2019 RESEARCH HIGHLIGHTS
अनुसंधान के मुख्य अंश

भाकृअनुप
ICAR








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भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान
कोषिक्कोड

ICAR- Indian Institute of Spices Research
Kozhikode

Editors
R Dinesh
R Praveena
C M Senthil Kumar
V Srinivasan
T E Sheeja
S J Eapen

Guidance
A K Singh (DDG, Hort. Sci.)
T Janakiram (Former ADG, Hort-II)

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Front cover pictures
High yielding accessions of nutmeg and clove
Mealy bug infestation on black pepper | High yielding accessions of vaniila, garcinia and black pepper
Biocapsules | High oil allspice accession

PREFACE

It is a great privilege to present the 2019 Research Highlights of the ICAR-Indian Institute of Spices Research, Kozhikode, Kerala. The spices economy is crucial to agricultural prosperity of our country, improving the quality of life and supporting tribal and rural populations. India continues to be the major supplier to the global spice basket and is the leading producer of an array of spice based products. Nevertheless, the various challenges that confront the country's spice sector have been further exacerbated by the unprecedented COVID-related developments. We are mindful of these new developments and are taking germane measures to find viable solutions to various issues related to spices cultivation and production.

On the research front, technological innovations are being vigorously pursued for the development of high yielding and stress tolerant varieties, new spice production technologies, new spice based products, and fostering spice entrepreneurship. Our Tribal Sub-Plan has helped to ensure tribal welfare even in the far flung regions of the north east, and other states of India. Besides, we are also focussing on spice based product development owing to the increasing demand for immunity boosters and wellness products during the current COVID crisis.

Apparently, our spices sector needs to become more resilient and holistic during the current pandemic. This will require revolutionary and multidisciplinary approaches that will aid in doubling farmers' income. We will, therefore, continue to develop technologies that ensure food safe spices. We will strike strategic partnerships with Spices Board (Kochi) and Directorate of Arecanut and Spices Development (Kozhikode) to foster collaborative innovations. We will also continue to encourage startups and new licensees thereby nurturing the spice farmers, spurring job growth and consolidating the spice economy.

I am extremely thankful to the ICAR in supporting us in our quest for transformative spice research and extension. I whole heartedly thank Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for his support and motivation. I am also extremely grateful to Dr. A.K. Singh, Deputy Director General (Hort. Sci.) and Dr. T. Janakiram, Former Assistant Director General (Hort-II) for their guidance and encouragement. We are indebted to the expert members of the Quinquennial Review Team on Spices for providing us new directions. Special thanks to the editors for their tireless efforts.

(**Santhosh J Eapen)**

Kozhikode
September, 2020

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RESEARCH HIGHLIGHTS

Fig. 1 A unique black pepper accession collected from Madikeri, Karnataka

BLACK PEPPER

CROP IMPROVEMENT

Genetic resources

In black pepper, 3466 accessions are being maintained at the Experimental Farm, Peruvannamuzhi. A unique accession with extra-long spike (34.5 cm) was collected from Madikeri, Karnataka (Fig. 1). A new field gene bank was established consisting of 300 accessions(Fig. 2). Eighty two germplasm accessions were characterized for 17 quantitative and 12 qualitative traits using IPGRI descriptors.

Breeding

Genetic variability and correlations for yield and yield attributes were estimated in nine genotypes comprising of five hybrids, two open pollinated progenies and two released varieties of IISR. Genotypes HP 2173 (HP1117 x Thommannkodi), OPKM, HP 780, HP 1411

Fig. 2 Newly established black pepper plot on non-living standards

and HP 820 were found promising for the economically important characters. Grouping of genotypes based on Scott-Knott test revealed Panniyur-1 and Nedumchola as contrasting genotypes for maximum number of traits.

Transcriptome analysis

Major genes encoding novel compounds were identified from transcriptomes of *P. nigrum* and *P. longum*. The alkaloid tropine synthesizing gene tropine reductase was identified and sequenced from *P. nigrum.* Lysine 6 dehydrogenase gene synthesizing the alkaloid 'Pipecolate', which induces systemic resistance in plants, was identified from *P. longum*.

CROP MANAGEMENT

Development of drip fertigation schedule

Drip fertigation schedules for three varieties IISR Thevam, IISR Girimunda and IISR Shakthi were standardized for yield and quality. Required quantities of recommended dose of fertilizers were mixed with irrigation water through dosing pumps and applied at 24 splits & 40 splits from September to May. Maximum yield was noticed in IISR Girimunda (1.50 kg dry/vine) followed by IISR Thevam (1.0 kg dry/vine).

Drought management

Antitranspirants such as Kaolin (2.0%), Kaolin (2.0%) + MOP (0.5 %), lime (1.5%) and lime (1.5%) + MOP(0.5%) were tested for imparting drought tolerance. Spraying lime (1.5%) showed higher photosynthetic rate with lower leaf temperature.

Chemo diversity analysis

Quality analysis of 25 genotypes indicated highest alkaloid content in Subhakara (35.7 mg/g) and lowest in Panniyur 4 (16.7 mg/g). Oleoresin was negatively correlated with bulk density but positively correlated with essential oil content and piperine content.

Biochemical and anatomical studies of abscission zone

Detachment force (DF) was reduced significantly with ripening and it varied among cultivars. About 88.0 and 40.0% reduction in DF was observed due to ripening of spike in Agali and Chumala, respectively. Phloroglucinol staining revealed clear lignification of the abscission zone in berry and spike with maturity.

CROP HEALTH MANAGEMENT

Recombinase polymerase amplification assay for detection of *Phytophthora* spp.

Ypt1 gene based recombinase polymerase amplification assay for detection of *Phytophthora* spp was developed for the detection of *P. capsici* and *P. tropicalis*. The assay was 10 times more sensitive and robust than PCR.

Screening of germplasm accessions

Forty-five germplasm accessions were screened using *P. capsici* (05-06) and *P. tropicalis* (98-93) by leaf inoculation technique. Six accessions (Acc. 5764, 6787, 7243, 7319, 7218 and 7344) showed stem lesion in the range of 0-5 mm size with total phenols of < 5 mg/100 mg, polyphenols of < 10 mg and conductivity < 300 mS.

Antagonistic studies of *Lecanicillium psalliotae* against *P. capsici*

Studies on the antagonistic activity of *Lecanicillium psalliotae* against *P. capsici* indicated that plants challenged with *P. capsici* recovered well after the application of *L. psalliotae* under greenhouse conditions. Under field conditions, there was 50.0% reduction in yellowing symptoms in four year old vines treated with *L. psalliotae*.

Biological management of *Pythium deliense*

Under *in vitro* conditions, *Streptomyces albulus* and *Trichoderma harzianum* showed 100% inhibition of *Pythium deliense*. *In planta* evaluation under greenhouse conditions and field evaluation showed reduction in the intensity of yellowing in *T. harzianum* and *S. albulus* treated vines to an extent of 75.2 and 74.4%, respectively.

RPA assay for detection of piper yellow mottle virus

Recombinase polymerase amplification (RPA) and reverse transcription (RT) RPA assays were developed and optimized for the detection of piper yellow mottle virus (PYMoV). The study showed that RPA and RT-RPA can be successfully adopted as a substitute to PCR for detection of PYMoV.

Distribution of mealy bugs

A spatial distribution pattern of different genera of mealy bugs was observed in different growing tracts of Kerala and Karnataka. Mealy bug species belonging to *Ferrisia* and *Icerya* genera were mainly found on young shoots and berries, whereas *Planococcus* spp. was found to be associated with berries, collar region and root system (Fig. 3).

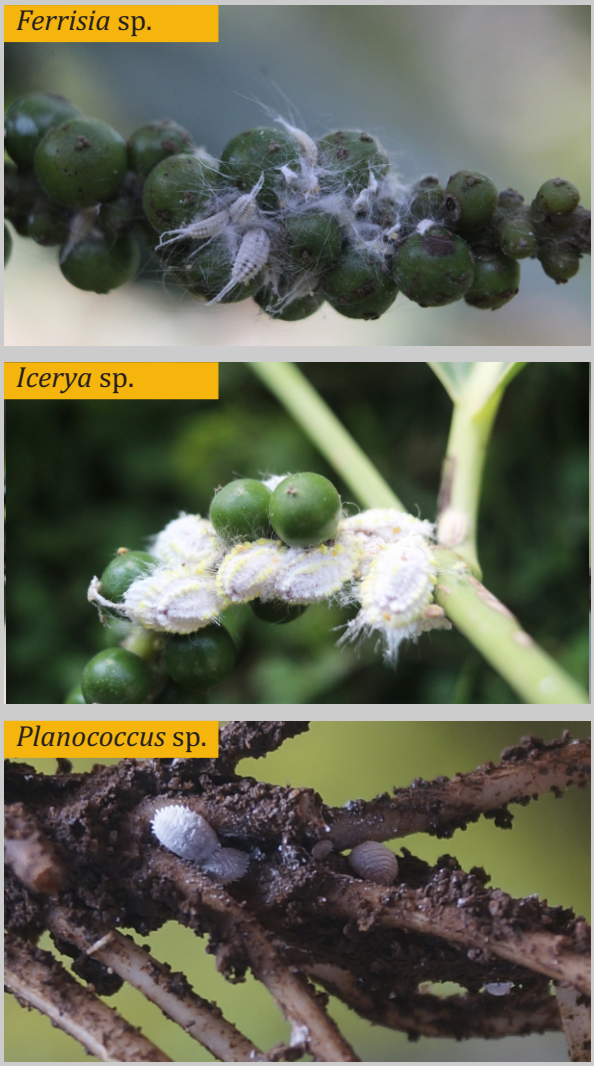


Fig. 3 Mealy bugs infesting black pepper

CARDAMOM

CROP IMPROVEMENT

Genetic resources

A total of 622 accessions are being maintained at National Active Germplasm Site (NAGS), which consists of 423 accessions from Appangala; 102 accessions from Pampadumpara; 41 accessions from Mudigere and 56 from Sakleshpur. Out of the 168 germplasm lines screened under field conditions, three lines *viz*., IC349358, IC349333 and IC349334 showed dual resistance to rhizome rot and leaf blight.

Breeding

A CVT trial with nine hybrids *viz.,* Bold × IC 547219, (GG × Bold) × Appangala 1 and (GG × NKE 19) × Bold from IISR RS, Appangala, MHC-1 & MHC-2 from ICRI, Myladumpara, SHC-1 & SHC-2 from ICRI RS, Sakleshpur and PH-13 & PH-14 from Pampadumpara along with variety Njallani Green Gold are being

evaluated in IISR RS, Appangala for different agronomical traits.

Interactive transcriptome database

A small cardamom mosaic virus interactive transcriptome database (SCMVTDb) was developed in collaboration with ICAR-IASRI.

CROP MANAGEMENT

Organic farming

Higher availability of major, secondary and micronutrients were recorded in soil, when FYM, VC (vermicompost) and NC (neem cake) were applied in combination compared to single application. The availability OC, N, P, Ca, Mg, Fe and Zn were high in organic and integrated management system(Fig. 4).

Drought tolerance

Drought tolerance studies with six genotypes recorded a yield of 400.34 and 278.78 kg/ha in Accession IC 584058 under control and stress, respectively followed by Accession IC 584090 (307.32 kg/ha) in control and 166.33 kg/ha under stress. Essential oil content ranged from 6.81 to 8.18% and oleoresin content ranged from 3.61 to 5.55%.

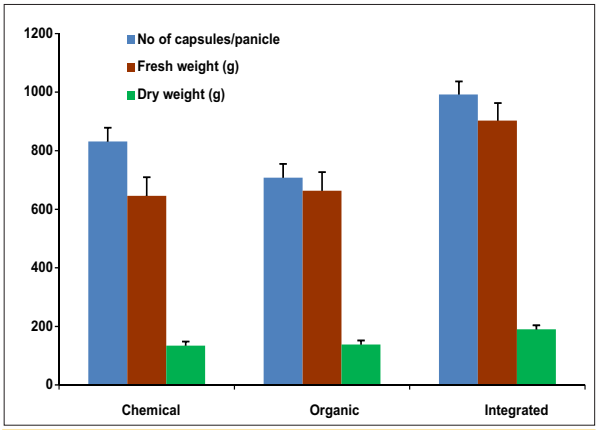


Fig. 4 Yield attributes of cardamom under different management systems

CROP HEALTH MANAGEMENT

Identification and characterization of cardamom vein clearing virus CdVCV

Based on molecular studies, the *cardamom vein clearing virus* (CdVCV) was found to be a new virus species in the genus, *Nucleo rhabdovirus*.

Plant morphological traits associated with field resistance to thrips

Field screening of 180 accessions for three years at Appangala resulted in identification of eight accessions resistant to cardamom thrips. Different morphological traits such as panicle type, persistence of bract and nature of adherence of leaf sheath were found to impart resistance against thrips.

GINGER

CROP IMPROVEMENT

Genetic resources

Six hundred sixty eight accessions are being maintained in the field gene bank, which was further enriched with 12 ginger accessions including five red ginger accessions from Nagaland. Characterization of 105 accessions for quality parameters recorded maximum essential oil in Acc. 282 and Acc. 396.

Breeding

Coordinated varietal trial of different ginger accessions for yield recorded maximum yield in accession SG 2604 followed by Acc. 247.

CROP MANAGEMENT

Micronutrient spray optimisation

Varada recorded the highest rhizome yield with two sprays of ginger micronutrient mixture (90 and 120 DAP), which was on par with the application of encapsulated Zn solubilizing bacteria *B. megaterium* at 60 and 90 DAP (Fig. 5).

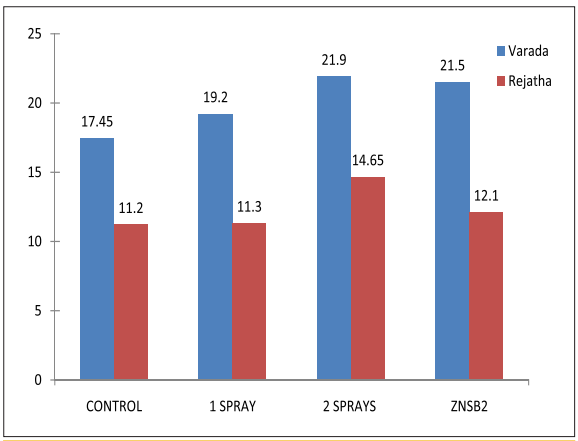


Fig. 5 Fresh yield (t/ ha) of ginger as influenced by micronutrient sprays and Zn solubilizer (ZnSB2)

High value compounds

Extracts of ginger were prepared using petroleum ether, methanol and water sequentially. Among them, petroleum ether extract showed highest antioxidant and antidiabetic activity. 6-shogaol showed higher antioxidant activity, whereas 6-gingerol exhibited higher antidiabetic activity.

CROP HEALTH MANAGEMENT

Bacterial wilt management

A new technology for integrated management of wilt integrating physical (soil solarization), chemical (soil amelioration with calcium chloride -3%) and biological (ginger apoplastic bacterium - *Bacillus licheniformis*) methods was developed. The formulation was launched as 'Bacillich'.

Effect of silicates on dry rot pathogen

In vitro studies with solid and liquid forms of sodium and potassium silicate and sodium meta silicate on dry rot causing fungi (*M. phaseolina*) showed that silicates restricted the mycelial growth of the fungus, while it enhanced the activities of peroxidase (POD), poly phenoloxidase (PPO) and phenylalanine ammonia lyase (PAL) in rhizomes inoculated with *M. phaseolina*.

Characterization of foliar pathogens

Morphological and molecular characterization of the foliar pathogens resulted in identification of *Exserohilum rostratum*, *Colletotrichum gloeosporioides*, *C. capsici* and *Botryodiplodia* sp.

Characterization of antagonists

Five strains of *Trichoderma* spp *viz*., *T. lixii* (IISR KA 15), *T. asperellum* (IISR TN 3), *T. harzianum* (IISR KL 3), *T. erinaceum* (IISR APT1) and *T. atroviridae* (IISR APT2) and 18 isolates of PGPR were characterized based on morphology and using molecular tools.

Evaluation of bacterial antagonists

Among the 18 PGPR isolates tested against fungal pathogens, isolates IISR GB1, IISR GB2, IISR GB7(3) and IISR TB4 showed maximum antagonistic activity against *Pythium myriotylum*, *Phytophthora capsici*, *Exserohilum rostratum* and *Macrophomina phaseolina* under *in vitro* conditions. Under greenhouse conditions, the rhizomes treated with the bacterial isolate IISR GB7 (3) (*Bacillus cereus*) and IISR TB4 (*Bacillus safensis*) did not develop any soft rot symptoms.

Field evaluation of fungicides against foliar diseases

Seed treatment and three rounds of foliar spraying with tebuconazole (0.1%) at 15 days interval were found to be effective in managing foliar diseases. Alternatively, first spray with tebuconazole (0.1%) followed by carbendazim + mancozeb (0.2%) at 15 days interval was also found to be equally effective.

Rhizome priming using *Trichoderma*

A protocol for priming rhizomes using the biocontrol fungi, *Trichoderma* spp. was developed to shorten the germination time of rhizomes, to improve the vigour of buds and to provide uniform tiller emergence (Fig. 6). Further, the priming process helps to regulate the germination process, prevents the growth of dry rot pathogens during storage and also provides protection from fungal pathogens during the initial stages of the crop.

Characterization of the ginger viruses

Two viruses associated with chlorotic fleck disease were identified as *ginger chlorotic fleck associated tombusviridae virus* (GCFaTV) and *ginger chlorotic fleck associated ampelovirus* (GCFaAV) and the complete genomes of GCFaTV and partial genome of GCFaAV were cloned, sequenced and analyzed.

Screening of insecticides against shoot borer

Field studies indicated that spinosad, flubendiamide and chlorantraniliprole were effective in the management of shoot borer (*Conogethes punctiferalis*) even at the lowest dose (0.3 mL/ litre of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect.

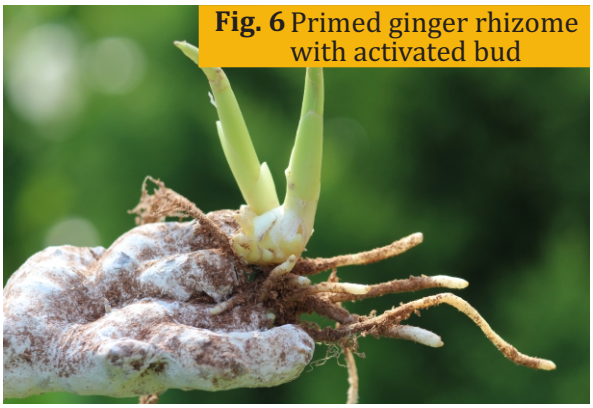


Fig. 6 Primed ginger rhizome with activated bud

MANGO GINGER

Two shortlisted mango ginger (*Curcuma amada*) accessions have been included in the new CVT trial 2019. The seed rhizomes of two genotypes (Acc. 265 and Acc. 347) were multiplied and supplied to seven AICRPS centres for multiplication and evaluation under CVT.

TURMERIC

CROP IMPROVEMENT

Genetic resources

A total of 1404 accessions are being maintained in the field gene bank. The germplasm conservatory was further enriched with four turmeric accessions from

Nagaland. Morphological characterization of 165 accessions was done and a total of 12 quantitative and 10 qualitative characters were recorded for each turmeric accession.

Inbreds and OP seedlings

First generation seedlings (204 Nos), mother genotypes (20 Nos), second generation seedlings (432 Nos), third generation seedlings (47 Nos), first generation inbreds (839 Nos), second generation inbreds (11 Nos), third generation inbreds (402 Nos), fourth generation inbreds (367 Nos) and inter-varietal hybrids (36 Nos) are being maintained. Pollen fertility based on stainability was tested in 10 third generation inbreds of 138/11/1. Five inbreds showed pollen fertility above 90.0 %.

CROP MANAGEMENT

Evaluation of different management systems

Among the management systems, organic system (75.0%) recorded maximum yield (13.9 t/ha) which was on par (13.8 t/ha) with integrated system (75.0% + 25.0%). Maximum oil content (5.3%) was recorded by organic 100.0% and organic 75.0% management system.The B/C ratio was found to be higher in integrated (50:50) system (2.22) followed by inorganic system (2.13).

Response of different turmeric varieties to organic farming

Among the 12 varieties evaluated under 100.0% organic management, significantly higher yield was recorded by IISR Pragati (22.1 t/ha) followed by Kanthi (19.2 t/ha). Higher oil content was noticed in varieties IISR Prathibha (6.0%), Alleppey supreme (5.9%) and least oil content was noticed in IISR Suvarna (Fig. 7).

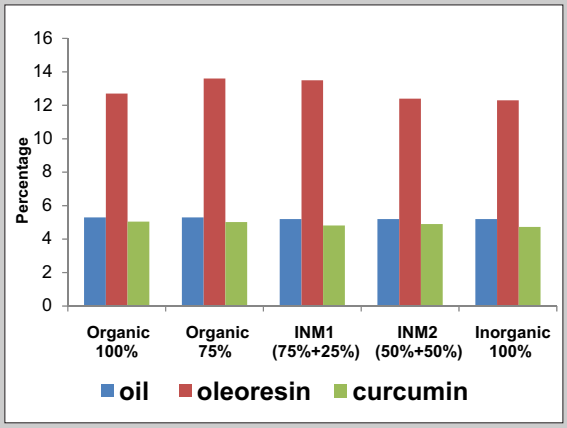


Fig. 7 Effect of different management system on quality of turmeric

Micronutrient spray optimisation

Micronutrient spray optimisation studies showed that IISR Pragati yielded significantly greater rhizome yield with the treatment involving application of encapsulated Zn solubilizing bacteria *B. megaterium* at 60 and 90 DAP, which was on par with the treatment involving single (60 DAP) and two sprays (60 and 90 DAP) of turmeric micronutrient mixtures.

Effect of curing and slicing on quality

Minimum drying time of 10 h was recorded for drying of cured sliced turmeric by hot air oven at 100°C and maximum time of 165 h (6.88 days) was recorded for sun drying of uncured sliced turmeric.The maximum value of essential oil (5.53%), oleoresin (13.07%)and curcumin content (5.01%) were recorded for uncured sliced turmeric.

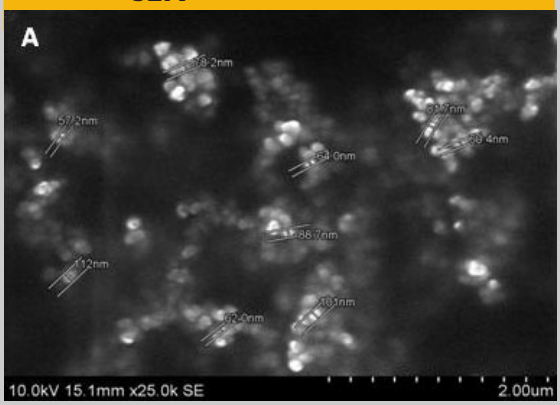
Nanocurmin

Nano-curcumin was prepared using sonication based protocol to increase the bio-availability of curcumin. The nano-curcumin thus developed had 2.5 fold increased solubility in both water as well as in virgin coconut oil and can be used as

potential bio-available formulation of curcumin (Fig. 8a & b).

Fig. 8a Curcumin crystals under SEM

Fig. 8b Nano curcumin crystals under SEM



CROP HEALTH MANAGEMENT

Lesion nematodes

Survey of hotspot areas indicated high population of the lesion nematode, *Pratylenchus* spp., in Thanneerpanthal region (3.2/g soil) in Coimbatore District (TN) and Gobichettipalayam (4.7/g soil) in Erode District (TN). *In vitro* screening of antagonistic bacteria against *Pratylenchus* spp. showed maximum mortality with *Pseudomonas putida* BP25 (92.7%) followed by *Alcaligens fecalis* IISR 859 (68.7%), *Bacillus megaterium* BP17 (58.1%) and *Bacillus licheniformis* GP107 (10%) 24 h after exposure.

Shoot borer

New generation insecticides such as spinosad, flubendiamide and chlorantraniliprole were effective in the management of turmeric shoot borer (*Conogethes punctiferalis*) even at the lowest dose (0.3 mL/ L of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect.

VANILLA

CROP IMPROVEMENT

Genetic resources

In vanilla,78 accessions (65 *Vanilla planifolia,* 7 *Vanilla* spp. from Andaman, 2 *Vanilla* spp. from Wayanad and one each of *V. pilifera, V. aphylla, V. tahitensis* and *V. wightiana)* are being conserved under protected conditions. A modified RP-HPLC method was standardized for simultaneous detection and quantification of major flavor compounds of vanilla *viz*., vanillin, p-hydroxybenzoic acid, p hydroxy benzaldehyde and vanillic acid.

CROP HEALTH MANAGEMENT

Biological control of wilt disease

Chaetomium isolates from healthy plants were characterized by sequencing the ITS region. Homology search using the BLAST showed 98 – 100% identity with *C. globosum*. Among the isolates tested against *Phytophthora meadii*, FVREP4 recorded maximum inhibition (56%) over control followed by FVLEP2 and FVLEP 7 with 40% inhibition. Field evaluation indicated that soil and foliar application of *B. amyloliquefaciens* reduced disease incidence to less than 10.0%.

Fig . 9 a *Cinnamomum macrocarpum* collected from Wayanad

Fig . 9 b *Cinnamomum gamblii* collected from Nelliyampathy

Fig. 10 Promising accession of *Garcinia gummigutta* with high yield and high dry recovery

TREE SPICES

CINNAMON

Genetic resources

Cinnamomum gamblii, *C. neolipsium* and *C. macrocarpum* were collected from Palakkad and Wayanad districts of Kerala (Fig. 9 a & b). The essential oil content in the bark samples of 10 cinnamon accessions was analyzed and the oil content varied from 1.2–3.0%.

High value compounds

[redacted]

GARCINIA

Garcinia morella and *G. talbotii* were collected from Wayanad District, two exotic species, *G. atroviridis* and *G. macrophylla* were collected from farmer's field in Wayanad and another exotic species, *G. madruno* was collected from Bengaluru, Karnataka. Elite lines of *G. gummigutta* trees at Peruvannamuzhi with high yield and dry recovery were identified (Fig. 10). The fresh fruit weight varied from 29.09 to 141.00 g, the fresh fruit to dry rind recovery varied from 5.13 to 14.5% and the dry rind yield per tree varied from 0.5 to 30 kg.

CLOVE

A wild relative of clove *Syzigium claviflorum,* collected from Nicobar Islands was obtained from ICAR- NBPGR, Thrissur and added to the germplasm. Essential oil content of clove samples collected from three locations varied from 10.0– 19.33%.

ALLSPICE

In situ data of elite allspice trees recorded from farmer's field at Wayanad, Kerala revealed that the dry fruit yield per tree per

High value compounds

The antioxidant and antidiabetic potential of

year varied from 5.0 to 27.3 kg and the dry recovery ranged from 25.5% to 32.3% (Fig. 11).

Fig. 11 Promising accession of allspice from Wayanad.

Fig. 12 Manifestation of symptoms
(a) Decline of tree
(b) Water soaked lesion
(c) Necrotic lesions on bark
(d) Necrosis of vascular tissues

allspice berry extracts in different solvents were determined. Hexane extract showed maximum antidiabetic potential. Total phenols were maximum in chloroform extract and flavonoids in methanol extract.

NUTMEG

Sex chromosome based markers

Sex chromosome specific RAPD markers were evaluated in male, female & monoecious plants of nutmeg. The NM1 D5 primer differentiated female from male and monoecious. The female showed two different specific patterns to discriminate themselves from male and monoecious.

Site specific nutrient management for nutmeg

Application of amendments (lime and lime + dolomite @ 1.0 kg each) along with site specific nutrients and micronutrients significantly enhanced soil fertility at all depths and yield. Supplemental micronutrient sprays specific to nutmeg along with the site specific soil fertility based nutrient management increased the nut and mace yield up to 25% in the treated plots as compared to farmers practice.

Etiology of decline disease

Etiology of nutmeg decline disease was studied in Peruvannamuzhi, Angamali, Kakkadampoyil and Palakkad regions of Kerala (Fig. 11). Based on morphological and molecular studies, the fungus isolated from diseased samples was identified as *Lasiodiplodia theobromae*.

GENERAL

DNA finger printing and barcoding facility

The facility for DNA finger printing and barcoding was established for undertaking finger printing services to facilitate varietal release for various AICRPS centres. So far 25

varieties of spices have been finger printed including black pepper, ginger, turmeric, coriander, fenugreek, fennel, celery and the uniqueness were established for the new varieties in comparison with its closely related/resembling varieties.

Micronutrient-microbial interaction

Two very promising Zn solubilizing bacteria have been isolated, characterized and tested for their solubilizing efficiency. The two isolates, IISR GB7 (3) (*Bacillus* sp.) and IISR TB4 (*Bacillus safensis*) possessed markedly higher Zn solubilization efficiency both in liquid and soil. The kinetics of Zn release was also determined in soils *per se* augmented with 50 ppm Zn as ZnO. The treatment with IISR Tb4 (*B. safensis*) registered markedly hig her Zn solubilization at 4, 6 and 8 DAI (Fig. 13).

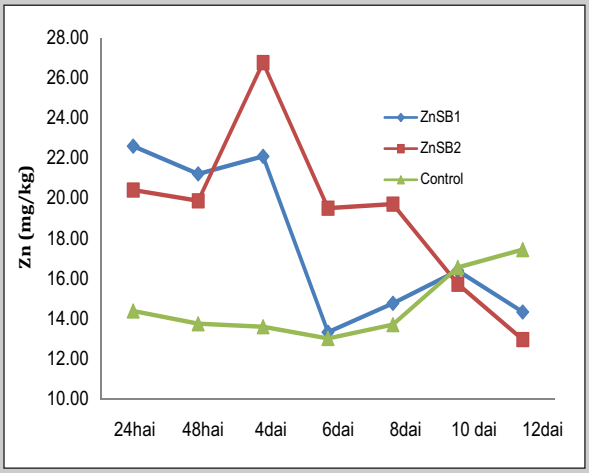


Fig. 13 Zn solubilization rates in soil augmented with Zn solubilising bacteria and insoluble Zn source [ZnO].

Value chain incubation facility for processing of spices

Spice processing facility was established at IISR main campus and started functioning for training and production of value added products (Fig.14).

Fig. 14 Spice processing facility

Surveillance and documentation of pests and diseases

Four cardamom and black pepper plantations in Sakleshpur and Shanivarasanthe (Karnataka), four nutmeg plots (Angamali, Kakkadamapoyil, Palakkad and Peruvannamuzhi in Kerala) and three black pepper plantations (Yercaud, Tamil Nadu) were surveyed for the incidence of pests/diseases. The major diseases observed in cardamom were leaf blight, rhizome rot, capsule rot, Katte and Kokkekandu, foot rot, slow decline and anthracnose in black pepper and general decline in nutmeg.

Studies on suitable substrates for mass multiplication of arbuscular mycorrhizal fungi (AMF) indicated that vermiculite +10% FYM followed by vermiculite +10%vermicompost were superior in enhancing the root biomass, shoot and root length of both the hosts. In comparison to maize, the increase in root colonization (80%) was much higher in napier grass under vermicompost amendment.

Production of nucleus planting materials of improved varieties

About 70000 rooted cuttings of improved varieties of black pepper were multiplied from main campus, Kozhikode and Regional Station (RS), Appangala and distributed to farmers. Improved varieties of ginger (200 beds) and turmeric varieties (550 beds) are planted and maintained for seed production at Experimental Farm, Peruvannamuzhi. The cardamom suckers 2000 were multiplied and distributed from Regional Station, Appangala. Three thousand seedlings of cinnamon varieties were produced and distributed to farmers for planting.

Microrhizome of ginger varieties (IISR Mahima, IISR Varada) and turmeric varieties (Sona, IISR Pratibha, Kanti and Varna) were subcultured and 3100 plantlets of ginger and 500 turmeric raised in cultures and are being hardened in portrays and poly bags under nursery. Twenty released varieties and cultivars of black pepper were tested with polymorphic primers to identify and develop the varietal specific markers.

Standardization of mass multiplication of AMF

Studies on suitable substrates for mass multiplication of arbuscular mycorrhizal fungi (AMF) indicated that vermiculite +10% FYM followed by vermiculite +10% vermicompost were superior in enhancing the root biomass, shoot and root length of both the hosts. In comparison to maize, the increase in root colonization (80%) was much higher in napier grass under vermicompost amendment. AMF structures such as arbuscules, vesicles and hyphae were observed in all the substrates inoculated (Fig. 15).

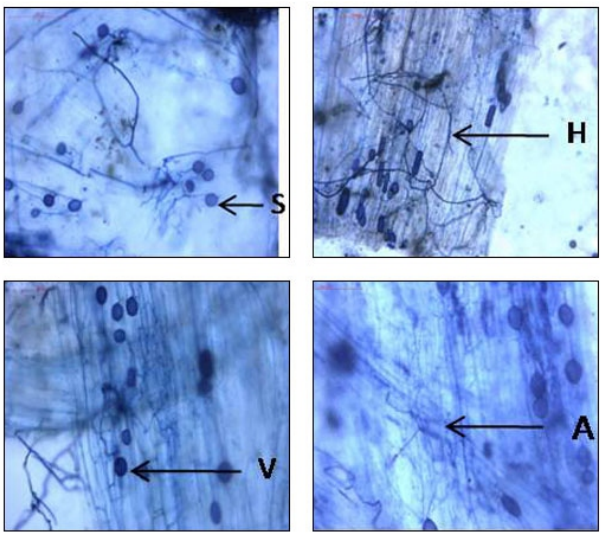


Fig. 15 Arbuscular mycorrhizal fungi structures : arbuscules (a), vesicles (b) and hyphae (h)

ECONOMICS

Futuristic crop planning

The projected per capita demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148.0 g, 53.0 g, 1.22 kg and 1.63 kg, respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7 –5.7 fold from the present levels.

Cinnamon economy

The global cinnamon demand has been growing at a CAGR of 4.1% since the turn of this century. The area under cinnamon has almost doubled during this period. Import substitution of cinnamon is possible through popularization of cinnamon cultivation, promotion of low coumarin cassia genotypes and establishment of effective mechanisms for aggregation and marketing of cinnamon produced within the country.

DUS TESTING FACILITY

Preliminary observations for the on-site testing of 4 black pepper and 6 small cardamom varieties were completed. Example varieties of black pepper, small cardamom, ginger and turmeric were maintained at respective centres. DUS testing completed for 19 turmeric varieties which include 14 farmers' varieties and 4 varieties of common knowledge and one extant variety. DUS testing completed for 7 ginger varieties which include 4 farmers' varieties and 3 varieties of common knowledge.

BIOINFORMATICS CENTRE

A detailed *in-silico* analysis was carried out in ginger *Ralstonia* strains, Race 4/Biovar 3 to get a better insight into the pathogenicity of strains and to predict host-adapted polymorphisms. A database on *Ralstonia solanacearum* causing bacterial wilt in several economically important crops was developed, which includes manually curated whole genome data of 11 Indian strains.

PESTICIDE RESIDUE ANALYSIS FACILITY

A facility for pesticide residue analysis has been established at ICAR-IISR. The facility is sponsored by State Horticulture Mission, Govt. of Kerala. The analytical lab contains Liquid chromatography mass spectrometry (LCMS MS) and gas chromatography with FPS and ECD detectors to check both non-volatile and volatile pesticide residues respectively in spice samples.

TRIBAL SUB PLAN (TSP) AND SPECIAL COMPONENT PLAN (SCP)

Capacity building and front line intervention programmes for tribal population in spices sector development in NE states and tribal empowerment in Paderu Tribal Agency Area, Visakhapatnam District, Andhra Pradesh, Attapady Tribal block, Palakkad District, Kerala, Golpara and Kamrup Districts, Assam, Namsai District in Arunachal Pradesh and Koraput District in Odisha were taken up under Tribal Sub Plan (TSP) and Special Component Plan (SCP).

ATIC AND EXTENSION SERVICES

ATIC provided advisory and scientific services including sale of technology products of the institute to various stakeholders. A total of 2467 farmers visited ATIC for advisory services and eighteen farmer groups from different states visited as a part of exposure visit programs under ATMA. Two editions of Certified Farm Advisor program (CFA) sponsored by National Institute of Agricultural Extension Management (MANAGE), Hyderabad were organized benefitting officials from

department of horticulture/agriculture representing various states. Under corporate social responsibility mode, training program on recent research advances and technologies in spices research was organized for Kancor Ingredients, Kochi and Fair Trade Network for Asia Pacific. Ten training programmes on production and processing technologies were organized for state department. The revenue generation through the sale of planting material and other products from ATIC was ₹45.24 lakhs during 2019.

ICAR - ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

The XXX Workshop of All India Coordinated Research Project on Spices was held at Tamil Nadu Agricultural University, Coimbatore during 16-18 November 2019. The workshop was inaugurated by Dr T. Janakiram, ADG (Hort. Sci.) ICAR, New Delhi. During the inaugural session the "Best AICRPS Centre Award 2018-19" was presented to High Altitude Research station, OUA&T, Odisha and Narendra Dev University of Agriculture & Technology, Kumarganj, Uttar Pradesh. Eight booklets/pamphlets on spices production technologies from different AICRPS centres were released during the workshop (Fig.16). Three varieties one each in fennel (RF-290), ajwain (Ajmer Ajwain-73) and nigella (Ajmer Nigella-1) suitable for different growing regions were recommended for release. Four different technologies covering ginger, coriander and cumin were also recommended for adoption:

- Technology for the management of bacterial wilt in ginger caused by *Ralstonia pseudosolanacearum*.
- Micro irrigation and fertigation management in cumin.
- Management of coriander powdery mildew using new generation fungicides.
- Use of organic nutrients for disease management in cumin.

Fig. 16 XXX Workshop of All India Coordinated Research Project on Spices

KRISHI VIGYAN KENDRA

Krishi Vigyan Kendra (KVK) conducted eighty training programmes in various disciplines, benefitting 3105 people. Three sponsored trainings were organized by KVK on beekeeping (sponsor- HORTICORP), planting material production and nursery management (sponsor- District Kudumbasree Mission), skill development trainings on "Quality seed production "and "Friends of Coconut" (sponsor- ASCI, New Delhi).

Training program sponsored by Coconut Development Board was conducted and the participants were given free coconut climbing machine and one-year life insurance through CDB.

A vocational training programme on "Breeding and culture of ornamental fishes" for rural youth including students and an on job training on "Good Agricultural practices' were organized for students.

National Agriculture Education Day was observed at KVK,during which 447 students and 53 teachers from eleven schools visited various demo units and interacted with scientists on new agricultural technologies. KVK observed world soil day by distributing soil health cards and black pepper micronutrient mixture to farmers.

Awareness seminar on "Protection of plant varieties and Farmer Rights Act also was organized for farmers. KVK organized video conferencing of six progressive farmers from Kozhikode District during the Hon'ble Prime Ministers web interaction programme with farmers from all over India.

Institute Technology Management - Business Planning & Development unit (ITM-BPD unit)

ITM-BPD unit of ICAR-IISR launched a new initiative christened "SPIISRY" to supply good quality spices and allied products to the consumers. SPIISRY was inaugurated by Dr. T Janakiram, Assistant Director General, ICAR, New Delhi (Fig.17). The institute entered

Fig. 17 SPIISRY inauguration by Dr. T Janakiram, Assistant Director General, ICAR, New Delhi on 12 July 2019

into an MOA (Memorandum of Association) with Kerala Start-up Mission (KSUM) for nurturing start-ups and innovation (Fig.18).

The unit organized an exhibition cum sales of the institute technologies, products and incubatee products at ICAR-IISR on 01 July 2019, which marked the 24th Foundation Day of ICAR-IISR.

The unit won accolades for promoting ICAR-IISR technology on Biocapsules during the ICAR Foundation Day held on 16 July 2019. M/s Codagu Agritech, a licensee of this technology, was a special invitee for this year's celebrations and presented the technology before the Hon'ble Prime Minister.

The Krishidhan Nursery of ITM-BPD Unit continues to provide marketing support through the sale of planting materials produced by registered farmers/licensees of spices. A product development lab facility has been set up for developing spice based innovative food and naturopathy products with the objective of better income through value addition.

HUMAN RESOURCE DEVELOPMENT

Conducted training programme on Information Security Awareness and Government e-Marketplace (GeM) was organized at ICAR-IISR for staff members.

one-month summer internship programme on "Advanced Techniques in Microbiology, Biochemistry, Biotechnology and Bioinformatics" for post-graduate students was organized from 01 to 31 May 2019.

As a prelude to NABL accreditation training programme on "Quality Management System and Internal Audit as per ISO/IEC 17025:2017"was organized from 04-07 September, 2019.

Twenty-three participants from IISR and administrative staffs from CPCRI and CMFRI participated in One-day workshop on ICAR-ERP MIS-FMS organized at ICAR-IISR on 13 December 2019.

Fig. 18 Signing of MOA between Kerala Start up Mission and ICAR-IISR for promoting Agritech Start-ups

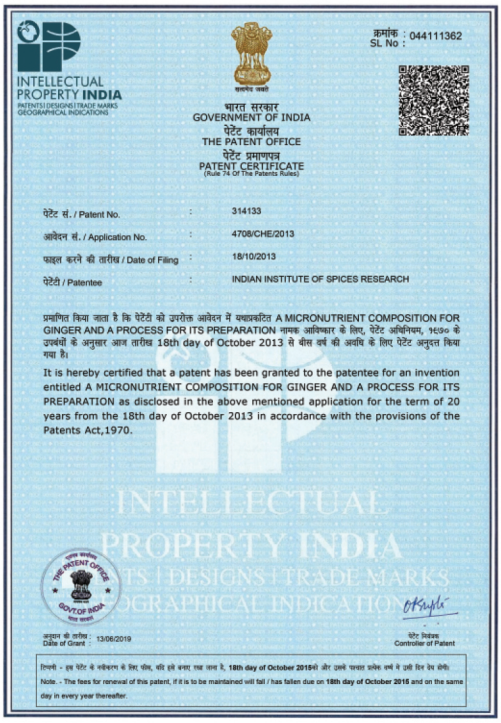
LIBRARY

Library subscribed twenty four Indian and eight foreign journals during the year in addition to journals accessible under Consortium of Electronic Resources in Agriculture (CeRA). Institute publications were uploaded to Krishi portaland all newly added publications were brought in to the 'KOHA' database.

MAJOR EVENTS

Day	Date
National Productivity week	12-18 February 2019
National Science day	28 February 2019
International Women's day	08 March 2019
World Water day	22 March 2019
Farmer Interface meeting	27 March 2019
World Environment day	05 June 2019
Third Dr. Y.R. Sarma Memorial Lecture	14 June 2019
International Yoga day	21 June 2019
Institute Foundation day	01 July 2019
Swachhata Hi Sewa	11 September - 02 October 2019
Vigilance Awareness week	28 October - 02 November 2019
Visit of Hon'ble Minister of State Shri Sanjay Shamrao Dhotre	13 November 2019
Certified Farm Advisor Program	11-25 November 2019
District level Farmers Training	28 November 2019
World Soil day	05 December 2019
Students-Scientists Interface	20 December 2019
Swachhata Pakhwada	16-31 December 2019

PATENTS



INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

सत्यमेव जयते

भारत सरकार
GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

क्रमांक : 044111362
SL No :

पेटेंट सं. / Patent No.	:	314133
आवेदन सं. / Application No.	:	4708/CHE/2013
फाइल करने की तारीख / Date of Filing	:	18/10/2013
पेटेंटी / Patentee	:	INDIAN INSTITUTE OF SPICES RESEARCH

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित A MICRONUTRIENT COMPOSITION FOR GINGER AND A PROCESS FOR ITS PREPARATION नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 18th day of October 2013 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

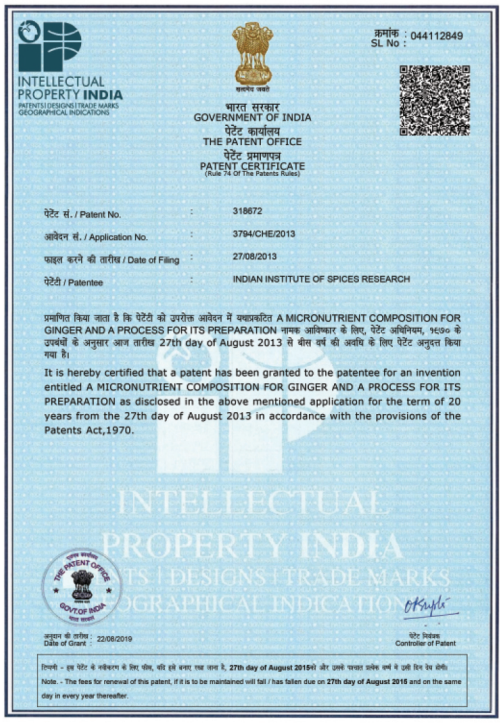
It is hereby certified that a patent has been granted to the patentee for an invention entitled A MICRONUTRIENT COMPOSITION FOR GINGER AND A PROCESS FOR ITS PREPARATION as disclosed in the above mentioned application for the term of 20 years from the 18th day of October 2013 in accordance with the provisions of the Patents Act,1970.

THE PATENT OFFICE GOVT OF INDIA

अनुदान की तारीख : 13/06/2019
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, **18th day of October 2015** को और उसके पश्चात प्रत्येक वर्ष में उसी दिन देय होगी।
Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on **18th day of October 2015** and on the same day in every year thereafter.



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THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

क्रमांक : 044112849
SL No :

पेटेंट सं. / Patent No.	:	318672
आवेदन सं. / Application No.	:	3794/CHE/2013
फाइल करने की तारीख / Date of Filing	:	27/08/2013
पेटेंटी / Patentee	:	INDIAN INSTITUTE OF SPICES RESEARCH

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित A MICRONUTRIENT COMPOSITION FOR GINGER AND A PROCESS FOR ITS PREPARATION नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 27th day of August 2013 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

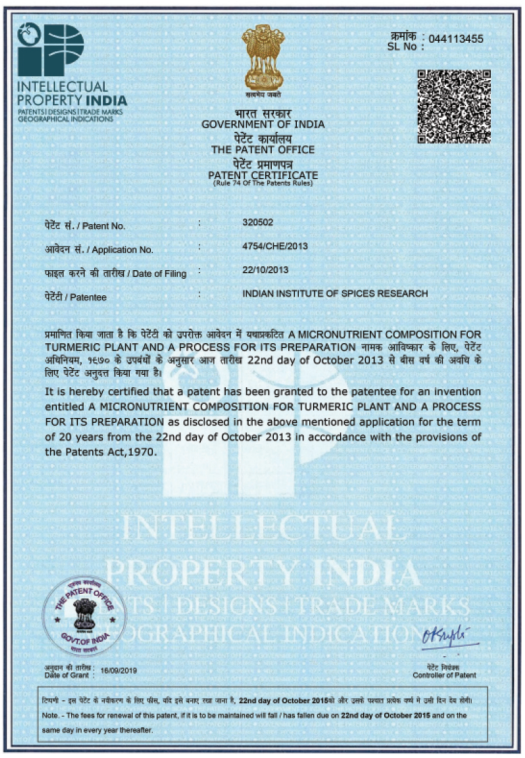
It is hereby certified that a patent has been granted to the patentee for an invention entitled A MICRONUTRIENT COMPOSITION FOR GINGER AND A PROCESS FOR ITS PREPARATION as disclosed in the above mentioned application for the term of 20 years from the 27th day of August 2013 in accordance with the provisions of the Patents Act,1970.

THE PATENT OFFICE GOVT OF INDIA

अनुदान की तारीख : 22/08/2019
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, **27th day of August 2015** को और उसके पश्चात प्रत्येक वर्ष में उसी दिन देय होगी।
Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on **27th day of August 2015** and on the same day in every year thereafter.



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THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

क्रमांक : 044113455
SL No :

पेटेंट सं. / Patent No.	:	320502
आवेदन सं. / Application No.	:	4754/CHE/2013
फाइल करने की तारीख / Date of Filing	:	22/10/2013
पेटेंटी / Patentee	:	INDIAN INSTITUTE OF SPICES RESEARCH

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित A MICRONUTRIENT COMPOSITION FOR TURMERIC PLANT AND A PROCESS FOR ITS PREPARATION नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 22nd day of October 2013 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled A MICRONUTRIENT COMPOSITION FOR TURMERIC PLANT AND A PROCESS FOR ITS PREPARATION as disclosed in the above mentioned application for the term of 20 years from the 22nd day of October 2013 in accordance with the provisions of the Patents Act,1970.

THE PATENT OFFICE GOVT OF INDIA

अनुदान की तारीख : 16/09/2019
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, **22nd day of October 2015** को और उसके पश्चात प्रत्येक वर्ष में उसी दिन देय होगी।
Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on **22nd day of October 2015** and on the same day in every year thereafter.

ICAR- Indian Institute of Spices Research
Marikunnu P.O., Kozhikode - 673012, Kerala, India
Phone: 0495-2731410, Fax:0495-2731187
Web site: spices.res.in