



अनुसंधान के मुख्य अंश Research Highlights 2017-18



भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिककोड
ICAR-Indian Institute of Spices Research
(Two times winner of Sardar Patel Outstanding ICAR Institution Award)
Kozhikode



The laboratories and administrative office of the institute are located at Chelavoor 11 km from Calicut (Kozhikode), Kozhikode District, Kerala, on the Calicut-Kollegal road (NH 766), in an area of 14.3 ha. The research farm is located 55 km North East of Calicut at Peruvannamuzhi on the Peruvannamuzhi-Poozhithode road in Kozhikode District, in an area of 94.08 ha. The Regional Station at Appangala (920 m above MSL), is located in Heravanad Village of Madikeri Taluk, Kodagu District, Karnataka on the Madikeri-Bhagamandala Road, 8 km from Madikeri, in an area of 17.4 ha.

“Our mission is to serve the spice growers by conducting goal-directed, peer-reviewed research and educating future generation to be science literate. Our institute seamlessly integrates research, education and global networking into its programmes, products and services”

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Research Highlights

2017-18



भाकृ अनुप
ICAR



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PREFACE

The Year 2017-18 was a very successful year for ICAR-Indian Institute of Spices Research. The Institute was recognized nationally in all fields. Two startups from ICAR-IISR viz., Kodagu Agritech, Karnataka and Natura Nursery, Kozhikode were selected for presenting their technologies to Hon'ble President of India during the Festival of Innovation and Entrepreneurship (FINE), hosted at the Rashtrapathi Bhavan, New Delhi during 19-21 March 2018. Two of our scientists bagged national awards. Dr. E. Jayashree, Principal Scientist received National Academy of Sciences India - ICAR award for Innovation and Research in Farm Machinery. Dr B. Sasikumar, Former Principal Scientist and Head won the National Award for Outstanding Efforts in Science & Technology Communication through Print Media including Books and Magazines (Category-B) instituted by DST, Govt. of India. He also bagged Karshaka Bharathi Award for farm journalism instituted by Govt. of Kerala. Dr. R. Dinesh, Principal Scientist was awarded the Fellow of National Academy of Agricultural Sciences and Dr D. Prasath, Principal Scientist won Dr D.P. Ghosh Young Scientist award instituted by Horticultural Society of India. Many of our scientists won best paper awards in various seminars. Our ITM-BPD unit signed thirteen license agreements for technology commercialization/services during 2017-18. The institute technologies on biocapsules and micronutrient mixtures are greatly appreciated by the farmers for their useful effects.

The Parliamentary Standing Committee on Agriculture headed by Shri. Hukamdeo Narayan Yadav visited IISR Regional Station, Appangala, Madikeri on 28 April 2017. The Committee appreciated and congratulated the institute for its excellent research work in the field of spices and also suggested a few points for further strengthening of spices research in the country based on national needs. Shri. Chhabilendra Roul, Additional Secretary (DARE) & Secretary (ICAR) also visited Appangala on 4 July 2017.

In the research front, management of rhizome rot of ginger using *Bacillus licheniformis* and calcium chloride was demonstrated in farmers field in Wayanad. Multifarious plant growth promoting traits of *Lecanicillium psalliotae* was reported for the first time. Complete genome sequencing of *Banana bract mosaic virus* was carried out. *Pythium deliense*, a new pathogen causing yellowing and wilt in black pepper and a new report on leaf blight of ginger caused by *Bipolaris rostrata* were identified and new databases were developed. Germplasm explorations were conducted to North East India including Karbi Anglong and Dima Hasao districts of Assam and Janitia hills of Meghalaya to look for enhanced genetic diversity of spices. Site-specific soil fertility management in black pepper and nutmeg enhanced the yields. Promising soil Zn solubilizing bacteria (ZnSB2) identified may help in alleviating Zn deficiency. Hypoglycemic potential of cinnamon and turmeric extracts provide new insights on controlling diabetes. Two spices varieties were released by Central Varietal Release Committee. Institute got external funding for two major projects viz. for Development of Pesticide Residue Lab from State Horticulture Mission and Establishing a value chain incubation facility for processing of spices from Govt. of Kerala.

During the AICRPS workshop which was held at Guntur, five spice varieties were recommended for release. The Institute also organized a Symposium on Spices and Aromatic Crops at Nagaland University, Medziphema, Nagaland which suggested a well guided road map for spices production in North East. The institute and the SAARC Agriculture Centre, Dhaka jointly organised Regional Expert Consultation Meeting on Technology Sharing of Spice Crops in SAARC countries during 11-13 September 2017 at ICAR-IISR, Kozhikode in which representatives from SAARC countries attended the meeting.

KVK conducted 122 training programmes in various disciplines during the year, benefiting 4761 participants out of which 18 were on value addition alone. KVK in collaboration with the institute organized Sankalp Se Siddi Programme which was inaugurated by Shri M K Raghavan, Hon'ble MP Kozhikode. KVK celebrated silver jubilee on 12 February 2018 to observe the completion of 25 years of its establishment. Adv. Shri. V. S. Sunil Kumar, Honourable Minister for Agriculture Development and Farmers Welfare, Government of Kerala, inaugurated the Turmeric fest held at ICAR-IISR during 19-20 January 2018.

On tribal development and welfare, the institute organised three training programmes in the tribal regions of Chintapalle, Paderu and Arku of Vishakapatnam on "Scientific cultivation of black pepper and turmeric" in collaboration with Spices Board, Guntur and AICRPS centre, HRS Chintapalle which were well attended by the tribal farmers of the region. The institute is developing seed villages in Andhra Pradesh and Telengana for the production of certified seeds in turmeric. Institute took up swachhta programmes with great commitment. Institute distributed soil health cards to farmers based on soil test results. Quality planting material of spices were distributed to farmers from different regions of the country.

I thank the spice fraternity consisting of all the scientific, administrative and non-scientific staff of the institute, farmers, researchers and all the stake holders for their continued support for the cause of spices. Still we have to go a long way in achieving the supremacy we once had in spices but I am sure, we can bring back the past glory with our united efforts and hard work.

I place on records the encouragement and guidance given by Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR. I sincerely acknowledge the strong support and guidance received from Dr A.K. Singh, Deputy Director General (Horticulture Science) and Dr T. Janakiram, Assistant Director General (Horticulture Science II). I thank the ICAR for the financial and administrative support for carrying out various programmes. Finally, I thank the editors for bringing out this publication.

Kozhikode
9 April 2018



(K. Nirmal Babu)

MAJOR EVENTS

PARLIAMENTARY STANDING COMMITTEE ON AGRICULTURE VISITS ICAR-IISR REGIONAL STATION

The Parliamentary Standing Committee on Agriculture visited IISR Regional Station at Appangala, Madikeri on 28 April 2017. Shri. Hukamdeo Narayan Yadav, Chairman of the Standing Committee was accompanied by three members each from Rajya Sabha and Lok Sabha. At Appangala, the Chairman and members were received by Director and staff of the Institute. Dr. T. Janakiram, ADG (HS II) welcomed the dignitaries in the official meeting that ensued. Dr. K. Nirmal Babu, Director,

ICAR-IISR made a detailed presentation on the programmes and progress of the on-going research activities carried out by the Institute. The Committee appreciated and congratulated the Institute for its excellent research work in the field of spices. A field visit was also organized for the benefit of the visiting delegation.

Ten important points covering various aspects of spices such as price fluctuation, import duty imposition, spreading of improved varieties and technologies to North East, focusing research activities on food safety, medicinal and nutraceutical properties, value addition, enhancement of budget allocation and manpower to strengthen research programmes etc. emanated out of the deliberations.



Fig. 1. Shri. Hukamdeo Narayan Yadav, Chairman of the Standing Committee chairing the meeting held at IISR Regional Station, Appangala

ADDITIONAL SECRETARY (DARE) & SECRETARY (ICAR) VISITS IISR REGIONAL STATION

Shri Chhabilendra Roul, Additional Secretary (DARE) & Secretary (ICAR) visited IISR RS, Appangala, Madikeri on 4 July 2017. Ceremonial planting of the nutmeg variety 'IISR Keralaashree' developed by the institute was done by Sh. C. Roul. A field visit and an exhibition depicting the achievements and success stories of technologies developed by the Institute was also arranged. Shri. C. Roul appreciated the work done by the staff of the station and he emphasized the need to maintain the record of success stories in the farmer's field and also to maintain the record on the farmers benefitted by the station.



Fig. 2. Shri. C. Roul and staff of ICAR-IISR with the ceremonial planted nutmeg

SAARC REGIONAL EXPERT CONSULTATION MEETING

The Regional Expert Consultation Meeting on Technology Sharing of Spice Crops in SAARC Countries, jointly organized by ICAR- IISR and SAARC Agriculture Centre, Dhaka was held at ICAR-IISR during 11-13 September, 2017.



The three day meeting was attended by scientists and policy makers from Afghanistan, Bangladesh, Sri Lanka, Bhutan, Nepal and India which also included country-wise presentations and brainstorming session on policy and technological interventions for spices value chain development in South Asia.



Fig. 3. Representatives of SAARC member countries

SYMPOSIUM ON SPICES, MEDICINAL AND AROMATIC CROPS (SYMSAC IX)

The National Symposium on Spices and Aromatic Crops (SYMSAC IX) jointly organized by Indian Society for Spices, Kozhikode and School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema with the theme “Spices for doubling farmer’s income” was held during 15-17 March 2018 at School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema Campus, Nagaland. The symposium was inaugurated by Shri. Padmanabha Balakrishna Acharya, Hon’ble Governor of Nagaland. The most notable feature of the symposium was the B2B meeting between buyers and sellers and also interactive meeting between farmers and scientists. During the symposium a clear cut road map for improvement of spices production and marketing in North Eastern region was suggested.



Fig.4. Hon’ble Governor of Nagaland Shri P.B. Acharya inaugurating the Symposium

TURMERIC FESTIVAL AND AWARENESS PROGRAMME ON PPV&FRA HELD AT IISR

A two day District level seminar and field day on turmeric titled “Turmeric fest” was organized by ICAR-IISR during 19-20 January 2018. Adv. Shri V S Sunil Kumar, Honourable Minister for Agriculture Development and Farmers Welfare, Government of Kerala, inaugurated the Turmeric fest. A turmeric themed exhibition was the highlight of the fest where more than 100 types of turmeric from across the country, several value added products from turmeric, lab equipments used in turmeric research, traded grades of turmeric and farmer varieties were on display. The awareness programme on Provisions of the Protection of Plant Varieties and Farmers’ Right Act (PPV&FRA) was inaugurated by Dr BNS Murthy, Horticulture Commissioner, Government of India on 19 January 2018. The farmer participants and other stakeholders were provided an opportunity to experience the varietal diversity of major spices through focused showcasing of varietal wealth in turmeric, black pepper, cardamom, ginger and nutmeg. More than 250 farmers from across the state attended the event.



Fig. 5. Adv. Shri V S Sunil Kumar, Hon’ble Minister inaugurating the turmeric fest



Fig. 6. A view of spices varietal exhibition

SWACHHTA PROGRAMMES

As per the guidelines of ICAR, Swachhta Pakhwara was observed during 16-31 May 2017 and Swachhta Hi Seva fortnight was observed at ICAR-IISR, Kozhikode during 15 September to 2 October, 2017. In order to spread the message of clean and green environment, programmes including planting of spices, avenue trees etc. were organized. Awareness programmes for farmers as well as students and session on organic waste management and literary competitions on swachhta were organized in different languages for the institute staff. Institute undertook a cleanliness programme at Government Mental Health Centre, Kuthiravattam, cleaning of Kozhikode beach, Sarwatra Swachhta (cleaning of public place) etc. Various housekeeping activities were organized to maintain cleanliness in the office buildings, rooms, laboratories, canteen, campus, planting material production units and residential area in which all the staff members actively participated. Emphasis was also given for speedy disposal and weeding out of files.

BLACK PEPPER

GENETIC RESOURCES

Germplasm explorations were conducted to North East India including Karbi Anglong and Dima Hasao districts of Assam and Janitia hills of Meghalaya. Forty four accessions were collected from the forests of North Eastern Region. Among the *Piper* spp. collected *Piper beteloides* (Fig.7) was found to be the widely distributed.



Fig. 7. *Piper beteloides*

About 3466 accessions are maintained at the nursery, while the field gene bank at Peruvanamuzhi holds 200 accessions. The alternate

field gene bank at CHES, Chettalli holds 735 accessions. Besides, a field gene bank comprising of 223 accessions is maintained at the Chelavoor campus. A block of released varieties and local cultivars was established at the germplasm conservatory on non-living standards. Also, 62 prominent local cultivars are being conserved using the column method.

CROP MANAGEMENT

Spiking intensity and fruit setting as influenced by rainfall

Spiking intensity and berry set percentage were recorded in 19 plantations in different locations with varying rainfall. Spike intensity ranged from 15 to 71.11 per 0.5 m² canopy area with mean of 31.55 per 0.5m². Number of developed berries ranged from 12.27 to 93.1 with a mean of 54.53 per spike, while undeveloped berries ranged from 10 to 50.87 with mean of 25.38 per spike. Berry set percentage ranged from 26.14 to 89.1 with a mean of 63.83. Low berry set percent was recorded in low rainfall area and less managed plantations.

Mitigation of climate change effects

Anti transpirants like spray lime (1.5%), spray lime (1.5%) + muriate of potash (0.5%), kaolin (2%), kaolin (2%) + muriate of potash (0.5 %); Miracle (3 ml/litre) were sprayed to yielding vines during January 2018 for second consecutive year to mitigate drought. Yield and photosynthesis data were recorded in February 2018 in different treatments. Data revealed that yield was relatively higher in sprayed vines compared to control. Higher photosynthetic rate was recorded in plants treated with spray lime (1.5%) which also maintained lower leaf temperature compared to other treatments.

Differential gene expression under drought

The Illumina data of leaf transcriptomes from the drought tolerant accession 4226 exposed to drought stress was analyzed to identify differentially expressed genes under stress. Digital gene expression analysis of the data showed 2862 transcripts up-regulated and 2052 transcripts down-regulated under water deficit stress.



Scheduling fertilizer dose for fertigation

Supplemental application of NPK and micronutrients as foliar sprays over and above fertigation increased the leaf concentration of K, P, Zn and B. Soil supplementation of fertilizers and foliar spray of NPK & micronutrients recorded higher yield (30.15 kg/std fresh) followed by fertigation + soil supplementation and foliar micronutrients alone (26.1 kg fresh) over fertigation alone. Additional investment of Rs. 10 to 15 per standard yielded an additional profit of Rs. 360-900 per standard, over and above fertigation.

Site-specific soil fertility management

The adoption of site-specific soil fertility management helped in increasing the yield of black pepper by 76-97% over control (farmers practice). Increase in yield (15-30%) was observed in demonstration plots too. Quality of the produce was also improved due to site-specific fertility management.

Delineation of efficient black pepper producing zones in India

Based on the relative spread and yield index, out of 97 black pepper growing districts in India, 84 were delineated as efficient producing zones with 26 districts in Assam, 2 districts in Goa, 19 districts in Karnataka, 9 districts in Kerala, 10 districts in Meghalaya, 7 districts in Nagaland and 11 districts in Tamil Nadu.

PLANT HEALTH MANAGEMENT

Field evaluation of strobilurin fungicides against foot rot & slow decline diseases

The promising strobilurin fungicides, kresoxim methyl and RIL significantly reduced yellowing of black pepper vines. No incidence of *Phytophthora* was noticed in any of the treatments. Metalaxyl-mancozeb + carbosulfan resulted in significant reduction in soil nematode population.

Field evaluation of promising bacterial and actinomycete consortia

In a field trial, combinations of several bacterial (*Pseudomonas putida* BP25, *Bacillus mega-*

terium BP17 and *Curtobacterium luteum*) and actinobacterial strains (Act 2, Act 5 and Act 9) were compared with *Trichoderma harzianum* + *Pochonia chlamydosporia* in managing *Phytophthora* and nematodes of black pepper. The nematode population was considerably reduced (>87%) in all the treatments compared to control.

Evaluation of novel fungicide molecules against Phytophthora under pot culture conditions

In an *in planta* assay, six new fungicide molecules (Curzate 0.2%, Melody duo 0.4%, Antracol 0.2%, chlorothalonil 0.2%, Equation Pro 0.1%), that showed 100% *in vitro* inhibition against *P. capsici*, were compared with the recommended fungicide metalaxyl-mancozeb for controlling *Phytophthora capsici* and the lowest infection was noticed with metalaxyl-mancozeb treatment.

Area wide integrated management

Demonstration of managing foot rot and slow decline diseases using biologicals and chemicals was continued in Muthappanpuzha and Thamarassery in Kozhikode district, Rajakkad in Idukki district and Adikolli in Wayanad district of Kerala. Under this programme five nurseries were established in all these locations and rooted cuttings of improved varieties of black pepper were multiplied and distributed to farmers. Field visits and farmers' awareness programs were also undertaken in these areas.

Molecular characterization of Colletotrichum spp. causing anthracnose disease

DNA from two leaf blight inciting isolates of *Colletotrichum* was isolated, internal transcribed spacer (ITS) and β tubular (TUB) gene regions were amplified and sequenced. Sequence comparison with other *Colletotrichum* species indicated that the fungus is closely related to *Colletotrichum fruticicola* and *C. gloeosporioides*.

Pythium deliense, a new pathogen causing yellowing and wilt

Pythium species was frequently observed in soil samples drawn from the rhizosphere of yellowing and wilt affected vines in several parts

of Kerala. The infected leaf baits when placed on detached black pepper leaves showed infection within 24 h. The re-isolated organism infected leaf, stem and roots (after nine days) of intact plants of 3-4 leaf stage without any collar infection.

The fungus has filamentous inflated/torulated sporangia, smooth oogonia, aplerotic oospores, apical intercalary antheridia and bending of oogonial stalks towards the antheridia that are characteristics of *Pythium deliense* (Fig. 8).

ITS rDNA amplification using ITS1 and 4 primers, showed a product of 700 bp with 99% identity to *P. deliense* from other hosts. *P. deliense* (MP1 & MP2) grows at a pH range of 4.5-10, temperature range of 15-40°C with optimum temperature of 28-32°C.

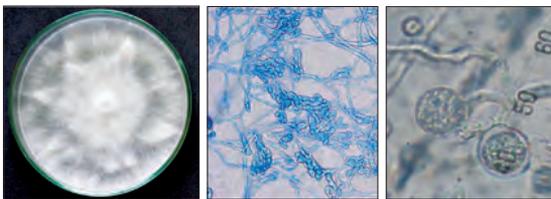


Fig. 8. *Pythium deliense*, a new pathogen of black pepper (from left) Culture on PDA, Torulated sporangia, Oogonia with curved stalk

Tripartite interaction proteomics

The label free proteomics on tripartite interaction (Fig. 9) revealed that *Trichoderma* induces systemic resistance pattern in black pepper for *Phytophthora*.

The enrichment of strong ROS related activity suggests that the ROS mediated signaling as major component in *Trichoderma* induced ISR (T-ISR) in black pepper and also the involvement of ET synthesis in the ISR development.

The isoflavanoid pathway and lignin synthesis are also found to be important components of T-ISR in black pepper. The proteins identified in this study are considered as quantitative resistance candidates mediated by *T. harzianum* in black pepper.

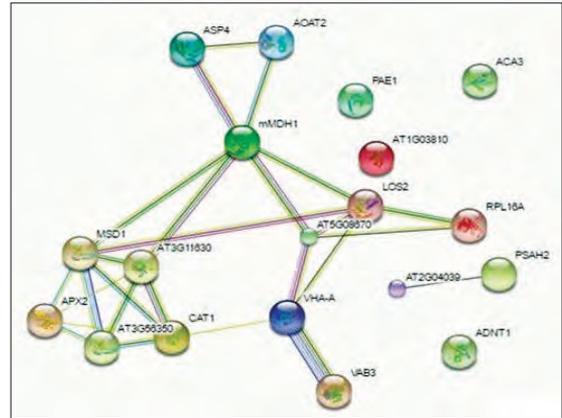


Fig. 9. Tripartite interaction diagram

CARDAMOM

GENETIC RESOURCES

A total of 599 cardamom accessions are presently being maintained at National Active Germplasm Site (NAGS) consisting 430 accessions which includes 7 related genera from Appangala, 72 accessions from Pampadumpara, 41 accessions from Mudigere and 56 from Sakaleshpur. The NAGS was enriched with 29 accessions from Cardamom Research Station, Pampadumpara. One Malabar type of cardamom was collected from BR hills of Karnataka.

BREEDING

Twenty three inter-varietal F1 hybrids (PET III) were evaluated for yield and their reaction to pest and diseases. Plant number 2 (Mudigere 1 x IISR Vijetha) recorded highest yield followed by Plant number 14 (ICRI 4 x IISR Vijetha). Three lines viz., GG x IISR Vijetha, Mudigere 1 x IISR Vijetha and Mudigere 2 x IISR Avinash were found to be highly susceptible to *Katte*.

CROP MANAGEMENT

Physiology of cardamom as affected by shade levels

The highest net photosynthetic rates and stomatal conductance were observed under 75% shade while highest quantum yield of photosystem II was observed under 50% shade. More number of opened stomata was displayed under 75% shade. Highest total phenol



and epicuticular wax contents were observed in plants grown in open condition and highest proline content was observed in plants grown under 50% shade. Chlorophyll a and b contents increased with increased shade levels. Plant height, chlorophyll content and photosynthetic parameters may have a role in shade adaptation in cardamom.

Organic farming v/s integrated and conventional management

Integrated management recorded significantly highest fresh capsule yield (930 g plant⁻¹) followed by fully organic management (660 g plant⁻¹) and lowest yield was recorded in conventional chemical management (Fig. 10). In pest management trial, higher capsule yield was recorded in alternate application of spinosad and *Lecanicillium* and spinosad with *Trichoderma* and *Pochonia* than control with <4% incidence of thrips damage on capsules.



Fig. 10. Field view of cardamom managed by different management systems

PLANT HEALTH MANAGEMENT

Evaluation of IPM strategies

Evaluation of IPM strategies against cardamom thrips continued at Wayanad, Kerala for the second year in a partnership mode with M/s A. V. Thomas and Company, Meppadi. The results of the trial showed that soil application

of *Lecanicillium psalliotae* was very effective in controlling thrips and the level of control was on par with chemical treatment (Quinalphos). Two sprays of spinosad (0.0135%) and soil application of *L. psalliotae* twice alternatively during March, April, May and August were also effective.

Plant growth promoting traits of *Lecanicillium psalliotae*

Lecanicillium psalliotae, an entomopathogenic fungus of the cardamom thrips exhibited both direct and indirect plant growth promoting characters. In pot culture experiments, the fungus enhanced the growth of cardamom seedlings leading to increase in root and shoot biomass, chlorophyll content, number of secondary shoots, shoot and root length etc. The fungus was also antagonistic to *Phytophthora capsici* and *P. meadii*, the major fungal pathogens of black pepper and cardamom, respectively. This is the first report on the multifarious plant growth promoting traits of this fungus.

Complete genome sequencing of Banana bract mosaic virus

The complete genome of *Banana bract mosaic virus* (BBrMV), a *Potyvirus* belonging to the family Potyviridae causing chlorotic streak disease of cardamom (*Elettaria cardamomum*) in India was determined for the first time from a naturally infected cardamom var. Njallani Green Gold. The complete genome has 9708 nucleotides excluding poly (A) tail and has the genome organization similar to that of BBrMV isolates infecting banana and flowering ginger (*Alpinia purpurata*).

GINGER

GENETIC RESOURCES

Six hundred and sixty eight ginger accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with 20 accessions and 6 *Zingiber* sp. collected from Meghalaya and Assam. Among the eight accessions evaluated during 2017-18, accession 278 was found to be promising for high yield and low fibre content.

BREEDING

Ten M1V5 and 102 M1V10 mutants have been maintained. Three potential mutants identified against *Pythium* sp. (V 0.5/2, R 0.8/1 and R 1.25/4) and three potential mutants against *Ralstonia solanacearum* (HP 0.5/2, HP 0.5/15 and M 0.5/1) were multiplied for further evaluation.

Induction of polyploidy

The rhizome buds of IISR Rejatha were submerged in different concentrations of colchicine (0.025, 0.050, 0.075, and 0.1 %) solution for 24 h and 48 h to induce polyploidy. The chromosome number analysis of rhizomes harvested from the plants derived from colchicine treated buds confirmed tetraploidy ($2n=44$) in two of them. Both were derived from buds treated with 0.1% colchicine for 48 h (0.1/48/3 and 0.1/48/5). These two promising tetraploids (Fig. 11) are being multiplied and characterized.

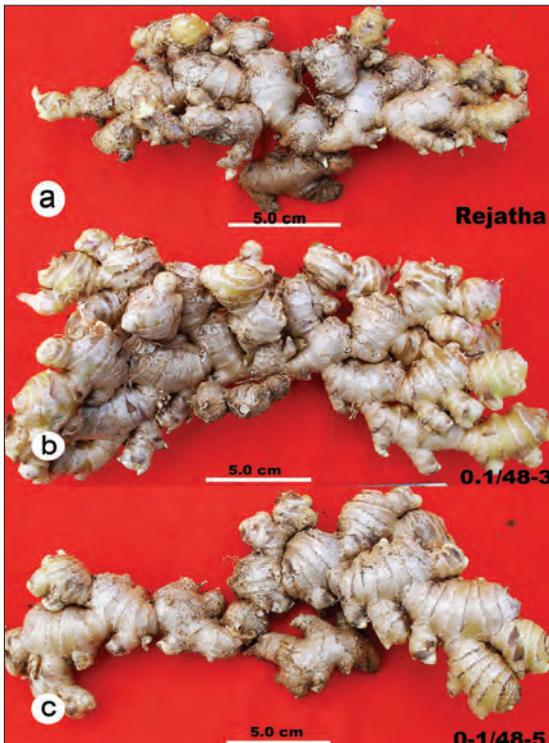


Fig. 11. Normal and induced polyploids in ginger (var. IISR Rejatha); a. A normal rhizome of IISR Rejatha; b&c. Induced polyploids from colchicine treated rhizome

CROP MANAGEMENT

Fertigation

Fertigation studies revealed that, 75% of recommended dose of fertilizers (RDF) supplied through fertigation produced significantly higher rhizome yield compared to 100% and 50% RDF supplied through fertigation or 100% RDF applied as solid fertilizers at monthly intervals. But partitioning to rhizomes was significantly reduced under fertigation treatments and these rhizomes had lower starch and fibre content compared to rhizomes obtained from the field (soil) grown ginger supplied with solid fertilizers at recommended dose. Hence, fertigation may be more suitable for vegetable ginger production where low fibre and starch are preferred.

PLANT HEALTH MANAGEMENT

Viral diseases

Genotypic variation was observed for the incidence of the chlorotic streak disease in ginger. Among the genotypes scored, 182, 72 and 58 accessions showed mild, moderate and severe symptoms respectively, while 177 accessions did not show any symptoms. The leaf dip electron microscopy of plants infected with chlorotic streak disease showed presence of isometric and flexuous rod shaped particles.

Isolation of pathogens associated foliar diseases

Different fungi were isolated from infected samples of ginger and turmeric collected from various locations. The fungi included *Bipolaris rostrata*, *Fusarium oxysporum*, *Fusarium* spp., *Colletotrichum gloeosporioides*, *C. capsici* and unidentified cultures.

Leaf blight caused by *Bipolaris rostrata*, a new report

Based on morphological characterization the fungal isolate causing leaf blight disease prevalent in Mysore and Chamarajanagar districts of Karnataka was identified as *Bipolaris rostrata* (Drechs.) Shoemaker [synonym- *Exerohilum rostratum*]. Phylogenetic analysis based on ITS and β -tubulin regions grouped



the ginger isolate GF5 with *B. rostrata* *Setosphaeria rostrata* *Exserohilum rostratum* isolates from NCBI with 100% bootstrap support. The fungus produced brown to dark brown coloured conidia with cylindrical shape and round at both ends, having 2-11 septate with bipolar germination (Fig. 12). This is a new report of *B. rostrata* causing leaf blight on ginger.



Fig.12. *Bipolaris rostrata* causing leaf blight of ginger (from left) Culture, Conidium, Germinating conidia and Bipolar germination.

Pathogenicity of leaf blight pathogens

Pathogenicity trials with *Bipolaris rostrata* on varieties IISR Rejatha and Rio-de-Janeiro produced reddish brown oval discrete spots with yellow halo on the margin and distal end of the lamina which later coalesces leading to the blighting of entire leaf. On the other hand *Colletotrichum gloeosporioides* and *C. capsici* produced elliptic or oblong spots with white colour surrounded with dark brown margin and yellow halo.

Host physiology as affected by foliar pathogens

Ginger plants infected with leaf spot (*Phyllosticta* sp.) and leaf blight (*Bipolaris rostrata*) diseases showed decreased activity of catalase and increased activity of peroxidase and polyphenol oxidase enzymes. The infection also reduced photosynthetic rate, stomatal conductance, total carbohydrates and total phenols.

Screening of fungicides against foliar pathogens

Ten fungicides were evaluated under *in vitro* conditions against *Bipolaris rostrata* and *Colletotrichum gloeosporioides*. The fungicides tebuconazole, carbendazim + mancozeb, cyoxanil + mancozeb and hexaconazole were found to be effective under *in vitro* conditions.

Front line demonstrations on management of bacterial wilt

Integrated management of bacterial wilt using the biocontrol agent, *Bacillus licheniformis* (GAP107 MTCC 12725) and calcium chloride was demonstrated in collaboration with Directorate of Arecanut and Spices Development (DASD), Kozhikode in two farmers' plots in Wayanad. No bacterial wilt was observed in ginger plots which were solarized prior to sowing and treated with either *B. licheniformis* or calcium chloride (Fig. 13) while control and adjacent plots showed more than 30% disease incidence. However highest yield was observed in plots amended with calcium chloride than *B. licheniformis*.



Fig.13. Ginger plots treated with (a) *Bacillus licheniformis* and (b) calcium chloride

TURMERIC

GENETIC RESOURCES

One thousand four hundred and four *Curcuma* accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with 32 *Curcuma longa* accessions and 13 *Curcuma* sp. collected from Meghalaya and Assam.

BREEDING

Self-pollination studies in first and second generation inbreds

Self-pollination of first and second generation inbreds of 138/11/1, first generation inbreds of 138/7/1, 69/5/22, 359/4, 359/2, 65/12 and a triploid Acc. No. 65 were performed. Fruit set was obtained in a first generation inbred of 138/7/1, five first generation inbreds of 69/5/22, three second generation inbreds of 138/11/1, and the triploid accession, Acc. No. 65. Seeds obtained from selfing of second generation inbreds of 138/11/1/11-12 started germinating and more than 250 third generation inbreds were established.

High pollen fertility in second generation inbreds

Pollen fertility analysis of second generation inbreds namely, 138/11/1/11-12/12-1, 138/11/1/11-12/12-2, 138/11/1/11-12/12-3 showed high pollen fertility (>85%) on staining. Inbred 138/11/1/11-12/12-2 showed 74.63% pollen fertility on *in vitro* germination in B&K medium containing 5% sucrose. This inbred produced more than 200 third generation inbreds on self-pollination.

PLANT HEALTH MANAGEMENT

Pathogenicity studies of leaf blight

In turmeric varieties IISR Prathibha and BSR-2, *C. gloeosporioides* and *C. capsici* infection developed as small elliptic spots of different sizes with a yellow halo on leaf lamina. The center of the spots was greyish white in colour which later coalesced into irregular patches.

Screening germplasm accessions against foliar diseases

Germplasm accessions (100 no.s) were screened for foliar diseases. Leaf blotch caused by *Taphrina maculans* was found to be severe in Narendra Haldi, BSR 1& 2, Co-2, Rajendra Haldi etc. and the per cent disease intensity ranged from 0 to 59.5. Genotypes BSR 2, SC 61 and accession 219 were found to be infected with leaf spot caused by *Colletotrichum* spp. with per cent disease intensity ranging from 0 to 27.5.

Incidence of shoot borer in relation to crop phenology and date of planting

The incidence of shoot borer infesting turmeric in relation to crop phenology was studied at fortnightly interval. The pest incidence was observed during second fortnight of August and the peak incidence was in second fortnight of October when the crop was planted in June. When planting of the crop was advanced to May, the pest infestation was observed first during the first fortnight of July and was high during the second fortnight of August.

POST HARVEST TECHNOLOGY AND VALUE ADDITION

Concentrated solar thermal unit for curing

Considering the minimum time required for drying and optimum retention of quality of dried material, 60 minutes curing of turmeric in concentrated solar thermal curing unit fitted with cooking vessel was considered optimum based on the maximum retention in the essential oil content and the minimum drying time required.

Studies on enhancing the bioavailability of curcumin

Cheminformatics data clearly indicated that bioactive compounds from spices can improve memory in Alzheimer's patients. A freeze dried powder extracted from fresh turmeric juice of variety Prabha is being tested to enhance the bioavailability of curcumin through its extractability in virgin coconut oil and olive oil. More than 80% extractability of curcumin could be obtained in both the oils indicating its potential for developing a product against Alzheimer's disease.



VANILLA

PLANT HEALTH MANAGEMENT

Fungal antagonists of Fusarium oxysporum in vanilla

Forty bacterial isolates were test evaluated under *in vitro* conditions against *Fusarium oxysporum* f.sp. *vanillae* and maximum inhibition of 53.33 % was recorded in VREN1 (Fig. 14 a). Thirteen fungal isolates were tested and FVLEP3 showed maximum percentage inhibition of 68.89. VREN1 is tentatively identified as *Bacillus amyloliquefaciens*. It produces IAA, siderophores (Fig.14 b) and GA and recorded higher growth promotion activity. Aqueous formulations with different amendments were tested for assessing survival ability of *B. amyloliquefaciens*. NA medium amended with 100 mM glycerol showed highest cfu (8×10^9), 60 days post inoculation.

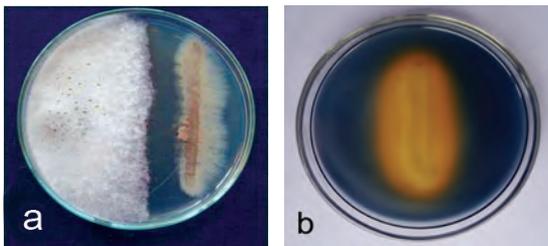


Fig. 14. a) Inhibition of *Fusarium oxysporum* f.sp. *vanilla* by VREN1, b) Siderophore production

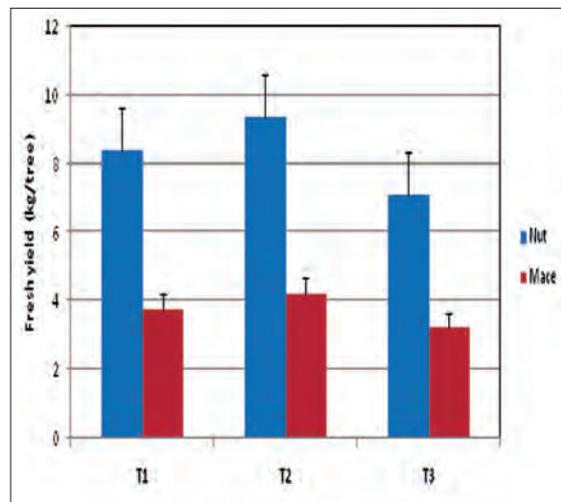
TREE SPICES

GENETIC RESOURCES

Three clove accessions *viz.* Madagascar clove, little leaved clove and Zanzibar clove and three accessions of cinnamon were added to the tree spices germplasm. In *Garcinia*, three promising *G. gummigutta* accessions from NBPGR Regional Station, Thrissur and seven *Garcinia* species from North East (*G. lancifolia*, *G. pedunculata* and three unidentified species and two exotic species (*G. forbesii*, one unidentified sp.) were added to the germplasm. Air layering in nutmeg was standardized with 70% success.

MANAGEMENT PRACTICES TO ENHANCE PRODUCTIVITY IN NUTMEG

In nutmeg, application of amendments (lime and lime + dolomite) along with site-specific nutrients and micronutrients, termed as best management practice (BMP) increased the yield significantly over the farmers practice. The yield increase was up to 50% in the treated plots in the experimental condition and from 10-25% in farmer's demonstration plots as compared to farmers practice (Fig.15). The farmers have registered an increase in income of Rs. 30,000-40,000 by the adoption of BMP in nutmeg in one year.



T1 – Best management practice (BMP); T2- BMP + (Lime + Gypsum); T3- Farmers Practice (FP)

Fig.15. Effect of treatments on the nut and mace yield of nutmeg

LEAF MINER CONOPOMORPHA SP. INFESTATION IN RELATION TO HOST PHYSIOLOGY IN CINNAMON

Young leaves showed higher epicuticular wax content ($612.4 \mu\text{g cm}^{-2}$) than matured leaves which would have influenced host preference leading to infestation. Net photosynthetic rate ($2.77 \mu\text{mol m}^{-2}\text{s}^{-1}$) and quantum yield of photosystem II were significantly higher in healthy leaves than infested leaves.

SPICE CROPS

ENTOMOPATHOGENS AND OTHER NATURAL ENEMIES

Surveys for natural enemies of insect pests of spice crops (black pepper, cardamom, ginger, turmeric, and nutmeg) in 16 locations (Wayanad and Kozhikode districts of Kerala and Chamarajanagar and Mysore districts of Karnataka) resulted in the documentation of three entomopathogenic fungi, one each from *Protopulvinaria longivalvata* (IISR-EPF-16), an unknown caterpillar infesting ginger (IISR-EPF-17) and *Mimegralla coeruleifrons* (IISR-EPF-18).

A nucleopolyhedrovirus was isolated from *Spodoptera* sp. (IISR-NPV-05) a highly polyphagous pest of economic importance. An isolate of *SpobNPV* – Ambalavayal isolate (IISR-NPV-04) was found to be cross infective to *Olepa ricini*. An ichneumonid larval parasitoid attacking ginger shoot borer was recorded from Wayanad district.

SURVEILLANCE AND DOCUMENTATION OF PESTS AND DISEASES

Leaf spot incidence in ginger was recorded in two locations of Kerala (Kozhikode and Wayanad). In Kodagu, the incidence of black pepper anthracnose ranged from 15-25%. During survey, in Somwarpet, Kodagu, occurrence of giant African snail causing damage to ginger and black pepper was noticed.

Surveys indicated that the incidence of foliar diseases in turmeric (Fig. 16) grown in Andhra Pradesh and Telangana was very high (60-80%) with the severity ranging from 10-40%. Incidence of rhizome rot disease was found to be very high (37.5%) with the severity ranging from 5-25%.

Root knot nematode (*Meloidogyne incognita*) infestation was observed where rhizome and root rot incidences were severe. Incidence of nematode infestation was also found to be high (42.4%).



Fig. 16 . Leaf spot and leaf blight disease prevalent in turmeric fields of Andhra Pradesh

AFRICAN SNAIL INFESTATION IN GINGER AND BLACK PEPPER

African snails were found to cause severe damage to ginger and black pepper plants near Shanivarasanthe, Kodagu, Karnataka. Studies on the nature of damage by the pest indicated that the snails caused damage by aggressively feeding on the growing young shoots. The snails weighed between 6.67 to 7.6 g.

ECOLOGICALLY SAFE MANAGEMENT OF SHOOT BORER

Three insecticides (spinosad, flubendiamide, chlorantraniliprole), which were found effective in earlier trials and also a treatment with spraying of chlorantraniliprole and spinosad alternatively were tested under field conditions at Peruvannamuzhi farm for dose optimization against shoot borer infesting ginger and turmeric. All the insecticides were very effective in the management of the pest even at the lowest dose (0.3 ml L⁻¹ of water) tested. The treatment of spraying of chlorantraniliprole and spinosad alternatively was also equally effective in controlling the insect.

HYPOGLYCEMIC POTENTIAL OF CINNAMON AND TURMERIC

Study conducted using diabetic rats to test the hypoglycemic potential revealed that extracts based on cinnamon could reduce blood glucose level up to 85% followed by 75% reduction with cinnamon-turmeric extract combination and 80% with turmeric extract alone in one



month's time after feeding the extract indicating their potential in developing an anti-diabetic product. The compounds responsible for the observed action are being evaluated.

PROMISING SOIL ZN SOLUBILIZING BACTERIA

Out of the six promising Zn solubilizing bacteria (ZnSB), ZnSB2 (*B. megaterium*, KY687496) was found to be the most potential strain owing to its enhanced Zn solubilization *in vitro*, in liquid culture and in soil *per se*. Further evaluation of ZnSB2 was done in the green house using turmeric as the test crop. The results revealed that rhizome yield, was at par in the treatments with ZnSB2 + 75% of Zn (154.2 ± 36.0 g pot⁻¹) and 100% Zn applied as ZnSO₄ (177.2 ± 36.7 g pot⁻¹). The study indicated that ZnSB2 strain was a potential candidate for enhanced Zn dissolution in soil, which would allow reduced inorganic Zn application rates.

SPICES ECONOMICS

THE SPHERE OF INFLUENCE OF SPICE TECHNOLOGIES

Estimates indicate that the technologies developed and deployed in spices can benefit more than seven million agricultural holdings across the country. The share of marginal and small holdings in the total holdings tends to be more than 90 per cent in most of the spice crops reflecting the potential of technology interventions in benefitting small holder production systems. The focus on spice crops cultivating holdings and their up-liftment in terms of farm income promotes equitable development and social justice.

YIELD ADVANTAGE OF SPICES VARIETIES

The yield relative which measures the advantage of improved varieties from ICAR-IISR with respect to the farmer yield levels attained over the XIIth plan period clearly indicates the potential benefits from varietal technology adoption. The yield relative was calculated using attainable yields in farmer plots which reflects a practically attainable yield with average management.

ECONOMIC BENEFIT FROM VARIETAL IMPROVEMENT IN NUTMEG

A conservative estimate of impact of nutmeg varietal improvement in terms of output shows that an annual additional production of 1000 tonnes could be attributed to the improvement in varietal profile of the crop.

IMPACT OF MICRONUTRIENT TECHNOLOGY IN SPICES

Crop specific designer micronutrient mixture for spice crops was developed at ICAR-IISR during the XIIth Plan period and the technology was released during 2013-14. The incremental production resulting from adoption of micronutrient technology in spices by the farmers is estimated to be about 366 tonnes in black pepper, 1755 tonnes in dry ginger, 1995 tonnes in dry turmeric and 15 tonnes in cardamom.

TURMERIC SURVEY IN ANDHRA PRADESH AND TELANGANA

A field survey of turmeric growers was conducted in Andhra Pradesh and Telangana, which together account for a significant share in area (38.64%) and production (58.98%) of turmeric in India. The study flagged several issues like low level of varietal awareness, the need to offer better cropping choices complementing the specific turmeric varieties, the high cost of plant protection arising from wrong time, wrong chemical and wrong method of pesticide use, need for rationalizing water use, etc. The study also highlighted the need for a sensitization drive on integrated plant protection strategies among field functionaries and farmers to address the indiscriminate use of pesticides.

EXTENSION AND TRAINING

FARMERS TRAINING IN TRIBAL AREA OF VISHAKAPATNAM, ANDHRA PRADESH

Three training programmes on "Scientific cultivation of black pepper and turmeric" were held in the tribal regions of Chintapalle, Paderu and Arku of Vishakapatnam during 17, 18 & 19 November 2017, respectively. It was jointly

organized by ICAR-Indian Institute of Spices Research, Kozhikode, Spices Board, Gun- tur and AICRPS centre, HRS Chintapalle of Dr. YSR Horticultural University. Rooted cut- tings of seven black pepper varieties brought from ICAR-IISR, Kozhikode were multiplied and distributed in this region. About 125 farm- ers attended training on these three days.



Fig.18 A snap shot of Agricultural Education Day celebra- tion



Fig.17.a)Shri Chiranjiv Choudhary, IFS, VC, Dr YSR Hort University, interacting with Scientists of ICAR-IISR and Spices Board during farmers training, b)News paper clip- ping of farmers training

INSTITUTE TECHNOLOGY MANAGEMENT - BUSINESS PLANNING AND DEVELOPMENT UNIT

RECOGNITION FOR ICAR-IISR STARTUPS

ICAR-IISR was selected for participation in the Festival of Innovation and Entrepreneurship (FINE), a week-long annual event hosted at the Rashtrapathi Bhavan during 19-21 March 2018. Two startups from ICAR-IISR viz., Dr Chaitra Narayanan, Kodagu Agritech, Karnata- kta and Mrs. Thabeera K, Natura Nursery, Kozhikode were selected for presenting their technologies. Hon'ble President of India ac- companied by Dr. Trilochan Mohapatra vis- ited the startup stall of ICAR-IISR. Dr. Chaitra Narayanan, presented a brief summary about her initiative on biocapsules (Fig.19). The tech- nology comprising encapsulating delivery of agriculturally important microorganisms (bio- capsules), a patented technology developed by ICAR-IISR is expected to herald a revolu- tion in biofertilizer industry. The ITM-BPD unit signed thirteen license agreements for technol- ogy commercialization/services during 2017- 18.

AGRICULTURAL EDUCATION DAY CELEBRATED

Agricultural Education Day was celebrated on 4 December 2017 with the involvement of post graduate students of various colleges of Kozhikode such as St. Josephs' college Deva- giri, Botany and Zoology Department, Univer- sity of Calicut, Guruvayoorappan College and Providence Womens' College. Sri. Snehil Ku- mar Singh, IAS, Assistant collector, Kozhikode was the Chief Guest.

PARTICIPATION IN VARIOUS EVENTS

ICAR-IISR participated in the Agricultural tech- nology show and event organized by ICAR-CT- CRI, Trivandrum during 27-28 October 2017. ICAR-IISR was invited to attend SAFARI 2, an international conference organized by CMFRI, Kochi during 15-17 January 2018. ICAR-IISR also participated in the XIth Indian Fisheries and aquaculture forum held during 21-24



November 2017 at Kochi organized by ICAR-CIFT. ICAR-IISR was an invited participant for the Kisan Mela cum Agribusiness Expo organized by ICAR-CPCRI, Kasaragod during 5-10 January 2018.



Fig. 19. Dr. Chaitra Narayanan presenting about her initiative to Hon'ble President of India during FINE 2018 held at Rashtrapathi Bhavan, New Delhi

KRISHI VIGYAN KENDRA

TRAINING PROGRAMMES

The Kendra conducted one hundred and twenty two training programmes in various disciplines during the year, benefitting 4761 participants. It included five trainings for extension functionaries on ornamental fish culture, aquaponics, freshwater fish culture, indigenous medicine for animals, spice production for 140 persons, a series of training programmes and demonstrations on jack fruit, nutmeg and ginger processing in different parts of the district. On value addition alone 18 training programmes were organized and 557 farmers were benefitted. KVK also organized two day training on Fresh water ornamental fish culture for youth of age group ranging from 15 to 25 years. A district level one day training on 'Spices propagation and integrated management' was also organized for the field and extension staff of Agriculture Technology Management Agency (ATMA), Kozhikode as a part of Coconut improvement project. KVK celebrated World Fisheries day, IIIrd International Yoga day, National Science day, World Environment day and World Honey day. KVK observed technology week during 12 to 17 February 2018. During the period KVK implemented seven FLDs and nine OFTs in 136 farmer fields. World Soil Day was organized at KVK on 5 December 2017. KVK distributed 436 soil health cards to the people of 25 villages.

SANKALP SE SIDDI PROGRAMME

KVK organized the programme on Sankalp Se Siddhi at ICAR-IISR, Kozhikode on 25 August 2017 for popularizing the vision, efforts and strategies adopted by Government institutions for doubling farmer's income. The programme was inaugurated by Shri. M. K. Raghavan, Hon. MP Kozhikode. Shri. Babu Parasseri, Zilla Panchayat President and Shri. Pradeep Kumar MLA, Kozhikode also witnessed the event. Dr. T.E. Sheeja, Principal Scientist, ICAR-IISR delivered a special lecture on "Doubling farmers' income – Strategies and success stories" during the occasion.

KVK SILVER JUBILEE CELEBRATION

Hon'ble Member of Parliament Shri Mullappally Ramachandran inaugurated IISR-KVK Silver Jubilee celebrations which was organized on 12 February 2018 to observe the completion of 25 years of IISR-KVK establishment. The MP applauded KVK activities and congratulated staff for their tireless service to farmers. The programme was presided by Dr. K. Nirmal Babu, Director, ICAR-IISR, Kozhikode.



Fig. 20. a) Silver jubilee celebrations; b) Distribution of soil health card during World Soil Day celebration; c) Inauguration of Sankalp Se Siddhi programme

ICAR-ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

XXVIII WORKSHOP OF ICAR-AICRP ON SPICES

The XXVIII Workshop of ICAR-All India Coordinated Research Project on Spices was held during 10-12 October 2017 at Horticultural Research Station, Dr. Y. S. R. Horticultural University, Lam, Guntur, Andhra Pradesh. The

workshop was inaugurated by Dr T. Janakiram, ADG, HS-II, ICAR, New Delhi. The “Best AICRPS Centre Award 2016-17” was presented to three AICRPS centres viz., Rajendra Prasad Central Agricultural University, Dholi, Dr. Y. S. R. Horticultural University centres at Guntur and Chintapalle during the occasion. ‘Brain Storming Session on Turmeric’ was also held during workshop. Two turmeric varieties Narendra Saryu, high yielding and high curcumin variety and CL-34 -tolerant to leaf spot and leaf blotch; two coriander varieties, Gujarat Coriander 3- high yielding, high volatile oil and high linalool contents and Ajmer Coriander 2- resistant to stem gall, high linalool and early maturing and one fenugreek variety Ajmer Fenugreek 5 - high seed yield, high antioxidant content and suitable for green leaf production were recommended for release during the workshop.

LOCATION SPECIFIC TECHNOLOGIES DEVELOPED BY AICRPS CENTRES

1. Standardization of drip fertigation in black pepper under Kerala conditions.
2. Liming in cardamom for Kerala.
3. Utilization of herbicides for effective control of weeds in ginger for Andhra Pradesh.
4. Micro nutrient management in fennel in Gujarat.
5. Management of blight and powdery mildew by spacing and potash application in cumin in Gujarat.
6. Organics for yield enhancement in small cardamom in Karnataka.
7. Standardization of fertigation in cardamom for Karnataka.



Fig. 21. a) Inauguration of AICRPS Workshop; b) Release of publications of AICRPS

HUMAN RESOURCE DEVELOPMENT

MoU FOR ACADEMIC INTERACTION

ICAR-IISR signed Memorandum of Understanding (MoU) on 4 October 2017 with Kerala Agricultural University, Thrissur and on 14 October 2017 with Providence Women’s College, Malaparamba, Kozhikode for academic interaction for facilitating collaborative training and post graduate research/doctoral studies.

HRD cell organized training programme on implementation of PFMS in Central Sector Schemes to the officials of Kerala Veterinary and Animal Sciences University on 23 January 2018. HRD cell conducted In-Plant training programmes for 65 B. Tech. (Agrl. Engg.) students from Kelappaji College of Agrl. Engg. & Technology, KAU, Tavanur at ICAR-IISR Experimental Farm, Peruvannamuzhi. HRD cell also facilitated the study visit of final year B.Sc. (Hort.) students from College of Horticulture, Mudigere to IISR Regional Station, Appangala during 22 May to 17 June 2017. One month Summer internship programme for M.Sc. students was organized by HRD cell from 8 May 2017 to 6 June 2017.

HINDI CELL NEWS

The Official Language Implementation Committee meetings were held once in every quarter (29.06.2017, 25.07.2017, 11.12.2017 and 20.02.2018) during the year. The committee reviewed the OL implementation and suggested solutions to improve the OL implementation. During the year four Hindi workshops were conducted for the benefit of staff members. In these workshops various experts handled sessions on Hindi noting and drafting, Hindi typing and usage of Hindi language. Hindi Week was celebrated from 14 - 20 September 2017. During this week various Hindi competitions were conducted for the staff members. The major publications in Hindi during this period include “Masaloon Ka Jaivik Utpadan”, “Anusandhan Ke Mukhya Ansh 2016-17” and two issues of Masala Samachar. Ms. N. Prasannakumari, Senior Technical Officer was awarded “Rajbhasha Sevi Samman” by Bhasha Samanvaya Vedi on 21 September 2017.

AWARDS

Dr. E. Jayashree, Principal Scientist received NASI - ICAR award for Innovation and Research in Farm Machinery during the ICAR foundation day celebration held on 16 July 2017 at NASC Complex, New Delhi.



Fig. 22. Dr. E. Jayashree receiving the NASI- ICAR award from Hon'ble Union Minister of Agriculture and Farmers Welfare Shri Radha Mohan Singh

Dr. B. Sasikumar, Retd. Head and Principal Scientist won the National Award for Outstanding Efforts in Science & Technology Communication through Print Media including Books and Magazines (Category-B) instituted by DST, Govt. of India. He also won Karshaka Bharathi Award for farm journalism instituted by Govt. of Kerala.



Fig. 23. Dr. B. Sasikumar receiving the 'Karshaka Bharathi Award for farm journalism' from Shri. V.S. Sunil Kumar, Minister of Agriculture Development and Farmers Welfare, Govt. of Kerala.



1. President of India interacting with ICAR-IISR startup
2. *Piper beteloides*
3. Conidium of *Bipolaris rostrata*
4. Germinating conidia of *Bipolaris rostrata*
5. Oogonia of *Pythium deliense*



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