhizome yield of 34.76 t/ha was obtained in NDH-18 followed by NDH-14 (34.11 t/ha), Rajendra Sonia (30.66 t/ha) and ACC-593 (29.72 t/ha). Variation in plant height ranged between 54.66 cm (TCP-11) and 123.56 cm (ACC-585). Maximum number of tillers was observed in ACC-585 (2.20) and minimum in TCP- 11 (1.20). PTS-52 took maximum days (272.33) to mature, whereas R.Sonia took minimum 201.66 days to mature. Four years pooled analysis data showed that the maximum fresh weight of turmeric rhizomes was obtained in NDH-18 (40.17 t/ha) and minimum in ACC-584.

**6****Chemical evaluation of clonal progenies of Chinese cassia**

N K Leela, P Gobinath, T J Zachariah, B Krishnamoorthy, J Rema &amp; P A Mathew

Indian Institute of Spices Research  
Marikunnu P.O., Calicut-673012, Kerala

Chinese cassia [*Cinnamomum cassia* (L.) Bercht. & Presl.] is grown for its aromatic bark, which is used as a spice. Bark oil and bark oleoresins are other products of commerce used in flavouring food and in pharmaceutical preparations. Evaluation of twenty-four clonal progenies of *C. cassia* indicated that bark oil and bark oleoresin contents ranged between 1.2-7.3% and 3.4-13.4%, respectively. The oil composition was determined by gas chromatograph equipped with flame ionization detector and OV-1 column. The components in the oil were identified by comparing the retention time of the peaks with that of authentic standards. The major constituent of the oil viz., cinnamaldehyde ranged from 53.9 to 74.5%, while  $\alpha$ -terpineol, limonene, 1,8-cineole and pinene ranged from 0.68 to 4.71%, 0.01 to 1.05%, 0.01 to 0.47% and 0.31 to 4.01% respectively.



7

**HISAR SURBHI – a new high yielding variety of coriander**

S K Tehlan, K K Thakral, P S Partap &amp; J L Mangal

AICRP on Spices, Department of Vegetable Science  
CCS Haryana Agricultural University  
Hisar-125004, Haryana

In Haryana, the area, production and productivity of coriander (*Coriandrum sativum* L.) are very low due to lack of improved varieties and poor adoption of package of practices. A high yielding variety of coriander suitable for cultivation under Haryana condition 'Hisar Surbhi (DH-246)' has been developed. It is a quick growing, dual purpose and high yielding variety with high oil content (0.45%). Besides, it is less susceptible to aphid and powdery mildew and tolerant to frost. It is suitable for cultivation in Haryana, Rajasthan, Bihar and Madhya Pradesh under irrigated conditions. This variety was evaluated at Vegetable Research Farm, All India Co-coordinated Varietal Trials and in multi-locational trials in farmer's fields. The results clearly indicated that DH-246 is the most promising among all the entries tested under AICRP on spices, varietal evaluation in the state and multi-location trials. This variety has recorded the highest yield of 19.97 q/ha, which was 28.8% higher over Hisar Anand (check) and ranked first among all the entries tested.

8

***In vitro* propagation of *Stevia rebaudiana***T E Sheeja<sup>1</sup> & A B Mandal

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<sup>1</sup>Indian Institute of Spices Research  
Marikunnu P.O., Calicut-673012, Kerala

*Stevia rebaudiana* is a natural sweetener known for its non-calorific sweetening value. The plant extract is also medicinally important as it facilitates weight loss due to its ability to reduce cravings for sweet and fatty foods and in treating diabetes, hypoglycemia, candidiasis, high blood pressure, skin abrasions and in inhibiting plaque forming bacteria. An improved micro-propagation protocol has been developed in *Stevia rebaudiana* involving nodal segments of field grown plants. A maximum multiplication of 49 shootlets per explant through direct regeneration was observed by maintaining culture on MS media supplemented with 10 mg/l GA<sub>3</sub>, 5 mg/l BAP and 0.05 mg/l IAA for a period of three weeks and subsequent transfer onto MS supplemented with 2 mg/l BAP for a period of 2 weeks. Rooting of fully-grown plantlets could be achieved in the absence of phytohormones on ½ strength MS. The *in vitro* regenerated plantlets were hardened on perlite and field transferred with 100% survival rate.



**Session II**  
**SUSTAINABLE PRODUCTION SYSTEMS**

## Oral Presentations

9

### Variability in black pepper yield during pre-yield stabilization period

K Kandiannan, K S Krishnamurthy, C K Thankamani & P A Mathew

*Indian institute of Spices Research  
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A study was conducted at the Peruvannamuzhi farm of Indian Institute of Spices Research between 1994 and 1999 to study the varietal variations for yield during initial bearing years and to quantify the yield increment over the years. Ten black pepper (*Piper nigrum* L.) lines viz., Sreekara, Subhakara, Panchami, Pournami, P 24, Panniyur 1 to 5 were selected for the study. Six months old uniform cuttings one each @ 40 per line were planted on 3 years old *Ailanthus malabarica* DC live support during July 1994. The fresh berry yield was recorded from first bearing year (1996-97) onwards up to the third bearing year (1998-99). The ranges for number of bearing vine, mean fresh berry yield (g/vine) and coefficient of variation (CV) for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> years were 10-32, 142-706, 44.4-75.9%; 28-39, 581-1431, 11.7-146.6% and 23-39, 1247-5232, 44.8-112.0%, respectively. The variability was not consistent over the years for the same variety and among the variety. Irrespective of varieties, the CV for 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> year yield was 72.1%, 50.1% and 35.6%. The yield increment was observed in all the varieties for 1<sup>st</sup> to 2<sup>nd</sup> year except Panniyur 1. The mean magnitude of yield increment was 164.9 % for 1<sup>st</sup> to 2<sup>nd</sup> year and 259.3 % for 2<sup>nd</sup> to 3<sup>rd</sup> year.



## 10

**Influence of nutrient levels on yield and quality of turmeric varieties**

B L Jadhao, V K Mahorkar, S R Dalal, Anjali Mohariya, A D Warade, D M Panchbhai, N D Jogdande, V G Ingle, V S Gonge, I R Hussain

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Field experiments were conducted in 2001-02 and 2002-03 to study the effects of six levels of nutrients [Zn-15 & 30 kg/ha; Fe-15 & 30 kg/ha each applied with the recommended dose of fertilizer (RDF)-120 kg N + 60 kg P<sub>2</sub>O<sub>5</sub> + 60 kg K<sub>2</sub>O/ha and their combinations] on four turmeric varieties viz., Krishna, Suverna, Salem and Waigaon. The design was split pot (varieties in main plot and nutrient levels in sub plot) with four replications. The results indicated that variety Krishna produced significantly higher yield in terms of mother rhizome and finger/ plant, fresh weight of mother rhizomes and fingers/ ha and highest per hectare monetary returns and B: C ratio when fertilized with RDF + Zn @ 30 kg/ha. Superior quality (curing percentage, oleoresin) of turmeric was, however, obtained in variety Suverna fertilized with RDF + Zn @ 30 kg/ha. Another field experiment was conducted on integrated nutrient management in turmeric during 2003-04. In addition to varieties and nutrient levels, the study also involved application of biofertilizers viz., Azotobacter (AZT) and Phosphate solubilizing bacteria (PSB). The design was FRBD with four replications. The study revealed that variety Krishna applied with 200 kg N + 100 kg P<sub>2</sub>O<sub>5</sub> + 100 kg K<sub>2</sub>O + biofertilizer @ 5 kg/ha (AZT and PSB each) recorded significantly higher yield followed by variety Waigaon applied with the above said fertilizer combination.

## 11

**Effect of different methods of planting and spacing on the fresh rhizome yield of turmeric**

S S Saini, A K Malik & B S Gill

Department of Agronomy and Agrometeorology  
Punjab Agricultural University, Punjab

The study comprised of 14 combinations of three methods (flat, ridge and flat sowing followed by ridging after 100 days), row spacing (30, 45 and 60 cm in flat sowing, ridge sowing and flat sowing) followed by ridging treatments with two plant-to-plant spacing of 15 and 20 cm; replicated four times in RBD. The results revealed that the flat sowing method in combination with 30 cm x 20 cm spacing produced the highest fresh rhizome yield (245.8 q/ ha) as compared to all other combinations of spacing under different methods of planting. It was significantly higher than 60 cm x 15 cm and 60 cm x 20 cm spacing under all the planting methods. The lowest fresh rhizome yield (153.0 q/ ha) was obtained under the combination of ridge planting with 60 cm x 20 cm spacing.

## 12

**Effect of coffee pulp compost and bio-agents on bean yield of vanilla**

M Dinesh Kumar, D Madaiah & K R Sriramulu

Zonal Agricultural Research Station, Mudigere, Karnataka

The experiment was conducted during 2002 and 2003 with the objectives of utilizing coffee pulp compost and testing the efficiency of bio agents on vanilla (*Vanilla planifolia* Andrews) bean yield. The treatments, laid out in randomized complete block design with three replications comprised of FYM (5 kg/vine), coffee pulp compost (5 kg/vine), FYM + *Azotobacter chroococcum*, FYM + *Aspergillus awamorie*, compost + *A. chroococcum*, compost + *A. awamorie* and compost + *A. chroococcum* + *A. awamorie*



tested against the recommended package (application of FYM @ 2.5 kg/vine and N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O @60:30:100 g/vine). The above treatments were applied in two equal doses i.e. June first week and September second week. Coffee pulp waste available from *Coffea arabica* parchment was utilized along with shade tree leaf wastes for preparing enriched compost. It contained about 0.4 %, 0.8 % and 0.25 % higher N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O respectively compared to FYM. The pooled result of two years indicated that application of coffee pulp compost led to significantly higher yield (1.52 kg beans/vine) compared to application of FYM (1.22 kg beans /vine). The recommended package produced significantly higher yield (1.45 kg beans/vine) than application of either FYM or FYM in conjunction with bio agents but lower than application of coffee pulp compost. Coffee pulp compost along with N fixer and P solubilizer resulted in maximum bean yield (1.98 kg/ per vine).

## Poster Presentations

### 13

#### Effect of *Pseudomonas fluorescens* (IISR 6) and *Trichoderma harzianum* on growth of black pepper varieties in the nursery

C K Thankamani, K Sreekala & M Anandaraj

Indian Institute of Spices Research  
Marikunnu P. O., Calicut - 673 012, Kerala

An experiment was conducted to find out the effect of *Pseudomonas fluorescens* (IISR 6) and *Trichoderma harzianum* (P-26) on growth of black pepper (*Piper nigrum* L.) varieties in the nursery. The treatments included various application methods and three varieties. Maximum height, number of leaves and leaf area were obtained with application of *Pseudomonas fluorescens* thrice. Number of roots, and biomass production were higher with combined application of *Pseudomonas fluorescens* and *Trichoderma harzianum*. Among the varieties, higher biomass was recorded by Panniyur-3. Raising rooted cuttings in *Trichoderma* applied potting mixture and applying *Pseudomonas*

*fluorescens* strain IISR 6 at the time of planting, first and second months after planting (thrice) is recommended for the production of healthy black pepper rooted cuttings in the nursery.

### 14

#### Comparison of sources and methods of zinc application on yield and quality of black pepper

S Hamza & A K Sadanandan

Indian Institute of Spices Research  
Marikunnu P.O., Calicut-673012, Kerala

Field and pot experiments were conducted from 1996 to 1999 to compare the sources (zinc sulphate and zinc EDTA) and methods (soil and foliar) of Zn application to black pepper in a zinc deficient soil. Results showed that leaf and berry Zn concentrations were maximum due to 0.5% foliar spray of ZnSO<sub>4</sub> followed by 0.25% ZnSO<sub>4</sub> and 0.1% Zn-EDTA chelate application. There was a significant increase in the levels of Zn in the soil (55%), leaf (20%) and berry (15%) due to 2.5 kg Zn application as Zinc EDTA chelate compared to 2.5 kg ZnSO<sub>4</sub>. The yield was maximum (1.68 kg/ vine) due to foliar application of 0.5% ZnSO<sub>4</sub>, which was on par with 2.5 kg Zn application either as ZnSO<sub>4</sub> or Zinc EDTA chelate or 2.5 kg ZnSO<sub>4</sub> +EDTA soil application. There was 20, 18.6 and 17% increase in yield over control due to 0.5% ZnSO<sub>4</sub> as foliar, soil application of 2.5 kg Zn as ZnSO<sub>4</sub> and 2.5 kg Zn as zinc EDTA chelate respectively. The oleoresin and piperine contents were maximum due to soil application of 2.5 kg Zn as Zn EDTA. Among sources and methods, soil application of ZnSO<sub>4</sub> produced maximum B/C ratio, which was on par with 0.5% ZnSO<sub>4</sub> foliar spray.



15

**Integrated weed control in ginger**

Luna Barooah &amp; S Saikia

*Assam Agricultural University  
Jorhat, Assam*

A field experiment was conducted during 2002-03 with a view to find out effective and economic weed control measure(s) for ginger (*Zingiber officinale*) cv. Nadia. The experiment was laid out in RBD with three replications. There were altogether 9 treatments comprising of chemical measures combined with manual and mechanical measures ( $t_1, t_2, t_3, t_4$ ), combination of mechanical and manual measures ( $t_5, t_6$ ), manual and mechanical measures combined with mulching ( $t_7$ ) and twice mulching ( $t_8$ ). These treatments were compared and evaluated against a weedy check ( $t_9$ ). The results revealed that  $t_7$  (mulching after planting + hoeing at 40 dap + grubber at 60 dap + hand weeding at 90 dap + mulching) recorded lowest weed population, dry weight and nutrient uptake by weeds followed by  $t_8$  (mulching after planting + after earthing up at 90 dap), while the highest was recorded under  $t_9$ . The treatment  $t_7$  showed superiority in case of growth, yield and quality parameters. The highest cost benefit ratio was also obtained in  $t_7$  (1:5.29) followed by  $t_8$  (1: 5.16) against the lowest cost benefit ratio of 1:1.95 in  $t_9$ . Hence,  $t_7$  proved to be highly effective in controlling weeds, improving growth, yield and profit in ginger.

16

**Production technologies on yield and returns from turmeric**K Kandiannan<sup>1</sup> & K K Chandaragiri*Department of Agronomy, Center for Soil and Crop Management Studies  
Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu*<sup>1</sup>*Indian Institute of Spices Research  
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Field investigations were carried out with the objective of studying the effect of production technologies on yield and return from turmeric (*Curcuma longa* L. syn. *C. domestica* Val.). Experiments were conducted at Bhavanisagar for two years (2000-01 & 2001-02) under irrigated condition in split plot design with three replications on a sandy loam soil. The combinations of two varieties (BSR 1 and BSR 2) and three times of planting (May 15<sup>th</sup>, June 15<sup>th</sup> and July 15<sup>th</sup>) constituted the main plot treatments. The combinations of three spacing (30 x 15, 45 x 15 and 60 x 15 cm) and three nitrogen levels (125, 150 and 175 kg ha<sup>-1</sup>) formed the sub plot treatments. The fresh and dry rhizome yields of BSR 2 were higher by 17.3 and 11.7 per cent respectively, over BSR 1. The late plantings (June 15<sup>th</sup> and July 15<sup>th</sup>) recorded 10.2 and 18.3 and 19.4 and 32.8 per cent reduced fresh and dry rhizome yields, respectively than May 15<sup>th</sup> planted crop. The closer spacing recorded 9.1 and 33.6 per cent higher fresh rhizome yield in the first year and 11.5 and 30.0 per cent in the second year than medium and wider spacing, respectively. The higher N level recorded 36.1 and 6.0 t ha<sup>-1</sup> of fresh and dry rhizome yields, respectively, which were higher than medium and lower levels. Similar trend was also observed in economic return. It is concluded that planting BSR 2 on 15<sup>th</sup> May at 30 x 15 cm spacing with 175 kg ha<sup>-1</sup> N is an ideal option to augment the turmeric production in this region.

17

**Response of patchouli to soil amendment and growth regulators**

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Hessaraghatta, Bangalore-560 089, Karnataka*

A field experiment was conducted to find out the effect of exogenous application of soil amendment and growth regulators on growth, fresh herbage, yield and essential oil content in patchouli (*Pogostemon patchouli* Pellet). The cultivar IIHR-PP-1 was used for the experiment. The soil amendment treatments included well-decomposed compost @ 30t/ha, lime @ 2t/ha, single super phosphate @600 kg/ha and gypsum @



2t/ha with or without recommended dose of NPK, in various combinations. Growth regulators such as TIBA was used in 3 concentrations viz., 25, 50, 100 ppm and Kinetin in 3 concentrations viz., 50, 100 and 200 ppm. The results showed that the highest herbage (5.75 t/ha) and oil (25.55 kg/ha) yields were recorded when gypsum and compost were applied together with the recommended NPK dose. In case of growth regulators, maximum fresh herbage production (3.23 t/ha) and oil yield (24.44 kg/ha) were recorded with the application of TIBA at 100ppm and Kinetin at 200 ppm.

## 18

### Studies on the effect of FYM and intercropping of cowhage in young rubber plantations

J E Adeline Vinila, J D Nirmalatha, J Prem Joshua, C Gailce Leo Justin & M Jayasekhar

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A trial was conducted during 2002-03 to evaluate the performance of cowhage (*Mucuna pruriens*) as an intercrop in three-year-old rubber plantations. This medicinal plant is a leguminous climber, which can be trailed on the ground by clipping the terminal growth. The seeds of this plant are used in the pharmacology as nerve tonic. Factorial randomized block design was adopted with five treatments and replicated four times. From the study it was found that intercropping and FYM application had a significant effect on increasing the rubber girth. The treatment, 10 t FYM/ha as basal and 10 t FYM/ha as top dress recorded the highest percentage of stem girth (3.79) in rubber trees. In case of *M. Pruriens*, maximum biomass yield (2.7 kg/m<sup>2</sup>), seed yield (2130 kg/ha.), number of seeds per plant (6.03) and 1000 seed weight (947 g.) were also recorded in the same treatment.

## 19

### Optimizing the agronomic requirements of fenugreek for Punjab

B S Gill, S S Saini, A Salaria & Devinder Singh

*Department of Agronomy and Agrometeorology  
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The investigation on fenugreek (*Trigonella foenum-graecum* L.) was initiated during the winter season on a sandy loam soil, low in organic carbon, medium in available phosphorus and high in available potassium. The study revealed that fenugreek should be sown from the last week of October to the first week of November in rows 22.5 cm apart using 30 kg of seed per hectare. The crop has meagre nitrogen requirement and does respond to phosphorus application. The integrated weed control treatments (hand weeding followed by pendimethalin 0.75 kg/ha or pendimethalin 0.75 kg/ha followed by hand weeding) or fluchloralin 1.25 kg/ha effectively controlled the weeds in fenugreek. The removal of fresh herb had significant effect on seed yield of fenugreek. The seed yield decreased significantly when crop was harvested for green herb.

## 20

### Utilization of spices as biomulches in intensive cropping system

K Haripriya & S Mullaimaran

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An attempt was made to study the feasibility of growing coriander, mint and fenugreek as biomulches in baby corn field. Comparison was made with organic mulches like sugarcane trash, plant residue, coir pith and saw dust. Results revealed that organic mulches except saw dust significantly



contributed to higher yield and returns per rupee invested (1.3 to 3.5) on the main crop. In the biomulching practice, coriander proved to be a good soil cover. Mint was slow growing and fenugreek, though fast growing did not provide good soil cover. So biomulching with mint and fenugreek was not effective in increasing the growth components as that of coriander biomulch, which was effective in suppressing weed population to significant levels. The equivalent yield also increased due to addition of green yield from biomulch (10.15). The return per rupee invested was 3.3 in coriander followed by 2.5 in mint and fenugreek.

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Session III

**DIAGNOSTICS AND BIOTECHNOLOGY  
IN THE CONTROL OF CROP PESTS**

## Oral Presentations

21

### **GIS Studies on the influence of environmental factors on stunted disease of black pepper**

Utpala Parthasarathy, A Ishwara Bhat, S Devasahayam, K Jayarajan, B H Ahamad Shareef & V A Parthasarathy

*Indian Institute of Spices Research  
Marikunnu P.O., Calicut 673 012, Kerala*

Stunted disease of black pepper caused by two viruses viz., *Cucumber mosaic virus* (CMV) and *Badnavirus* are normally transmitted through planting materials. Mealy bugs and aphids act as vectors for the secondary spread of the virus. With the help of total cropped area and area under black pepper cultivation, important districts of Kerala were selected and surveyed for incidence of stunted disease of black pepper cultivation. The percentage of disease incidence was plotted on the map with the help of longitude and latitude using DIVA-GIS. It was found that in Idukki and Wayanad districts the percentage of incidence was very high whereas the incidence was low in other districts. Environmental factors like altitude, temperature and rainfall were also studied with DIVA-GIS. The results indicated that Wayanad and Idukki are at higher altitude than other areas and have comparatively less temperature and rainfall, which are conducive for the multiplication of the virus as well as the vectors. In areas, which are in lower altitude and possess higher temperature such as Kasaragod and Kozhikode districts the incidence of the disease is probably due to the infected planting material. The GIS study was also extended to other districts of Kerala like Kollam, Malappuram and Kottayam.



22

## Methods for screening ginger germplasm for bacterial wilt resistance

A Kumar

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Bacterial wilt of ginger caused by *Ralstonia solanacearum* is found to occur in Kerala, Karnataka, Himachal Pradesh, Sikkim, West Bengal, Assam and other North Eastern states. The strain causing bacterial wilt belongs to either Biovar 3 or Biovar 4, the former being highly virulent in India. Unfortunately, none of the bacterial wilt management strategies viz., selection of disease free seed rhizomes, rhizome treatment using hot air, hot water, solarization, crop rotation, periodical rouging of infected plants etc., have practically arrested the spread of the disease during the monsoon. However, exploitation of host resistance can be an important disease control strategy. Three *in vivo* methods viz., pseudo stem inoculation, soil inoculation, rhizome inoculation and a novel *in vitro* method i.e. direct incorporation of bacterial cells in the medium when the plantlets are at 2-3 leaf stage were evaluated by using different concentrations of bacterial cells for screening ginger germplasm for bacterial wilt resistance. Among the methods evaluated, pseudostem inoculation resulted in wilting of plants in 5-7 days, followed by soil inoculation in 7-10 days, rhizome inoculation in 40-45 days and the *in vitro* method in 10-15 days. Interestingly, the *in vitro* method did not result in typical wilting of plants but showed only yellowing. Occurrence of 'disease escapes' was observed during the first round of screening. The PCR assay confirmed the absence of the pathogen in the soil around the uninfected plants, which necessitated the need for multiple round of inoculation for reliable screening for the disease. When inoculation was repeated three times, the escaped plants succumbed to the wilt. Soil inoculation, which closely mimics the natural condition, is recommended for screening for bacterial wilt resistance of ginger. Plants surviving even after three rounds of inoculation can be further screened through the *in vitro* method standardized in this work.

23

## Efficacy of rhizobacterial cultures in managing soft rot disease of ginger

R Suseela Bhai, V K Kishore, A Kumar, M Anandaraj &amp; S J Eapen

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Soft rot disease of ginger (*Zingiber officinale*) incited by species of *Pythium* viz., *P. aphanidermatum*, *P. vexans*, *P. myriotylum* etc., causes severe crop loss in many of the ginger growing tracts. Present strategy for disease management is through use of planting material from disease free localities as well as through fungicides and *Trichoderma*. As an alternate method, an attempt was made to screen plant growth promoting rhizobacteria for managing this disease. Twenty different rhizobacterial cultures viz., IISR 6, IISR 13, IISR 51, IISR 853, IISR 859, IISR 906, IISR 907, IISR 909, IISR 910, IISR 912, IISR 913, IISR 914, IISR 915, IISR147, IISR 148, IISR 149, IISR 150, IISR 151, IISR 152 and IISR 153 were tested both under *in vitro* and *in vivo* conditions to evaluate their efficacy in inhibiting the pathogen as well as reducing the disease incidence. The tested isolates included *Pseudomonas fluorescens*, *Enterobacter agglomerans* and *Bacillus* sp. Under *in vitro* conditions 80% of the tested rhizobacterial cultures proved satisfactory in inhibiting the pathogen *P. myriotylum*. Pot culture evaluation of these cultures in comparison with conventional metalaxyl-mancozeb at 0.2% revealed that the isolates IISR 51, IISR 859, IISR 906, IISR 914, IISR 915 and IISR 151 are far superior to fungicide treatment in reducing the disease incidence to less than 20%. Out of this, three treatments IISR 51, 914 and 915 showed good colonization of VAM on roots and treatments IISR 13, IISR 51 and 915 were found very promising in increasing the yield.



24

### Evaluation of carbendazim and biocontrol agents on wilt of coriander

R P Saxena, V P Pandey, J Dixit &amp; V K Singh

Department of Vegetable Science  
N D University of Agriculture & Technology  
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In a study conducted from 2001-04, the incidence of wilt (*Fusarium oxysporum*) varied every year. Thirty per cent of the disease was recorded in untreated plots during the year 2003-04. Out of six treatments viz., seed treatment with carbendazim (T1), seed treatment with *Trichoderma viridae* and soil application (T2), seed treatment with *T. harzianum* and its soil application (T3), seed treatment with *Bacillus subtilis* and its soil application (T4), seed treatment with *Pseudomonas fluorescens* and its soil application (T5), seed treatment with carbendazim and its soil application and untreated controls (T7), treatment T6 showed maximum disease control of 72.23% over control. Maximum increase in seed yield of 173.22% was also observed in this treatment.

25

### Non-chemical management of root knot nematodes in turmeric

B A Patel, R V Vyas &amp; J G Patel

Department of Nematology  
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In Gujarat, heavy losses due to *M. incognita* and *M. javanica* are incurred in turmeric grown in light soils. For management of this malady, field experiments were conducted for three years in which various non-chemicals viz., soil application of various organic amendments like dry

azolla, poultry manure, FYM, mustard cake & neem cake, soil solarization using 25 $\mu$  LLDPE film for 15 days in summer and rabbing with bajra husk @ 7kg/ m<sup>2</sup> were tested along with chemical nematicide, carbofuran. The pooled results for 3 years showed that among the treatments, soil solarization was found to be the most effective in terms of yield increase and nematode management and carbofuran was the least effective.

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### Integrated management of root-knot nematode in fennel

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Anand Agricultural University, Anand-388 110 (GS)

In Kapadvanj areas of Middle Gujarat, root-knot nematode (*Meloidogyne javanica* pt.2) adversely affects profitable cultivation of fennel by causing 28% loss in yield. With a view to find out an effective integrated management practice, the treatments of organic amendments i.e. castor cake and neem cake each @ 1 t/ha, neem guard @ 20 kg/ha, phorate @ 1.0 kg/ha individually and also in various combinations viz., castor cake + phorate, neem guard + phorate and neem cake + phorate were tried with appropriate controls in a nematode infested field (Initial population 258 J<sub>2</sub>/200 g soil). The treatments were tried in randomized block design in three replications. The inter- and intra-row spacings were 100 cm and 10 cm respectively. The local cultivar highly susceptible to root-knot nematodes was used in the trial. Results of two years pooled data (1999 through 2001) indicated that maximum fennel yield (2762 kg/ha) was obtained in the treatment of neem cake + phorate followed by neem guard + phorate (2566 kg/ha) compared to control (1667 kg/ha). Minimum root-knot index (1.64) was also recorded in the combined treatment of neem cake + phorate followed by application of castor cake + phorate treatment (1.72) compared to 3.63 in the control. It can, therefore, be concluded that integration of neem cake @ 1 t/ha and phorate @ 1.0 kg/ha would be very effective in economic management of *Meloidogyne javanica* pt.2 in fennel. This treatment gave 65.7 percent higher yield with 121.3 percent reduction in root-knot disease (ICBR 1:4.95) and gave a net realization of Rs. 22,775/ha.



## Poster Presentations

27

### Evaluation of plant materials for mass multiplication of root mealybug infesting black pepper in the laboratory

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Indian Institute of Spices Research  
Marikunnu P.O., Calicut 673 012, Kerala

The root mealybug (*Planococcus* sp., Heteroptera, Pseudococcidae) is a serious insect pest of black pepper (*Piper nigrum* L.) especially in Wayanad (Kerala) and Kodagu (Karnataka) districts. The pest infestation causes yellowing and wilting of leaves, defoliation, drying of branches and mortality of vines. Twelve fruits/ vegetables/ tubers viz., pumpkin, squash, ash gourd, bottle gourd, cucumber, water melon (Cucurbitaceae), colocasia, elephant foot yam (Araceae), potato (Solanaceae), ginger and turmeric (Zingiberaceae) were evaluated for their suitability for mass culturing of *Planococcus* sp. in the laboratory for conducting various basic studies on the pest. The number of adults obtained after 30, 60 and 90 days of culture was significantly higher in squash (*Cucurbita moschata*), when compared to all other materials indicating its suitability for mass culturing of *Planococcus* sp.

28

### *In vitro* evaluation of antimicrobial activity of essential oils from black pepper, turmeric and clove

P Gobinath, P Murugavel & B Chempakam

Indian Institute of Spices Research  
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The antimicrobial activity of volatile oils from black pepper, turmeric and clove against various strains of bacteria and fungi were evaluated *in vitro*

using the established protocols viz., paper diffusion method and food poison technique. Bacterial strains *Bacillus* sp, *E. coli*, *Proteus* sp, *Klebsiella* sp and *Staphylococcus aureus* and fungal species *Candida albicans*, *S. cerevisiae*, *A. flavus*, *A. niger*, *Fusarium* sp and *P. capsici* were used in the study. Volatile oil from the three spices could inhibit the growth of *E.coli*, *Proteus* sp, *S. cerevisiae* and *C. albicans*. While *Staphylococcus aureus* was inhibited by clove and turmeric oil, *Klebsiella* sp did not show any inhibition against any of the oils. Clove oil showed potent antifungal activity against *A. flavus*, *A. niger*, *Fusarium* sp and *P. capsici* while only *Fusarium* was inhibited by turmeric leaf and rhizome oils. *P. capsici* did not show any inhibition against turmeric and black pepper oils.

29

### Evaluation of neem based insecticides for control of thrips and shoot and capsule borer of cardamom

D Jemla Naik, N E Tyagaraj, M Dinesh Kumar, D Madaiah & V V Belvadi

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The experiment was conducted for three years during 2000 to 2003 with the objective of evaluating the efficacy of neem-based insecticides on control of thrips (*Sciothrips cardamomi* Ram), shoot and capsule borer (*Conogethes punctiferalis*) of cardamom (*Elletaria cardamomum* Maton). The experiment comprised of seven different treatments laid out in randomized complete block design with three replications. The treatments include different type of neem products (neem gold-0.03%, neem oil cake-500 g/plant, NSCK-4%, neem oil-0.3% and eco neem plus-0.03%) tested against standard check and control. Applications were done in March, May and June second fortnight. In standard check, application of Monocrotophos (0.045%) was done during March followed by application of Phosalone (0.07%) during May and June. Application of standard check successfully controlled (47.35% in thrips and 77.29% in borers) both the type of damage in all the years of study. Application of different types of



neem products, though slightly effective against borers (30.52%), was not effective against thrips.

### 30

#### Efficacy of *Pseudomonas fluorescens* in relation to disease incidence of soft rot of ginger

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Ginger (*Zingiber officinale* L.) is seriously damaged during monsoon by soft rot caused by *Pythium aphanidermatum* in Uttara Kannada district of Karnataka. Application of *Pseudomonas fluorescens* @  $10^8$  CFU as seed treatment and three sprays at 15 days interval from 30 days after planting showed reduced incidence of soft rot disease and improved the vigour and yield of ginger.

### 31

#### Liquid formulation of *Pseudomonas fluorescens* in different isotonic solutions and its advantages over carrier based formulations and applications in vanilla nurseries

Charles K Thomas & Renny Jacob

PLANTRICH Chemicals & Fertilizers Limited  
Industrial Estate, Manarcadu P.O.  
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*Pseudomonas fluorescens* isolated from different areas were tested for its antagonistic effects on different fungal pathogens. We attempted to preserve centrifuged pellets of cells in isotonic media of arabitol, erythritol, glycine, glycerol and trehalose at different concentrations. Among these 0.96 M trehalose was found effective giving more than  $10^9$  CFU after 12 months. The advantages over carrier-based formulation were

tested *in vivo* as well as *in vitro* in vanilla nurseries. Vanilla nursery plants sprayed with liquid formulation showed more growth of vines, shoots and foliage compared to those drenched and sprayed with powder formulations.

### 32

#### Biological control of coriander wilt disease

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Field trials were conducted during the rabi seasons of 2001-02, 2002-03 and 2003-04 for identifying an effective bio control method to manage coriander wilt (*Fusarium oxysporum fsp. coriandri*). The experiment consisted of seven treatments and three replications in RBD. The observations were recorded on the incidence of wilt and the seed yield of coriander (CO 3). The pooled analysis of the three seasons data revealed that seed treatment using *Pseudomonas fluorescens* @ 10 g/kg with soil application of *P. fluorescens* @ 5kg/ha + soil application of neem cake @ 150 kg (T<sub>5</sub>) was effective in reducing the wilt incidence by 62.43%. It was on par with seed treatment with *P. fluorescens* @ 10g/kg + soil application of *P. fluorescens* @ 5kg/ha (T<sub>4</sub>) which reduced the disease incidence by 60.56%. The treatment (T<sub>5</sub>) also recorded the highest seed yield of 572.3 kg/ha followed by T<sub>4</sub> (560.3 kg/ha). The C: B ratio was, however, highest (1:8.65) in T<sub>4</sub> than the other treatments. Hence, seed treatment with *P. fluorescens* @ 10 g/kg + soil application of *P. fluorescens* @ 5kg/ha was the cost effective biocontrol method for coriander wilt.



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### Major diseases of clove in Konkan region and their management

S P Raut, S H Gaikwad, J Y Khare &amp; M S Joshi

Department of Plant Pathology  
DBSKKV, Dapoli (MS)

In Konkan region, clove in the seedling stage suffers from pre-emergence and post-emergence rots and then wilt resulting in 2.38-20.51% mortality due to *Rhizoctonia bataticola*, *Nigrospora spherica*, *Fusarium oxysporum* and *Fusarium culmorum*. The clove seedlings were also affected by fungal leaf spot, anthracnose, die-back, twig blight and leaf blight. *Colletotrichum gloeosporioides* caused anthracnose while leaf blight was incited by *Pestalotia versicolor*, *Ozonium texanam* and *Alternaria alternata*. *In vitro* total inhibition of *Colletotrichum gloeosporioides* was achieved by 0.05% Derosal and 0.5% Bordeaux mixture, while *Pestalotia versicolor* was completely inhibited by 0.2% Difolatan, 0.05% Derosal, 0.5% Bordeaux mixture or 0.5% Agrozim. Total inhibition of *Fusarium oxysporum* causing root rot of clove seedlings was achieved by 1% Bordeaux mixture and *Fusarium culmorum* was totally inhibited by 1% Bordeaux mixture. In a field trial, spraying with 0.1% Bavistin and drenching with 0.3% Difolatan totally controlled the seedling diseases of clove. *Trichoderma viride* resulted in 65.22 % reduction of *Fusarium oxysporum*, while it was 54.94% reduction of *Fusarium culmorum* over control in dual culture studies. In a field trial, leaf blight caused by *Cylindrocladium quinquesepertum* Boedijn and Reitsma was effectively reduced by 5 sprays at 20 days interval with 0.1% Carbendazim (78.16%) followed by Carbendazim + Mancozeb (74.44%).

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### Wilt of patchouli and its management

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Patchouli (*Pogostemon patchouli* Pellet.), an important aromatic plant used in perfumery, soaps, scents, body lotions, creams, detergents and as medicine to treat cold, headaches, diarrhoea, nausea etc is reported to suffer from leaf blight (*Cercospora* sp. *Alternaria alternata*), wilt (*Fusarium solani*, *Rhizoctonia solani* and *Pythium aphanidermatum*). A survey at Dapoli recorded 27.6 per cent seedling mortality accompanied with heavy defoliation due to *Fusarium oxysporum* Schlecht. Laboratory studies proved it to be a potential pathogen, which grew and sporulated excellently on PDA, Czapek's and Richards' media. The chlamydospores were produced in 10 to 14 days old culture. Total inhibition of fungus by PFT was recorded in 0.5 per cent Bordeaux mixture as also with 0.1 percent Bavistin and 0.2 percent Blue copper. The bioagent, *Trichoderma viride* reduced the pathogen by 63.32 per cent over control, while *T.harzianum* by 53.65 per cent. Five fusarial isolates obtained from wilted seedlings collected from Pune, Thane, Kharawate, Sawarde and Dapoli were tested for their virulence by soil inoculation method and also by water culture technique. An isolate No.1 was found most virulent resulting in wilting within 10 days, while by water culture seedlings wilted within a day of inoculation.



**Session IV**

**COMMERCIALIZATION OF TECHNOLOGIES**



## Oral Presentations

35

### **EDXRF and PIXE: Novel Techniques for heavy metal elemental analysis in spices and medicinal herbs**

D Joseph

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Spices, the essential ingredient of Indian diet can be adulterated with colours and other additives. Similarly medicinal and ayurvedic drugs may also contain toxic elements beyond the permissible limits. Therefore it is essential to analyze the metal content in these essential edible materials through rapid, sensitive, non-destructive and less cumbersome techniques. The trace element content of Indian spices and ayurvedic drugs such as *Jasad Bhasm* was determined by Energy Dispersive X-ray Fluorescence (EDXRF). The samples were powdered and mixed with cellulose as a binding material and pelletized to obtain self-supporting pellets which were analyzed by EDXRF set up consisting of a radioisotope source, a semi-conductor detector such as Si (Li) detector of resolution 5.9 at 170 eV, Mn-K $\alpha$  X-ray and an amplifier. The counts were recorded in a PC-based MCA which was later loaded for off-analysis. Proton Induced X-ray Emission (PIXE), a complementary technique to EDXRF has better sensitivity since it uses proton beam of 3 MeV energy to study the elemental variation in spices and medicinal herbs. The results indicated that significantly higher levels of K followed by Ca, Fe, Rb, and Sr. Titanium and chromium were present only in black pepper and were within permissible levels. Laboratory preparations of *Jasad Bhasm* prepared by two different processes showed Zn levels at 99.3% and 95.6% respectively. However, preparations from various pharmaceutical companies showed that Zn concentration varied from 76.3 to 90.5% (Zandu-90.5%, Baidyanath-83.78% and Manilal-76.3%).



36

### Constraints and channels in the commercialization of medicinal crops in India

S K Patil, V Suryanarayana, G O Manjunath

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Medicinal plant (MP) resources are fast depleting through unsustainable management practices and over-exploitation. Though India is blessed with rich MP repository, wide spectrum of agro-climatic conditions, different soil types, research institutions and hard working farmers, commercialization of MPs remains a question mark. Therefore, from the point of reducing pressure on the forests, protection of rich cultural heritage, conservation, employment generation and quality concern and as a national economic drive "Commercial cultivation of MPs" is the need of present day. Commercialization of MPs can be geared up through research priorities such as, retrieval and consolidation of research data generated on MPs at one place, standardization of agro-practices for commercially important Medicinal Crops (MCs), development of high yielding varieties, establishment of organized marketing infrastructure at national and state levels and taking up farm demonstrations. Other suggestions that need to be considered are establishment of region wise collection, storage and processing facilities, sharing of trade information with farming community, making buy-back arrangement with industries, extension of crop insurance to MCs sector and inception of courses on MPs. Government assisted and promoted national network framed by combined efforts of planners, economists, policy makers, scientists, industrialists and progressive farming communities can be the unique solution in commercializing MCs.

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### Preliminary screening of red pepper genotypes for ascorbic acid, capsaicin and oleoresin contents

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Forty-nine germplasm lines of red pepper (*Capsicum annum* L.) were evaluated for dry matter, vitamin C, capsaicin and oleoresin contents. Significant variation ( $p < 0.05$ ) was observed among the genotypes for the above quality characters. The dry matter percentage and ascorbic acid (vitamin C) content ranged from 6.14% to 50.25% and 20 to 340 mg/100g, respectively. Maximum vitamin C content was recorded in accession 9771-26, whereas minimum vitamin C was recorded in 92-1206. The capsaicin content in the red ripe fruits ranged from 0.10%-0.70% (15000-105000 SHU) and the maximum value was recorded in BS-35 (1.47%; 220500 SHU). The colour values in the fruits powder ranged from 20790-192390 SICU and the extractable colour ranged from 53.3 ASTA to 481.34 ASTA units. Oleoresin content ranged from 7.2% (92-1203) to 17.6 % (PBC-380) among these accessions.



## Poster Presentations

38

**Chemical quality of berries from black pepper varieties grafted on *P. colubrinum* Link**

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Phytophthora foot rot is the major disease, affecting black pepper (*Piper nigrum* L.) killing the entire vine. *P. colubrinum* Link, a related pepper species is unaffected by this fungi. Grafting of *P. nigrum* on *P. colubrinum* is one approach to safeguard black pepper plants from this disease. The chemical quality of berries from *P. nigrum* grafted on *P. colubrinum* was evaluated. The study included volatile oil, oleoresin and piperine contents and the components of essential oil such as pinene, sabinene, myrcene, limonene, linalool, terpinene-4-ol,  $\alpha$ -terpineol and  $\beta$ -caryophyllene. Grafting was found to have little influence on the chemical quality of the berries.

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**Medicinal Plants based non-alcoholic beverages and pickling industry- a potential means of commercialization**

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A system of using medicinal plants (MPs) in our daily diet is possible through tasteful consumables like pickles, chutney and non-alcoholic beverages. With this ideology a case study was conducted on a small-scale industry engaged in production and supply of MP based consumables located at Shiralakoppa of Shimoga district in

Karnataka. Information on its inception, source of inputs and protocols for preparation and marketing systems was generated. It was established five years back with the knowledge gathered from ayurvedic literature and herbal healers. Inputs were obtained from forests, cultivators, local markets and through import. The inception was with a single product, "pickles made out of young bamboo culms" which gained high popularity. Presently, over 20 different products in the form of pickles and chutney of different MP are being produced. In addition, a herbal beverage made out of 17 medicinal herbal ingredients has also gained popularity. Eighty per cent of working force consists of women and the marketing system is well spread through a web of marketing units in the state's capital and in the neighboring district head quarters. This enterprise can encourage the public on commercial cultivation of MPs.

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**Essential oil of Shevroyan lemongrass-chromatographic study**

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The lemongrass [*Cymbopogon flexuosus* (Nees) Wats] is used world wide in perfumery, cosmetic and pharmaceutical industries for its citral content. The samples collected from Shevroys were hydro-distilled and the oil was analyzed by GC. A total of 51 peaks were recorded, out of which two citral compounds ( $\alpha$ -citral (31.65%) and  $\beta$ -citral (49.53%)) together comprising about 81.18% of the oil have been identified.



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### Commercialization of Patchouli in waste lands- A Success story in Uttara Kannada

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Patchouli (*Pogostemon patchouli*), an important aromatic crop is a high profit-fetching crop. A case study was made on a commercial farmer (Sri. Raiker) in Uttara Kannada who initiated patchouli cultivation in a small patch of land with 800 plants during 2002. Information was collected phase wise on planning, cultivation practices and income. The information revealed that it was started in a wasteland of 6 acres by enriching it with river soil @ 400 tonnes per acre. Patchouli cultivation was initiated with 800 cuttings of Johar variety. Presently the crop-covered area is 5 acres and a further extension to 14 acres has been planned for the year. Application of FYM and mulching with forest litter are being practiced for crop nutrition. Irrigation is provided for 1-2 hours on alternative days using micro-sprinklers. Except the application of nematicide with FYM to soil before planting, no chemicals were used for plant protection. On an average the yield was 2-2.5 tonnes per acre per harvest with a net profit of Rs. 25,000 to 35,000 per harvest. This case study revealed that one can get a net profit of Rs. 75,000 –1,00,000 per acre per year from patchouli cultivation in wastelands having irrigation facility.

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### Low cost technology for propagation of *Jasminum sambac*

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Commercial propagation of *J. sambac* through cuttings of runner shoots is a costly venture. Therefore, a simple method of propagation aimed at

reducing the cost of production of cuttings from runner shoots has been developed. Three node cuttings prepared from runner shoots (white to brown skin) were inserted (without rooting hormone treatment) in 150 gauge poly bags (16 x 10 cm) containing pot mixture and watered profusely. Over these bags, a small poly tunnel was constructed with five numbers of 1.5 m length 8 gauge GI wire arches (UV stabilized for covering). This acts as mini mist chamber, maintains temperature and humidity, protects plants from desiccation and saves labour (watering once in 15 days). Besides, this chamber can accommodate 300 bags. Bavistin (1g/l) was drenched before and after 15 days of covering. The sprouting of shoots was observed in one week and rooting of 70% of cuttings with four or five pairs of leaves was recorded in 45 days. 80% well rooted cuttings were produced with in 50 days. The cost of production of a single rooted cutting was one rupee.



**Session V**

**INDIGENOUS KNOWLEDGE  
VS  
IMPROVED TECHNOLOGY**



## Oral Presentations

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### **Hill garlic production system in Kerala – Potentials for development**

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In Kerala, commercial garlic cultivation is confined to Vattavada - Kanthallur region in the high ranges of Idukki district. Hill garlic produced in this region has great reputation for its intrinsic quality mainly in terms of pungency. The indigenous hill garlic production system at Vattavada, situated 7200 ft above MSL, its constraints and suggestions for improvement are discussed. Garlic cultivation is undertaken by the native tribes as well as other inhabitants in stable terraces made all along the hills. Traditional know how on cultivars, cultural practices, manuring, plant protection, harvesting and storage are described. Input wise cost of cultivation is worked out and the share of each item to the total cost arrived at. Credit and marketing linkages, marketing channels, input – output flow etc. are analyzed. The benefit: cost ratio worked out indicated that garlic cultivation has become less and less viable. The paper also examines the constraints in the hill garlic production system. Drastic changes in land use pattern, the onslaught of chemical agriculture accompanied by mismatching technologies and the resultant depletion of natural resources and soil fertility have disrupted this fragile agro – ecosystem and has made it more vulnerable to external stresses and shocks. Areas of possible technological interventions for the overall development of the system are suggested.

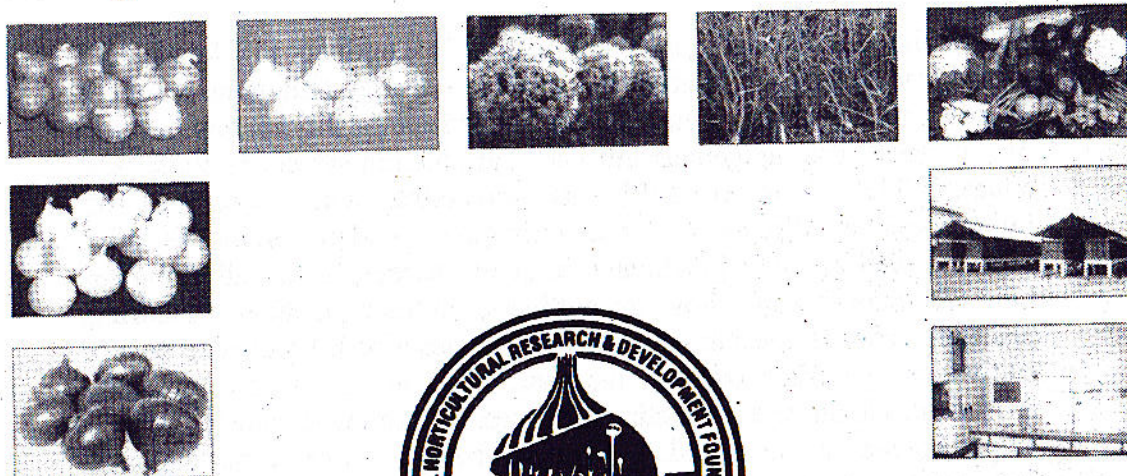


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