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Annual Report
2019

ICAR - Directorate of Medicinal and Aromatic Plants Research

(ISO 9001: 2015 Certified)

Boriavi, Anand – 387 310, Gujarat, India

On the cover:


Gloriosa superba
Chlorophytum borivilianum
Asparagus racemosus
Aloe barbadensis
Acorus calamus
Ocimum basilicum

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PREFACE

Plants based drugs have become more popular under the incidences of new diseases due to their inherent ability to boost immunity, safety and efficacy. Apart from their medicinal value, medicinal and aromatic plants (MAP) play very important role in ensuring livelihood security to millions of people in India. Demand for herbal products is increasing every year in India and the world. The export value of ayurvedic and herbal products amounted to about 446 million US dollars from India in fiscal year 2019. There was consistent increase in the value of these exports since fiscal year 2015. Agricultural and allied sectors, of which ayurvedic and herbal products are part of, contributed to about 8.6% of the country's exports. India exported USD 330.18 million worth of herbs during 2017-18 with a growth rate of 14.22% over the previous year. Also, the export of value-added extracts of medicinal herbs/herbal products during 2017-18 stood at USD 456.12 million recording a growth rate of 12.23 % over the previous year. According to WHO the international market of herbal products is around 6.2 billion US dollars, which is poised to grow to 5 trillion USD by the year 2050. Majority of MAP are being harvested from the forests and a few of them (20%) are drawn from cultivation. Besides conservation of their genetic resources, cultivation offers uniformity of the materials thus ensuring quality of material and good income to the cultivators. It also provides opportunities for value-addition through processing, providing a better environment through utilizing waste and unproductive lands, and continuity of supply of raw drug. The cultivation will also bring the supply of uniform and high-quality raw material to the end users.

Cultivation of MAP is becoming challenging due to climate change, lack of good agricultural practices, lack quality seed and planting materials and volatile markets. At this directorate, efforts are being made to develop climate resilient crop varieties and cultivation practices so as to bring more MAP under cultivation. Quality seed and planting materials of important genetic stocks are being produced and distributed to the farmers for the cultivation. Although, ICT tools such as E-charak platform has been developed by linking buyers and sellers to address the volatile markets of MAP produce in the country, there is a need for bring in entrepreneurs in MAP sector. In this line, Medi-Hub TBI (Technology, Business and Incubation), a DMAPR technology incubator is becoming operational at ICAR-DMAPR to facilitate entrepreneurship development. Further, efforts are being made to develop value added products and to forecast the demand and supply of some of the highly valued MAP produce through Remote Sensing. The directorate has brought out a "Road map for Isabgol Promotion in India" in consultation with Isabgol

stakeholders.

I take this opportunity to thank Dr. Trilochan Mohapatra, Secretary (DARE) and Director General, ICAR for his motivation, support and guidance in this endeavor. I express my heartfelt thanks to Dr. A.K. Singh, Deputy Director General (Hort. Science) for his support, guidance and critical comments. I acknowledge the timely guidance, support and help rendered by Dr. T. Janakiram, Assistant Director General (Hort. Science) in the implantation of programs of ICAR at this Directorate. The visit of dignitaries, viz., Mr. Kanwal Singh Chauhan, Member, ICAR Governing Body; Dr. A. K. Singh, DDG (HS), ICAR, New Delhi; Dr. P. Das, Director, Science Foundation for Tribal and Rural Resource Development, Bhubaneswar, Odisha; Dr. N. C. Patel, Vice Chancellor, AAU, Anand and Mr. Anand Sherkhane, Addl. Development Commissioner, Ministry of MSME, Govt. of India, New Delhi during this year has immensely motivated the ICAR-DMAPR fraternity to a larger extent by their critical comments. I appreciate the scientists and staff of ICAR-DMAPR and AICRP-MAP&B for their untiring efforts in this regard. I thank my editorial team for their efforts in bringing this collation in time.

Jai Hind

Anand *Satyajit Roy*
13th June, 2020

ABBREVIATIONS USED

AAU	Anand Agricultural University/ Assam Agricultural University
AICRP - MAPB	All India Coordinated Research Project on Medicinal and Aromatic Plants & Betelvine
BAU	Bihar Agricultural University/ Birsa Agricultural University
BCKV	Bidhan Chandra Krishi Vishwa Vidyalaya
B:C ratio	Benefit cost ratio
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
cfu	Colony-forming units
CTAB	Cetyl trimethyl-ammonium bromide
DAP	Days after planting
DAS	Days after sowing
DAT	Days after transplanting
DST	Department of Science and Technology
DUS	Distinctiveness uniformity and stability
DMAPR	Directorate of Medicinal and Aromatic Plants Research
ETL	Economic Threshold Limit
FWB	Fresh Weight Basis
FYM	Farm Yard Manure
GAP	Good Agricultural Practices
GC-MS	Gas Chromatography and Mass Spectrometry
ha	Hectare
HPLC	High Performance Liquid Chromatography
HPTLC	High Performance Thin Layer Chromatography
IBA	Indole Butyric Acid
ICAR	Indian Council of Agricultural Research
ICM	Integrated Crop Management
ICT	Information and Communication Technology
IDM	Integrated Disease Management
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IIHR	Indian Institute of Horticultural Research
IPR	Intellectual Proprietary Rights
ISSR	Inter Simple Sequence Repeat
IW/CPE	Irrigation Water/Cumulative Pan Evaporation

JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya
KAU	Kerala Agricultural University
LC-MS/MS	Liquid Chromatography—Mass Spectrometry
LER	Land Equivalent Ratio
MAP	Medicinal and Aromatic Plants
MPKV	Mahatma Phule Krishi Vidyapeeth
N ha^{-1}	Nitrogen per hectare
NAIP	National Agricultural Innovation Project
NDUAT	Narendra Dev University of Agriculture and Technology
NPK	Nitrogen-phosphorous-potash
OUAT	Orissa University of Agriculture and Technology
PDA	Photo diode array/Potato dextrose agar
Plant ha^{-1}	Plant per hectare
PDI	Percent Disease Index
PDKV	Dr. Punjabrao Deshmukh Krishi Vishwavidyalaya
PE	Potential evaporation
PPV & FRA	Protection of Plant Varieties & Farmers' Rights Authority
PSB	Phosphate Solubilising Bacteria
q	Quintal (100 kg)
RDF	Recommended Dose of Fertilizers
RAPD	Random Amplified Polymorphic DNA
RAU	Rajendra Agricultural University
RDF	Recommended Dose of Fertilizer
RIL	Recombinant Inbreed Line
RVSKVV	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
SSR	Simple Sequence Repeats
t	Tonne (1000 kg)
TLC	Thin Layer Chromatography
TNAU	Tamil Nadu Agricultural University
TSP	Tribal Sub Plan
UBKV	Uttar Banga Krishi Vishwa Vidyalaya
UUHF	Uttarakhand University of Horticulture and Forestry
VAM	Vesicular Arbuscular Mycorrhiza
YSPUHF	Dr. Y.S. Parmar University of Horticulture and Forestry
YSRHU	Dr. Y. S. Rajasekhara Reddy Horticulture University

SUMMARY

ICAR Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR) and its outreach program All India Coordinated Research Project on Medicinal and Aromatic Plants & Beletvine (AICRP-MAPB) are engaged in research on Medicinal and Aromatic Plants and Betelvine. Salient research findings of 2019 are presented below:

ICAR-DMAPR

ALOE (*Aloe barbadensis*)

Soft rot disease of aloe was identified as a complex disease caused by an interaction of enterobacterium *Dickeya zeae* and a saprophytic fungus *Fusarium solani*. To characterize the pathogens, DNA was isolated from pure culture of the fungus and bacteria and three partial genes (*dnaX, icdA* and *mdh*) of bacteria and fungus (*ITS, TEF-1α* and *RPB2*) were amplified using specific primers, sequenced and submitted to the NCBI GenBank.

ASHWAGANDHA (*Withania somnifera*)

Germplasm evaluation

One-hundred and twenty-two accessions were evaluated and IC0210601, IC0262388, IC0385221, IC0510842, IC0510841, RVA-100 and AWS-1 recorded high root yield .

Three hundred and twenty seven pure lines were screened for withanolides (Withaniferine-WA, 12-deoxywithastramonolide-WD, Withanoilde-WDA) content in roots samples by HPLC-PDA method.

Pythium aphanidermatum, fungus causing damping off disease of ashwagandha was characterized based on the morphological characteristics. Under *in vitro* condition, metalaxyl-M (apron XL) showed the highest efficacy to inhibit the mycelium growth of *P. aphanidermatum*.

BASIL (*Ocimum basilicum*)

Green and purple colour intensity in leaf was identified as field note for initial screening of accessions for essential oil content.

Based on the morphological and molecular observation the associated pathogen causing downy mildew of basil was identified as *Peronospora belbahrii*.

Similarly, association of Bihar hairy caterpillar, *Spilosoma obliqua* Walker was confirmed causing herbage loss in basil through morphological and molecular method (Accession No. MK491177). The damage incidence on basil ranged from 4.33 to 60 and 10 to 63.33 per cent during 2018 and 2019, respectively.

BRAHMI (*Bacopa monnieri*)

Three-bud cuttings from lower part of runner with mud solution (FYM, loamy soils and water in 1:1:5 ratio) was found as the best propagation material for commercial multiplication of brahmi.

CHAKODA (*Senna tora*)

Four explorations were undertaken in Gujarat, Rajasthan, Karnataka, Madhya Pradesh, Maharashtra and Chhattisgarh and collected 25 accessions.

GILOE (*Tinospora cordifolia*)

Corynespora cassicola, Exserohilum rostratum and *Coletotrichum* spp. were isolated from the infected plants of giloe causing leaf spot and blight symptoms.

ISABGOL (*Plantago ovata*)

Eighty-seven (87) isabgol accessions were maintained in field gene bank and were characterized using DUS descriptors and morphological traits.

Two trait specific accessions, *viz*., DPO-185 (IC0627267, INGR19025) and DTPO-6-6 (IC 0627269, INGR 19026): were registered with NBPGR, New Delhi.

Germplasm accessions and breeding lines were screened for aphid resistance using 0 to 5 scale.

Front line demonstrations of Vallabh Isabgol-1 were conducted at different villages of Gujarat.

Transcriptome sequences of DPO-14 (early maturing) and DPO-185 (Late maturing) genotypes were explored for various maturity genes especially, genes encoding various enzymes involved in flowering pathways.

Inheritance pattern of male sterility in isabgol was unravelled and it was found that male sterility is governed by a single recessive gene.

The first genetic map was constructed using single nucleotide polymorphism (SNP) markers to unearth quantitative trait loci (QTL) for the agronomic traits and comparative mapping of *Plantago*.

Genomic SSR markers were developed from the raw reads (24.3 gb) of the isabgol genome downloaded from the SRA-NCBI database.

During the current year, eleven reference varieties of isabgol were maintained.

Vallabh Isabgol-1 a new variety developed at the Directorate was demonstrated to farmers at Radhanpur, Bachau, Santalpur and Raper talukas of Gujarat.

Expression analysis of pathogenesis related genes (RxLR effector genes) of fungal pathogen *Peronospora plantaginis* was studied and differential expression of RxLR gene with *Peronospora* fungi infection level indicated involvement of RxLR effectors in interaction with host genes. Similarly, study of Resistance (R) genes in the host revealed differential expression of R genes in the infected and control of resistant (DPO-185) and susceptible (DPO-14) genotypes.

Using multi-temporal SAVI (LISS-IV) data, the total acreage of isabgol was found as 1675 ha, 5753 ha and 4245 ha, respectively in for Bhachau, Rapar and Santalpur blocks, during the year 2018-19.

Wilt is one of the most important disease of *P. ovata* and the disease incidence varied from 10 to 60%. The pathogen was identified as *Fusarium oxysporum* species complex based on the morphological and molecular methods.

INDIAN SARASAPARILLA (*Hemidesmus indicus*)

A High performance thin layer chromatographic (HPTLC) method was developed for separation and determination of 2-hydroxy-4-methoxybenzaldehyde, 2-hydroxy-4- methoxybenzoic acid, 3-hydroxy-4-methoxybenzaldehyde and 4-hydroxy-3- methoxybenzaldehyde in *H. indicus*. Extraction efficiency of major phytochemicals by different polarity solvents was tested in *H. Indicus* and major phytochemicals were found highest in ethyl acetate extract, followed by chloroform extract, acetone extract, ethanol extract, petroleum extract, methanol and water extract.

KALMEGH (*Andrographis paniculata*)

A new high yielding variety, Vallabh Kalmegh 01 (DMAPR AP 35) was recommended for submission to the CVRC by the Varietal Identification Committee meeting held during the XXVIIth AICRPMAP&B group Meeting.

Twenty three reference varieties were maintained during the kharif 2019 for pure seed production.

Study on genome-wide identification and expression profiling of small RNA processing proteins in *A. paniculata* was conducted.

Twenty six genotypes were exposed to rain-fed condition during early-season rain-fed and mid-season rain-fed conditions to assess their suitability for rain-fed cultivations in sub-tropical region of Gujarat.

Combined application of biochar and chemical fertilizers was found improving crop yield and quality along with the soil quality of the cultivation land.

KOKKUM (*Garcinia* spp.)

Anti-cancer properties of standardized extracts and isolated compounds from *Garcinia* sp. were validated in animal model against colon cancer (Colo-205).

A simple and rapid process was developed for isolation of xanthochymol from *G. xanthochymus*.

Antibacterial lead for methicillin-resistant *Staphylococcus aureus* from *Garcinia* species was established.

MADHUNASHINI (*Gymnema sylvestre*)

SSR markers were developed for assessment of genetic diversity in madhunashini.

Stomatal, gaseous and fluorescence parameters were studied in different genotypes of *G. sylvestre*

To understand the transcriptomic insights of the biosynthesis of gymnemic acid, *de novo* transcriptome sequencing of leaf, flower and fruits of *G. sylvestre* genotype DGS-22 was

performed and putative pathway of the gymnemic acid biosynthesis is proposed.

Mealy bug. *Paracoccus marginatus* was found to damage various parts of madhunashini. The peak activity of the pest causing maximum leaf foliage damage was observed during the hot weather condition like April to July months. Another pest *Aphis nerii* was first observed in 41st and 45th standard metrological weeks (SMW) of 2018 and 2019, respectively and the population peak was observed during the 06th SMW of both the years.

SALAPARNI (*Desmodium gangeticum*)

Four explorations were undertaken in Gujarat, Madhya Pradesh, Karnataka, Chhattisgarh and Maharashtra and a total of 40 accessions were collected.

SENNA (*Cassia angustifolia*)

Two-hundred and thirty accessions were evaluated for morphological and agronomic traits.

A16-18 recorded maximum dry herbage yield (7197 kg ha^{-1}) which was followed by DCA-149 (7135 kg ha^{-1}) and DCA-96 (7037 kg ha^{-1}) at ICAR-DMAPR, Anand.

Characterization of Chorismate synthase (caCS) gene and 3-phosphoshikimate 1-carboxyvinyltransferase (caEPSP) the sixth and penultimate enzyme in the shikimate biosynthesis pathway involved in the biosynthesis of sennosides were accomplished.

Field experiment conducted at Samni experimental farm of ICAR-CSSRI, RRS, Bharuch showed that senna could be a good candidate for saline soil with a view to improve the livelihood security of the resource poor farmers having land with salinity problem.

TULSI (*Ocimum sanctum*)

Based on three years' field trial, DOS-22 was identified as an elite line for herbage yield as compared to checks Angna and DOS-1

DOS-1 was found suitable as an intercrop in fruit orchards for male fruit fly management due to the presence of high methyl eugenol content (73.88%) in essential oil present in the herbage..

Detailed study of identification and characterization of rosmarinic acid synthase in tulsi (OtRAS) was accomplished.

Anthocyanin biosynthesis pathway analysis in purple subtype of tulsi was studied and the key genes CHS and CHI (chalcone synthase and chalconeisomerase) for early biosynthesis and anthocyanidin synthase and dihydroflavonol 4-reductase (ANS and DFR) for late biosynthesis of anthocyanins in *O. sanctum* were identified.

Diversity analysis of genotypes belonging to green and purple subtypes of *O. sanctum* were done using SSR markers.

Incorporation of cluster bean crop residue prior to transplanting and application of 100% N equivalent through FYM + Arka Microbial consortia could be recommended as organic production technology in tulsi to obtain maximum herbage yield and quality.

AICRP MAP&B

ALOE (*Aloe barbadensis*)

Six elite genotypes were evaluated at CCSHAU, Hisar and significantly superior gel content was in IC 112526 (62.50%) which was at par with HAV-05-08 (62.00%).

Dipping of the suckers in carbendazim 0.1% solution before planting and foliar spray of mancozeb @ 0.2% was found superior for management of leaf spot diseases at BAU, Islampur.

ALOE (*Aloe barbadensis*)

Maximum plant growth, sucker number and leaf yield as well as water use efficiency were recorded with ridge and furrow method of planting while crop irrigated at IW: CPE= 1 was found recording maximum leaf yield at BAU Islampur. At CCSHAU Hisar, the highest leaf (36667 kg ha^{-1}) and gel (20449 kg ha^{-1}) yields were recorded with application of vermicompost (7.5 t ha^{-1}).

ASALIO (*Lepidium sativum*)

At AAU Anand, significantly higher seed yield was recorded (1556 kg ha^{-1}) with treatment receiving FYM (10 t ha^{-1}) + bio NPK.

Maximum seed yield (2010 kg ha^{-1}) and net return (Rs. 44418/-) with B:C ratio (2.8) was observed with the treatment receiving 80 kg N + 40 kg P ha^{-1} along with phosphate solubilizing bacteria (PSB) and Azotobacter at CCSHAU, Hisar.

At RVSKVV, Mandsaur, application of nitrogen fertilizer (40 kg ha^{-1}) with three equal split application recorded maximum seed yield (1700 kg ha^{-1}).

Application of NPK (60:40:30 kg ha^{-1}) recorded maximum seed yield (5.11g $plant^{-1}$), test weight (1.71) and seed yield (1370 kg ha^{-1}) at NDUAT Faizabad.

At YSPUHF Solan, application of FYM (10 t ha^{-1}) + NPK (60:40:20 kg ha^{-1}) recorded significantly higher seed weight (1.77 g $plant^{-1}$) and seed yield (8.31 q ha^{-1}). Application of NPK (120:60:30 kg ha^{-1}) under peach based agro forestry system was found effective for better income.

ASHWAGANDHA (*Withania somnifera*)

An Advanced evaluation trial with four promising lines with four checks viz., GAA-1 (AWS 1), JA134, JA20 and RVA100 were tested at Akola, Anand, Coimbatore, ICAR-DMAPR, Hisar, ICAR-IIHR, Mandsaur, Raipur, and Udaipur to identify promising lines for higher yield and quality.

At RVSKVV, Mandsaur, 120 lines of ashwagandha were evaluated for thirteen different characters and MWS 326 recorded the highest dry root yield.

At MPUAT, Udaipur**,** 74 lines maintained were evaluated and 29 lines exhibited higher dry root yield (kg ha^{-1}) over the grand mean of the experiment (233.19 kg ha^{-1}).

At PDKV, Akola, 18 entries were tested and dry root yield was found highest in genotype AKA-08 (661.37 kg ha^{-1}).

At MPUAT, Udaipur, 11 promising genotypes were evaluated along with 3 checks and the

study revealed that none of the entries exhibited significantly higher dry root yield over the best check JA-134.

Sowing of ashwagandha on 1st September recorded significantly highest dry root yield (764 kg ha^{-1}), GMR (Rs. 1, 22,271 ha^{-1}) and NMR (Rs. 78241 ha^{-1}) at PDKV, Akola.

At MPUAT, Udaipur, application of 50 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} was found effective for getting maximum root yield (418.33 kg ha^{-1}) in UWS-10 variety.

MPUAT, Udaipur; RVSKVV, Mandsaur and JNKVV, Jabalpur center are working on eco-friendly disease management of leaf spot and other diseases of ashwagandha. Among the modules, seed treatment with (Carbendazim 12%+ Mancozeb 63%)-75WP @0.30% plus three foliar sprays with Tebuconazole 25EC @ 0.10% was found as the best treatment to minimize leaf spots diseases. Among the organic modules, foliar spray of either alone or combination of azadirachtin (@ 1500ppm), salicylic acid (@ 200 ppm) and cow urine (1:10), was found to minimize the disease incidence up to 36.75%.

BACH (*Acorus calamus*)

APAc-5 (Swarna Swara) developed by YSRHU, Venkataramannagudem was recommended for submission to the CVRC by the Varietal Identification Committee meeting held during the XXVIIth AICRPMAP&B group meeting.

At UBKV Kalimpong, higher fresh (2820 kg ha^{-1}) and dry (930 kg ha^{-1}) rhizome yields were recorded with treatment receiving neem cake @2.5 t ha^{-1}.

BASIL (*Ocimum basilicum*)

An Advanced Evaluation Trial (AVT-II) with three entries AOB 4, AOB 5, DOB along with GAB-1 as a check were tested at Anand, ICAR-DMAPR, Mandsaur, Pusa, Rahuri, Faizabad and Islampur.

At AAU Anand, the highest oil yield on pooled basis in the year of 2018-19 was recorded in planting during 3rd week of July (131.3 kg ha^{-1}) and spacing of 60 × 45 cm (131.1 kg ha^{-1}).

Transplanting of basil during 15th June with spacing of 60 × 45 cm recorded maximum dry herbage yield (6130 kg ha^{-1}) followed by 1st July transplanting at MPKV Rahuri.

At RVSKVV Mandsaur, application of 100% N through chemical fertilizer recorded maximum plant height (73 cm), number of branches (17), dry herbage yield (610 kg ha^{-1}) and seed yield (2200 kg ha^{-1}).

BETELVINE (*Piper betle*)

Multilocational trial initiated including five hybrids with two local checks showed that overall leaf yield per vine was found to be significantly highest in HY-09-13 followed by Swarna Kapoori at YSRHU, Venkataramannagudem.

Significantly higher marketable leaf (94.14 $vine^{-1}$) was registered under 100% RDF through inorganic fertilizer (200:100:100 NPK kg ha^{-1}) at BAU Islampur.

AAU,Jorhat working on epidemiology and complex diseases *viz*., Antrhacnose leaf spot, Phytophthora leaf blight, bacterial leaf blight and foot and root rot management of betelvine reported that percent disease index of phytophthora leaf rot was found maximum (35.4 %)

during the month of September, whereas, the percent disease index of anthracnose leaf spot was recorded maximum (30.8%) during the month of January. The spray of *Pseudomonas* (2 g^{-1})+ neem oil (0.2%) on 30 DAP and 60 DAP was found superior for management of phytophthora leaf rot and anthracnose leaf spot disease.

CHAMOMILE *(Matricaria chamomilla)*

At YSPUHF Solan, the maximum fresh flower weight (58.70 g $plant^{-1}$), dry flower weight (20.20 g $plant^{-1}$), fresh flower yield (434962 kg ha^{-1}), dry flower yield (149987 kg ha^{-1}), oil content (0.60%) and gross income (Rs.78989.60 ha^{-1}) were recorded under treatment receiving FYM (10 t ha^{-1}) + NPK (60:40:30 kg ha^{-1}).

GLORY LILY (*Gloriosa superba*)

Survey was made at different parts of Tamil Nadu and about fifteen accessions were collected and added to the existing 15 collections at TNAU.

Studies on floral biology and development of hybridization technique were developed at TNAU, Coimbatore and YSPUHF, Solan.

Minimum seed certification standards were developed by TNAU, Coimbatore

INDIAN VALERIAN (*Valeriana jatamansi)*

At UBKV Kalimpong, maximum fresh (2.33 t ha^{-1}) and dry (0.55 t ha^{-1}) rhizome yields were recorded under 75% shade intensity. The highest fresh (3.09 t ha^{-1}) and dry (1.10 t ha^{-1}) rhizome yield was recorded with treatment receiving FYM (5 t ha^{-1}) + vermicompost (2 t ha^{-1}) along with phosphate solubilizing bacteria.

Study revealed that maximum rhizome yield (2.64 g $plant^{-1}$) and essential oil content (0.29%) with treatment receiving vermicompost (7.50 t ha^{-1}) at UUHF Bharsar.

ISABGOL (*Plantago ovata*)

At CCSHAU, Hisar, 13 entries were evaluated including three checks and significantly higher seed yield was in HI-137 (370.00 kg ha^{-1}) which was however at par with HI-135 (362.50 kg ha^{-1}).

At CCSHAU Hisar, application of N:P 37.5:18.75 kg ha^{-1}+ FYM 10.0 t ha^{-1} recorded maximum seed yield (1460 kg ha^{-1}).

Application of 45 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1} was found optimum for maximum seed yield (622.50 kg ha^{-1}) in the genotype UI-124 at MPUAT Udaipur.

At NDUAT Faizabad, closer spacing (30×10 cm) recorded higher seed yield of 680 kg ha^{-1} as compared to wider spacing (30×20 cm). Application of FYM @ 20 t ha^{-1} also resulted in better seed yield (773.33 kg ha^{-1}) at the centre.

MPUAT, Udaipur and RVSKVV, Mandsaur and YSRHU University, Venkataramannagudem centers are engaged in development of integrated disease management module for downy mildew and leaf spots/blight diseases of isabgol.

KALMEGH (*Andrographis paniculata*)

At BCKV Kalyani, seedlings planted at 30 × 20 cm spacing recorded the highest dry herbage yield (10700 kg ha^{-1}).

Application of vermicompost (7.50 t ha^{-1}) recorded maximum fresh biomass (12680 kg ha^{-1}) which was found at par with application of chemical fertilizer (80:40:20 NPK kg ha^{-1}) at DRPCAUR, Pusa.

At YSPUHF Solan, the maximum fresh (5890 kg ha^{-1}) and dry leaf (3440 kg ha^{-1}) yield, fresh (2412 kg ha^{-1}) dry shoot yield (2106 kg ha^{-1}) and net return (Rs. 52537/- ha^{-1}) was observed under peach plantation with treatment receiving chemical fertilizer (NPK 120:60:30 kg ha^{-1}).

LAVENDER (*Lavendula angustifolia*)

At SKUAST Srinagar, the maximum rhizome yield (10336.6 kg ha^{-1}) was recorded when rhizomes were planted at a spacing of 30 cm×30 cm followed by 8207.7 kg ha^{-1} at a spacing of 30 cm×45 cm.

LONG PEPPER (*Piper longum)*

MLT evaluation of promising lines of long pepper for high yield and quality

An Initial evaluation trial with two test entries and one check (Viswam) was conducted at three locations *viz*., Bhubaneswar, Jorhat and Trichur.

At AAU, Assam, 30 accessions of long pepper were evaluated along with check Viswam and significantly higher dry pipli yield was in JPL-22 and significantly higher piperine content was in JPL-11.

At OUAT, Bhubaneswar, 32 accessions collected from different locations were catalogued for morphological characters by using the minimum descriptor as recommended by NBPGR. Based on the yield and yield contributing characters such as spike length, spike diameter, fresh weight of spike per plant, number of spikes per plant, dry weight of spike per plant and piperine content, accessions IC-615512, IC-615517 and IC-615511were found to be promising as compared to the released variety Viswam.

At AAU, Jorhat, promising lines JPL1 and JPL-19 -19 were tested at three different agro-ecological locations in Assam and JPL-19 outperformed the check variety at all the testing locations. JPL-19 was superior in terms of piperin content (5.65%) also.

At AAU Jorhat, the maximum dry yield (1351.87 kg ha^{-1}) was recorded in 60 × 40 cm spacing. The treatment receiving NPK 175:75:75 kg ha^{-1} + FYM (10 t ha^{-1}) + neem cake (5 q ha^{-1}) had also resulted in maximum dry yield (567.25 kg ha^{-1}) at the centre.

At OUAT, Bhubaneswar, application of FYM @ 20 t ha^{-1} (100% substitution of recommended dose of nitrogen) resulted in maximum values for the traits such as number of catkins per plant (218.65), dry weight of catkin (961.90 kg ha^{-1}) and piperine yield (15.29 kg ha^{-1}). However, the piperine content of long pepper was influenced by the application of organic manures.

At AAU, Jorhat, organics, bioagents and chemicals were evaluated to manage the diseases in long pepper. The results indicated that leaf spot leading to blight/rot was controlled by treatment involving soil treatment with *Trichoderma viride* @3 g m^{-2} with 20 t FYM ha^{-1} +neem cake @ 2 t ha^{-1}.

MUCUNA (*Mucuna pruriens*)

An advanced evaluation trial I (AVT I) with five test entries and one check (CIM-Ajar) was conducted at five locations *viz*., DMAPR, Raipur, Ranchi, IIHR and Venkataramannagudem with an objective to identify superior varieties with high yield and quality. At YSRHU,

Venkataramannagudem epidemiological studies on yellow mosaic disease (YMC) indicated that the disease incidence had significant positive correlation with white fly population.

MADHUNASHINI (*Gymnema sylvestre*)

Sixty six accessions of *Gymnema sylvestre*_were characterized for morphological and yield characters at TNAU, Coimbatore.

At BAU Ranchi, maximum fresh (75844.90 kg ha^{-1}) and dry (35156.80 kg ha^{-1}) biomass yields at harvesting period was recorded with mid July transplantation at spacing levels of 30 cm×40 cm. The maximum yield of dry leaves (5208.30 kg ha^{-1}) was recorded in 10 t ha^{-1} vermicompost +10 t ha^{-1} neem cake +10 t ha^{-1} castor cake +50:50:50 kg NPK ha^{-1}

At JNKVV Jabalpur, cuttings treated with 750 pmm IBA solution and planted in the month of August showed maximum survivability (28.33%). Application of FYM @ 10 t ha^{-1} recorded maximum dry weight (48.7 g $plant^{-1}$) and B: C ratio (2.87).

OPIUM POPPY (*Papaver somniferum*)

Advanced varietal trial with five test entries (UOP20, UOP79, UOP80, MOP278 and MOP511) and two checks (Chetak Aphim and JOP540) was conducted at three locations Udaipur, Mandsaur and Faizabad with an objective to identify superior varieties with high yield and quality.

At MPUAT, Udaipur**,** 85 lines were evaluated and 19 lines exhibited higher morphine content than the check Chetak Aphim (11.89%); two entries *viz*., UOP-30 and UOP-35 were found statistically at par with the best check Chetak Aphim for latex yield; UOP 30 gave seed yield at par with the best check Chetak Aphim and UOP-30 gave husk yield at par with Chetak Aphim.

At MPAUT, Udaipur, significantly higher latex yield (46.15 kg ha^{-1}), seed yield (1120.3 kg ha^{-1}), husk yield (1123.83 kg ha^{-1}) and morphine content (11.98%) were observed with the genotype Chetak aphim.

RVSKVV, Mandsaur concluded that drip irrigation system is not economically profitable as compared to traditional flood system of irrigation in terms of latex, seed, husk, net returns and B: C ratio. Treatment receiving 160 kg N ha^{-1} resulted in maximum seed yield (1175 kg ha^{-1}) and latex yield (59.50 kg ha^{-1}). Similarly, plant density of 4 lakh plant ha^{-1} had maximum latex yield (60.70 kg ha^{-1}) at the centre.

NDUAT, Faizabad; MPUAT, Udaipur and RVSKVV, Mandsaur centers are engaged in diseases management of Opium poppy. The IDM module, in-furrow soil application of neem cake mixture (100g sqm^{-1}) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus seed treatment with Streptocycline @ 0.035% plus drenching of Copper oxychloride 50 WP @ 0.3% at 40, 55 and 70 DAS followed by drenching of Copper hydroxide 77 WP @ 0.3% at 40, 55 and 70 DAS was found as the best in management of bacterial stem rot.

PASHANBHED (*Bergenia ciliata*)

Pollination studies conducted at UBKV, Kalimpong revealed maximum fruit set and seed yield per capsule were in autogamy (selfing by bagging),

SAFED MUSLI *(Chlorophytum borivilianum)*

At PDKV, Akola, 16 genotypes were evaluated and the results revealed the dry fleshy root weight per plant and saponin content were found highest in genotype AKSA-07.

SARPAGANDHA (*Rauvolfia serpentina*)

At BAU, Ranchi, the highest fresh root (7129.2 kg ha^{-1}), dry root (2844.0 kg ha^{-1}) yields at harvesting period was recorded from treatment combination of mid May transplantation at spacing levels of 30 cm×40 cm. Combination of organic and inorganic treatments receiving 10 t ha^{-1} vermicompost+10 t ha^{-1} neem cake+5 t ha^{-1} castor cake+30:40:40 kg NPK ha-1 also resulted in maximum production of fresh root yield (2846.70 kg ha^{-1}) at the centre.

Application of FYM @ 20 t ha^{-1} (100% substitution of recommended dose of nitrogen) in sarpagandha recorded maximum plant height, primary branches and LAI at 12 months after planting at OUAT Bhubaneswar.

SATAVARI (*Asparagus racemosus*)

Plant spacing of 60 cm×60 cm with application of 20 t FYM ha^{-1} and 80:60:50 kg NPK ha^{-1} recorded the highest dry root yield (2630 kg ha^{-1}) at IGKV, Raipur.

At JNKVV, Jabalpur, application of 50% recommended dose of NPK+50% through FYM recorded the highest fresh root yield (4690 g $plant^{-1}$) and dry root yield (748.25 g $plant^{-1}$)

SENNA (*Cassia angustifolia*)

Advance varietal trial II (AVT II) with four test entries and three checks (ALFT-2, Sona and KKM-01) was conducted at four locations *viz*., Anand, Coimbatore, DMAPR and Rahuri with an objective to identify superior varieties with high yield and quality.

TULSI (*Ocimum sanctum*)

The trial with four test entries and one check (Angna) was conducted at seven locations *viz*., Anand, DMAPR, Faizabad, Islampur, Mandsaur, Pusa and Rahuri with an objective to identify superior varieties with high yield and quality.

At BAU, Islampur, irrigation schedules with $IW_{30\ mm}$/CPE= 1.0 recorded maximum green leaf yield (9689.60 kg ha^{-1}) and dry leaf yield (2010.80 kg ha^{-1}). Consecutive 4 years' study concluded that application of NPK (50: 40: 30 kg ha^{-1}) + FYM (10 t ha^{-1}) resulted in higher fresh (14930 kg ha^{-1}) and dry (3610 kg ha^{-1}) herbage yields at the centre.

Treatment combination of 1st July planting with spacing of 60×45 cm recorded maximum fresh herbage yield (17910 kg ha^{-1}) and dry herbage yield (3093 kg ha^{-1}) at MPKV, Rahuri.

At YSPUHF, Solan, maximum fresh biomass yield (10234 kg ha^{-1}), dry biomass yield (2728 kg ha^{-1}), oil yield (18.35 lit ha^{-1}), gross income (Rs. 218261/- ha^{-1}) and net income (Rs. 113295/- ha^{-1}) were recorded with treatment receiving FYM (2 t ha^{-1})+NPK (120:60:30 kg ha^{-1}) in green tulsi. Application of NPK (120:60:30 kg ha^{-1}) recorded the maximum fresh leaf yield (3020 kg ha^{-1}), dry leaf yield (1119 kg ha^{-1}) and gross income (Rs. 126842/- ha^{-1}) under peach based agro forestry system at the centre.

Introduction

INTRODUCTION

The Indian Council of Agricultural Research (ICAR) established a National Research Centre for Medicinal and Aromatic Plants at Anand, Gujarat in 1992 which was rechristened to ICAR-Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR) by backward linking of its outreach programme, the All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine (AICRP-MAPB).

The ICAR Directorate of Medicinal and Aromatic Plants Research has been in the forefront for sustainable production and utilization of major agriculturally important MAP through its research and development to meet the immediate demands and also to address future national and international challenges.

The ICAR-DMAPR continues to contribute in this sector in the very basic link of quality raw drug supply by research using its core competent area of agriculture which is equally important as drug discovery. Thus, quality raw drug supply sector demands research for varietal improvement, development of good agricultural practices for assuring end quality, quality assessment, supply of quality planting material, fixing of standards, certification, *etc*. The emerging challenges and opportunities demand for an innovation driven research system using modern tools of ICT, biotechnology, molecular biology, biochemistry *etc*., to link with all the stakeholders in the entire MAP supply chain.

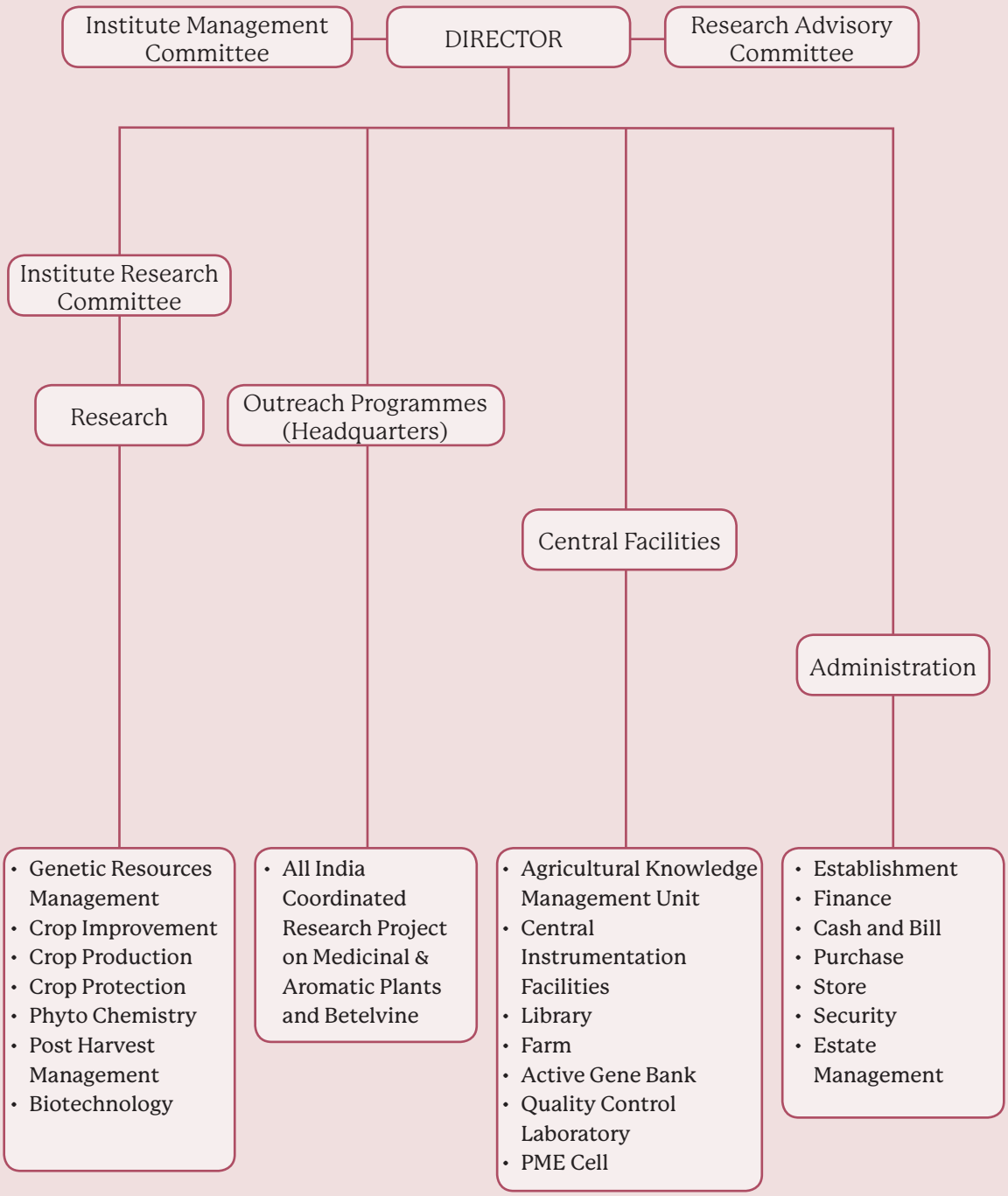
Mandate

- Basic, strategic and applied research on genetic resource management, crop improvement and enhancing productivity of Medicinal and Aromatic Plants through Good Agricultural Practices and organic farming technologies.
- Identification, purification and synthesis of active biomolecules of Medicinal and Aromatic Plants.
- Transfer of technology, capacity building and impact assessment of technologies.
- Coordinate research and validation of technologies through AICRP on Medicinal and Aromatic Plants.

Mandate crops

- Aloe (*Aloe barbadensis* Mill.)
- Ashwagandha (*Withania somnifera* Dunal)
- Giloe [*Tinospora cordifolia* Willd. (Miers)]
- Guggal [*Commiphora wightii* (Arn.) Bhandari]
- Isabgol (*Plantago ovata* Forsk.)
- Kalmegh (*Andrographis paniculata* (Burm. f.) Wall. ex Nees.)
- Lemongrass [*Cymbopogon flexuosus* (Nees ex Steud.) W. Watson]
- Palmarosa [*Cymbopogon martinii* (Roxb.) Wats.]
- Safed musli (*Chlorophytum borivilianum* Sant. & Fern.)
- Salaparni (*Desmodium gangeticum* (L.) DC.)
- Satavari (*Asparagus racemosus* Willd.)
- Senna (*Cassia angustifolia* Vahl)

Organisational Structure



Outreach programmes

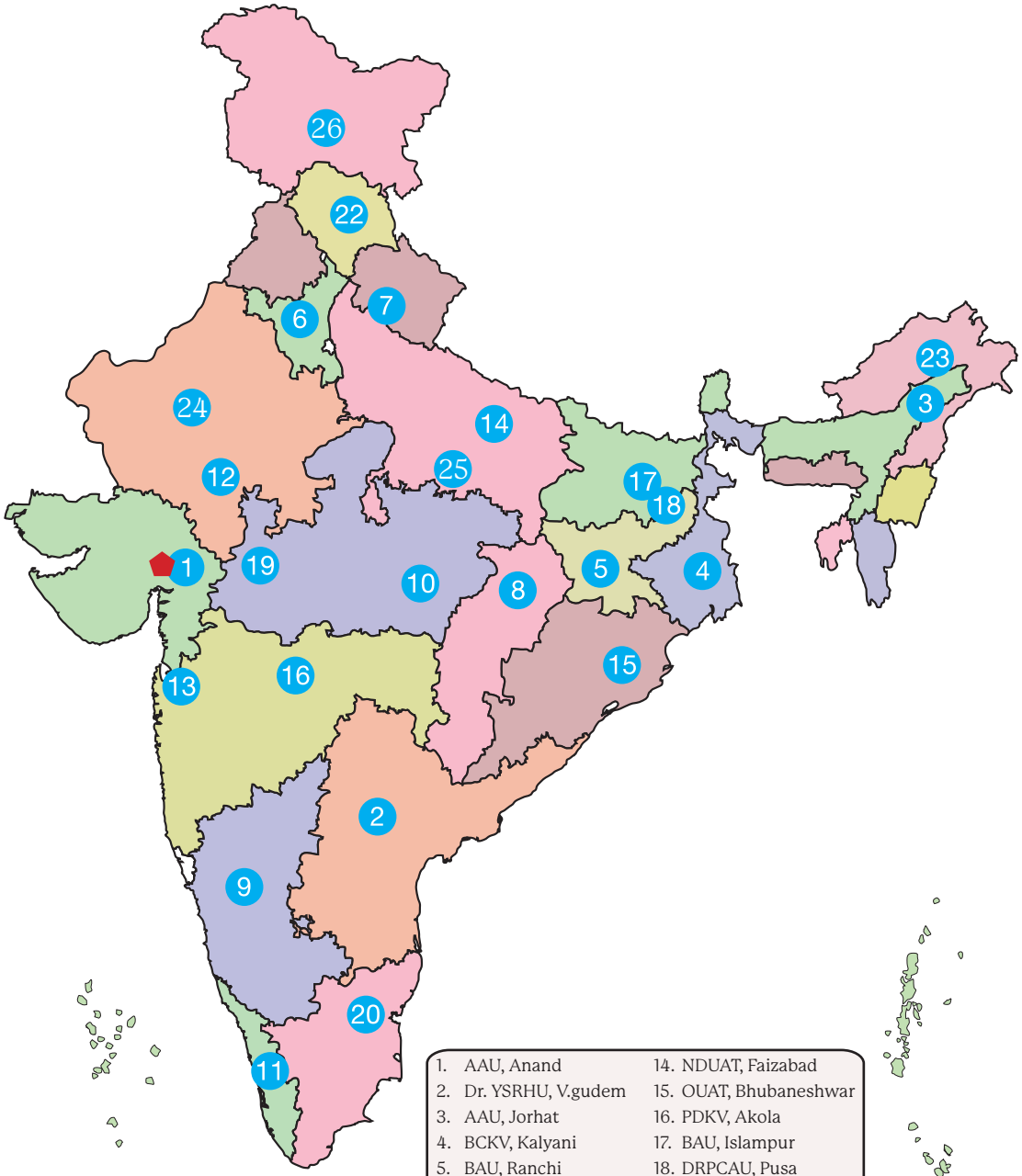
AICRP-MAPB is located at ICAR-DMAPR and the Director, ICAR-DMAPR is also responsible for coordination and monitoring of research work of the project as Project Co-ordinator. Recently three voluntary centres *viz.*, Agriculture University (AU), Jodhpur; Banda University of Agriculture and Technology (BUAT), Banda and Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Kashmir were added in this project. The centres of AICRP-MAPB are as follows:

1. Anand Agricultural University (AAU), Anand
2. Assam Agricultural University (AAU), Jorhat
3. Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani
4. Bihar Agricultural University (BAU), Islampur
5. Birsa Agricultural University (BAU), Ranchi
6. C. C. S. Haryana Agricultural University (CCSHAU), Hisar
7. Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur
8. ICAR - Indian Institute of Horticultural Research (IIHR), Bengaluru
9. Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur
10. Kerala Agricultural University (KAU), Trichur
11. Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur
12. Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri
13. N. D. University of Agriculture and Technology (NDUAT), Faizabad
14. Orissa University of Agriculture and Technology (OUAT), Bhubaneshwar
15. Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola
16. Dr. Rajendra Prasad Central Agricultural University (DRPCAU), Pusa
17. Rajmata Vijayraje Scindia Krishi Vishwa Vidyalaya (RVSKVV), Mandsaur
18. Tamil Nadu Agricultural University (TNAU), Coimbatore
19. Uttar Banga Krishi Viswavidylaya (UBKV), Kalimpong
20. Uttarakhand University of Horticulture & Forestry (UUHF), Bharsar
21. Dr. Y. S. Parmar University of Horticulture and Forestry (YSPUHF), Solan
22. Dr. Y. S. Rajasekhara Reddy Horticulture University (Dr. YSRHU), Venkataramannagudem
23. Central Agricultural University (CAU), Pasighat

Voluntary Centres

24. Agriculture University (AU), Jodhpur
25. Banda University of Agriculture and Technology (BUAT), Banda (Voluntary Centre)
26. Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Kashmir (Voluntary Centre)

Centres of AICRP on Medicinal & Aromatic Plants and Betelvine



1. AAU, Anand	14. NDUAT, Faizabad
2. Dr. YSRHU, V.gudem	15. OUAT, Bhubaneshwar
3. AAU, Jorhat	16. PDKV, Akola
4. BCKV, Kalyani	17. BAU, Islampur
5. BAU, Ranchi	18. DRPCAU, Pusa
6. CCSHAU, Hisar	19. RVSKVV, Mandsaur
7. UUHF, Bharsar	20. TNAU, Coimbatore
8. IGKV, Raipur	21. UBKV, Kalimpong
9. ICAR - IIHR, Bengaluru	22. YSPUHF, Solan
10. JNKVV, Jabalpur	23. CAU, Pasighat
11. KAU, Trichur	24. AU, Jodhpur
12. MPUAT, Udaipur	25. BUAT, Banda
13. MPKV, Rahuri	26. SKUAST, Kashmir

■ ICAR-DMAPR, Anand, Headquarters

Budget profile for financial year 2019

Head	Expenditure (Rs. in Lakhs)
ICAR Funded	
Institute-DMAPR	789.63
AICRP on Medicinal & Aromatic Plants and Betelvine	907.17
ICAR Schemes/Projects	28.71
Externally Funded	
Externally Funded Projects	91.25
Total	**1816.76**

Research Achievements

RESEARCH ACHIEVEMENTS
ICAR-DMAPR

ALOE *(Aloe vera)*

Aloe belongs to family, Liliaceae. The species is introduced from African countries which

was later naturalized in India. The plant is perennial in habit with fleshy leaves and condensed stem. Leaves contain mucilage (polysaccharides) and leaf exudates contain aloin and aloe emodin which are commercially useful. The mucilage has a cooling and moisturizing action and hence used in cosmetic industries. Aloin and aloe emodin are used as pain killer and purgative. The species flowers during November to February. Flowers are having saffron to orange yellow colour which attracts birds for pollination. There is large-scale agricultural production of Aloe vera in Australia, Bangladesh, Cuba, the Dominican Republic, China, Mexico, India, Jamaica, Kenya, Tanzania and South Africa, along with the USA to supply the cosmetics industry. In India, the crop is under cultivation in Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh. Raw material is collected both from wild and cultivation for the industry. The species is valued about $30-40 million in global sale annually. The demand for this plant may likely to be increased due to increasing utilization of natural medicinal products throughout the world. Suckers are mainly used for propagation.

Etiology, pathogenesis and molecular characterization of pathogens associated with soft rot disease

Soft rot disease of aloe is identified as a complex disease caused by an interaction of enterobacterium *Dickeya zeae* and a saprophytic fungus *Fusarium solani*. It is imposing major constraint in cultivation of the crop. The etiology and pathogenesis of the disease were not established so far. The naturally infected plants possess healthy intact root

systems and the rotting starts on the collar region of plants at soil line. The artificially inoculated plants with the bacteria at roots did not develop disease symptoms, eliminated the possibility of pathogen entering through roots. Further, on the naturally infected plants, the association of *Fusarium* spp. was repeatedly observed in infected plants on the collar region. The lesions produced due to fungal infection predisposed the plants for infection to the *Dickeya* sp. was established in the current study. To

characterize the associated pathogens, DNA was isolated from pure culture of the fungus and bacteria which were isolated from the naturally infected aloe plants. Three partial genes (dnaX, icdA and mdh) of bacteria and fungus (ITS, TEF and RPB) were amplified using the specific primers and sequenced. The sequence analysis revealed that *Dickeya zeae* and *Fusarium solani* were associated with the soft rot of aloe. This suggests complex host-bacterium interaction for soft rot symptoms development and the requirement of storing and transporting aloe leaves at low temperatures. (Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R. P. Meena).

Etiology, pathogenesis and molecular characterization of associated pathogens of soft rot disease of aloe

ASHWAGANDHA (*Withania somnifera*)

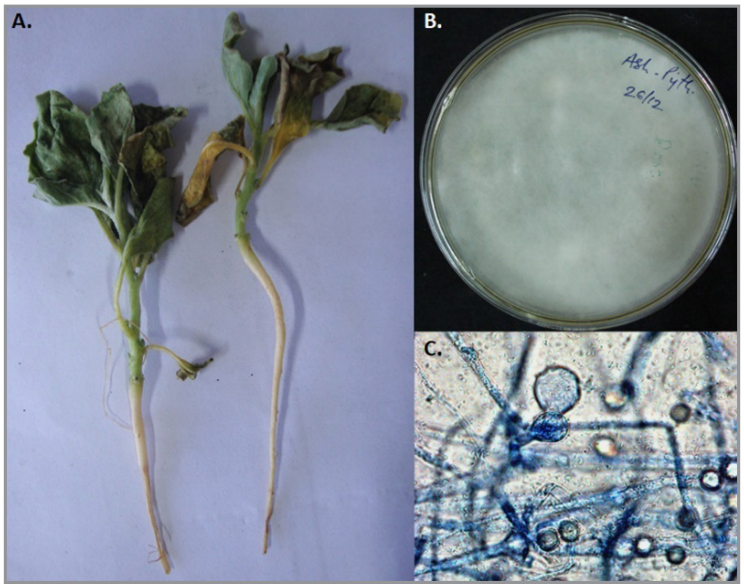
The plant belongs to family Solanaceae and is considered as wonder herb with multiple medicinal properties. It is cultivated in North-western and Central India. The species is an annual to perennial, branched, under shrub to herb of about 30 cm to 120 cm height. Root is the major medicinally important part in addition to leaves and seeds. Roots are used in preparation of vital tonics. It is a stress reliever and is used in treating senile dysfunctions. Its effect on controlling anxiety, depression, phobias, alcoholic paranoia, schizophrenia, etc., is clinically established by different tests. The active ingredient that attributed to the medicinal property is the alkaloids and steroidal lactones.

Germplasm evaluation

One-hundred and twenty-two accessions were evaluated for morphological and agronomic traits. Accessions, IC 0210601, IC 0262388, IC 0385221, IC 0510842, IC 0510841, RVA-100 and AWS-1 recorded high root yield (more than 1500 kg ha^{-1}). (*Project 1: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel).*

Efficacy of fungicides and biocontrol agents against damping off disease

Damping off disease is the most common disease under moist and cool atmosphere in ashwagandha and nurseries raising seedlings of Solanaceae crops. In *W. somnifera*, damping off disease incidence was recorded about 15-20% at the seedling stage. The present study investigate about the associated pathogen of damping off disease and evaluated various management strategies including seed dressing with chemicals, bio-control agents and its different combinations. The causal agent of damping off disease on *W. somnifera* was identified based on the morphological characteristics as *Pythium aphanidermatum*. Among the eight fungicides tested under *in vitro* condition, metalaxyl-M (apron XL) showed the highest efficacy to inhibit the mycelium growth of *P. aphanidermatum* on PDA.



Symptoms of damping off disease on ashwagandha (*W. somnifera*) seedlings; (B.) Colony morphology of isolated pure culture of *Pythium aphanidermatum* and (C) Microscopic view of sporangia of *Pythium aphanidermatum*

The seeds treated with gibberellic acid @ 600mg l^{-1} showed significantly higher germination in field condition. Seed treatment using metalaxyl M (1 ml kg^{-1}) along with *Trichoderma viride* (10 g kg^{-1}) and furrow application of well decomposed FYM (1kg m^{-2}) enriched with *T. viride* talc based formulation at 2.0% significantly reduced the seedling mortality caused by damping off disease in *W. somnifera*. (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R. P. Meena*).

Study of chemotypes in breeding lines

Three hundred and twenty seven pure lines were screened for withanolides (Withaniferine-WA, 12-deoxywithastramonolide-WD, Withanoilde-WDA) content in roots samples. HPLC-PDA method was used for quantification of withanolides in hydro-alcoholic extracts of *W. somnifera*. WA (%) content varied from 0.0002- 0.2467 with a mean value of 0.0392; WD (%) content was in the range of 0.0005-0.3496 with a mean value of 0.0143%. The mean value of WDA was 0.0518 % and it varied from 0.0003-0.3241%. Pure lines namely DWS-184 (WA= 0.249%, WD= 0.076%, WDA= 0.147%), DWS-228 (WA= 0.038%, WD= 0.350%, WDA= 0.0727%), DWS-266 (WA= 0.155%, WD=0.085%, WDA= 0.224%), DWS-290 (WA= 0.188%, WD=0.083%, WDA= 0.145%), DWS-296 (WA= 0.120%, WD=0.081%, WDA= 0.235%), DWS-300 (WA= 0.116%, WD= 0.057%, WDA= 0.274%), and DWS-315 (WA= 0. 027%, WD= 0.050%, WDA= 0.324%) had withanolides content greater than 0.401%. Selected chemotypes could be utilized for development of *W. somnifera* varieties which would be more remunerative for farmers and preparation of drugs rich in desired withanolide content. (*Project 06: Bio-prospection, quality and post harvest technology in medicinal and aromatic crops; Investigators: Dr. Satyanshu Kumar, Dr. P. Manivel and Dr. Raghuraj Singh*)

BASIL (*Ocimum basilicum*)

Basil belongs to family Lamiacea and is widely distributed throughout India. The species is believed to be originated in India, Pakistan and Thailand. Basil prolifically produces large green or purple leaves, measuring around 2 inches in length, throughout the summer. Basil has the ability to synthesize and convert phenylpropenes. The flavor and smell of basil varieties are largely determined by their chemical components present in the essential oil. Basil varieties contain cinnamate, citronellol, geraniol, linalool, methyl chavicol, myrcene, pinene, ocimene and terpineol. Basil has been used as a folk remedy for an enormous number of ailments, including, cancer and convulsion.

Field note developed for essential oil content

Green and purple colour intensity in leaf was identified as field note for initial screening of accessions for essential oil content in basil. The number of peltate glands (PGs) in the younger leaf, green leaf colour and oil content had positive relationship in both the types of basils. The PG formation takes place only in younger leaf stage and therefore, the number of PGs per unit area reduced in mature and older leaves due to expansion of leaf area with progression of age. It was also found that the number of PGs on abaxial surface of younger leaf and oil content had positive relationship with each other. Purple and green leaf colour intensities can be used as morphological markers for essential oil content in herbage. (*Project 1: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. P. L. Saran).*

Study of downy mildew disease on basil

Severe incidence of downy mildew disease in basil was observed during 2019. Leaves of infected plants were initially slightly chlorotic, especially near the central vein. Within 2 to 3 days, a characteristic grey, furry growth was evident on the lower leaf surface and sometimes on the upper leaf surface. Based on the morphological observation, *Peronospora* sp. was found causing downy mildew in basil. (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R. P. Meena*).

Symptoms and severity of downy mildew disease of basil caused by *Peronospora* sp.

First report of Bihar hairy caterpillar, *Spilosoma obliqua* on a new host crop, basil

The Bihar hairy caterpillar, *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae) is a polyphagous and sporadic pest on several cash crops in the Oriental region. The polyphagous feeding habit enables it to survive on a variety of crops and also the pest expanding its host crops by feeding on new plants. The identity of the pest confirmed through morphological and molecular methods (Accession No. MK491177). The current study provides biological parameters of *S. obliqua* on its newly reported host, basil. The total life cycle was longest during winter season (male, 68.67; female, 73.27 days) comparing to kharif season. The phylogenetic analysis indicated the distribution of uniform population of *S. hysic* infesting soybean and basil, but subtle difference was found compared to population infesting potato. The damage incidence on basil ranged from 4.33 to 60 and 10 to 63.33 per cent during 2018 and 2019, respectively. The minimum temperature and morning relative humidity were found negatively correlated with the incidence of *S. obliqua* during the study period. *S.obliqua* on basil was parasitized by *Glyptapanteles* sp. (11%) and *Carcelia* sp (17%) (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Mr. K.T. Shivakumara*).

Spilosoma oblique **a. larvae; b. affected plant portion; c. Infected plant; d. Adult insect.**

First report of occurrence of *Pyrausta panopealis* on basil

Perilla leaf moth, *Pyrausta panopealis* (Lepidoptera: Pyralidae) was found to cause economic damage at 20 to 100 per cent plant incidence and population density at 0.07 to 13.56 plant-1 on basil in different seasons in India. The identity of the pest species was determined through morphological and DNA barcoding (Accession number MK559412). Biology of the pest was studied and the mean incubation period, larval period, pupal period (male and female) and longevity of the pest (male and female) were 3.19 ± 0.53 days; 13.81 ± 1.18 days; 5.40 ±0.49 (male), 6.27±0.44 (female) and 3.86±1.05 (male), 4.40 ±1.0v7 (female), respectively. The total life span of the male and female insects ranged from 22 to 33 days (average 27.49) and 24 to 35 days (average 28.90), respectively. The number of eggs varied from 91 to 131 with an average of 111.75±14.06 eggs. (Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Mr. K. T. Shivakumara).

Pyrausta panopealis **a. Larva; b. Pupa; c. Adult; d. Infected plant**

CHAKODA (*Senna tora*)

Senna tora (= *Cassia tora*) is a dicot legume in the subfamily Caesalpinioideae. It grows abundantly in parts of Afghanistan, India, China, Pakistan, Nepal and Bhutan. Its most common English name is Sickle Senna. The whole plant and roots, leaves, and seeds have been widely used in traditional Indian and South Asian medicine. The plant and seeds are edible. Young leaves can be cooked as a vegetable while the roasted seeds are used as a substitute coffee. The seeds and leaves are used to treat skin disease and its seeds can be utilized as a laxative. This herb is used in Ayurveda for treatment of swellings.

Exploration and collection

Germplasm constitute the basic raw materials required for the improvement of crop plants. Exploration was planned with an objective to collect genetic variability of chakoda germplasm from the wild for conservation and use in crop improvement programs. Four explorations were undertaken in Gujarat, Rajasthan, Karnataka, Madhya Pradesh, Maharashtra and Chhattisgarh and collected 25 accessions. Variability was observed for days to flowering, days to maturity and pod characters. (*NMPB Project: Breeding medicinal plants for improved yield and quality; Investigators: Dr. R. Nagaraja Reddy, Dr. P. Manivel, Dr. V. Thondaiman and Dr. Stayanshu Kumar*).

Quantification of two anthraquinone glycosides emodin and chrysophsanol

Two anthraquinone glycosides namely emodin and chrysophsanol were quantified in seed extracts of *Cassia tora* samples using a reversed phase high performance liquid chromatography method. Emodin content (%) ranged from 0.0015-0.0182 % with a mean of 0.0079. Maximum EMOP was observed in DCT-2 (0.0182), followed by DCT-19 (0.0179), DCT-21 (0.0178) and DCT-1 (0.0152).Chrysophenol content (%) ranged from 0.0058-0.1002 %. Maximum CRYP was observed in DCT-4 (0.1002), followed by DCT-14 (0.0538), DCT-10 (0.0458) and DCT-5 (0.0413). Minimum CRYP was recorded in DCT-41 and DCT-28(0.0058), followed by DCT-36 (0.0082). (*NMPB Project: Breeding of medicinal plants for yield and quality; Investigators: Dr. Satyanshu Kumar and Dr. R. Nagaraja Reddy*).

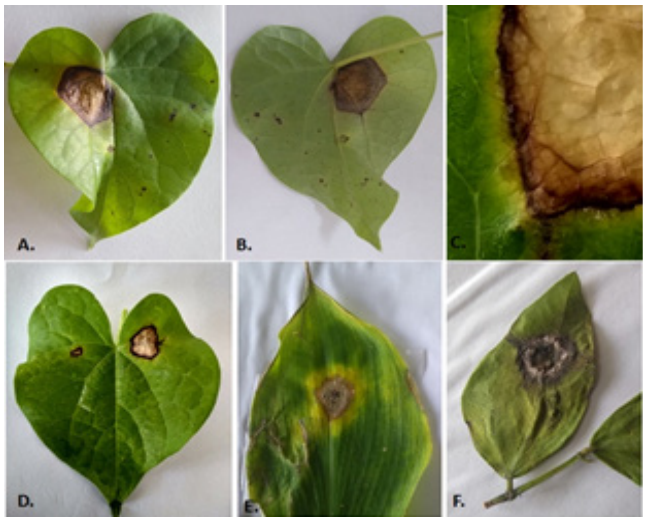
GILOE (*Tinospora cordifolia*)

Giloe is a member of family menispermaceae. It is a deciduous perennial climber and is distributed throughout tropical india. the species produces a lot of aerial roots. It is propagated by stem cuttings as well as by seeds. The stem and leaves are medicinally used as raw drug. Tinospora stem is a common constituent of a number of ayurvedic vital tonics for the treatment of general debility, dyspepsia, fevers and urinary diseases.

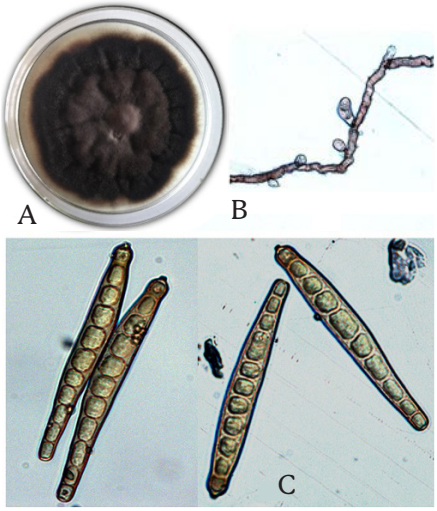
Starch present in the stem along with alkaloids is the active principle of the species. The leaf also contains a number of alkaloids and are used for the treatment of gout, jaundice and rheumatism. Raw drug is mainly obtained from the wild. The plant is not under regular cultivation and it is grown as a climber on trees in the wild. One year old plants are ready for use as raw drug. The stem is collected from the wild and dried and used for starch extraction.

Morphological and molecular characterization of *Exserohilum rostratum* causing leaf spot disease of giloe

A new leaf spot disease of *Tinospora cordifolia caused by Exserohilium rostratum* has been found since 2017-18 at ICAR-DMAPR, Anand in India. Infected leaves of *T. cordifolia* initially showed small water-soaked spot and soon the spots turned into dark brown to black with the greyish brown center while the outer periphery of the lesions remained dark brown with yellowish margins. Single spore derived isolate AET-1 was retrieved from the symptomatic leaf tissues of *T. cordifolia* and pathogenicity test to the host was established following the Koch's postulates. The emerging fugal colonies were circular, grey to deep brown, with abundant cottony aerial mycelium. Conidiophores were single, septet, cylindrical, dark brown, geniculate, and 4 to 6 μm thick with an inflated or swollen basal cell. Conidia were deep olivaceous brown, with the typical protruding truncate hilum and consisted 8–9 septa with 14 x 72 μm sizes. Further, to verify the identification, internal transcribed spacer (ITS) region was amplified using primer pair ITS1/ITS4 and the sequenced AET-1 isolate sequence was submitted to NCBI with the accession number of MK911727.1. The ITS sequence of AET-1isolate shared > 99% similarity with published sequences of *E. rostratum* in BLAST*N* analysis. Thus the isolate was identified as *E. rostratum* based on the morphological as well as Rdna ITS sequences. The host range experiment demonstrated that *E. rostratum* isolate of *T. cordifolia* may infect the cross genera infection on other plant species. (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R. P. Meena*).



Symptoms of *E. rostratum* on giloe (A-D) and other host plants (E-F)



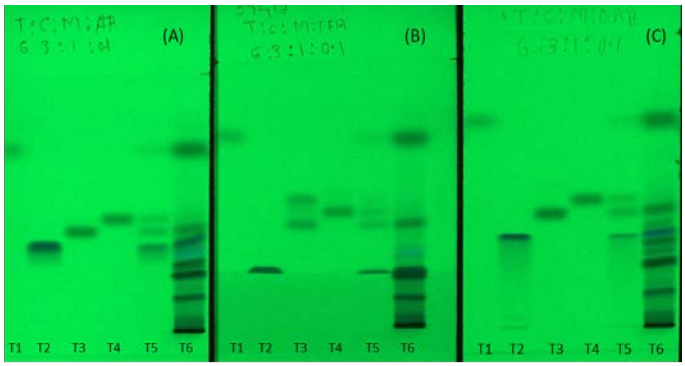
Morphological features of *E. rostratum*

INDIAN SARASAPARILLA (*Hemidesmus indicus*)

Indian sarasaparilla also known as anantamool, is a species of Apocynaceae family and is distributed throughout the tropical and subtropical parts of India, especially in upper Gangetic plains, Bengal, Madhya Pradesh, and Southern parts of India. It is a slender, laticiferous vine which trails on the ground and climbs by means of tendrils growing in pairs from the petioles of leaves. The vine emerges from a long, tuberous rootstock, and can reach up to 1-3 m. Flowering occurs during October-January. The species is popular for its immense medicinal values. Root is aromatic and is therapeutically important. It is administered in the form of powder, infusion or decoction as syrup. It is one of the Rasayana plants of Ayurveda. It is used for treating leprosy, fever, asthma, skin diseases, arthritis, rheumatism, gout, epilepsy, abdominal distension, intestinal gas, debility, impotence and turbid urine.

HPTLC method development for major phytochemicals

A High performance thin layer chromatographic (HPTLC) method was developed for separation and determination of 2-hydroxy-4-methoxybenzaldehyde, 2-hydroxy-4-methoxybenzoic acid, 3-hydroxy-4-methoxybenzaldehyde and 4-hydroxy-3- methoxybenzaldehyde in *H. Indicus*. The chromatographic separation was achieved by using TLC pre-coated silica gel 60 F254 aluminium base plate with mobile phase combination of toluene-chloroform- methanol- glacial acetic acid. The resolved bands were recorded at R_f 0.74± 0.005, 0.289±0.005, 0.357±0.005 and 0.42±0.007. (*NASF Project: Chemotyping and molecular profiling of bioactive metabolites in Hemidesmus indicus and Costus speciosus adapted to different geographical zones and identification of candidate genes related to metabolic pathways; Investigators: Dr. Narendra Gajbhiye and Dr. V. Thondaiman).*



TLC profile of reference standards T1: 2- hysicn-4-methoxybenzoic acid, T2: 3- hysicn-4- methoxy benzaldehyde, T3: 4-hydroxy-3-methoxy benzaldehyde; T4: 2-hydroxy-4- methoxybenzaldehyde, T5: mixture of standards and T6: methanol extract of root

Extraction efficiency of major phytochemicals by different polarity solvents

Selection of appropriate solvent is very important for optimum extraction of targeted compounds. Dried root powder samples of *H. indicus* were extracted by different polarity solvents *viz*., petroleum ether, chloroform, ethyl acetate, methanol, ethanol, acetone and water. Extractive yield was found highest in water extract (32.38±0.37%) followed extracts

by methanol (28.73±0.23%), ethanol (24.83±0.09%), acetone (8.38±0.11%), ethyl acetate (8.85±0.52%), chloroform (6.02±0.13%) and petroleum ether (4.81±0.09%). Content of major active compounds *viz.,* 2-Hydroxy-4-methoxybenzaldehyde, 2-Hydroxy-4-methoxybenzoic acid, 3-Hydroxy-4-methoxybenzaldehyde and 4-Hydroxy-3-methoxybenzaldehyde in different extracts were tested. Total major phytochemicals were highest in ethyl acetate extract, followed by chloroform extract, acetone extract, ethanol extract, petroleum extract, methanol and water extract. (*NASF project: Chemotyping and molecular profiling of bioactive metabolites in Hemidesmus indicus and Costus speciosus adapted to different geographical zones and identification of candidate genes related to metabolic pathways; Investigators: Dr. Narendra Gajbhiye and Dr. V. Thondaiman).*

ISABGOL (*Plantago ovata*)

The species belongs to the family Plantaginaceae. It is an annual herb grown during the rabi season. Seed coat is known as psyllium husk under trade. The swelling property of the seed coat or husk after absorption of water is used in medicines against constipation and gastrointestinal disorders. In addition, it is used in food industries for the preparation of ice creams, candy, etc. India is the only isabgol producing country in the international trade. Country earns on an average ₹ 400 crores annually from its export. It is widely cultivated in North Gujarat, adjoining Rajasthan and Madhya Pradesh over an area of about 2, 50,000 ha. A number of high yielding varieties are available in the crop for cultivation.

Germplasm maintenance and characterization and germplasm exchange

Eighty-seven (87) isabgol accessions were maintained in field gene bank and were characterized using DUS descriptors and morphological traits.

Accessions DPO-1, DPO-6, MIB-121, DM-6, DM-5, AM-6, MIB-124, MIB-4, MIB-122, MIB-125, RI-156, MIB-2, DPO-8, DPO-7, EC427062 and RI-87 were exchanged with NDUAT, Faizabad and DPO-14, DPO-185, DPO-385, DPO-174, DPO-185, DPO-9 and DPO-1 of isabgol were exchanged with YSPUHF, Solan. *(Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel).*

Germplasm registration

Two accessions *viz*., DPO-185 (IC 0627267, INGR 19025) and DTPO-6-6 (IC 0627269, INGR 19026): were registered with ICAR-NBPGR, New Delhi. DPO-185 was erect, with distinct yellow leaf tip coloration followed by tip drying during flowering, resistant to downy mildew (DM) disease, late maturing (130-140 days) and low yielding. DPO-185 can be a potential allelic donor to improve host plant resistance to DM disease in isabgol. Further, the genotype is useful for unravelling genetic mechanism/s underlie DM-host pathogen interaction. Yellow leaf tip trait

can be used as DUS character for identification of elite germplasm lines and cultivars. DTPO6-6 is a tetraploid line (2n = 4x = 16) of isabgol which was developed from the variety GI 2 using hysicngl (0.1 to 0.5%) seed treatment. The tetraploidy was confirmed through flow cytometry, root anatomy, phenotypic observation and cytology. The tetraploids were fertile and stable over years (2010-2017). Morphologically the tetraploids were more vigorous than the diploids but late maturing. The anatomical comparison revealed that the size of xylem and phloem of stem and inflorescence stalk were thicker in tetraploids than diploids. The seed yield was higher in tetraploids than the diploids. Further selection and breeding can be done in tetraploid lines for the qualitative and quantitative improvement of isabgol after inter crossing between tetraploid lines. (*Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy*).


DPO-185

Hybridization and advancement of generation

Crosses were made to study the genetics for various agro-morphological traits as well as to introduce desirable traits into elite genotypes. Successful hybrid seeds were produced in crosses viz., DPO-185 × DPO-9, DPO-9 × DPO-174, DPO-9 × DPO-14, DPO-353-1 × DPO-353-5, DPO-353-1 × DPO-294-4, DPO-353-1 × DPO-185, DPO-185 × DPO-14 and DPO-185 × DPO-1. Further, the crosses INGR 19025 ICAR – DMAPR ANNUAL _EPORT 2018-19 33 viz., RIL 133 × RIL 44, RIL 39 × RIL 35, DPO 184 × DPO 14, DPO 14 × DPO 185, RIL 58 × RIL 115, and RIL 35 × RIL 39 were advanced from F1 to F2 generation. (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy*).

Study of male sterility

Inheritance pattern of male sterility in isabgol was unravelled and it was found that male sterility is governed by a single recessive gene. Accordingly, maintainer line (DMAPR PO 10 B) was also developed. Now the male sterility can be utilized for heterosis breeding and hybrid production. A new male sterile line (DMAPR PO 22) was identified in the year 2016 was also maintained for further studies. *(Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. Aarti Kawane and Dr. Geetha K.A.)*


DMAPR PO 22

Genetic mapping of genome

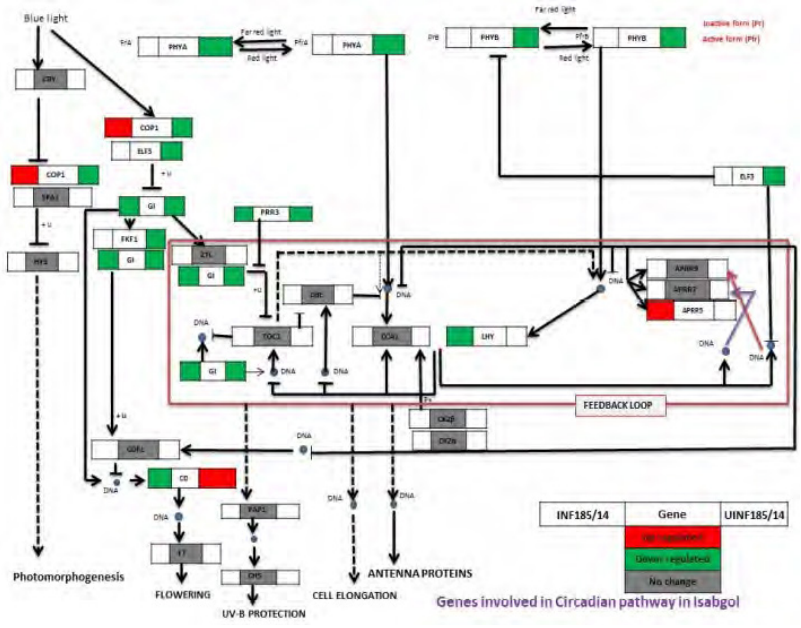
The first genetic map was constructed using single nucleotide polymorphism (SNP) markers to unearth quantitative trait loci (QTL) for the agronomic traits and comparative mapping of *Plantago*. The genetic map was constructed using DPO-14 x DPO-185 recombinant inbred lines mapping population (160) of isabgol. The map has >200 SNP markers and linkage groups were aligned using Kosambi mapping function. (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel*).

Genomic SSR markers

Simple sequence repeats (SSR) markers are one of the most popular molecular markers frequently used in fingerprinting of cultivars, genetic diversity studies, linkage analysis and marker assisted breeding of crop plants. Raw reads (24.3 gb) of the isabgol genome were downloaded from the SRA-NCBI database and *de novo* assembled using CLC software. There were 2,43, 681 contigs sequences of 292,141,447 bp were obtained with an N50 of 2912 bp. SSR search using MISA yielded 3,14,206 SSRs with a frequency of 1.08 per kb. Over 2,00,000 genomic SSR markers were developed of which 100 SSR markers were validated by PCR amplification. Genomic SSR markers thus developed will have potential markers-based applications in isabgol improvement. (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel*).

Exploration of maturity genes

Transcriptome sequences of DPO-14 (early maturing) and DPO-185 (late maturing) genotypes were explored for various maturity genes. Genes encoding various enzymes involved in flowering pathways in autonomous pathway (7), circadian pathway (32) photoperiod (5) and vernalization (4) were identified. Further, several of these genes were differentially expressed between DPO-14 and DPO-185. Understanding flowering pathways help for breeding early maturing varieties in the crop. (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel*).



Maintenance of reference varieties for DUS testing

The guidelines for isabgol DUS testing were notified by the PPVFR authority and published in Plant variety Journal (Vol. 04, No. 10) in October 01, 2010). During the current year, eleven reference varieties of isabgol, *i.e.,* DMAPR PO1, DMAPR PO2, DMAPR PO3, DMAPR PO4, DMAPR PO5, DMAPR PO6, DMAPR PO7, DMAPR PO8, DMAPR PO9, DMAPR PO10 and DMAPR PO11 were maintained. (*PPVFRA project: Development of DUS Guidelines in medicinal, aromatic and seed spices crops; Investigators: Dr. Aarti Kawane and Dr. Geetha K.A.*)

Front line Demonstration of Vallabh Isabgol-1

Vallabh Isabgol-1 a new variety developed at the Directorate was demonstrated to farmers at Radhanpur, Bachau, Santalpur and Raper talukas of Gujarat. Nineteen front line demonstrations (FLDs) were laid at different villages of Gujarat. *(Project 7: Improving knowledge and skill of stakeholders for improving production of medicinal and aromatic crops; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy)*

Resistance (R) gene cloned

Isabgol production suffers from tremendous losses due to downy mildew (DM) disease. Moreover, chemical control of DM is costly and is a potential hazard to the ecosystem. To address the problem of downy mildew an extensive study of plant Resistance genes (R-genes) is crucial to develop DM resistant cultivars. Coiled coil (CC)-Nucleotide Binding Site (NBS)-Leucine Rich Repeats (LRR) class of resistance (R) gene plays a major role in conferring disease resistance in plants in general and oomycetes in particular. The gene, *Plantago ovata Resistance (poR)* has 4338bp which includes 86bp-5'UTR, 2673bp-coding sequence (CDS) and 350bp-3'UTR. The *poR* gene consists of two introns- one located in the coding sequence (1113bp) and the other located in the 3'UTR (116bp) with splice sites GA-AG and TC-GC respectively. The gene *poR* encodes a protein of 890 amino acids and contains Coiled-coil (CC), Nucleotide-binding site (NBS) and 6 Leucine-Rich Repeat (LRR) domains at 2-118, 154-440 and 606-834 amino acid residues respectively. Sequence comparison of POR protein

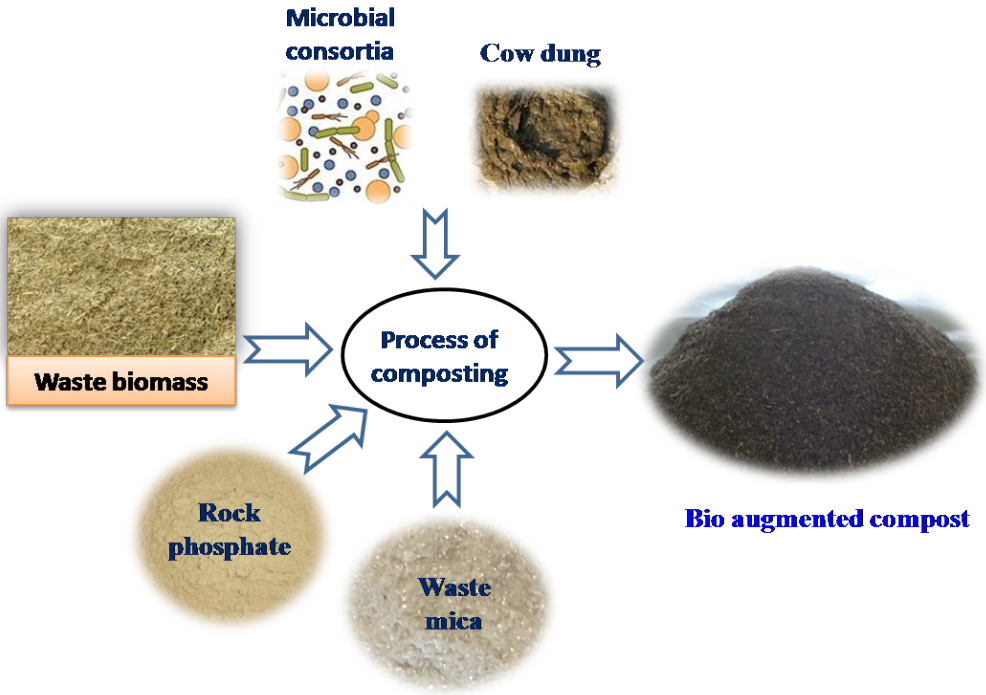
with 39 known R-genes revealed that the POR forms a distinct clade with R1, R8 and Rpi-blb2 genes. It is closely related to R1 gene followed by R8 and Rpi-blb2 of potato against late blight disease. Comparative expression pattern of poR gene in two isabgol genotypes DPO-14 (DM susceptible) and DPO-185 (DM resistant) at three levels of disease severity showed increased expression of poR with respect to disease severity in DPO-185. The cloned *poR* gene will provide an important resource to develop downy-mildew resistant isabgol cultivars and further help in understanding disease resistance mechanism in plants. (*DST-SERB project: Transcriptome based discovery of pathways and genes related to resistance against downy mildew disease in isabgol (Plantago ovata Forsk.); Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy*).

Acreage estimation

Traditionally isabgol area was estimated based on the cropping information in the land records which is inaccurate, incomplete and cumbersome. Recently, geographical information system (GIS) and remote sensing (RS) are extensively used for crop identification and crop area estimation. Further, area under isabgol fluctuates every year due to variation in prices and bad climatic condition. In this study, acreage estimation of isabgol in Bhachau, Rapar and Santalpur blocks of Gujarat was carried out using GIS and RS data. Unsupervised classification with ISODATA clustering technique was applied to multi date LISS-III data to generate different class. Soil adjusted vegetation index (SAVI) spectral profile was used to segregate isabgol crop from other crops. The ground truth survey using hand held GPS (Global Positioning System) was carried out during cropping season. The estimated isabgol acreage is 1675 ha, 5753 ha and 4245 ha for Bhachau, Rapar and Santalpur blocks, respectively during the year 2018-19. Accurate estimation of isabgol area and expansion of existing area will help planning and export management of isabgol in the country. (*Project: ISRO-SAC Work plans for Inventory of Medicinal plants; Investigators: Dr. R. Nagaraja Reddy, Dr. P. Manivel, Dr. B. B. Basak, Satyajit Roy and Dr. Sujay Dutta*)

Production of bio-augmented enriched compost

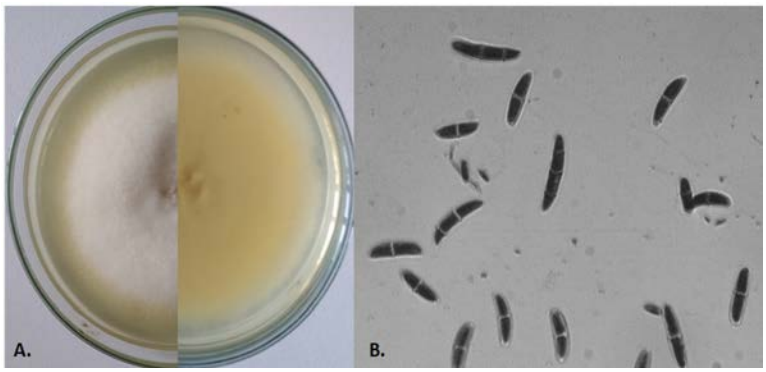
Bio augmented enriched organic fertilizer was prepared from isabgol crop residue and low-grade mineral (rock phosphate and waste mica) through composting and microbial interventions. The organic fertilizer was enriched with major plant nutrients particularly P and K. Isabgol straw biomass along with two levels of mineral powder (2 and 4% as P and K) was used for preparation enriched composts. Bio hysicng phosphate hysicngls (*Bacillus coagulans*) and potassium mobilizing (*Enterobacter asburiae*) bacteria were added to the compost mixture for better solubilisation of P and K, respectively from mineral powder. Mature compost (C: N ratio < 20:1) was obtained within 120 days after composting. This bio-augmented compost has significantly higher amount P (5 times) and K (2 times) than ordinary organic manure and compost. So it can be considered as promising low-cost enriched organic fertilizer for cultivation of medicinal plants. **(***Project 6: Sub-project 5: Valorisation medicinal and aromatic plant waste as a potential soil amendment, bio-sorbent*, *Investigators*: *Dr. B. B. Basak and Dr. Ajoy Saha***)**



Production process of bio-augmented compost

Morphological and molecular characterization of *Fusarium* spp. Causing wilt disease of isabgol and its management strategies

Wilt is one of the economically important and devastating diseases which infects *P. ovata* from seed germination to maturity of the crop and imposed the production of crop in India. Incidence of wilt disease was influenced by several agronomical and environmental factors and varied from 10 to 60% in *P. ovata*. The present study was carried out to identify and characterize the associated *Fusarium* species with morphological and advanced molecular approaches. Two types of symptoms were observed on infected plants, *i.e.,* under dry condition typical wilting symptom appears on the outer whorl where leaves dried and turned silvery in colour, whereas in moist soil condition rotting on collar region and cortical roots of the plants. On PDA the fungal colony appeared white to pale violet with cottony mycelium growth. The macro-conidia were straight to slightly curved and relatively slender in shape. Length of the macro-conidia was 25-40 μM with 3-7 μM of width. Further, for accurate identification and characterization of the isolate, partial ITS, translation elongation factor (EF-1α) and RNA polymerase II (RPB2) were amplified in PCR. The sequencing result analysed in BLAST*N* similarity search and *Fusarium* MLTS database, confirmed the *Fusarium oxysporum* species complex association with the wilt disease in *P. ovata*. For management of the disease, it was found that seed dressing using carbendazim (50 WP) along with soil application of *Trichoderma viride* enriched neem cake mixture before sowing significantly reduced the disease incidence. To the best of our knowledge, this is the first comprehensive report on molecular characterization of *Fusarium oxysporum* associated with wilt disease of *P. ovata*. (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R. P. Meena*).



Fusarium isolate (isbfu-1) (A) colony morphology of the pure culture on PDA and (B) Macro-conidia of Fusarium isolate (isbfu-1) observed under microscope.

KALMEGH (*Andrographis paniculata*)

Kalmegh is a branched annual herb of family Acanthaceae and is of about 30-100 cm tall. The species is distributed in India, Sri Lanka, Bangladesh and Malaysia. The species is commonly known as 'King of bitters'. In India, it is found in the plains of Himachal Pradesh to Assam and Mizoram and also in Peninsular India. The whole herb is medicinally used. Andrographolide is the major active principle having the therapeutic action. The herb is used for treating diabetics, bronchitis, piles, jaundice and fever. It is considered as a blood purifier and is used for the treatment of skin diseases. It is cultivated as kharif season crop in Gujarat, Uttar Pradesh, West Bengal, Madhya Pradesh, Orissa, Andhra Pradesh and Tamil Nadu. The plant is propagated by seeds and it is cultivated as a transplanted crop.

A new high yielding variety, Vallabh Kalmegh 01 (DMAPR AP 35) was recommended by the Varietal Identification Committee

A new high yielding variety, Vallabh Kalmegh 01 (DMAPR AP 35) was recommended for submission to the CVRC by the Varietal Identification Committee meeting held during the XXVIIth AICRPMAP&B group meeting. The proposed variety Vallabh Kalmegh 01 has superior herbage yield. It has better andrographolide content *i.e.,* about 19.49% more andrographolide content than the check variety, AK 1 and has better andrographolide yield *i.e.,* about 23.69% more andrographolide than AK 1. The newly proposed variety is distinct with its erect (closed) branching pattern with medium height (50-70 cm) and dark green leaves with columnar plant canopy shape (as per DUS descriptors notified by the PPVFRA). SRAP (Sequence-related amplified polymorphism) markers based DNA finger printing was also carried

out to discriminate the newly identified Vallabh kalmegh 1 from the cultivar AK1. (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. Geetha K.A. and Dr. N.A. Gajbhiye*)

Maintenance of reference varieties

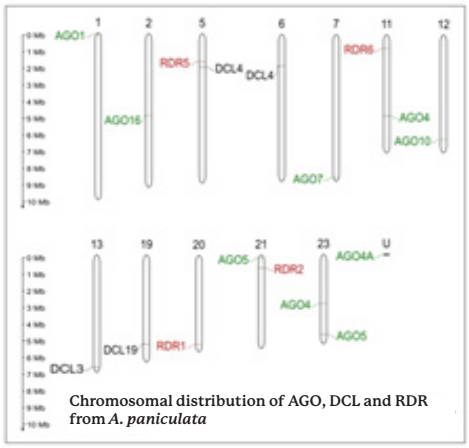
The guidelines for kalmegh DUS testing were notified by the PPVFR authority and published in Plant variety Journal (Vol. 10, No. 01) in January 15, 2016. The major characteristics identified were leaf colour (light green, green or dark green), leaf lamina shape (lanceolate, elliptical, ovate/ ovate lanceolate/elliptical); leaf lamina length (short, long), leaf lamina breadth (narrow, medium, broad); stem shoot apex (tender leaf grouped at apex, tender leaf not grouped at apex), leaf lamina (inwardly closed or outwardly curved); leaf lamina surface (smooth, wrinkled); stem branching pattern (erect, spreading); anthesis pattern (early, medium and late); spikelet type (flower buds closely arranged or distantly arranged); plant main axis growth habit (erect or prostrate); stem internode length (short, long); plant canopy shape (columnar, bushy/globular, pyramidal); plant height (short, medium, tall) and leaf andrographolide content (low, medium, high). Accordingly 23 reference varieties were identified which were maintained during the kharif 2019 for pure seed production. DMAPR 35-1, a new morphotype which was identified during 2016 showed its stability in the identified traits i.e., feathery canopy with very late and shy flowering behaviour during 2019 also. (*PPVFRA project: Development of DUS Guidelines in medicinal, aromatic and seed spices crops; Investigators: Dr. Aarti Kawane, Dr. Narendra Gajbhiye and Dr. Geetha K.A.*)

Leaf colour types

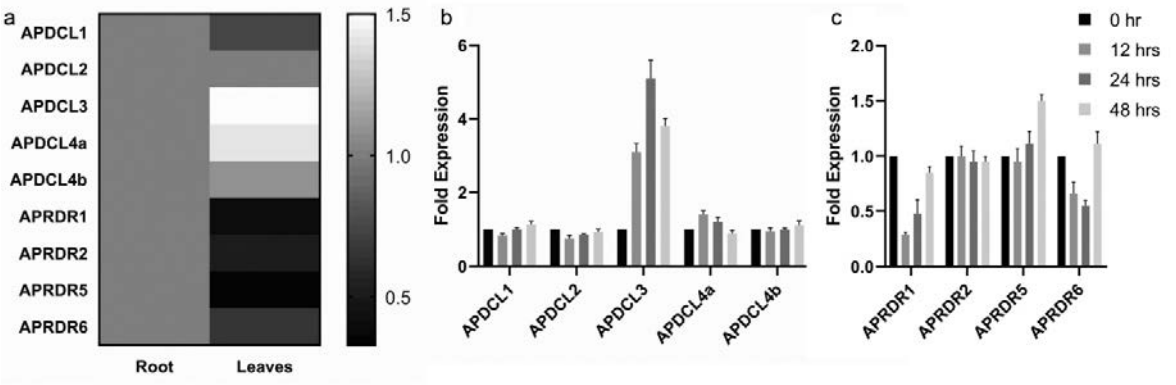
Genome-wide identification and expression profiling of small RNA processing proteins

Small RNAs (sRNAs) involved in various gene silencing pathways play important and diverse roles in the development and differentiation of organisms through regulating gene expression at the transcriptional and post-transcriptional levels, affecting heterochromatin formation, and responding to biotic and abiotic stresses. In plants, sRNAs are generated from double-stranded RNAs (dsRNAs) through various pathways and may be classified into two major classes, including microRNAs (miRNAs) and small interfering RNAs (siRNAs), based on the source of dsRNA. MiRNAs are produced from plant transcripts with internal stem-loop structures, whereas siRNAs are derived from transcripts with inverted-repeat sequence, dsRNAs copied from single-stranded RNA (ssRNA), over-lapping regions of bidirectional transcripts, or dsRNAs formed by virus replication. The biogenesis pathways of plant sRNAs involve in various gene families, such as the Dicer-like (DCL) family and the RNA dependent RNA polymerase (RDR) family, and each pathway appears to be taken part in by different

member of a gene family. To regulate gene expression, the generated Srna duplexes from dsRNAs are loaded into RNA-induced silencing complexes (RISCs) with Argonautes (AGOs) as the central components. RISCs remove the star strand (known as miRNA* or siRNA*) of Srna duplex and select the functional strand as a guide to interact with homologous RNA or DNA molecules for direct RNA cleavage, translational repression or DNA methylation. In *A. paniculata*, 9 AGO, 4 RDR and 5 DCL genes were identified. These proteins are expressed both in root as well as leaves. The expression of these genes was studied in control as well as methyl jasmonate treated *A. paniculata* plants. Simultaneously, chromosome wise distribution of AGO, RDR and DCL were identified. Results showed that in *A. paniculata* transcription of AGO, DCL and RDR are differentially regulated under methyl jasmonate elicitation. *(Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)*



Chromosomal distribution of AGO, DCL and RDR from *A. paniculata*



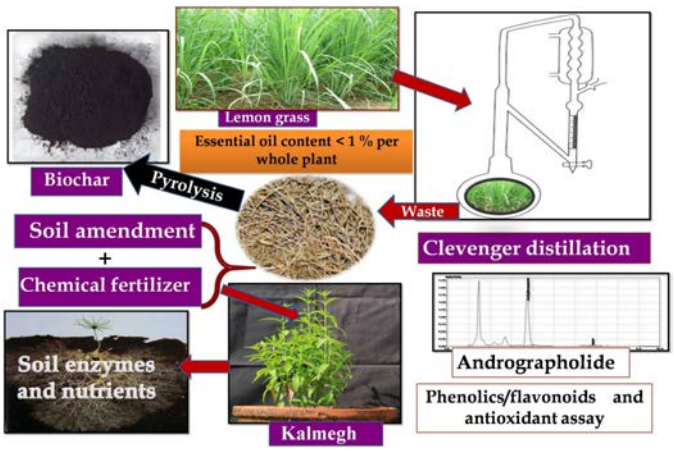
Expression analysis of APDCL and APRDR genes in root and leaves (a) and under methyl jasmonate elicitation (b and c).

Screening genotypes for rain-fed condition

Andrographis paniculata is an important medicinal plant containing a diterpene lactone called andrographolide. Twenty six genotypes of *A. paniculata* were exposed to rain-fed condition during early-season rain-fed and mid-season rain-fed conditions to assess their suitability for rain-fed cultivations in sub-tropical region of Gujarat, India. The treatments were (i) Control (irrigation to replenish field capacity at 10 days interval) and (ii) early-season rain-fed condition (45-90 days after transplanting) and (iii) mid-season rain-fed condition (75-115 days after transplanting). Mid-season rainfed condition caused 29% herbage yield loss. The promising genotypes identified for early season rainfed conditions were AP 6 and AP 12. The promising genotypes for mid-season rainfed conditions were AP 19 and AP 6 (*Project 4: Integrated water and nutrient management and physiological manipulation for improving productivity of medicinal and aromatic plants; Investigator: Dr. K. A. Kalariya*)

Effect of biochar and chemical fertilizer for improvement of yield, quality and soil health

To cultivate medicinal plants by maintaining sustainable environment with low chemical inputs, a pot culture experiment was attempted to integrate the biochar prepared from lemongrass (*Cymbopogon flexuosus*) distillation waste and chemical fertilizers (CF) in different ratios to find out their influence on yield, physiology and quality of *A. paniculata* and on soil chemical/ biological properties. Biochar application, remarkably improved the soil carbon content, cation exchange capacity and nutrients accessibility. However, the affects were maximum when biochar combined with recommended dose of CF was applied. The same treatment revealed higher soil microbial biomass C, fluorescein diacetate hydrolytic, dehydrogenase and alkaline hysicngl activities and non-significant affect on acid phosphates activity. Total phenol/flavonoid contents, as well as antioxidant (DPPH and ABTS) activities were higher in sole biochar treated plant and it was further increased after addition of CF. In general application of biochar or CF does not have any significant influence on leaf andrographolide content but their combination increased the content. All the growth parameters and yield were significantly influenced by the integrated biochar and CF application. Therefore, it is recommended to use combined biochar and chemical fertilizers which not only improve crop yield and quality but also the soil quality. (*Project 4: Integrated water and nutrient management and physiological manipulation for improving productivity of medicinal and aromatic plants; Investigators: Dr. Ajoy Saha, Dr. B. B. Basak Dr. N. A. Gajbhiye and K. A. Kalariya*)



Use of biochar from distillation waste biomass as soil amendment in kalmegh

KOKKUM (*Garcinia spp.*)

Garcinia spp. belong to the family Clusiaceae (Guttiferae) are trees of about 5-15 m tall with rounded crown and horizontal or drooping branches. *G. cambogia* and *G. indica* are the to important species of the genus. Both the species are distributed in semi-evergreen to evergreen forests of Western ghats in Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. *G. cambogia* is popularly known as Bilatti amli or kokkam. In addition to *G. cambogia* and *G. indica, G. talbotti* and *G. lanceifolia* are two underutilized and less known species of the Genus. *G. talbotti* is a dioecious medium

sized tree distributed in the semi evergreen to evergreen forests of Western Ghats. It produces fruit with sweet pulp and abundant yellow latex. It is often misidentified as *G. spicata* in the regional floras of northern Western Ghats. *G. lanceifolia* is distributed North eastern parts of India. It grows up to 12 feet under the dense shade of other trees. Its fruits and young leaves are eaten raw and cooked as vegetables or made into pickles by the local people of Northeast India. The rinds of the fruits extracted from the species are medicinally important and used for the treatment of ulcers, inflammations, bleeding piles, diarrhoea, dysentery and indigestion. Commonlly these species are propagated by seeds, stem cuttings and grafts.

Validation of anti-cancer properties of standardized extracts and isolated compounds in animal model for colon cancer (Colo-205)

Efficacy study of two standardized extracts (G1 and G18) and two isolated compounds (GI-PC and GM-PC) from *Garcinia* spp.were evaluated in a group of six NOD-SCID mice in tumor model Colo-205. Parameters such as tumor volume, body weight and mortality were investigated. Oral dose (200 mg kg^{-1}, 5 days a week) for four weeks were used. As a positive control 5-fluorouracil (5mg kg^{-1} I.P. for 9 days) was used. Significant reduction in relative tumor volume (RTV) was in mice treated with G1, G18, GI-PC and GM-PC. Also, the percentage survival rate was higher in mice treated with the standardized extracts and isolated compounds. (*ICAR Network Project: High Value Compounds/Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh*)

A simple and rapid process developed for isolation of Xanthochymol from *G. xanthochymus*

G. xanthochymus is native to India and its fruit is used in traditional medicine for treating diarrhoea and dysentery. *G. xanthochymus* fruits are also used as yellow dye for fabric and watercolours. *G. xanthochymus* exhibited activity against colon cancer cells. Xanthochymol showed multiple activities against *Candida albicans* biofilms and biological activity against methicilin-resistant *Staphylococusaureus* (MRSA). A simple and rapid process was developed for isolation of xanthochymol from *G. xanthochymus*. (*DBT Project: Inventorization, molecular identification and characterization of Garcinia species from northeast India for isolation of polyisoprenylated benzophenones as taxol mimics; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh*)

Antibacterial lead for methicillin-resistant *Staphylococcus aureus* from *Garcinia* species

Staphylococcus aureus is one of the prominent medically important bacterial pathogen. *S. Aureus* infections are often fatal in nature and are associated resistance to several beta-lactam antibiotics used in hospitals. Methicillin resistant *Staphylococcus aureus* **(**MRSA) is responsible for several difficult-to-treat infections in humans. MRSA is common in hospitals, prisons, and nursing homes, where people with open wounds, invasive devices such as catheters, and weakened immune systems are at greater risk of hospital-acquired infection. MRSA began as a hospital-acquired infection, but has become community-acquired as well as livestock-acquired. Two pure compounds (GM and GI) isolated from *Garcinia* species were tested for MRSA activity. GM exhibited very good activity. Ciprofloxacin was used as a control.

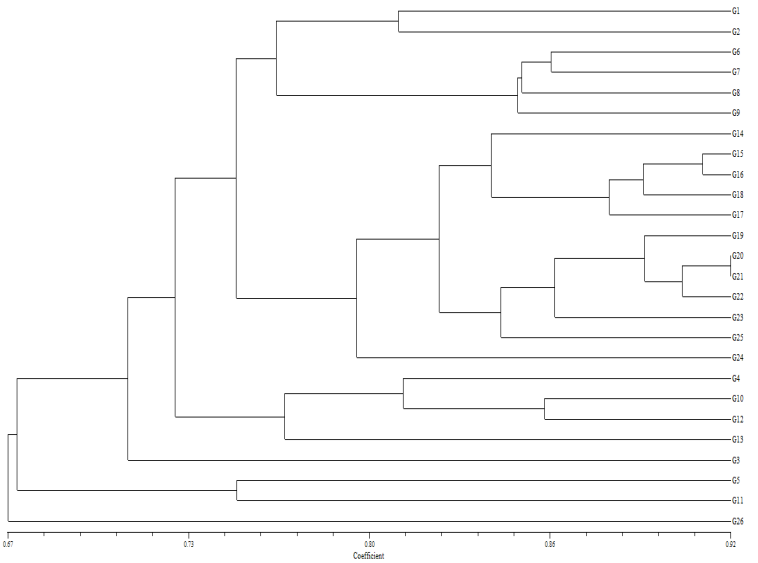
Based on the MIC value of GM, it has a prospect of being considered as a potential treatment option for MRSA infections. (*ICAR Network Project: High Value Compounds/Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh*).

MADHUNASHINI (*Gymnema sylvestre*)

Gymnema sylvestre (FAmily: Apocynaceae) is commonly known as gudmar or madhunashini. The leaves are having remarkable property of inhibiting the taste of sweetness when the leaves are chewed, hence it is known as 'gudmar'. *Gymnema sylvestre* is native to India and widely distributed in the tropical forests of southern and central India and Sri Lanka. The species is naturally found in Banda, Western Ghats and Deccan extending parts of western and northern India. The leaves are saltish and acidic. It is prescribed as antidiabetic. The sugar constituent of the species is found as mixtures of triterpine saponins which are designated as gymnemic acids. The plant is propagated mainly by stem cuttings and also by seeds.

Assessment of genetic diversity of germplasm using SSR markers

100 SSR markers were used for screening of 26 genotypes of *G. sylvestre* which are maintained in the field gene bank of DMAPR. Among the 100 SSR primers, 58 primers produced alleles ranged from 1 to 6 and maximum number of alleles (6) found in XDAGSM10 and it showed the highest polymorphic information content (0.602) and allelic diversity (0.662) followed by XDAGSM55 which recorded maximum PIC (0.607) and allelic diversity (0.671). Hence these two primers were proved as highly efficient polymorphic markers and can be used to distinguish the genetic variability of *G. sylvestre* germplasm. The highest genetic similarity value (0.968) was observed between genotypes DGS-21 and DGS-5 and the lowest value (0.384) was observed between genotype DGS-26 and DGS-17. UPGMA dendrogram grouped genotypes into two major clusters at 67 percent similarity. Among the genotypes, DGS-10, DGS-22, DGS-16, DGS-5 and DGS-23 were found to be distinctly divergent and can be used in future breeding



UPGMA dendrogram of *G. sylvestre* germplasm based on SSR primers

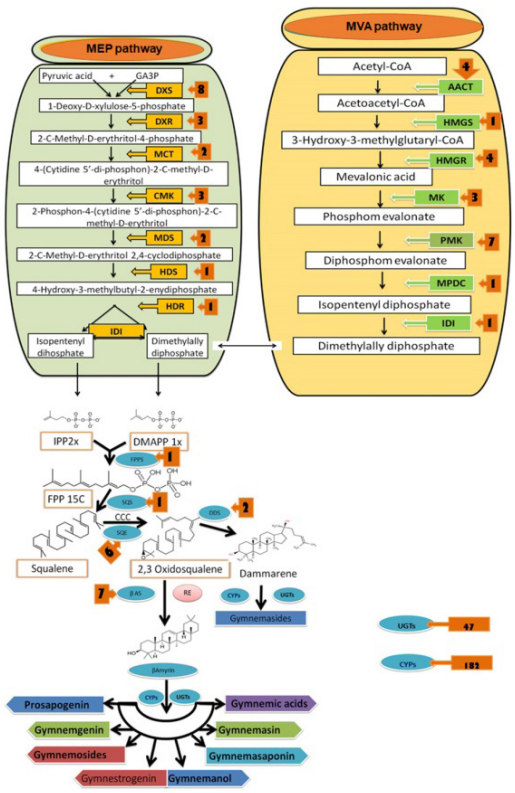
programme. *(NMPB funded project: Sustainable production technology of gudmar (Gymnema sylvestre R. Br.) a medicinal plant with antidiabetic compound gymnemagin; Investigator: Dr. Akula Chinapolaiah)*

Physiological efficiencies in madhunashini genotypes

Stomatal, gaseous and fluorescence parameters were studied in *G. Sylvestre.* There was no variation in stomata density and stomatal index among these genotypes. Chlorophylls and carotenoids content were high in DGS 22 but, net photosynthetic rate was high in DGS 3.The Fv/Fm was similar but, F'v/F'm and ΦPSII were high in DGS 3.Transcriptome analysis showed connection of 123 genes across five relevant pathways. The Rubisco small subunit (rbcS) was significantly down regulated in DGS 22. High non photochemical quenching (NPQ) was supported through an efficient hysicngls cycle in DGS 22. (*Project 1: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. K. A. Kalariya*).

Study of biosynthesis of gymnemic acid by deep sequencing-based *de novo* transcriptome analysis

Oleanane and dammarene classes of triterpene saponins having anti-diabetic property from *G. sylvestre* are collectively known as gymnemic acid. To understand the transcriptomic insights of the biosynthesis of the gymnemic acid, *de novo* transcriptome sequencing of leaf, flower and fruits of *G. sylvestre* genotype DGS-22 was performed. Total of 71676, 99643 and 92770 CDSs were annotated against protein databases for leaf, flower and fruit, respectively. A total of 22933, 30420, 29631 and 33282 CDSs of leaf, flower, fruit and master assembly, respectively were assigned at least one GO term. Pathway mapping based on master assembly using KEGG database revealed probable candidate genes involved in gymnemic acid biosynthesis which showed that there were total of 287 CDSs encoding genes involved in the gymnemic acid pathway. Validation and expression profiling of nine genes through real time PCR showed up regulation of these genes in leaves of DGS 22 as compared to DGS 3 confirming efficient gymnemic acid biosynthesis in DGS 22 which was in accordance with chemo-profiling of these genotypes. Based on the available information from the master assembly, a putative pathway of the gymnemic acid biosynthesis is proposed. (*GSBTM project- Unraveling the biosynthetic pathway of active ingredients in diabetes curing tropical medicinal herb Madhunashini (Gymnema sylvestre) through transcriptome analysis; Investigator: Dr. K. A. Kalariya*).



New report of invasive papaya mealybug, *Paracoccus marginatus* on madhunashini from Gujarat, India

Field observations on the occurrence of insect pest on G. sylvestre revealed mealy bug species Paracoccus marginatus damaging various plant parts *viz.*, leaves, stems and young shoots of the host plant. Sucking the sap by the insect resulted in curling, crinkling, hysicng, twisting and general leaf distortion and finally sooty mould was developed. The mealy bug infestation caused 100 percent plant infestation along with decrease in the quantity and quality of the leaf yield. The activity of the pest was present throughout the year, but peak leaf foliage damage was observed during the hot weather condition *viz.,* April to July months. (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Mr. K.T. Shivakumara*).

a. Nymphs and female adults; b. Ovisacs along with nymphs; c. Severely affected plant parts and d. Severely affected plant

Occurrence and population dynamics of *Aphis nerii*

Population level of *Aphis nerii* and its natural enemy population as influenced by weather parameters on madhunashini was estimated during 2018-19 without taking any plant protection measures. The results showed that the per cent plant incidence ranged from 0 to 100 per cent in both the years. The aphid's population was first observed in 41st and 45th standard metrological weeks (SMW) of 2018 and 2019, respectively; peak populations of *A. nerii* population were observed on 06th SMW during both the years. The aphid population showed a negative correlation with maximum and minimum temperatures and morning relative humidity, whereas evening relative humidity had a positive correlation in 2018. On the other hand, aphid's populations were showed a negative correlation with maximum and minimum temperatures, morning and evening relative humidity and rainfall parameters in 2019. (*Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Mr. K. T. Shivakumara*).

Infestation on Aphis nerii; (a). Nymphs; (b). Affected tender shoot; (c). Affected shoot; (d). Severely affected plant.

SENNA (*Cassia angustifolia*)

Senna belongs to family Caesalpiniaceae. There are two species of *Cassia viz., C. angustifolia (Senna angustifolia)* and *C. acutifolia* (= *C. senna*= *S. acutifolia*) which are known under the common name senna. It is cultivated mainly in India and Pakistan. Leaves, tender pods and flowers are medicinally important. The glucosides, sennosides A and B are the major active principles responsible for the therapeutic action of the crop. It lowers bowels, increases peristaltic movements of the colon by its local action upon the intestinal wall. It is used as expectorant, wound dresser, antidysentric, carminative and laxative. It is also useful in loss of appetite, indigestion and anaemia. It is propagated by seeds and cultivated as kharif crop.

Germplasm evaluation

Two-hundred and thirty accessions were evaluated for morphological and agronomic traits. Morphologically distinct accessions *viz*., DCA-153 with light green plant type and DCA-84 with dark green plant type with ovate round leaf shape were identified. High dry leaf yield (>7000kg ha^{-1}) was recorded in accessions *viz*., DCA-18, DCA-22, DCA-24, DCA-26, DCA-28, DCA-41, DCA-45 and DCA-48. (*Project 1: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel)*

Multilocation trial

Advanced evaluation trial (AVT I) with four test entries and three checks (ALFT-2, Sona and KKM-01) was conducted with an objective to identify superior varieties with high yield and quality at DMAPR, Anand. The genotype, A16-18 recorded maximum dry herbage yield (7197 kg ha^{-1}) which was followed by DCA-149 (7135 kg ha^{-1}) and DCA-96 (7037 kg ha^{-1}) at ICAR-DMAPR, Anand. (*Project 02: Genetic improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel)*

Characterization of *Chorismate synthase* (*caCS*) gene

Chorismate synthase (CS) catalyzes the last seven steps in the shikimate pathway involved in the biosynthesis of sennosides. The gene encoding CS was cloned and characterised using homology approach and named as *caCS*. *CaCS* gene has 13 exons of length ranged from 81 to 151bp. The length of the gene is approximately 10 Kb while its orthologue in soybean is about 10.5 Kb size. *CaCS* gene encodes a protein of 439 amino acids. *(Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigators: Dr. Dr. R. Nagaraja Reddy and P. Manivel)*

Gene map of the caCS gene in senna (*Cassia angustifolia*)

Characterization of 3-phosphoshikimate 1-carboxyvinyltransferase (caEPSP) gene

5-Enolpyruvylshikimate-3-phosphate synthase (EPSP) is the sixth and penultimate enzyme in the shikimate biosynthesis pathway involved in the biosynthesis of sennosides. The gene encoding EPSP was cloned and characterised in senna. The *EPSP (caEPSP)* gene has eight exons of length ranged from 62 to 245 bp. The length of the gene is approximately 8.2 Kb while its orthologue in soybean is about 8.3 Kb size. *CaCS* gene encodes a protein of 525 amino acids. *(Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigators: Dr. Dr. R. Nagaraja Reddy and P. Manivel)*

Gene map of the *caEPSP* gene in Senna (*Cassia angustifolia*)

Exploration of senna cultivation in degraded land

The main aim of this study was to explore senna cultivation in unconventional area particularly degraded soils such as salt affected soil. The present study investigates the effect of salinity stress on growth and metabolic changes of senna under field conditions with its established medicinal property. Field experiment was conducted at Samni experimental farm of ICAR-CSSRI, RRS, Bharuch. The soil mostly comes under salt effected vertisols having sub-surface salinity, low hydraulic conductivity and narrow working moisture range. The electrical conductivity of soil extract of the experimental site was up to 10 Ds m^{-1} and irrigation water was up to 9 Ds m^{-1}. The growth and yield of senna grown in normal rain fed condition was compared with the present investigation. The dry weight of leaf and pods were 614 and 460 kg ha^{-1}, respectively recorded under saline condition which is higher than average herbage yield under rain fed condition. The main bioactive principle of senna is sennoside which was significantly influenced under sanity stress. So, commercially important medicinal plant like senna could be a good candidate for saline soil with a view to improve the livelihood security of the resource of poor farmers having land with salinity problem. *(NMPB project: Exploration of medicinal and aromatic plants cultivation under different cropping systems and on marginal and degraded land of semi-arid regions of India; Investigators: Dr. B. B. Basak; Dr. A. R. Chinchmalatpure; Dr. Darshan Lodiaya and Ms. Pooja Patel)*

Field view of senna cultivation in salt affected soil of Samni farm of CSSRI Bharuch

TULSI (*Ocimum sanctum*)

Tulsi is an erect highly branched aromatic perennial herb belonging to family Lamiaceae. Two plant types are commonly available, one is with green leaves and the other one is with purple leaves. The species is distributed throughout India and is also under cultivation. Leaves, flowers and occasionally the whole plant are medicinally used to treat heart diseases, leucoderma, asthma, bronchitis and fever. The essential oils obtained have immense value in aroma industry. Propagation is mainly done by seeds. Seedlings are raised in nursery and transplanted at 4-5 leaf stage at the onset of monsoon. Freshly harvested material is distilled for oil extraction.

DOS-22 an elite line for herbage yield

Tulsi accessions were studied for yield and yield contributing parameters at full flowering stage. The study showed that maximum herbage yield was recorded in DOS-22 during the years 2017, 2018 and 2019 (197.12, 204.16 and 205.48 q ha^{-1}) as compared to checks (Angna and DOS-1). The highest leaf area, root weight and stem weight were also observed in DOS-22. (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigator: Dr. P.L. Saran).*

DOS-1, a trap crop for male fruit fly management in fruit orchards

DOS-1 was found suitable as an intercrop in fruit orchards for male fruit fly management due to the presence of high methyl eugenol content (73.88 %) in essential oil present in the herbage. This will help to reduce the yield loss in crops especially in cucurbits, mango, guava, *etc.* The B: C ratio over net return of 1.39 showed the suitability of tulsi as a commercial crop for farmers. Thus medicinal plants like tulsi can be integrated into existing farming systems as a trap crop for male fruit fly as well as for sustainable production. On an average, farmers get an average of Rs. 1,28,528 net returns per hectare from cultivation of tulsi as a sole crop. (*Project 1: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. P. L. Saran).*

Male fruit fly attracted on DOS-1 panicles under cultivation

Identification and characterization of rosmarinic acid synthase (RAS)

Rosmarinic acid synthase from tulsi (OtRAS) was amplified and cloned using RACE (rapid amplification of Cdna ends). Further, structure-function analysis was carried out for OtRAS

protein. The full-length Cdna of OtRAS (accession no. MN542659) has 1278 bps, which encodes 425 amino acid residues. Multiple sequence alignment revealed that amino acid residues of OtRAS had about 88% similarity with RAS proteins of other Lamiaceae members. Phylogenetic analysis showed that OtRAS belongs to BAHD acyltransferase superfamily proteins and possesses characteristic motifs of BAHD acyltransferase family members. Three-dimensional structure of OtRAS comprises two pseudo symmetrical domains and an active site in between these two domains. OtRAS active site has conserved His41, His152, Trp363 and Lys391 residues. The OtRAS gene expression was highest in *in-vitro* grown callus as compared to tissues derived from field grown plants and coincides with the accumulation of rosmarinic acid in *O. sanctum. (Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)*

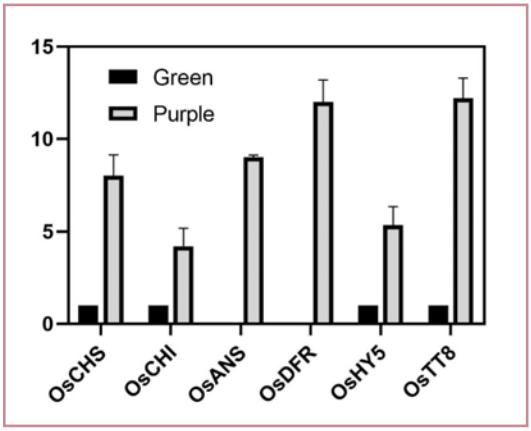
Identification and characterization of phenylalanine ammonia lyase and tyrosine aminotransferase

Phenylalanine ammonia-lyase (PAL) is a control point for branched phenylpropanoid and terpenoid pathways. It represents the first regulatory step to provide a metabolic flux to produce of the precursors needed for biosynthesizing main volatile phenylpropanoid compounds (methyleugenol and methylchavicol) in tulsi. It is crucial during the stage of the environmental and development stimulants. To obtain better knowledge of the biosynthesis of these phenylpropene compounds, characterization and cloning of *Ocimum sanctum* PAL (OsPAL) Cdna and its heterologous expression and enzyme activity were assessed. The full-length OsPAL was 2082 bp in size encoding a 693-amino-acid polypeptide with molecular weight of 75.36 kDa and theoretical Pi of 8.51. Phylogenetic analysis revealed a significant evolutionary relatedness of OsPAL with the PAL sequence reported in different species of Lamiaceae. To further confirm its function, OsPAL was cloned into Pet28a vector and expressed in *E. Coli*. The recombinant protein exhibited high PAL activity and could catalyze the L-Phe conversion to trans-cinnamic acid.

Tyrosine aminotransferase (TAT) is the entry point enzyme of the tyrosine-derived pathway in Rosmarinic acid (RA) biosynthesis. RA biosynthesis in *O. Sanctum* involves both the phenylpropanoid pathway (for the caffeic acid moiety) and the tyrosine-derived pathway (for the DHPL moiety). TAT reversibly catalyses Tyr to 4-hydroxyphenylpyruvate (4-HPP), which is the substrate for pathways producing plastoquinone, tocopherols, phenolic acid. OsTAT was isolated from transcriptome and genome database and annotated. Full length Mrna was cloned and expressed in bacterial cells using Pet28 vector system. Purified protein showed monomeric size of 45.2 kDa and Pi 6.35. Enzyme assay indicated that OsTAT used L-tyrosine and phenylpyruvate. *(Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)*

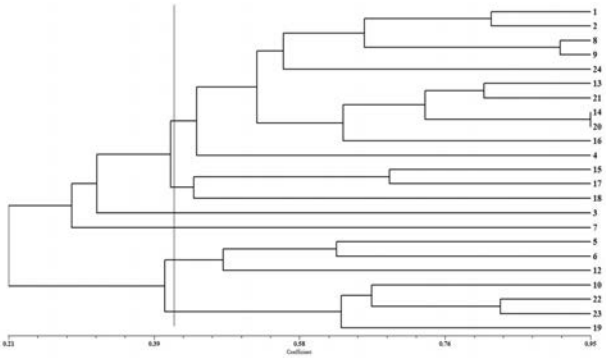
Anthocyanin biosynthesis pathway analysis in purple subtype of tulsi

Anthocyanins are a type of flavonoid, a class of compounds with antioxidant effects. Anthocyanins are the pigments that give red, purple, and blue plants for their rich coloring. Anthocyanins and its biosynthetic pathway were studied in *O. sanctum*. Quantitative estimation showed that purple subtype of tulsi has around 47 mg anthocyanins per 100 g fresh sample. Stability analysis indicated that anthocyanins extracted from *O. sanctum* were more stable under acidic Ph than in neutral and alkaline Ph conditions. The key genes CHS and CHI (chalcone synthase and chalconeisomerase) for early biosynthesis and anthocyanidin synthase and dihydroflavonol 4-reductase (ANS and DFR) for late biosynthesis of anthocyanins in *O. sanctum* were identified. CHS and CHI were up-regulated in purple subtype as compared to green subtype. The expression of ANS and DFR was only reported in purple subtype. Simultaneously, the key transcription factors HY5 and a Bhlh putatively involved in regulating the biosynthesis of anthocyanins were also identified. The expression of HY5 and Bhlh was significantly higher in purple subtype than green subtype of *O. sanctum*. *(Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)*

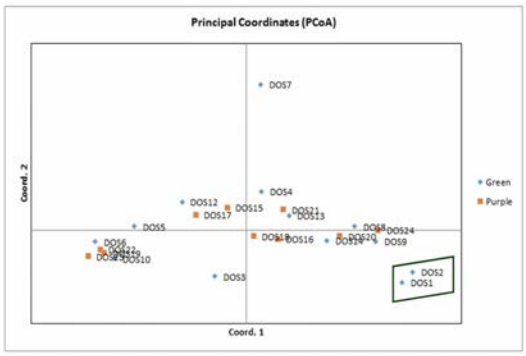


Diversity analysis in tulsi genotypes using genomic SSR markers

Genotypes belonging to green and purple subtypes of *O. sanctum* were used for diversity analysis. Genotyping was carried out using genomic SSR markers using PCR amplification followed by agarose gel electrophoresis. The banding patterns obtained were used for 0,1 scoring. Using NTSYS tool, Jaccard similarity coefficient was calculated and further used for phylogenetic analysis. A phylogenetic tree was constructed using NTSYS tool. PCA analysis was also conducted for the relationship analysis of germplasm. SSR analysis indicated that collected germplasm showed diversity at DNA levels.Green and purple genotypes did not make two groups and showed diversity among and between these two sub groups. Overall, SSR markers showed diversity among various genotypes for *O. sanctum*. *(Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)*



Relationship among various Tulsi genotypes based on SSR markers analysis



PCA analysis of Tulsi genotypes

Organic nutrient management practices through organics, crop residue and microbial consortia

In order to study the influence of organic source of nutrients on growth, yield and quality of tulsi (Purple type), a field experiment was conducted at the ICAR-DMAPR for two consecutive seasons to study the effect of green manuring with cowpea and crop residue of cluster bean along with application of FYM and microbial consortia. The experiment was devised in split plot design with three main plot treatments (no organic/fallow, green manuring with cowpea and crop residue of cluster bean) and seven sub plot treatments (Control / no FYM, 50% N equivalent through FYM, 75% N equivalent through FYM, 100% N equivalent through FYM, 50% N equivalent through FYM + Arka Microbial consortia (AMC), 75% N equivalent through FYM + AMC and 100% N equivalent through FYM +AMC) in three replications. Results revealed that dry herb yield and content of essential oil of pooled mean of two harvests (5.03 t ha^{-1}, 1.35 % and 6.79 kg ha^{-1}) were recorded maximum in the treatment which received cluster bean crop residue. Among sub plot treatments, application of 100% N equivalent through FYM + AMC (N fixing, P & Zn solubilising and plant growth promoting microbes) recorded maximum dry herb yield (6.30 t ha^{-1}), essential oil content (1.71%) and essential oil yield (10.79 kg ha^{-1}) for the pooled mean of two harvests. Application of different crop residues significantly influenced organic carbon (SOC), soil fertility and biochemical properties. With these results it can be concluded that incorporation of cluster bean crop residue prior to transplanting and application of 100% N equivalent through FYM + Arka Microbial consortia could be recommended as organic production technology in tulsi to obtain maximum herbage yield and quality. (*Flagship project: Standardization of organic farming practices for important medicinal plants Investigators: Dr. G. R. Smitha, Dr. B. B. Basak, Dr. V. Thondaiman and Dr. Ajoy Saha*)

OTHER EXPERIMENTS

Exploration and collection of germplasm of salaparni (*Desmodium gangeticum*)

Explorations were planned with an objective to collect genetic variability of salaparni germplasm from the wild for conservation and use in crop improvement programs. Four explorations were undertaken in Gujarat, Madhya Pradesh, Karnataka, Chhattisgarh and Maharashtra and a total of 40 accessions were collected. Variability was found in the collected germplasm for plant height, root traits and leaf characters. (*NMPB Project: Breeding medicinal plants for improved yield and quality; Investigators: Dr. R. Nagaraja Reddy, Dr. P. Manivel, Dr. V. Thondaiman and Dr. Satyanshu Kumar*)

Plastering technique: an easy and cost-effective way brahmi (*Bacopa monnieri*) multiplication

Three-bud cuttings from lower part of runner with mud solution (FYM, loamy soils and water in 1:1:5 ratio) was found as the best propagation material for commercial multiplication of brahmi. Plastering technique lowers transplanting cost and labour cost compared to traditional technique, therefore it is proved as a very easy and cost-effective way for faster multiplication of brahmi. (*Project 1: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. P. L. Saran).*

DNA isolation method for *Ocimum* sp., *Aloe* sp and *Plantago ovata*

Essential oil, polysaccharides and various secondary metabolites present in plants like *Ocimum* species, Aloe species, *Plantago ovata* etc. Come as contamination along with DNA isolated from these plants. These contaminations hamper the subsequent molecular studies by hindering the enzyme actions. A universal DNA isolation method was developed for the plants rich in essential oil, polysaccharides and other secondary metabolites. In this method putative contaminating compounds are removed with sucrose buffer prior to cell lysis. This method yielded high quality DNA which was tested by PCR amplification using various primers (*Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigator: Dr. Manish Kumar Suthar)*

Production of enhanced biochar formulation from waste biomass and mineral powder

Conversion of distillation waste biomass of aromatic plants into biochar is a promising technology for recycling of waste biomass as fertilizer replacement formulation or directly as soil amendment. However, low nutrient content and large application rate limit its wider acceptability. For optimizing biochar performance, an enriched biochar (EB) was synthesized by mixing biochar with manure, minerals and clay in hydrothermal reaction at low temperature. The EB was developed from biochar derived from distillation waste biomass and low-grade mineral powder to form biochar-mineral complex (BMC) with improved hysic-chemical properties and nutrient availability. Blending of low-grade mineral powder with biochar significantly improve surface properties and nutrient content of the final product. Compared to the pristine biochar, total C content in the BMC was low because the mineral addition created a dilution effect for the C content. On other hand, hydrothermal reaction of biochar with RP and waste mica increased the available and total P and K contents in BMC. The BMC was also found as superior to conventional organic amendments (FYM and vermicompost) in terms of surface properties and nutrient content. However, little is known about the potential of BMC in agriculture as an alternative of chemical as well as other organic fertilizer. The study revealed the possible utilization of waste biomass and low-grade mineral powder for production of cost effective BMC precursor with a benefit of environmental sustainability. **(***Project 6- Sub-project 5: Valorisation medicinal and aromatic plant waste as a potential soil amendment, bio-sorbent*; *Investigators*: *Dr. B. B. Basak and Dr. Ajoy Saha***)**

Enhanced biochar from waste biomass and mineral powder

Optimization of drying conditions for better storage stability and bioactive ingredients of selected medicinal plants

Selected medicinal plants (Senna- *Cassia angustifolia*, Safed musli- *Chlorophytum borivilianum;* Mamejo- *Enicostemme axillare*) were dried using different methods of drying namely, sun shine drying, solar dryer drying, shade drying and hot air oven drying. The dried material was stored in different materials like gunny bags, polythene bags and plastic containers at ambient conditions in light and dark. To study the quality change and effects of storage, the samples were taken from these stored plant material at an interval of 03 months and analyzed by HPLC for active ingredients. The changes in content of active ingredients were recorded. In senna, the active ingredients sennosides A and B varied from 0.06 to 0.37%, 0.05 to 0.30% and 0.05 to 0.24% for sun drying, shade drying and solar dryer drying, respectively; under storage in polythene bags, gunny bags and plastic containers in light and dark conditions. In safed musli, the active ingredients *i.e.,* total saponins varied from 10.31 to 27.65% and 10.62 to 34.79% for sun drying and hot air oven drying under storage in polythene bags, gunny bags and plastic containers in light and dark conditions. In mamejo, the active ingredients swertiamarin varied from 0.38 to 2.27%, 0.33 to 6.57%, 0.32 to 2.17% and 0.00 to 0.54% for hot air oven drying, solar dryer drying, sun drying and shade drying, respectively under storage in polythene bags in light and dark conditions. Mathematical models for bioactive ingredients variation were also developed based on the variation in bioactive ingredients like total saponin in safed musli, sennoside A and sennoside B (SA+SB) in senna and swertiamarin in mamejo. **(***Project 6- Sub-project: Optimization of drying conditions for better storage stability and bioactive ingredients of selected medicinal plants*; *Investigators*: Dr. *Raghuraj Singh and Dr. Satyanshu Kumar*)

Exploration of low-grade silicate minerals as source of plant available potassium

The K supplying capacity of low-grade silicate minerals was evaluated through chemical and biological methods. Silicate mineral samples (waste mica, feldspar and green sand) were collected from different parts of the country. The details mineralogical compositions of the silicate mineral powder were analyzed by the X-ray fluorescence (XRF) spectroscopic method. The total K (% K_2O) content in the silicate mineral followed the order feldspar (14.9%) > waste mica (7.24-9.72%) > greensand (4.56-5.4%). Different chemical extractants, water, neutral 1 M ammonium acetate, 0.01 M citric acid and boiling 1 M nitric acid (HNO_3) were used to study the K release from the low-grade silicate minerals. The K release by different chemical extraction methods showed significant variation. The amount of K release by various extractants followed the order: water < 0.01 M citric acid < 1M ammonium acetate (NH_4Oac) < 1 M boiling nitric acid. To study the plant intervention on K release from silicate mineral powder, a greenhouse experiment was conducted in K deficient soil. Results indicated that K recovery from waste mica (39.3 - 42.5%) is quite higher than feldspar (19.7-22.5%) and greensand (5.4-7.5%) irrespective of plant species. So, these low-grade silicate minerals may be identified as a potential K source for agricultural application. The scope of these silicate minerals for organic cultivation of medicinal and aromatic plants may also be exploited. (*SERB project: Evaluation of potassium availability from unconventional sources for sustainable farming system; Investigator: B. B. Basak)*

Occurrence and seasonal incidence of *Nephopteryx eugraphella* on *bakul*

Studies on incidence and foliar damage by sapotta leaf webber, *Nephopteryx eugraphella* Ragonot (Pyralidae: Lepidoptera) on bakul (*Mimusops elengi*) was carried out during the rainy season of 2019. Incidence and foliar damage of leaf webber were ranged between 32 to 100% and 4.86 to 32.53 per cent, respectively. The peak incidence and foliar damage were noticed during 36th Standard Metrological Week. The correlation studies of leaf webber with weather parameters showed that the per cent incidence and per cent leaf damage of *N. eugraphella* negatively correlated with maximum temperature whereas, both the factors positively correlated with minimum temperature, relative humidity (morning and evening) and rainfall.(*Project 5:Integrated pest and disease management in medicinal and aromatic plants; Mr. K.T. Shivakumara*).

***Nephopteryx eugraphella* a. Larva; b. Adult; c. Infected plant part**

Field trials of anti-tick natural formulation

To evaluate the field efficacy of a newly developed anti-tick natural formulation, *flowable* (F10) trials were conducted at Raipur and Pingli villages of Parbhani Taluka, Bori village of Jintur Taluka and Kolsewadi village of Pathri Tauka of district Parbhani, Maharashtra. The trials were conducted under the supervision of Livestock Development Officers (LDO) and Assistant Professor of Parbhani Veterinary College, Parbhani. Cattle breeds at these locations were mainly Red kandhari, Deoni, Jersey, HF and Non-descriptive (ND). Pre-treatment infestation pattern was noted, recorded, photographed and the farmers were interviewed to assess the problem of tick infestation. The F10 formulation was applied on 100 animals using foam as per the laboratory developed protocol. The animals were observed after 4 and 7 days after application and efficacy data were collected. As reported by animal owners and LDOs, the efficacy of the formulations was more than 80% against natural tick infestations. For conducting trial, a farmer's kit was developed and provided to the animal owners. (*NASF Project: Chemical, structural and functional characterization of identified anti-tick lead phyto-chemicals and optimization of delivery matrix for effective application of natural formulation for the control of acaricide resistant ticks; investigator: Dr. Satyanshu Kumar*)

Microencapsulated herbal product with ovicidal and larvicidal properties against *Ancylostoma duodenale*

Ovicidal and larvicidal properties of microencapsulated herbal products (APSD3 and APSD5) on field isolates of *A. Duodenale* were validated. APSD3 and APSD5 exhibited ovicidal and larvicidal properties comparable/ better than the standard drug albendazole and therefore

can be a potent therapeutic option. (*ICAR Network Project: High Value Compounds/ Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh*)

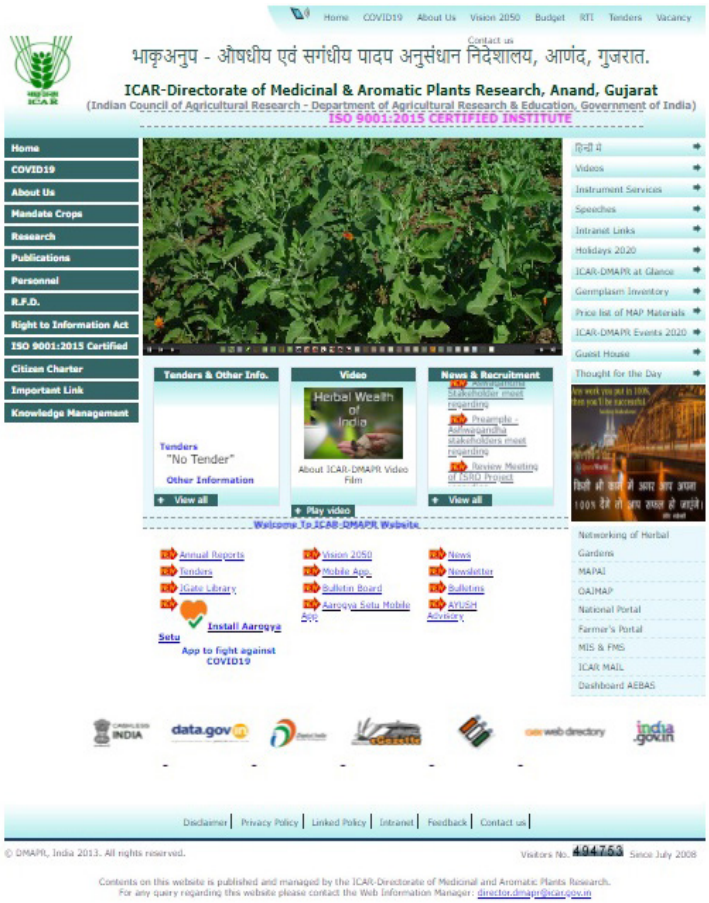
Agri-Business incubator commissioned

Agri-Business Incubator (ABI) under National Agricultural Innovation Fund (NAIF) of Indian Council of Agricultural Research was commissioned at the directorate to facilitate technology incubation and development of Enterpruneship among the various medicinal and aromatic plants stakeholders. (*NAIF project: Establishment/setting up of Agri-Business Incubation (Abls) Centres; Investigators: Dr. R. Nagaraja Reddy; Dr. Stayanshu Kumar; Dr. B. B. Basak and Dr. Satyjit Roy*).

AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT (AKMU)

Institute website

Institute website was updated regularly with institute news, training details, thought of the day, recruitment advertisement, tender notices, publications *viz.,* bulletins, newsletters, annual reports, etc and all day to day information of the directorate by Event launcher. AKMU developed and maintained Networking of herbal garden of India website and MAPAI website. We had linked our website with all important links of ICAR, FMS/MIS, OAJMAP, NAIP, NMPB, National Portal, Farmers' portal, ICAR MAIL, AEBAS Dashboard, *etc*. Institute website in bilingual English-Hindi and received more and more hits per one year.



Institute online database systems and website of Networking of Herbal Gardens of India:

Online database of Networking of herbal garden of India maintained by AKMU successfully registered more than 122 herbal gardens of all over India. MAPAI website- Webiste of Medicinal and Aromatic Plants Association of India developed was maintained by the AKMU. OAJMAP – Open Access Journal of Medicinal and Aromatic Plants developed by the AKMU was maintained from ICAR website.

Mobile Application software

Updated data and outlook of "Herbal Kisan" mobile application developed and launched by AKMU in google play store for free access by student, farmers and drug manufacturers with good agriculture techniques for best results and good quality medicinal and aromatic crops agriculture.

National Knowledge Networking

Under this NKN Project our institute received 100 mbps internet connection which was managed and shared with more than 110STATIC IP. ICAR-DMAPR is a partner of National Knowledge Network (NKN) Project of National Informatics Centre (NIC), Govt. Of India, New Delhi for sharing research information through online database and website.

Online Examination Center

AKMU manages ICAR-DMAPR Online Examination Center with two IBM Server and 105computers, Internet facility for conducting online examination under ASRB. For power backup we have 180 KV Generator set and dedicated 20 KVA UPS. During last year we had successfully conducted two online examination of ASRB in April and December, 2019

RESEARCH ACHIEVEMENTS

AICRP MAP&B

ALOE (*Aloe barbadensis*)

Aloe belongs to family, Liliaceae. The species is introduced from African countries which was later naturalized in India. The plant is perennial in habit with fleshy leaves and condensed stem. Leaves contain mucilage (polysaccharides) and leaf exudates contain aloin and aloe emodin which are commercially useful. The mucilage has a cooling and moisturizing action and hence used in cosmetic industries. Aloin and aloe emodin are used as pain killer and purgative. The species flowers during November to February. Flowers are having saffron to orange yellow colour which attracts birds for pollination. There is large-scale agricultural production of Aloe in Australia, Bangladesh, Cuba, the Dominican Republic, China, Mexico, India, Jamaica, Kenya, Tanzania and South Africa, along with the USA to supply the cosmetics industry. In India, the crop is under cultivation in Gujarat, Rajasthan, Madhya Pradesh and Uttar Pradesh. Raw material is collected both from wild and cultivation for the industry. The species is valued about $30-40 million in global sale annually. The demand for this plant may likely to be increased due to increasing utilization of natural medicinal products throughout the world. Suckers are mainly used for propagation.

Evaluation of germplasm

CCSHAU, Hisar: Six elite genotypes were evaluated for the selection of a superior variety of high gel content. The study revealed that the highest number of leaves per plant was in HAV-07-09 (17.0 leaves plant^{-1}). The highest leaf length was in HAV-04-4 (56.00 cm) however, it was at par with IC112526, HAV-07-9, IC112516 and IC112516. Out of six genotypes, the highest fresh leaf yield (41250 kg ha^{-1}) was recorded by IC112526 followed by HAV-05-8 (40333 kg ha^{-1}), HAV-04-4 (39400 kg ha^{-1}), IC112516 (38800 kg ha^{-1}), HAV-07-9 (37100 kg ha^{-1}) and HAV-1(35000 kg ha^{-1}). Significantly superior gel content was in IC 112526 (62.50%) which was at par with HAV-05-08 (62.00%).

Planting method and irrigation scheduling on growth, yield and water use efficiency

BAU, Islampur: A study was conducted to standardize planting method and irrigation schedule to optimize the crop yield. The study revealed that the different planting methods of *Aloe vera* caused significant variations on all the growth and yield parameters. The highest plant height (44.3 cm), plant spread (56.20 cm), leaf length (52.80 cm), leaf width (6.40 cm), number of suckers (6.30 plant^{-1}), number of leaves (11.90 plant^{-1}) and fresh leaf yield (6.20 kg plant^{-1}), WUE (2.76 kg ha^{-1}cm^{-1}) and B:C ratio (2.55) was noted under ridge and furrow method of planting. The crop irrigated at IW: CPE= 1 registered maximum value of plant height (45.7 cm), plant spread (58.5 cm), leaf length (53.4 cm), leaf width (6.98 cm), number of suckers (6.5 plant^{-1}), number of leaves (12.6 plant^{-1}) and fresh leaf yield (6.55 kg plant^{-1}) and B:C ratio (2.84) which significantly higher than rain fed conditions.

Organic nutrient management

CCSHAU, Hisar: Field experiment was conducted during 2018-19 with different organic manures (FYM, vermicompost and neem cake) to standardize organic nutrient management for optimum growth and yield of aloe. The maximum plant height (59.70 cm), suckers (4.50 plant^{-1}), numbers of leaves (10.80 plant^{-1}) and leaf length (57.60 cm) were observed with the treatment receiving vermicompost (7.50 t ha^{-1}) which was significantly higher than control as well as and treatment receiving neem cake (1.50 t ha^{-1}). The highest leaf (36667 kg ha^{-1}) and gel (20449 kg ha^{-1}) yield were recorded with treatment which was significant with rest treatments except treatment receiving FYM (15 t ha^{-1}) and neem cake 2.5 t ha^{-1}.

Management of leaf spot disease

BAU, Islampur: Leaf spot incidence caused by *Colletotrichum gloeosporioides* occurred naturally on aloe after 2nd week of January and 100% incidences were found up to 1st week of February with 45% severity. Out of eight management treatments tested, the treatment involving dipping of the suckers in Carbendazim @ 0.1% solution before planting + foliar spray of Mancozeb @ 0.2% was found superior for management of leaf spot diseases in *Aloe vera* and reduced the disease by 87.30% followed by the treatment of dipping of the suckers in Carbendazim 0.1% solution before planting + foliar spray of neem oil @ 0.2% which reduced the diseases by 82.7%.

Symptoms of leaf spot of Aloe caused by *Colletotrichum gloeosporioides*

ASALIO (*Lepidium sativum*)

The plant belongs to family Brassicaceae. The species is a native of Ethiopia and introduced to Europe and Asia. Plants are of about 45-60 cm tall. Leaves are entire or variously lobbed or pinnatisect. Flowers are small and white, arranged in racemes. It is cultivated as winter crop in selected parts of Rajasthan, Gujarat, M.P. and Tamil Nadu for seeds. The seeds are galactagogue, laxative and diuretic. The mucilage obtained from the seeds is used against intestinal irritations. The leaves are also used as diuretic and to treat liver diseases. It is also used as salad for treating anaemia. Seeds are used for propagation.

Effect of nutrient management practices on yield and quality

AAU, Anand: Field experiment was conducted to study the effect of different organic manure and microbial consortium (bio NPK) on growth, yield and quality of asalio. The effect of different organic manure and bio NPK Consortium on plant population, plant height at 60 DATP, days to 50% flowering, days to maturity was found non-significant. Whereas number of branches per plant at harvest were recorded significantly higher (14.55) with treatment receiving FYM (10 tha^{-1}) + bio NPK which was remain at par with treatment receiving FYM (10 t ha^{-1}), neem cake 1 t ha^{-1} and neem cake 1 t ha^{-1} + bio NPK. Significantly higher seed yield was recorded (1556 kg ha^{-1}) with treatment receiving FYM (10 t ha^{-1}) + bio NPK which was found at par with rest of the treatments. Whereas the straw yield, harvest index, oil content (%) and test weight was found non-significant.

CCSHAU, Hisar: Field experiment was conducted during 2018-19 with different doses of chemical fertilizers and bio-fertilizers in different combinations to study the effect on growth and yield of asalio. The maximum plant height (121.6 cm), number of branches (21.1), number of pods (1309), seed yield (2010 kg ha^{-1}) and net return (Rs. 44418) with B:C ratio (2.8) was observed with the treatment receiving 80 kg N + 40 kg P ha^{-1} along with phosphate solubilizing bacteria (PSB) and Azotobacter. The treatment was significantly higher than all other treatments.

RVSKVV, Mandsaur: Field experiment was conducted during 2018-19 to study the effect of nitrogen levels and mode of nitrogen application on growth and seed yield of asalio. The maximum seed yield (1800 kg ha^{-1}) was recorded in the treatment receiving N (40 kg ha^{-1}) while the lowest (1200 kg ha^{-1}) was recorded in N (40 kg ha^{-1}) under different nitrogen levels. Maximum seed yield (1700 kg ha^{-1}) was recorded in 3 equal split applications of nitrogen while minimum in case of 3 split (25, 50 and 25%) applications of nitrogen.

NDUAT, Faizabad: Field experiment was conducted during 2018-19 to study the effect of manures and fertilizers on growth and yield of asalio. Maximum plant height (100.20 cm), number of branches (18 $plant^{-1}$), number of pods (2990 $plant^{-1}$), seed yield (5.11g $plant^{-1}$), test weight (1.71) and seed yield (1370 kg ha^{-1}) was noted with treatment comprising of NPK 60:40:30 kg ha^{-1} followed by application of Vermicompost 5 t ha^{-1} while minimum in case of FYM 5 t ha^{-1}. Maximum cost of cultivation of Rs. 41960 ha^{-1} was noted with application of vermicompost @ 5 t ha^{-1}, however, maximum cost of produce (Rs. 32897 ha^{-1}), net return (Rs. 34547 ha^{-1}) and benefit cost ratio (1.71) were noted with treatment comprising of RDF NPK 60:40:30 kg ha^{-1}.

YSPUHF, Solan: Field experiment was conducted during 2016-17 and 2017-18 to study the comparative efficacy of different organic manures (FYM and vermicompost) and bio-dynamic preparations (*Panchgayya* and *Jivamrut*) on growth and yield of asalio. The results indicated that treatment receiving FYM + NPK (10 t ha^{-1} + 60:40:20 kg ha^{-1}) recorded significantly higher straw yield (13 17g $plant^{-1}$), fresh weight (15.04 g $plant^{-1}$), seed weight (1.77 g $plant^{-1}$) and seed yield (8310 kg ha^{-1}) as compared to other treatments. However, maximum B: C ratio (2.93) was observed in the treatment receiving Jivamrut from native cow dung.

Studies on the performance of asalio under peach based medicinal agro forestry system

YSPUHF, Solan: The experiment was conducted during 2016-17 and 2017-18 to study the performance of asalio under peach orchards as an intercrop. The maximum plant height (48.93 cm), number of branches (10.84 plant^{-1}), straw yield (11.37g plant^{-1}) and seed yield (8310 kg ha^{-1}) with B:C ratio (3.42) was recorded when asalio was grown under peach trees with application of NPK (120:60:30 kg ha^{-1}). But in combination of peach + asalio + Jivamrut recorded maximum B:C ratio (4.90). Hence, peach + asalio + Jivamrut combination is recommended for getting the maximum B: C ratio (4.90).

Analysis of oil content, antioxidant activity and mucilage content in seeds asalio genotypes

MPUAT, Udaipur: Analysis of oil content (%), antioxidant activity (%) by AAS method, mucilage content (%) and iron content (ppm) in seeds of asalio genotypes showed that it ranged from 18.15 to 25.74, 22.10 to 30.98 (%),13.0% to 15.5% and1.44 to6.77 ppm, respectively. The highest oil content was found in ULS-15 (25.74%) and minimum was in ULS-3(18.15 %), whereas maximum antioxidant activity was in genotype ULS-15 (30.98%) and minimum was found in genotype GA-1(22.10%). Similarly, the highest mucilage content was found in ULS-15 (15.5%) and the lowest (13.0%) was in ULS-2; maximum iron content was found in genotype ULS-15 (6.77ppm) and the minimum was in genotype ULS-5 (1.44ppm).

Management of foliar diseases

JNKVV, Jabalpur: For managing foliar disease of asalio, an experiment was consecutively conducted for four years. It was found that disease incidence ranged from 24.25% to 50% while the seed yield varied from 971.93 to 1857 kg ha^{-1} during 2018-19. The minimum disease incidence (24.25%) and maximum seed yield (1857 kg ha^{-1}) were recorded in seed treatment (ST) with (Carbendazim 12%+ Mancozeb 63%) @ 0.30% along with three foliar sprays (FS) of Tebuconazole 25EC @ 0.10% first at initiation of disease followed by 15 days interval. ST with (Carbendazim 12%+ Mancozeb 63%-75WP) @0.30% plus three FS of Trifloxystrobin 50WG@ 0.05% first at initiation of disease followed by 15 days interval significantly reduced the disease incidence (31.50%) and was recorded as the third best treatment for increased seed yield (1535 kg ha^{-1}).

MPUAT, Udaipur: Integrated disease management modules against downy mildew and leaf spot disease of asalio were evaluated under inoculation condition during rabi season 2018-19. Downy mildew disease did not appear in experimental field and nearby growing fields of asalio whereas, leaf spot disease was observed frequently. Among the modules, seed treatment (ST) with (Carbendazim 12%+ Mancozeb 63%)-75WP @0.30% plus three foliar sprays (FS) with Tebuconazole 25EC @ 0.10% was found effective with minimum leaf spots disease (8.40%) and maximum disease control (89.75%), along with increased seed yield (1591 kg ha^{-1}) . This was followed by treatment comprising ST with (Carbendazim 12%+ Mancozeb 63%)-75WP @0.30% plus three FS with Mancozeb 75WP @ 0.25% which showed 23.00 per cent leaf spot, 71.95 per cent of disease control and 1497 kg ha^{-1} seed yield and increased mucilage content. However, among the modules, treatment comprising ST with (Carbendazim 12%+ Mancozeb 63%)-75WP

@0.30% plus three FS with Ridomil MZ 72 WP @ 0.25% and ST with Metalaxyl 35 SD @ 8g kg^{-1} seeds plus three FS with Copper oxychloride @ 0.30% and Copper hydroxide were found moderately effective against leaf spot disease (PDI-30.33; 33.67 and 34.83%) higher seed yield comparing to the rest of the treatments and the control (PDI-82.00%).

ASHWAGANDHA (*Withania somnifera*)

The plant belongs to family Solanaceae and is considered as wonder herb with multiple medicinal properties. It is cultivated in North-western and Central India. The species is an annual to perennial, branched, under shrub to herb of about 30 cm to 120 cm height. Root is the major medicinally important part in addition to leaves and seeds. Roots are used in preparation of vital tonics. It is a stress reliever and is used in treating senile dysfunctions. Its effect on controlling anxiety, depression, phobias, alcoholic paranoia, schizophrenia, etc., is clinically established by different tests. The active ingredient that attributed to the medicinal property is the alkaloids and steroidal lactones.

MLT Evaluation of promising lines of ashwagandha (Early maturing group i.e., annual type)

An Advanced evaluation trial with four promising lines with four checks viz., GAA-1 (AWS 1), JA134, JA20 and RVA100 were tested at Akola, Anand, Coimbatore, ICAR-DMAPR, Hisar, ICAR-IIHR, Mandsaur, Raipur, and Udaipur to identify promising lines for higher yield and quality. The trial failed at Hisar due to poor seed germination. Akola centre has not sent the data. At Anand, Mandsaur and and Raipur, the entries did not show significant differences in the case of dry root yield. At ICAR IIHR, maximum dry root yield was recorded in IWS8-18 (566.52 kg ha^{-1}) which was at par with HWS12-12 (462.83 kg ha^{-1}). At Udaipur, significantly higher dry root yield was in HWS8-18 (608.00 kg ha^{-1}) which was at par with HWS12-12 and IWS3.

Evaluation and characterization of germplasm

RVSKVV, Mandsaur: One hundred and twenty lines of ashwagandha maintained at Mandsaur centre were evaluated for thirteen different characters. Among the lines wide range of variability was observed. Plant height ranged between 17.00 cm (MWS-142) and 39.0 cm (MWS-310). The plants were classified on the basis of branching pattern *viz*., biparous (RVA-100, MWS-101, MWS-117, MWS-119 RAS-10 and RAS-11) and triparous (MWS- 90-111, MWS-136, MWS-207). Plants were either bushy or erect. Berry colour were yellow, orange and red. Yellow berried lines were MWS 104, MWS- 106, MWS- 119 and RAS-7; orange berried lines were MWS-125, MWS- 127 and MWS-135 and red berried lines were RAS-16, RAS-22. On the basis of duration of plant maturity, plants were classified into three groups, *i.e.*, early maturing type which took 150-165 days for crop maturity, medium maturing type which took 165-180 days for crop maturity and late maturing type which took 180-195 days for crop maturity. Majority of the lines were either in medium or late maturing types. Length and diameter of roots ranged from 13.6 cm to 28.8 cm and 4.11 mm to 7.20 mm, respectively.

Mean dry root yield ranged from 10 kg ha^{-1} to 1000 kg ha^{-1}. The entry MWS 326 recorded the highest dry root yield (1000 kg ha^{-1}) followed by MWS-90-125 (788.83 kg ha^{-1}), MWS 318 (744.48 kg ha^{-1}), MWS-119 (933.33 kg ha^{-1}) as compared to the check RVA-100 (311.11 kg ha^{-1}). Mean seed yield ranged from 33.33 kg ha^{-1} to 633.33 kg ha^{-1}. The entry MWS 525 recorded the highest seed yield followed by MWS 317 (517.78 kg ha^{-1}), MOP 525 (633.33 kg ha^{-1}), MWS 221, MOP-310 (500 kg ha^{-1}) RAS-40 (466.6 kg ha^{-1}) as compared to check RVA-100 (475 kg ha^{-1}).

MPUAT, Udaipur: A total of 74 lines maintained as genetic stock in the project belonging to annual types (early maturity) were evaluated. The observations were recorded for individual line for plant height, number of primary branches, root length, root diameter, dry root yield, days to 50% flowering, days to 75% maturity and total alkaloid content in addition to observations on root type (woody/starchy), berry color (yellow/red) and plant type (erect/spreading). A total of 29 lines *viz.,* UWS-7, UWS-99, UWS-65, UWS-20, UWS-37, UWS-58, UWS-95, UWS-106, UWS-78, UWS-32, UWS-14, UWS-63, UWS-84, UWS-256, UWS-21, UWS-35, UWS-80, UWS-104, UWS-111, UWS-122, UWS-144, UWS-75, UWS-16, UWS-72, UWS-97, UWS-110, UWS-125, UWS-127, and UWS-135 exhibited higher dry root yield (kg ha^{-1}) over the grand mean of the experiment (233.19 kg ha^{-1}). Dry root yield for the trial ranged from 155 kg ha^{-1} (UWS-28) to 335 kg ha^{-1} (RVA-100).

Evaluation of promising lines

PDKV, Akola: Eighteen entries were tested under rainfed condition during rabi season. The data revealed that the root length recorded highest in genotype AKA-08 (22.80 cm) followed by AKA-04 (21.00 cm) and AKA-02 (19.80 cm) and it was recorded lowest in genotype AKA-01 (11.40 cm). The data showed that the dry root yield was found highest in genotype AKA-08 (661.37 kg ha^{-1}) followed by AKA-04 (533.72 kg ha^{-1}) and AKA-02 (489.32 kg ha^{-1}) and it was recorded lowest in genotype AKA-13 (105.45 kg ha^{-1}).

MPUAT, Udaipur: Eleven promising genotypes were evaluated along with 3 checks (JA-20, JA-134 and RVA-100). All the test genotypes were annual type (early maturing). The study revealed that none of the entries exhibited significantly higher dry root yield over the best check JA-134 (383 kg ha^{-1}). Overall mean for dry root yield of this trial was 338 kg ha^{-1} and the dry root yield varied from 259 kg ha^{-1} to 416 kg ha^{-1}.

Maintenance breeding of ashwagandha varieties

RVSKVV, Mandsaur: Maintenance breeding of all released varieties of ashwagandha viz; Jawahar Ashwagandha- 20, Jawahar Ashwagandha - 134 and Raj Vijay Ashwagandha- 100 was done through selfing and single plant selection method and purity maintained by rouging of off type plants.

Effect of sowing dates on growth, yield and quality of ashwagandha

PDKV, Akola: The field experiment was conducted for three consecutive years (2016-17 to 2018-19) to study the effect of sowing dates on yield and quality of ashwagandha. Sowing of ashwagandha on 15th September recorded significantly higher root length (21.6 cm) which was at par with 1st October sowing. However, average root diameter (9.08) was significantly more

in sowing at 1st September and 1st August. Sowing of ashwagandha on 1st September recorded significantly highest dry root yield (764 kg ha^{-1}). Significantly higher GMR (Rs. 1, 22,271 ha^{-1}) and NMR (Rs. 78241 ha^{-1}) was recorded with sowing of ashwagandha on 1st September. Similarly, the highest B: C ratio was recorded with sowing on 1st September (3.30).

Performance of ashwagandha varieties under varying fertilizer application

MPUAT, Udaipur: The experiment was conducted during 2018-19 to work out performance of ashwagandha varieties for plant growth and yield parameters. The growth and yield parameters *viz*., plant height at harvest (53.33 cm), number of primary branches (4.9 $plant^{-1}$), root length (18.0 cm), root diameter (5.4 mm) at collar region and dry root yield (418.33 kg ha^{-1}) were recorded maximum under the genotype UWS-37 followed by UWS-10. Among the two levels fertilizer application, the growth and yield parameters were proved significantly higher with 50 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1}. On the basis of one-year results, it is concluded that UWS-37 produced significantly higher dry root yield.

Eco-friendly disease management of Alternaria leaf blight

JNKVV, Jabalpur: To manage the disease of *Alternaria* leaf blight of ashwagandha, combinations of bio-agents as soil treatment and foliar spray either alone or combinations of azadirachtin (1500ppm), salicylic acid (200 ppm) and cow urine (1:10) were tested. Minimum (36.75%) disease incidence was recorded in soil treatment with *Trichoderma asperellum* (Ta)+ *Pseudomonas fluorescens* (Pf) @ 5g kg^{-1} of FYM + 1stfoliar spray of salicylic acid (200 ppm) followed by 2nd foliar spray of azadirachtin (1500ppm) at 15 days interval followed by soil treatment with Ta+ Pf @ 5g kg^{-1} of FYM + 2 spray of salicylic acid (200 ppm) at 15 days interval (41.25%); soil treatment with Ta+ Pf @ 5g kg^{-1} of FYM +1st spray of azadirachtin (1500ppm) +2nd spray of cow urine (1:10) at 15 days interval (45.50%) and soil treatment with Ta+ Pf @ 5g kg^{-1} of FYM + 2 sprays of azadirachtin (1500ppm) at 15 days interval (48.25%) during 2018-19. Significant effect of treatments on root yield was observed during 2018-19. The highest root yield (521 kg ha^{-1}) was also recorded in the best treatment. However, seed yield was superior under soil treatment with Ta+ Pf @ 5g kg^{-1} of FYM + 2 spray of salicylic acid (200 ppm) at 15 days interval.

MPUAT, Udaipur: Integrated disease management including organic modules against root rot and leaf spots/blight of ashwagandha was evaluated. The organic module *i.e.,* in-furrow soil application of neem cake mixture (100g sqm^{-1}) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus three foliar sprays of garlic bulb extract (w/v) @10 % or cow urine @10 % resulted in minimum root rot disease (20.37; 19.15%,) and leaf spots (22.70; 25.73%) with higher yields of seed (458; 440 kg ha^{-1}) and dry roots (408; 428 kg ha^{-1}) with increased alkaloid content and were statistically significant when compared to the rest of the organic modules and the control. The moderate incidence of root rot (20.47; 20.93%) and leaf spots (36.00; 42.00 %) as well as increased yields of dry roots (394; 400 kg ha^{-1}) and seeds (422; 450 kg ha^{-1}) with increased alkaloid content were recorded in treatment modules comprising of in-furrow soil application of neem cake mixture

(100g sqm^{-1}) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus three foliar sprays of seven days old buttermilk @ 10% and treatment of in-furrow soil application of neem cake mixture (100g sqm^{-1}) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus three foliar sprays of neem leaves extract (w/v) @10% when compared to the control. The chemical treatment module *i.e.,* seed treatment with (Carbendazim 12%+ Mancozeb 63%)-75WP @ 0.30% plus drenching and three foliar sprays with Tebuconazole 25 EC @ 0.1% first at initiation of disease followed at 15 days interval was most effective with minimum incidence of root rot (10.20%) and leaf spots (12.33%) and increased yields of dried roots (526 kg ha^{-1}), seed (597 kg ha^{-1}) and alkaloid content comparing to organic treatment modules and chemical treatment comprising seed treatment with (Carbendazim 12% + Mancozeb 63%)-75WP @ 0.30% plus drenching and three foliar sprays with Mancozeb 75WP @ 0.25%.

BACH (*Acorus calamus*)

It is a member of family Araceae and is a small perennial aromatic herb grown naturally in marshy fields. It is a native of Europe and now found distributed throughout India specially in foot hills. The species is cultivated in some parts of India mainly in Andhra Pradesh. The rhizomes are used for medicinal purposes. The dried rhizomes constitute the commercial raw drug 'Calamus'. It is believed to improve memory power and intellect. In southern parts of India the rhizome is given to the newborn children alongwith honey to improve brain development. It is also useful in the treatment of diarrhoea, dysentery, abdominal obstructions and colic. Recently, anti-carcinogenic property of the species has also been reported.

A new high yielding variety, APAc -5 (Swarna Swara) recommended by the Varietal Identification Committee

YSRHU, Venkataramannagudem: Four entries (APAc-2, APac-4, APAc-5 and APAc-9) along with check (Symbolia) were evaluated for yield and quality across different locations for three years. Among these entries, APAc -5 (Swarna Swara) developed by YSRHU, Venkataramannagudem was recommended for submission to the CVRC by the Varietal Identification Committee meeting held during the XXVIIth AICRPMAP&B group meeting.

Organic nutrient management practices on rhizome yield

UBKV, Kalimpong: Experiment was conducted to study different sources of organic manure like FYM, vermicompost and neem cake were applied at various doses along with recommended dose of chemical fertilizer on rhizome yield. The highest fresh (2820 kg ha^{-1}) and dry (930 kg ha^{-1}) rhizome yield was recorded with treatment receiving neem cake 2.5 t ha^{-1} which was significantly higher than the control. However, other treatments did not show any significant difference among them.

Management of diseases

BCKV, Kalyani: The result showed that treatment with Copper oxy chloride 50WP @ 0.4% recorded the highest leaf blight disease reduction in bach *i.e.,* 41.66% in severity and 38.32% in incidence. Among the other treatments, treatment comprising of salicylic acid @ 0.01% recorded the 2nd best result in by reducing severity (27.39%) and incidence (18.95%) followed by the treatment DL-β-aminobutyric acid @ 0.01% (24.49% PDI and 17.42% incidence); *Panchyagavya* @3.0% (rhizome treatment + 1 spray) (19.26% PDI and 13.30% incidence) and *Panchyagavya* @3.0% (3 sprays) (18.37% PDI and 16.64% incidence).

BASIL (*Ocimum basilicum*)

Basil belongs to family Lamiacea and is widely distributed throughout India. The species is believed to be originated in India, Pakistan and Thailand. Basil prolifically produces large green or purple leaves, measuring around 2 inches in length, throughout the summer. Basil has the ability to synthesize and convert phenyl propenes. The flavor and smell of basil varieties is largely determined by their chemical components presenting the essential oil. Basil varieties contain cinnamate, citronellol, geraniol, linalool, methyl chavicol, myrcene, pinene, ocimene and terpineol. Basil has been used as a folk remedy for an enormous number of ailments, including, cancer and convulsion in addition to its use in table purposes and aromatherapy.

Evaluation of promising lines of basil for yield and quality in MLT during 2017-18

An Advanced Evaluation Trial (AVT-II) with three entries AOB 4, AOB 5, DOB along with GAB-1 as a check were tested at Anand, ICAR-DMAPR, Mandsaur, Pusa, Rahuri, Faizabad and Islampur. At locations DMAPR, Faizabad, Islampur and Pusa, green leaf yield did not differ significantly among the entries. At Anand, significantly higher green leaf yield was in the Check GAB 1 (15494 kg ha^{-1}), which was at par with DOB 5 and AOB 5. At DMAPR, significantly higher green leaf yield was in DOB 5 (10288.82 kg ha^{-1}) which was however at par with the check GAB 1. No significant differences were observed in the case of dry leaf yield at Banda, Faizabad and Pusa. Among the other locations, at DMAPR, significantly higher dry leaf yield was in DOB 5 ; at Anand and Islampur, it was in AOB 5 (4875 kg ha^{-1}, 2468.14 kg ha^{-1}) , however it was at par with the check GAB 1 at both the centres.

MLT evaluation of promising lines of Basil (Seed purpose) for high yield and quality

An Advanced evaluation trial (AVT-II) with six entries (four from Mandsaur) and one entry each from DMAPR and Rahuri were tested at Anand, DMAPR, Faizabad, Islampur, Mandsaur, Pusa, Rahuri and Banda during 2018-19. The trial failed at Rahuri. Seed yield data were not reported by Anand and DMAPR. At locations Banda, Faizabad, Islampur and Pusa, entries showed no significant differences in the case of seed yield and Mandsaur, MOB 14 had significantly higher seed yield (1581 kg ha^{-1}) which was at par with MOB 19, DOB 1 and Rahuri 1.

Effect of dates of transplanting and spacing on herbage and oil yield

AAU, Anand: Field experiment was conducted to study the effect of date of transplanting and spacing on herbage and essential oil yield for two consecutive years. Significantly higher total green herbage yield (41690 and 43180 kg ha^{-1}) of basil was recorded during planting on 3rd week of July 2018-19 which was at par with planting during 1st week of August. Significantly higher green herbage yield was found with spacing (60 × 45 cm) in the year of 2018-19 and on pooled basis. Similarly the highest green (46130 kg ha^{-1}) and dry (7090 kg ha^{-1}) herbage yield was recorded with combination of planting on 3rd week of July with spacing of 60 × 45 cm under Anand location. The highest oil yield on pooled basis in the year of 2018-19 was recorded in planting during 3rd week of July (131.3 kg ha^{-1}) and with spacing S_2: 60 × 45 cm (131.1 kg ha^{-1}) respectively.

MPKV, Rahuri: Transplanting of basil on 15th June recorded maximum plant height (100.41 cm), number of primary branches (19.17), fresh herbage yield (31059 kg ha^{-1}), dry herbage yield (4138 kg ha^{-1}) and seed yield (438 kg ha^{-1}). Plant spacing of 60 × 45 cm recorded maximum plant height (98.90 cm), number of primary branches (16.74), fresh herbage yield (31893 kg ha^{-1}), dry herbage yield (5456 kg ha^{-1}) and seed yield (393 kg ha^{-1}). Transplanting of basil during 15th June with spacing of 60 × 45 cm recorded maximum dry herbage yield (6130 kg ha^{-1}) followed by 1st July transplanting. The results indicated that, 15th June to 1st July time was most effective with spacing of 60 × 45 cm for basil.

Integrated nitrogen management on herbage and seed yield

RVSKVV, Mandsaur: Field experiment was conducted during 2017-18 to study the effect of integrated nitrogen management on herbage yield and quality of basil. The result revealed that maximum plant height (73 cm), number of branches (17), dry herbage yield (6100 kg ha^{-1}) and seed yield (2200 kg ha^{-1}) was recorded in treatment receiving 100% N through chemical fertilizer followed by treatment consisting of 20% N from vermicompost and 80% N from chemical fertilizer.

Screening of germplasm lines against *Cercospora* leaf blight

RVSKVV, Mandsaur: An experiment was conducted on screening of *O. basilicum* germplasm lines against *Cercospora* leaf blight during 2016-17 & 2018-19 at Research field, College of Horticulture, Mandsaur. A total of 21 genotypes of basil were tested under field condition. Disease severity was recorded in 0-9 scales and the lines were grouped as follows:

Resistant	:	Nil
Moderately Resistant	:	MOB-8, MOB-11, MOB-13, MOB-14, MOB-16 and MOB-19
Susceptible	:	MOB-1, MOB-2, MOB-3, MOB-4, MOB-5, MOB-6, MOB-7, MOB-9, MOB 10, MOB-12, MOB-15, MOB-17, MOB-18, MOB-20 and MOB-21

Evaluation of bioagents and organic based products for management of diseases

BAU, Islampur: Leaf spot (*Alternaria alternate*) infected plants showed small, irregular shaped brown spot of 1-2 mm size on the leaves and stem of basil. First appearance of leaf

spot incidence was noticed after 2nd week of October and its incidence was reached 100% in January (2nd week) in control plot with 35.0 % severity. Correlation of disease severity of leaf spot and weather factors showed that PDI was positively correlated with rainfall and negatively correlated with other factors like RH, Temperatures-min, max, and average. Out of 7 treatments applied for management of foliar disease, treatment of soil application of FYM (1.0 kg m^{-2}) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at planting time along with three sprays of mancozeb @ 0.25% from the onset of disease symptoms, followed by 15 days interval was found superior for management of leaf spot diseases which reduced the disease by 84.9% The green leaf yield was also high in the best treatment (8250 kg ha^{-1}) as compared to the control (7213 kg ha^{-1}).

BETELVINE (*Piper betle*)

It is a perennial evergreen dioecious climber, belonging to family Piperaceae. It is a native of Central and Eastern Malaysia and has spread throughout tropical Asia and Malaysia; Madagascar and East Africa at a later date. The plant grows well in shady conditions having moderate temperature with high humidity. The major cultivating countries are India, Bangladesh, Srilanka, Pakistan, Malaysia, Thailand, Indonesia, Maldives, Vietnam and Papua New Guinea. In India it is cultivated in an area of about 50,000 ha. Fresh leaves are consumed along with betel nuts. It is also medicinal and is used in Indian System of Medicines to cure indigestion, stomach ache, flatulence and to heal wounds, swellings, and gum disorders. Recent studies also revealed that the leaf improves immune system and inhibits cancer growth.

Hybrid evaluation trial

YSRHU, Venkataramannagudem: A multilocational trial was initiated including five hybrids along with two local checks. The results showed that hybrid HY-09-13 recorded significantly highest vine length of 264.83 cm which was at par with Swarna Kapoori (234.18 cm) where as in case of orthotropic vine length Swarna Kapoori recorded significantly highest plant height of 49.37 cm followed by HY-09-16 (43.97 cm). In terms of internodal length, lowest values of 4.17 cm and 2.49 cm were recorded in HY-08-23 followed by Tellaku Ponnuru with 5.31 cm and 3.64 cm, respectively for main stem and orthotropic branches. The highest number of branches along with maximum stem girth was recorded in HY-09-13 (3.67, 2.47 cm) followed by Swarna Kapoori (3.42, 2.10 cm). Maximum leaf length and leaf width of 16.43 cm and 10.48 cm was recorded in HY-09-13 followed by Swarna Kapoori with 16.31 cm and 10.21 cm on main stem. Regarding leaf length and leaf width of leaves on orthotropic branches maximum length of 21.48 cm and width of 8.13 cm was recorded in HY-09-16 followed by Swarna Kapoori with 12.93cm length and 7.79 cm leaf width. Among plageotropic branches, maximum length of 7.84 cm and width of 4.20 cm were recorded in HY-09-13 followed by HY-09-16 with 6.17cm length and 3.54 cm leaf width. Recording petiole length among orthotropic branches, maximum petiole length of 4.79 cm was recorded in HY-09-16 followed by Swarna Kapoori with 4.37cm. Among plageotropic branches HY-09-13 recorded highest petiole length of 2.04 cm followed

by HY-09-16 with 1.30 cm. Overall leaf yield per vine was found to be significantly highest in HY-09-13 with 66.92 leaves followed by Swarna Kapoori with 52.17 leaves. The leaf yield among lateral branches was found to be significantly higher in HY-09-16 with 6.59 leaves per branch followed by Swarna Kapoori with 5.41 leaves per branch. Significantly maximum 100 leaf weight of 372.95 g was recorded in HY-09-16 followed by Thellaku Ponnuru with 353.13g.

Nutrient management practices for enhancing leaf production

BAU, Islampur : A field experiment was conducted to study the effect of organic manures *viz*., FYM, vermicompost and mustard cake on growth and yield of betelvine. One RDF as inorganic fertilizer was included for comparison. Magahi pan was taken as variety for the study. The results showed that 100% RDF (200:100:100 kg NPK ha^{-1}) produced maximum marketable leaves (94.14 $vine^{-1}$) and benefit cost ratio (2.08). However this treatment was found at par with application of FYM 15 t ha^{-1} + vermicompost 7.5 t ha^{-1} + mustard cake- 1.5 t ha^{-1} (89.1 leaves $vine^{-1}$ and B:C ratio 1.87) and FYM 10 t ha^{-1} + vermicompost 5 t ha^{-1} + mustard cake 1t ha^{-1} (86.1 leaves $vine^{-1}$ and B:C ratio (1.84). These treatments were significantly superior to individual application of FYM (30 t ha^{-1}), vermicompost (10 t ha^{-1}) and mustard cake (2 t ha^{-1}). Based on benefit cost ratio and soil health from the 3 years experimentation, it may be concluded application of FYM 10 t ha^{-1} + vermicompost 5 t ha^{-1} + mustard cake 1 t ha^{-1} was suitable for obtaining higher marketable leaves (86.09 $vine^{-1}$) and return (B:C ratio 1.84) with improvement of soil health.

Epidemiological study of leaf spot, leaf blight and foot and root rot diseases

AAU, Jorhat: To study the epidemiological aspects on different diseases of betelvine, an experiment was conducted during 2018 -19. Planting of betelvine cutting collected from farmers' field (Asomiya pan) was done at 30 x 10 cm spacing after fertilizing the plots with mustard oil cake @ 6 t ha^{-1} per year. The mustard oil cake was applied in two equal doses during May and September. All the cultural practices like weeding, watering, earthing up, pruning, vine lowering and other operations were followed as per the recommendation of Assam. Partial shade was provided with a 30% agroshade net. The disease severity was recorded and expressed as percent disease index.

Antrhacnose leaf spot was found highest (42.46%) during the month of July followed by August (36.26%). Highest disease severity was recorded during July to September. Higher incidence of the disease was found associated with the increasing rate of rainfall land temperature. Regression line showed a strong positive linear relationship between disease severity and maximum and minimum temperatures having coefficient, r = 0.7117 and r = 0.6967 and equation y= 24.03 + 0.246 x and y = 11.124 + 0.379x, respectively. A strong positive linear relationship between relative humidity (evening) and disease severity was observed with coefficient, r = 0.7141 and equation y= 60.782- 0.375x and weak linear relationship between relative humidity (morning) and disease severity was observed with coefficient, r = - 0.0894 and equation y= 95.1-0.02x. Positive linear relationship was also observed for rainfall and disease severity with co-efficient r= 0.5539 and equation y= 1.203+ 7.159x. On the other hand, weak negative relationship was observed for bright sunshine hours (BSSH) and disease severity with coefficient, r = - 0.2774 and equation 5.203 -0.03x.

Highest severity of bacterial blight (30.46%) was observed during the months of August followed by September (24.28%). The bacterial leaf blight was found sharply increased from June when the crop received maximum rainfall (399.2mm) 16.42% to 30.36% during the month of July and August, respectively. Bacterial leaf blight was found decreasing from the months of October onwards and reached 2.21 during the month of January 2019 thereby it increased to 3.10%. During the period of October to March, the crop received higher BSSH as compared to the other months. Regression line showed a strong positive linear relationship between bacterial blight severity (BBS) and temperature (both maximum and minimum); BBS and morning and evening relative humidity (%) and BBS and rainfall. No relationship between BSSH and bacterial blight disease severity was observed. Phytopththora blight disease incidence (PBDI) was observed throughout the year with highest disease severity during September with 30.0%. This was followed by August with disease severity of 29.99%. A strong positive linear relationship for PBDI was observed with maximum temperature and minimum temperature. PBDI showed a negative linear relationship with morning relative humidity but PBDI showed a strong positive linear relationship with evening relative humidity. Correlation study revealed that strong linear correlation with rainfall but literally no relationship with BSSH. Foot and root rot caused by *Sclerotium rolsii* was noticed highest during the month of October with severity percent of 28.66% followed by November with disease severity percent of 24.44%. Thereafter disease was found decreasing from the month of December to November, 2019. When correlation study was done it showed a positive linear correlation with temperature (Max) with coefficient r = 0.1213 and equation y = 28.279 + 0.048x. No linear relationship was observed between minimum temperature and diseases severity with coefficient r = - 0.0134 and equation y = 18.426- 0.0008x. A linear positive relationship was observed with morning relative humidity while negative linear relationship was observed with evening relative humidity with respective coefficient r = - 0.1428 and equation y = 68.66 -0.087x. On the other hand, negative linear relationship was observed between rainfall and foot and root rot disease severity with coefficient, r = -0.3025 and equation y = 187.127-4.688x and strong positive linear relationship was observed between BSSH and disease severity with coefficient r = 0.7148 and equation y = 3.914 + 0.09x.

CHAMOMILE (*Matricaria chamomilla*)

Chamomile or camomile is the common name for several daisy-like plants of the family Asteraceae. Two of the species are commonly used to make herbal infusions for traditional medicine, and there is some evidence that chamomile has an effect on health. Chamomile is one of the oldest, most widely used and well documented medicinal plants in the world and has been recommended for a variety of healing applications. Traditionally, chamomile has been used for centuries as an anti-inflammatory, antioxidant, mild astringent and healing medicine. As a traditional medicine, it is used to treat wounds, ulcers, eczema, gout, skin irritations, bruises, burns,

canker sores, neuralgia, sciatica, rheumatic pain, hemorrhoids, mastitis and other ailments Two types of chamomile used are German chamomile (*Matricaria recutita*) and Roman chamomile (*Chamaemelum nobile*). Chamomile tea is an herbal infusion made from dried flowers and hot water. Chamomile may be used as a flavoring agent in foods and beverages, mouthwash, soaps, or cosmetics. The main constituents of chamomile flowers are polyphenol compounds, including apigenin, quercetin, patuletin, and luteolin. Chamomile has historically been used in beer also.

Comparative efficacy of organic manures and chemical fertilizers on growth and yield

YSPUHF, Solan: Field experiment was conducted to study the comparative efficacy of different organic manures and fertilizers on growth and yield of *Matricaria chamomilla*. Maximum plant height (35.86 cm), number of flowers (395.3 plant^{-1}), fresh flower weight (58.7 g plant^{-1}), dry flower weight (20.2 g plant^{-1}), fresh flower yield (434962 kg ha^{-1}), dry flower yield (149987 kg ha^{-1}), oil content (0.60%) and gross income (Rs.78989.6 ha^{-1}) were recorded under treatment receiving FYM (10 t ha^{-1}) + NPK (60:40:30 kg ha^{-1}) however, maximum B:C ratio was found in the treatment receiving *jivamrut* prepared from *desi* cow (3.82).

CITRONELLA (*Cymbopogon winterianus*)

Citronella is an important aromatic grass of Indian origin. The leaves and shoot of the plant is used to extract essential oil which is rich in geraniol and citranellol content (75-85%). Lemongrass oil is one of the most important essential oil produced in the world. The oil is mainly used in the manufacture of perfumes for soaps, hair oils, scents and medicines. The oil obtained by the distillation of the grass of *C. winterianus* is the genuine oil of commercial importance. Presently it is commercially cultivated in Kerala, Assam, Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh and Uttar Pradesh.

Effect of water and nutrient management on growth, herbage and oil yield

IGKV, Raipur: Field study was conducted to evaluate the effect of water and nutrient management on growth, herbage and oil yield of citronella grass. The highest plant height (122.17 cm) was found with four irrigation per year (at 130,160,190 and 220 DAP) or 30 days interval followed by six irrigation per year (at 130, 150, 170, 190, 210, 230 DAP) or 20 days interval. The application of six irrigation per year (at 130, 150, 170, 190, 210, 230 DAP or 20 days interval) was produced significantly higher fresh herbage yield per plant (932.4 g plant^{-1}), fresh herbage yield (25899 kg ha^{-1}) and oil yield (142.89 kg ha^{-1}) over other irrigation schedules under three cutting in a year. The highest plant height (123.35 cm) was found with application of 10 t FYM ha^{-1} + 40:30:25 kg NPK ha^{-1} followed by 150:60:60 kg NPK ha^{-1} Year^{-1}, 10 t FYM ha^{-1} Year^{-1} and control, respectively .The application of 150:60:60 kg NPK ha^{-1} Year^{-1} (100% inorganic) was produced significantly fresh herbage yield per plant (973.9 g plant^{-1}), fresh herbage yield (27053 kg ha^{-1}) and oil yield (149.26 kg ha^{-1}) as compared to other treatments

under three cutting in a year. However, application of six irrigations along with 150:60:60 kg NPK ha^{-1} $Year^{-1}$ recorded highest oil yield (175.5 kg ha^{-1}).

COLEUS (*Coleus forskohlii*)

C. forskohlii (syn. *Plectranthus barbatus*) belongs to family Laminaceae and is grown mainly in South India. It is propagated by stem cuttings. The tuberous roots are of commercially importance which produces a diterpenoid, froskohlin in addition to rosmarinic acid, flavonoid glucuronides and diterpenoids. Forskolin helps to lower blood pressure, dilates the blood vessels. It is considered as a good heart tonic. Although synthesis of forskolin was reported, but till now its main source is roots of *C. forskohlii* either collected from wild or cultivated. Coleus is used in Indian folk medicines and is a traditional digestive remedy. Leaves are thick velvety which is used against stomach ailments.

Bio-suppression of *Macrophomina* root rot

TNAU, Coimbatore: A field eperiment was conducted in the farmers' field at Perundurai, Coimbatore district, Tamil Nadu during 2018-2019 on the management of root rot of *Coleus forskohlii* caused by *Macrphomina phaseolina* . *Coleus* cuttings were used as planting material. Basal soil application of bioagents and spot drenching of fungicides were done at 30 and 45 days after planting. The disease intensity was recorded from 30,45,60,75 and 90 days after planting. Also the yield parameters such as number of tuberous roots per plant, tubersous root length and fresh tuber yield were recorded. The treatment with basal soil application (SA) of *Bacillus subtilis* (Bs1) 2.5kg ha^{-1} + dipping cuttings in 0.2% *B. subtilis* (Bs1) + SA of *B. subtilis* (Bs1) and treatment with basal SA of *B. subtilis* (Bbv 57) 2.5kg ha^{-1}+ dipping cuttings in 0.2% (Bbv 57) + SA of Bbv 57 and treatment with basal SA of *P. fluorescens* (Pf1) 2.5kg ha^{-1}+ dipping cuttings in 0.2% Pf1 + SA of 0.2% Pf1 on 30 and 45 DAP resulted in reduced root rot disease incidence of 8.53 to 9.18 % with reduction in disease incidence ranging from 69.1 to 71.3 % when compared to the other biocontrol treatments, fungicide treatment and the control.

INDIAN VALERIAN (*Valeriana jatamansi*)

It is a perennial herb, 15 -60 cm tall, velvet-hairy to hairy. Rhizomes are elongate, with fibrous roots. Stems are 3-6 in number. Leaves at the base are heart-shaped or ovate, toothed or wavy-toothed. Flowers are white which are borne in flat-topped clusters on top of the stems. Upper bracts are linear-lance shaped, about 3 mm long. Stigma is 3-fid. Seed-pods are velvety, shorter than the upper bracts. The species is found throughout the Himalayas, from Afghanistan to SW China, at altitudes of 1500-3600 m. Flowering occurs during March to May. Roots of the species are useful in diseases related to eye, blood, liver and spleen. Leaves are used for the treatment of headache. Roots are

also used in aromatic industry. Raw drug is collected mainly from the wild since cultivation is not yet popularized. Since it is a temperate plant, it requires cold weather for proper growth. The plant is propagated by seeds as well as by root stocks.

Effect of shade percentage on growth and yield

UBKV, Kalimpong: Field experiment was conducted to standardize shade intensity for *Valeriana jatamansi* cultivation. Different shading intensities showed a significant difference in fresh aerial biomass (g plant^{-1}) and underground biomass (g plant^{-1}). Shade intensity of75% showed significantly higher aerial and underground biomass yield than the rest of the treatments. Maximum fresh (2330 kg ha^{-1}) and dry (550 kg ha^{-1}) rhizome yield was recorded under 75% shade intensity which was significantly higher than 25% shade as well as open condition. Therefore, it is recommended to cultivate valeriana in shade of plantation trees or to use shade net of 50% or 75%.

Organic nutrient management practices on rhizome yield

UBKV, Kalimpong: Experiment was conducted to study the effect of different sources of organic manure like FYM and vermicompost applied at various doses along with recommended dose of chemical fertilizer on rhizome yield. Rhizome is the main economic part and its fresh and dry weight were recorded highest with treatment receiving FYM @ 5 t ha^{-1} + vermicompost @ 2 t ha^{-1} along with phosphate solubilizing bacteria which was significantly higher than the control. However the other treatments did not show any significant difference among them.

UUHF, Bharsar: Experiment was conducted to study different organic manures (FYM, vermicompost and mustard cake) on rhizome yield and quality in comparison to recommended dose of chemical fertilizer. Initial study revealed that rhizome yield (2.15 g plant^{-1}) of the plants was lowest in control. The highest rhizome yield (2.64 g plant^{-1}) and essential oil content (0.29%) were recorded with treatment receiving vermicompost (7.5 t ha^{-1}) and found superior to application of recommended dose of chemical fertilizer.

GLORY LILY (*Gloriosa superba*)

The plant belonging to Liliaceae family is a climbing herb commonly found in the forests throughout India up to 2000 m. It is distributed in tropical and southern Africa and temperate and tropical Asia. It is naturalized and cultivated elsewhere (Europe, Australia) and listed as weedy in Australia and United States of America. This species is a perennial herb growing from a fleshy rhizome. It is scandent, climbing using tendrils, the stem reaching 4 meters long. The leaves are mainly alternately arranged, but they may be opposite, as well. Rhizomes are cylindrical, bifurcated usually V-shaped with two limbs equal or unequal in length. It flowers with great profusion in rainy season. The alkaloid, colchicine is extracted from roots as well as from seeds. It is used for

treatment of variety of diseases such as gastro-intestinal disorders, colic, chronic ulcers, cancer and piles. It is widely cultivated now in Tamil Nadu, Maharashtra and Himachal Pradesh. The plant can be propagated sexually by seed or vegetatively by dividing the rhizome. Problems during cultivation include inadequate pollination, fungal diseases such as leaf blight and tuber rot and crop pests.

Exploration and collection of germplasm

TNAU, Coimbatore: Survey was made at different parts of Tamil Nadu and about fifteen accessions were collected and added to the existing fifteen collections. The thirty collections were evaluated for growth and yield characters .The result revealed that the vine length ranged from 60.25 cm to 126.74 cm. Stem girth ranged from 0.97 to 2.31 cm. Number of pods per plant ranged from 5.28 to 28.02 and dry seed yield (g per plant) ranged from 22.17-86.7. Accession TN*Gsu*-28 recorded the highest vine length (136.74 cm) and the accession TN*Gsu*-17 recorded the highest stem girth (2.40cm). Number of pods per plant was highest in the accession TN*Gsu*-30 (28.20). Accession (TN*Gs*u-30) recorded the highest dry seed yield per plant (86.74 g per plant).

Studies on floral biology and development of hybridization technique

TNAU, Coimbatore: Glory lily is a cross pollinated crop. Five stages of flower development *viz.,* bud initiation, bud opening, pre- anthesis, anthesis and post pollination stage were observed. The flower colour changed during each stage of flower development. The perianth lobes at the bud opening stage were light greenish in colour followed by the stigma receptive stage which was characterized by perianth lobes that were scarlet red at the tip, yellow in the middle and greenish towards the base. Post pollination stage was characterized by the upper half of the perianth lobes being scarlet red and the lower portion being yellow coloured. Lastly the perianth lobes turned entirely into scarlet red.

Anthesis was observed to occur than 7.30 am to 9.30 am with 40 per cent of the flower opening by 7.30 am, 50 per cent by 8.30am and the rest 10 per cent by 9.30 am. One day after anthesis, the anther started dehiscing earlier than 7.30 am to 9.30 am. On an average, five per cent of the anthers dehisced before 7.30am, 70 per cent before 8.30 am and another 25 per cent by 9.30 am. 97.50 per cent pod set was observed in flowers which were pollinated on the day of anthesis. Pod set percentage was higher in early morning hours (7.00 to 11.00am). The mean percentage of fertile pollen was highest on the day of anther dehiscence and declined as the age of pollen increased.

The protocol for hybridization was developed as follows:

The female flowers at pre-anthesis stage should be selected for emasculation. For female parents, emasculation should be done between 7.00 to 9.00 am and bagged with butter paper cover. Simultaneously, for male parents, the flower buds should be bagged at pre-anthesis stage without emasculation to avoid contamination by foreign pollen for collection of pollen grains. Pollen from bagged flowers of pollen parents should be collected between 8.00 and 9.00 am in the next day morning and dusted on the stigma of emasculated flowers of the

respective female parents. The flowers were bagged with butter paper covers and then labeled. Later the covers are to be removed after ensuring proper pod set.

YSPUHF, Solan: Seven pollination methods *viz.*, open pollination, selfing by bagging, controlled selfing within a flower, open cross with emasculation, controlled cross with emasculation and assisted pollination were tried for finding out the best method for enhancing seed yield in *Gloriosa superba*. From the studies for one season, it was found that assisted pollination performed much better than the other methods in terms of fruit set (100%), number seeds per fruit (57.10), pod length (6.69 cm), pod diameter (17.38 mm) and seed dry weight (2.68 g per 100 seeds).

Development of minimum seed standards

TNAU, Coimbatore: Standardization of minimum seed standards were worked at TNAU, Coimbatore as follows:

I. Application and Amplification of General Seed Certification Standards
   A. The General Seed Certification Standards are basic and, together with the following specific standards constitute the standards for certification of garlic seeds.
   B. The General Standards are amplified as follows to apply specifically to glory lily.
   C. The tuber multiplication shall be carried out with the seed tubers whose source and identity may be assured and approved by the Certification Agency.

II. Land Requirements

   Land to be used for seed production of glory lily shall be free from volunteer plants.

III. Field Inspection

   A minimum of two inspections shall be made as follows;
   1. The first inspection shall be made when plants are at 45 days large enough to verify isolation, Off-types including and other relevant factors.
   2. The second inspection shall be made when the pods attained complete maturity and before lifting of tubers to verify isolation, Off-types and other relevant factors.

IV. Field Standards

A. General requirements
   1. Isolation

      Seed fields of glory lily shall be isolated from the contaminants shown in the column 1 of the Table below by the distances specified in columns 2 and 3 of the said Table:

Contaminants	*Minimum distance (meters)*	
	Foundation	*Certified*
1	2	3
Fields of other varieties	5	5
Fields of the same variety not conforming to varietal purity requirements for certification	5	5

B. Specific requirements

Factor	*Maximum permitted (%)**	
	Foundation	*Certified*
1	2	3
*Off-types	0.10	0.20
Designated diseased plants (Tuber rot)	0.01	0.02

*Maximum permitted at the time of tuber uprooting

V. Seed (tubers) Standards

1. The average weight of each tuber shall be more than 40g. In a seed lot, tuber not confirming to specific size of tuber shall not exceed more than 10 % (by number).
2. Cut, bruised, cracked and damaged tuber shall not exceed more than 1 %
3. Incidence of tuber rot shall not exceed more than 1%

Diseases	*Maximum permissible limits*	
	Foundation	*Certified*
1	2	3
Tuber rot	None	None

Development of protocol for cost effective microtuber production

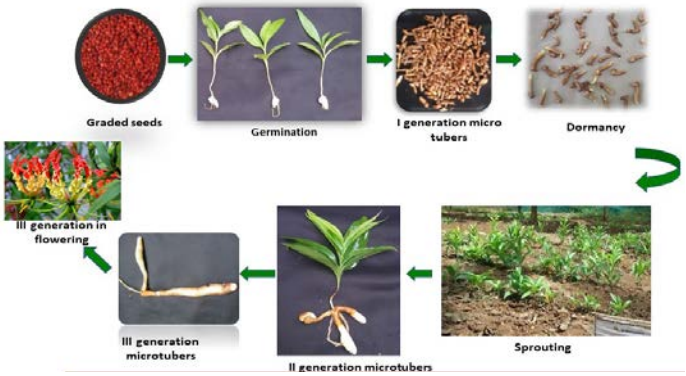
TNAU, Coimbatore: Gloriosa is a high value medicinal plant in the pharmaceutical sector owing to the widespread application as a potential drug against gout disease. The plant is grown in about 3000 ha area in India. More than 7000 farmers are engaged in glory lily cultivation and majority of them are small and marginal farmers (cultivation glory lily in half an acre to one acre). Gloriosa is a herbaceous perennial propagated vegetatively through tubers. The species is already under the RET list and needs conservation of the wild habitat. Due to the high cost of tubers in the last few years (Rs.300 per kg), the threat on wild population has increased inadvertently.

With the growing demand for glory lily seeds, it is anticipated that the area under this crop will increase in forthcoming years creating high demand for the planting material. In lieu of the above, it was quite appropriate that TNAU has pioneered in gloriosa research by developing a feasible technology on cost effective multiplication of micro tubers through seed propagation.

This technology has multi-faceted benefits of reducing the seed material (tuber) cost, mass multiplication of healthy planting material, evasion of tuber borne diseases, exclusion of genetic erosion from conventional areas, lowers cost of cultivation and enhanced seed yield.

In this context, TNAU standardised protocol for cost effective multiplication of tubers from seeds. Various aspects related to the study viz., pollination, maturity indices, grading, methods to induce seed germination through which micro tuber production protocol was developed. The micro tubers evolved were advanced for two more generations until the tubers bulked to 40-45 g weight which is the acceptable form to farmers. These tubers were tested in

farmers field in 2018 and the results indicated that this technology was successful in reducing the tuber cost as low as Rs. 50,000 per acre as compared to Rs. 1.50 lakhs per acre in conventional practice of using wild traded tubers. By using this microtubers evolved from this technology, nearly 20 per cent increased seed yield was obtained. The significant merits of this technology are:



Protocol for micro tuber production developed at TNAU, Coimbatore

- Quality planting material (tubers) can be generated and distributed to the farmers on sustained basis
- Saving in the cost of tubers upto Rs. 1.0 lakh per acre
- Uniformity in crop growth leading to higher seed yield when compared to the conventional practice

This is a new technology evolved from the Department of Medicinal and Aromatic crops, TNAU, Coimbatore. The technology is now proposed for adoption focusing on the production of quality planting material in glory lily.

Management of foliar diseases of *G. superba* with bioagents and fungicides

TNAU, Coimbatore: Foliar spray of *Pseudomonas fluorescens* (Pf1) 0.2% on 30 DAP+ foliar spray (FS) of *Bacillus subtilis* (Bs1) 0.2% on 45 DAP + FS of *Streptomyces geysiriensis* (Pts-2) 0.2% on 60 DAP resulted in reducing the leaf blight intensity with least PDI of 10.68 (63.10 % reduction in disease) next to carbendazim (9.31 PDI and 67.90 % reduction in disease). The individual spray of bioagents, *P. fluorescens* (Pf-1), *B. subtilis* (Bs-1) and *S. geysirenisis* (Pts-2) resulted in disease reduction from 48.60 to 51.40 %; but when provided as sequential application resulted in offering better protection of the crop. The fungicide Tebuconazole + trifloxysttrobin provided up to 74.10% reduction in disease control. The treatment FS of *P. fluorescens* (Pf1) 0.2% on 30 DAP+ FS of *B. subtilis* (Bs1) 0.2% on 45 DAP + FS of *S. geysiriensis* (Pts-2) 0.2% on 60 DAP significantly contributed for reduction in flower blight intensity when compared to other the treatments. The growth and yield parameters were found to be the maximum in the treatments involving spraying of biocontrol agents. The plant height was found to be the maximum in the treatment with FS of *S. geysirenisis* (Pts-2) (0.2%) on 30 45 and 60 days after planting (121.80 cm) and in treatment involving *P. fluorescens* (Pf1) 0.2% on 30 DAP+ FS of *B. subtilis* (Bs1) 0.2% on 45 DAP + FS of *S. geysiriensis* (Pts-2) 0.2% on 60 DAP, with 123.98 cm. Also the treatment of foliar spraying with *S. geysirenisis* (Pts-2) (0.2%) on 30 45 and 60 DAP (121.80 cm) and in treatment involving spraying of *P. fluorescens* (Pf1) 0.2% on 30 DAP+ FS of *B. subtilis* (Bs1) 0.2% on 30 45 and 60 DAP recorded the maximum yield parameters *viz.*, number of flowers per plant (47.07), number of pods per plant (47.30) and number of seeds per pod (62.67).

HARDE (*Terminalia chebula*)

Terminalia chebula (Family: Combretaceae), commonly known as *harde* or *haritaki* is native to South Asia from India and Nepal east to southwest China (Yunnan), and south to Sri Lanka, Malaysia, and Vietnam. *T. chebula* is a medium to large deciduous tree growing to 30 m tall, with a trunk up to 1 m in diameter. The dull white to yellow flowers are borne in terminal spikes or short panicles. The fruits are smooth ellipsoid to ovoid drupes, yellow to orange-brown in colour, with a single angled stone. Its habitat includes dry slopes up to 900 m in elevation. The fruit of *T. chebula* is a main ingredient in the Ayurvedic formulation *Triphala* which is used for kidney and liver dysfunctions. The dried fruit is also used in Ayurveda as a purported antitussive, cardiotonic, homeostatic, diuretic, and laxative.

Characterization and maintenance of germplasm

BAU, Ranchi: *Terminalia chebula* germplasm from BTC 1 to BTC 10 was planted in July 2015 and BTC 11 to BTC 41 were planted in December 2017. Among the 2015 planted accessions, mean value of maximum plant height and collar diameter was in BTC 2 (246.00 cm and 47.51 mm). Diameter of secondary branches and number of branches per plant were highest in BTC 4 (23.85mm, 5.25). The mean values of maximum East-West (176.25 cm**)** and North-South (167.50 cm**)** crown diameter were observed in BTC 4. The mean values of maximum leaf length (16.77 cm**)** and breadth (7.54 cm**)** were recorded in BTC 10 and BTC 3, respectively.

Among the 2017 planted germplasm, the mean value of maximum height was in BTC 12 (87.20 cm) and minimum (20.00 cm) was in BTC 39 germplasm. The mean values of maximum collar diameter (23.00 mm) and diameter of secondary branches (17.24 mm) were in BTC 11 germplasm while the minimum collar diameter (9.04 mm) and diameter of secondary branches (6.71) were in BTC 39 and BTC 18, respectively. Mean value of maximum number of branches per plant was in BTC 13 (3.20). Mean values of maximum East-West (84.00 cm) and North-South (94.00 cm**)** crown diameter was observed in BTC 11. Mean values of maximum leaf length (18.96 cm) and breadth (9.20 cm) were observed in BTC 13 and BTC 20, respectively.

ISABGOL (*Plantago ovata*)

The species belongs to the family Plantaginaceae. It is an annual herb grown during the rabi season. Seed coat is known as isabgol husk under trade. The swelling property of the seed coat or husk after absorption of water is used in medicines against constipation and gastrointestinal disorders. In addition, it used in food industries for the preparation of ice creams, candy etc. India is the only isabgol production country in the international trade. Country earns on an average ₹ 400 crores annually from its export. It is widely cultivated in North Gujarat, adjoining Rajasthan and Madhya Pradesh

over an area of about 2,50,000 ha. A number of high yielding varieties are available in the crop for cultivation.

Advanced varietal evaluation trial (AVT) (Medium maturing group-120 days)

A trial was conducted to compare the performance of DPO267-3, MIB124 (UI-124), DTPO11-1, DTPO6-6 and MIB 5 along with checks GI-2, JI-4, RI, Vallabh Isabgol -1, Vallabh Isabgol -2, Vallabh Isabgol -3 at seven centres *viz.,* Anand, DMAPR, Mandsaur, Faizabad, Hisar, Jodhpur and Udaipur. Entries, DTPO 6-6 and DTPO 267-3 had poor or failed germination at Anand, Hisar, Jodhpur and Udaipur. The results showed that, among the locations tested, at five locations, *viz.,* Faizabad, Hisar, Jodhpur and Udaipur, no significant differences were found among the tested entries in the case of seed yield. At Anand, significantly higher seed yield (812.50 kg ha^{-1}) was in the check JI 4 which was at par with entries, MIB 5& MIB 124 and checks RI, Vallabh Isabgol 1 and Vallabh Isabgol 3. At ICAR-DMAPR, significantly higher seed yield was in RI (875.00 kg ha^{-1}), which was however at par with MIB 5, MIB 124 and checks Vallabh isabgol 1 (703.70 kg ha^{-1}).

Evaluation of promising lines

CCSHAU, Hisar: In this trial, 13 entries were evaluated including three checks namely Niharika, GI-2, JI-4 and one Local Check (HI-5). The study revealed that plant height ranged from 34.13 to 38.33 cm), days to 50% flowering ranged from 83.00 to 89.00 days, number of branches ranged from 5.73 to 6.87), number of spikes per plant ranged from 29.47 to 38.87, length of spikes (average of central two spikes) ranged from 4.78 to 5.70 cm, length of peduncle (average of central two spikes ranged from 27.13 to 30.83 cm, number of florets (average of central two spikes ranged from 32.42 to 39.42), number of leaves per plant ranged from 64.75 to 84.80 and seed yield ranged from 175.80 to 370.00 kg ha^{-1}. Significantly higher seed yield was in HI-137 (370.00 kg ha^{-1}) which was however at par with HI-135 (362.50 kg ha^{-1}) and seed yield in the best (HI-5) was check 281.00 kg ha^{-1}.

Maintenance breeding

RVSKVV, Mandsaur: Maintenance breeding of isabgol released variety viz; Jawahar Isabgol-4 was done through selfing and purity was maintained by rouging of off type plants.

Performance of isabgol varieties under varying fertilizer application

MPUAT, Udaipur: The experiment was conducted during 2018-19 to study the performance of isabgol varieties for plant growth and yield parameters. The growth and yield parameters *viz*., plant height (31 cm), number of branches per plant (6.73), number of effective spikes per plant (39.48), spike length (4.55) and seed yield (622.50 kg ha^{-1}) were significantly higher in genotype UI-124 followed by UI-89. The fertility levels significantly affected all the growth and yield parameters. Among the two fertility levels, the growth and yield parameters were proved significantly higher with application of 45 kg N + 30 kg P_2O_5 + 20 kg K_2O ha^{-1}. On the basis of one-year results, it is concluded that UI-124 produced significantly higher seed yield

Effect of biofertilizers, organic and inorganic fertilizers on growth and yield

CCSHAU, Hisar: Field experiment was conducted to study the effect of different doses of

biofertilizers, organic and inorganic fertilizers in different combinations on growth and yield of isabgol. It was observed that treatment receiving N:P 37.5:18.75 kg ha^{-1}+ FYM 10.0 t ha^{-1} was statistically superior in terms of plant height (45.7 cm), number of branches (5.87 $plant^{-1}$), number of effective spikes (44.9 $plant^{-1}$), spike length (5.72 cm) and seed yield (1460 kg ha^{-1}) under Hisar condition.

Impact of plant spacing and nutrient management on growth, yield and quality

NDUAT, Faizabad: Field experiment was conducted during 2018-19 to study the impact of plant geometry and source of nutrients on growth, yield and quality of isabgol. Wider plant spacing (30 cm × 20 cm) produced significantly maximum number of branches (6.10 $plant^{-1}$) as compared to closer spacing. However wider spacing (30 × 20 cm) recorded significantly less seed yield (597.50 kg ha^{-1}) as compared closer spacing (30 × 10 cm) which recorded seed yield of 680 kg ha^{-1}. Maximum seed yield (773.33 kg ha^{-1}) was recorded with application of FYM (20 t ha^{-1}) followed by RDF (50:40:20 kg NPK ha^{-1}) along with 10 t FYM ha^{-1}, while minimum seed yield (503.33 kg ha^{-1}) was recorded under control. The maximum net return (Rs. 32897 ha^{-1}) and benefit cost ratio (1.56) was noted in combination of closest plant spacing with recommended dose of fertilizer.

Integrated disease management of downy mildew and leaf spots/blight diseases

MPUAT, Udaipur: Integrated disease management modules against downy mildew and leaf spots disease (*Alternaria alternata*) of isabgol were evaluated under sick plot and inoculation condition during rabi season 2018-19. Seed treatment with Metalaxyl 35 SD @ 8g kg^{-1} seeds plus three foliar sprays with (Ametoctradin 22.7 % + Dimethomorph 17% SC) @ 0.1% followed by treatment comprising seed treatment with Metalaxyl 35 SD @ 8g kg^{-1} seeds plus three foliar sprays with Copper hydroxide @ 0.30% which resulted in minimum downy mildew disease (10.17;14.89%) with maximum disease control (87.44; 81.61%) and increased percentage of mucilage content (10.77; 12.97 cc g^{-1}) and was statistically significant when compared to the control. However, among the modules against leaf spots, treatment comprising seed treatment with Metalaxyl 35 SD @ 8g kg^{-1} seeds plus three foliar sprays with Tebuconazole 25EC @ 0.10% was found most effective against leaf spot disease with minimum disease (9.60%) when compared to rest of the treatments and the control. Overall, among the IDM modules, treatment comprising seed treatment with Metalaxyl 35 SD @ 8g kg^{-1} seeds plus three foliar sprays with Copper hydroxide @ 0.30% or seed treatment with Metalaxyl 35 SD @ 8g kg^{-1} seeds plus three foliar sprays with Ridomil MZ 72 WP (Mancozeb 64%+ 8% Metalaxyl) @ 0.25% was found effective for management of downy mildew and leaf spots of isabgol.

RVSKVV, Mandsaur: An experiment was conducted on integrated disease management of downy mildew and leaf spot/blight disease of isabgol during rabi season 2016-17 to 2018-19 at Research field, College of Horticulture, Mandsaur. Among the seven treatments, dry seed treatment with Metalaxy 35 SD @ 8 g kg^{-1} seeds plus three foliar sprays with Metalaxyl 72 MZ WP (Mancozeb 64% + Metalaxyl 8%) @ 0.25% first at initiation of disease followed by 15 days interval resulted in minimum disease incidence (17.04 %) and higher seed yield (813.21 kg ha^{-1}) followed by dry seed treatment with Metalaxyl 35 SD plus three foliar sprays with

Mancozeb 75 WP @ 0.25% first at initiation of disease followed by 15 days interval which recorded 24.26% disease incidence and 696.71 kg ha^{-1} seed yield over the untreated control which had 55.92% disease incidence and 459.47kg ha^{-1} seed yield kg ha^{-1}, respectively.

KALMEGH (*Andrographis paniculata*)

It is a branched annual herb of family Acanthaceae and is of about 30-100 cm tall. The species

is distributed in India, Sri Lanka, Bangladesh and Malaysia. The species is commonly known as 'King of bitters'. In India, it is found in the plains of Himachal Pradesh to Assam and Mizoram and also in Peninsular India. The whole herb is medicinally used. Andrographolide is the active principle having the therapeutic action. The herb is used for treating diabetics, bronchitis, pile, jaundice and fever. It is considered as a blood purifier and is used for the treatment of skin diseases. It is cultivated as kharif season crop in Gujarat, Uttar Pradesh, West Bengal, Madhya Pradesh, Orissa, Andhra Pradesh and Tamil Nadu. The plant is propagated by seeds and it is cultivated as a transplanted crop.

Effect of planting time and density for optimum growth and yield of kalmegh

BCKV, Kalyani: The experiment was conducted to evaluate the performance of crop growth and yield under four different plant spacing (30 × 20, 30 × 30, 45 × 30, 45 × 45 cm) for last four years (2015-16 to 2018-19). The pooled effect of different plant spacing showed that the performance of individual plant (107 g plant^{-1}) was better under wider spacing (45 × 45 cm). However, the yield per hectare was significantly higher (10700 kg ha^{-1}) at closer spacing (30 × 20 cm). However, plant height was increased and number of primary branches was decreased in lower spacing. From overall observation it may be concluded that at Kalyani (lower gangetic alluvial plain) spacing of kalmegh may adopted as 30 × 20 cm for higher yield when transplanting in the month of July. However, seedlings planted on 1st June recorded the highest canopy spread (67.77cm) which was significant over other dates of planting. Planting at 1st June recorded more than two-fold increase in canopy (67.77cm) over planting on 1st August.

RVSKVV, Mandsaur: Field experiment was conducted during 2018-19 to study the effect of mode of nitrogen and plant spacing on growth and herbage yield of kalmegh. Result revealed that significantly higher plant height (42 cm), stem girth (6.2 mm), number of branches (16.7) and herbage yield (69 q ha^{-1}) were recorded in the treatment receiving 100% N through RDF as compared to rest treatments. Overall result revealed that due to N level, maximum herbage yield (6900 kg ha^{-1}) recorded in the treatment receiving 100% N through RDF and minimum herbage yield (5900 kg ha^{-1}) in the treatment combination of 50% N through RDF + 50% by organic source. The maximum (6700 kg ha^{-1}) and minimum (5600 kg ha^{-1}) herbage yield was recorded in spacing of 30 × 10 cm and 20 × 7.5 cm.

Organic nutrient management practices for optimum herbage yield of kalmegh

DRPCAU, Pusa: A field experiment was conducted during 2018-19 to study the effect of organic manures, fertilizer and biofertilizers on biomass yield of kalmegh. Application of vermicompost (7.5 t ha^{-1}) recorded maximum fresh biomass (12680 kg ha^{-1}) and found significantly higher than (9250 kg ha^{-1}) FYM (15 t ha^{-1}) application. However, the vermicompost treatment was found at par with application of chemical fertilizer (80:40:20 NPK kg ha^{-1}) and castor cake (2.5 t ha^{-1}). Bio-mass production also varied with the application of bio-fertilizers but the differences were found to be non-significant.

Performance of kalmegh under peach based medicinal agroforestry system

YSPUHF, Solan : Field experiment was conducted for two consecutive years on kalmegh under peach based medicinal agroforestry system applied with organic and inorganic fertilizers. Mean performance of kalmegh was found maximum when it was grown under peach trees with application of chemical fertilizer (NPK 120:60:30 kg ha^{-1}). The maximum plant height (56.89 cm), number of branches (18.96), fresh and dry leaf yield (5890 and 3440 kg ha^{-1}), fresh, dry shoot yield (2412 and 2106 kg ha^{-1}) and net return (Rs. 52537 ha^{-1}) was observed under peach plantation with treatment receiving chemical fertilizer (NPK 120:60:30 kg ha^{-1}). However, the maximum B: C ratio was found under peach tree with application of *Jivamrut*.

LAVENDER (*Lavendula angustifolia*)

Lavandula (common name lavender) is a genus of 47 known species of flowering plants in the mint family, Lamiaceae. It is native to the Old World and is found from Cape Verde and the Canary Islands, Europe across to northern and eastern Africa, the Mediterranean, southwest Asia to southeast India. The most widely cultivated species, *L. angustifolia*, is often referred to as lavender, and there is a color named for the shade of the flowers of this species. The leaves are covered with fine hairs or indumentum, which normally contain the essential oils. Some 100 individual phytochemicals have been extracted from lavender oil, including major contents of linalyl acetate (30-55%), linalool (20-35%), tannins (5-10%), and caryophyllene (8%). The relative amounts of these compounds vary considerably among lavender species. It is also used as a spice or condiment in pastas, salads and dressings, and desserts.

Effect of plant spacing on biomass production

SKUAST, Srinagar: The experiment was conducted to study the effect of plant spacing (30 cm × 30 cm, 30 cm × 45cm & 30 cm × 60 cm) on biomass production. Maximum rhizome yield (10336.6 kg ha^{-1}) was recorded when rhizomes were planted at a spacing of 30 cm × 30 cm followed by spacing of 30 cm × 45 cm (8207.7 kg ha^{-1}). The lowest rhizome yield was observed at 30 cm × 60 cm spacing (5,821.50 kg ha^{-1}). However, maximum rhizome diameter of (74.17 mm) was observed at a spacing of 30 cm × 45 cm followed by spacing of 30 cm × 60 cm (73.08 mm). Similarly, fresh and dry weights of rhizome (292.3 and 113.3 g $plant^{-1}$) were recorded highest at spacing of 30 cm × 45 cm and minimum value of fresh and dry weights

of rhizome (242.03g and 93.03g) recorded with spacing of 30 cm × 30 cm.

LONG PEPPER (*Piper longum*)

It is a member of family Piperaceae. The plant is a slender aromatic perennial herb distributed

in Central Himalayas, Assam, Khasi hills, Bengal, Western Ghats and Andaman and Nicobar Islands. Matured green fruits and roots are used as the raw drug. India imports a large quantity of raw drug from Malaysia and Singapore. The fruits are used as spice also. It has a pepper like taste. Piperine and piplartine are the two important alkaloids responsible for the therapeutic action. In addition, the raw drug contains a number of essential oils. Raw drug is collected both from the wild and cultivated areas. The crop is under cultivation in parts of Maharashtra, Kerala, Assam and Tamil Nadu. Stem cuttings are used for the propagation of the species. From 8th months onwards, fruits are ready for harvesting and in the third or fourth year, the entire plants are uprooted and thicker stem parts and roots are also harvested. The harvested products are sun-dried and used.

MLT evaluation of promising lines of long pepper for high yield and quality

An Initial evaluation trial with two test entries and one check (Viswam) was conducted at three locations *viz*., Bhuvaneswar, Jorhat and Trichur. At Trichur, the crop was lost due to severe flood. Among the two remaining centres, at Bhuvaneswar, dry catkin yield and piperin content was significantly higher in the check Viswam (1135.43 kg ha^{-1} and 5.65) and at Jorhat, the entry JPL 19 had significantly higher yield (1051.87 kg ha^{-1}).

Collection, morphological characterization, evaluation and maintenance of germplasm

AAU, Assam: Thirty accessions of long pepper were evaluated along with check Viswam. It was found that there was lot of variation in the morphological characters of the *Piper longum* cultivars. Leaf size was maximum in the germplasm JPL-17(132.23 cm^2) and the lowest was in JPL-21(25.67 cm^2**).** The differences in leaf length and breadth ratio were found non-significant among the accessions. Most of the accessions had ovate shape and dark green coloured leaves. Internode length was maximum in JPL-11(11.81cm) and the least was in JPL-16 **(**5.05cm). Catkin length ranged from 3.25cm (JPL-19) to 1.56cm (JPL-10). Significantly higher dry pipli yield was in JPL-22 (768.74 kg ha^{-1}) and it was 300.72 kg ha^{-1} in the check Viswam. Piperine content varied from 7.85% to 1.67%. Significantly higher piperine content was in JPL-11 which was however at par with JPL-9 (7.64%).

OUAT, Bhubaneswar: Thirty two accessions collected from different locations and maintained in the germplasm bank of AICRP on MAP&B, Bhubaneswar were catalogued for morphological characters by using the minimum descriptor as recommended by NBPGR, New Delhi for *Piper longum*. Out of 32 accessions evaluated, five accessions such as IC-615522, IC-615523, IC-615520, IC-615515 and IC-615524 were found male and the rest were females. All the accessions showed sub-erect and prostrate growth habit, glabrous stem and leaves and cordate leaf

lamina and leaf base with acuminate tip.

The maximum range of means was noticed for number of spikes per plant (104.75-475.93) followed by dry spike yield per hectare (331.57-550.52 kg) and length of longest vine (103.68-178.40) while the minimum range was observed for fresh weight of spikes (0.20-0.60 g) followed by spike diameter (0.31-0.59 cm).

The fresh weight of spike per plant ranged from 62.83-104.319 (g). Maximum fresh weight of spike plant was recorded with Viswam- check (104.31gram) which was at par with IC-615512 (103.37 g). Numbers of spikes per plant ranged from 104.75 to 475.93. Maximum number of spikes was observed in IC-615529 (475.93) and the minimum was in IC- 615525 (104.75). Dry weight of spikes per plant ranged from 11.94 g (IC-615525) to 19.82 g (Viswam). Dry spike yield ranged from 331.57 kg ha^{-1} (IC-615525) to 550.52 kg ha^{-1} (Viswam). The piperine content ranged from 1.32% (IC-615540) to 2.28% (IC-615519). The piperine yield ranged from 4.66 (IC-615530) to 11.24 kg ha^{-1} (IC-615512). Dry weight of spikes per plant and piperine content showed high heritability coupled with average genetic advance percent of mean which indicated additive gene action for expression of these characters.

The estimates of PCV and GCV were high (>20%) for intermodal length, petiole length, number of spikes per plant and moderate for length of longest vine, leaf length, leaf width, days take for planting to emergence of spike, days taken for planting to 75% emergence of spike, spike length, spike diameter, dry weight of spike per plant and piperine content.

Internodal length (rp=0.394, rg=0.405), spike length (rp=0.475, rg=0.526) and spike diameter (rp=0.533, rg=0.535) exhibited positive correlation with dry spike yield per plant both at genotypic and phenotypic levels. However, the character leaf length (rg=0.303) exhibited positive correlation with dry spike yield per plant at genotypic level but remained non-significant at phenotypic level. Association of other characters like length of longest vine, leaf width, petiole length, days taken from planting to emergence of spike, days taken from planting to 75% emergence of spike, number of spikes per plant and piperine content were found non-significant.

The direct and indirect effects of different yield contributing traits on spike yield were estimated using genotypic and phenotypic correlation coefficient. Length of the longest vine (0.337), internodal-length (0.659), leaf width (0.683), spike diameter (1.236) and days taken from planting to emergence of spike (0.515) had positive direct effect on dry weight of spike per plant. On the other hand, leaf length (-1.520), petiole length (-0.015), spike length (-0.428), days taken from planting to 75% formation of spike (-0.805), number of spikes per plant (-0.028) and piperine content (-0.549) had negative direct effect on dry weight of spike per plant.

Based on the yield and yield contributing characters such as spike length, spike diameter, fresh weight of spike per plant, number of spikes per plant, dry weight of spike per plant and piperine content, accessions IC-615512, IC-615517 and IC-615511were found to be promising as compared to the released variety Viswam.

Evaluation of promising lines for high yield and quality

AAU, Jorhat: Promising lines JPL1 and JPL-19 -19 were tested at three different agro-ecological locations in Assam. The study showed that JPL-19 outperformed the check variety at all the testing locations. At location 1, dry catkin yield was 492.73 kg ha^{-1} in JPL-19 in comparison to 218.17 kg ha^{-1} dry catkin yield in Viswam; at location 2, it was 450.63 kg ha^{-1} in JPL-19 in comparison to 201.14 kg ha^{-1} dry catkin yield in Viswam and at location 3, dry catkin yield was 490.35 kg ha^{-1} in JPL-19 while it was 200.18 kg ha^{-1} in Viswam. The cultivar JPL-19 was superior in terms of piperin content (5.65%) also. Piperine content was 5.05% in Viswam.

Planting method and spacing of long pepper on growth and yield

AAU, Jorhat: A field experiment was conducted to study suitable planting method and spacing in long pepper. It was observed that the plants grown with support yielded maximum dry yield (1551.87 kg ha^{-1}), which was significantly higher than the crop grown without support. In the case of plant geometry, the maximum dry yield was obtained in 60 × 40 cm spacing (1351.87 kg ha^{-1}). The other yield attributing parameters were also found superior in the crop grown with support and plant spacing of 60 × 40 cm.

Integrated nutrient management on growth and yield

AAU, Jorhat: The field experiment was conducted to study the effect of INM on yield and contributing parameters**.** There were significant differences in yield and yield attributing characters of the *Piper longum* due to different INM treatments. Among the INM treatments maximum dry yield (567.25 kg ha^{-1}) was obtained in the treatment receiving NPK 175:75:75 kg ha^{-1} + FYM (10 t ha^{-1}) + neem cake (5 q ha^{-1}) and it was minimum in the treatment receiving FYM (10 t ha^{-1}). This may be due to insufficient supply of nutrient or uptake. Similar trend was also noticed in other yield contributing characters.

Effect of organic sources of nutrients on plant growth and yield

OUAT, Bhubaneswar: Applications of different organic manures were found effective in increasing the growth and yield of long pepper. Treatment receiving FYM @ 20 t ha^{-1} (100 % substitution of recommended dose of nitrogen) resulted in maximum values for the traits such as plant height (68.3 cm), number of leaves per plant (83.78), leaf area (77.38 sq cm), number of catkins per plant (218.65), dry weight of catkin (961.90 kg ha^{-1}) and piperine yield (15.29 kg ha^{-1}). However, the piperine content of long pepper was not influenced by the application of organic manures.

Field trial on management of basal stem rot of long pepper caused by *Sclerotium rolfsii*

AAU, Jorhat: Result showed that basal stem rot incidence was lowest (7.23%) when carbendazim was applied in the soil. This was followed by soil application of mustard oil cake (MOC) @1kg per plot fortified with *T. harzianum* @ 5 ml m^{-2} and soil application of *Trichoderma* sp. @5 ml m^{-2} with disease incidence of 10.65% and 14.98%, respectively. After 90 days of application of treatments, population dynamics of *T. harzianum* was recorded and it was found to be increased from $4.87X10^3$ to $8.46X10^5$ cfu g^{-1} of soil in plots where soil application of MOC @1kg per plot fortified with *T. harzianum* @ 5 ml m^{-2}. This was followed by soil application of *T. harzianum* @ 5 ml m^{-2}. No population of *Trichoderma* was

observed in plots treated with carbendazim @0.3%. Plant growth parameter like plant height, internode length, catkin number per plot and yield per plot were found highest in plot where soil application of MOC @1kg per plot fortified with *T. harzianum* @5ml m^{-2} was done.

MUCUNA (*Mucuna pruriens*)

The species is a pubescent annual climber belonging to family Leguminoseae. The fruit (pod) is covered densely with stinging hairs. It is distributed almost throughout India and also cultivated in limited areas. The seeds are used to treat, Parkinson's disease, sexual disorders, cholera, urinary troubles and liver and gall bladder diseases. L-dopa present in the seeds is the active principle responsible for therapeutic action. Seeds are used for propagation and sowing is done at the onset of monsoon at a spacing of 60x60 cm. Land preparation is made with the addition of FYM @ 10q/ ha. Since it is a climber, support is required and irrigation is given during the dry season at 30 days intervals. Flowering starts after 40 days of growth and pods picking is done 3-4 times per season. An average of 35q ha-1 seeds are harvested.

Evaluation of promising lines for high yield and quality under MLT

An advanced evaluation trial I (AVT I) with five test entries and one check (CIM-Ajar) was conducted at five locations viz., DMAPR, Raipur, Ranchi, IIHR and Venkataramannagudem (VR gudem) with an objective to identify superior varieties with high yield and quality. At DMAPR, the crop failed due to viral infection. Pod yield data were not reported by Raipur centre. At Ranchi, the entries did not vary significantly in the case of pod yield. At IIHR, Arka Dhawatari showed significantly higher pod yield (4608.90 kg ha^{-1}) and at VR gudem, none of the entried could out-perform the check CIM Ajar. In the case of seed yield, at Raipur and Ranchi, the entries did not show significant differences. At IIHR, Arka Dhanwantari had significantly higher seed yield (2353.87 kg ha^{-1}), however it was at par with the check CIM Ajar and entries IIHR Sel 2, IIHR Sel 3 and IIHR Sel 8.

Studies on floral biology

YSRHU, Venkataramannagudem: Flower of makoi is regular (Actinomorphic), white to pale purple in colour; corolla is wheel shaped, 5 lobed, 6-4 mm wide; calyx is fused, companulate, deeply 5 lobed; stamens consists of 5 anthers in a conical group; gynoecium is composed of 2 fused carpels; inflorescence is 3-8 flowered cyme and pedunculate. Anthesis time was between 5.00 am to 6.00 am. It was found that during anthesis period *i.e.,* between 5.00 am to 6.00 am, relative humidity was 53% and temperature was 26°C. Pollen was released for 2 days from anthesis day onward. Flower remained as visual flag for 10 days to the pollinators. Pollinators were small bees and syrphid flies.

Epidemiological studies on yellow mosaic disease

YSRHU, Venkataramannagudem: Epidemiological studies on yellow mosaic viral (YMV)

disease of mucuna varieties indicated that YMV disease incidence had significant positive correlation with white fly population in local variety only, while pooled data analysis revealed that there was significant positive correlation in all the varieties. Similarly whitefly population as well as YMV disease incidence in six varieties correlated with weather parameters during 2018-19 and pooled data of 5 years showed that whitefly population had significant negative correlation with maximum temperature in Selection-3 and Selection-8, while it had significant positive correlation with minimum temperature and evening relative humidity in Selection-2 and Selection-8 during 2018-19. Pooled data revealed that Whitefly population had significant negative correlation with maximum temperature (except local variety), minimum temperature and rainfall in all the varieties.

In all the varieties YMV disease incidence had significant negative correlation with minimum temperature (except Arka Aswini), while it had significant negative correlation with evening relative humidity (except Arka Dhanvanthari) during 2018-19. Pooled data revealed that YMV disease incidence had significant negative correlation with minimum temperature, morning relative humidity and evening relative humidity in all the five IIHR varieties. Pooled data revealed that YMV disease incidence had significant negative correlation with minimum temperature and minimum relative humidity in all the five IIHR varieties.

MADHUNASHINI (*Gymnema sylvestre*)

It is a pubescent woody climber belonging to family Asclepiadaceae. Leaves are 2-5 cm long and

1.2-3.0 cm broad, usually elliptic ovate or ovate lanceolate, upper surface dark green, shining, under surface pale green, shortly pubescent at venation. It grows naturally in Western ghats, Konkan area, Tamil Nadu, Madhya Pradesh and in some parts of Bihar. The leaves are saltish and acidic and they suppress the activity of taste buds of tongue for sweet taste hence the name Madhunashini or Gurmar. It is prescribed as antidiabetic. The sugar suppressing constituent of the species is found as mixtures of triterpine saponins which are designated as gymnemic acids. The plant is propagated mainly by stem cuttings and also by seeds.

Collection, characterization, evaluation and maintenance of germplasm

TNAU, Coimbatore: Sixty six accessions of *Gymnema sylvestre* were characterized for morphological and yield characters. The collected accessions were multiplied and planted in the main field. Passport data was submitted to NBPGR along with germplasm deposition certificate from DMAPR and the IC numbers were obtained. The characterization of germplasm was made based on the Kew Plant Glossary. Based on the characterization, variations were observed for leaf characters *viz.,* leaf shape, leaf base leaf tip and leaf pubescence. Leaf shape varied from ovate, elliptic and lanceolate. 24% of the germplasm had ovate shaped leaves; 15 % of the germplasm had elliptic shape and 12% had lanceolate shape. The shape in other entries *ie* 48 % of the germplasm had shape which varied from ovate-elliptic, elliptic-ovate,

ovate- lanceolate and ovate-oblanceolate. Of the varied leaf shapes observed, ovate with round base is common and considered as reference or check. The accession TN*GSy* 33–IC-0630536 which is collected from Palani, Dindigul district of Tamil Nadu is the reference genotype which has ovate shaped leaves with round base and acute tip. Pubescence is present in the leaves. Accession TN*GSy*55-IC-0630558 was found as an elite genotype which has elliptic shape with obtuse base and acute tip. Pubescence is absent in the leaves. The accession was collected from Mettupalayam taluk of Coimbatore district. Compared to the reference genotype, the elite genotype TN*GSy*-55–IC-0630558 varied for leaf shape, leaf base and leaf pubescence. Observations on morphological and yield characters were recorded for the 66 accessions and the *per se* performance of the genotypes ranged from 2.40- 4.58 cm for leaf length; 1.57 - 2.90 cm for leaf breadth; 0.47 - 1.37 cm for petiole length and 1.07- 2.74 cm for intermodal length. The *per se* performance for leaf dry weight ranged from 0.08- 0.75 kg and 0.48-1.54 % for gymnemagenin content. The elite genotype recorded leaf length of 2.57cm; leaf breadth of 2.17cm; petiole length of 1.14cm; intermodal length of 1.69 cm and leaf dry weight of 0.26 kg plant^{-1} with gymnemagenin content of 1.07%. Application was submitted to NBPGR Germplasm Registration Information System (Application number R.0012420052, dt : 07.03.2020) for registering as elite line with distinct traits *viz*., elliptic leaf shape with obtuse base.

Planting time and spacing on growth and yield parameters

BAU, Ranchi: *Gymnema sylvestre* were transplanted in experimental field with three time of transplantation *viz*. mid July, mid August and mid September at spacing of 40 × 30 cm, 50 × 40 cm and 50 × 50 cm. Maximum fresh (75844.9 kg ha^{-1}) and dry (35156.8 kg ha^{-1}) biomass yields at harvesting period were recorded from treatment combination of mid July transplantation at spacing levels of 30 cm × 40 cm and minimum in treatment combination of mid August transplantation at spacing levels 50 cm × 50 cm (27573 kg ha^{-1}). Leaf yield was recorded maximum (14137.6 kg ha^{-1}) in the treatment combination of mid September transplantation at spacing levels of 30 cm × 40 cm.

Integrated nutrient management on growth and yield parameters

BAU, Ranchi: The experiment was conducted to study the effect of integrated nutrient management on growth and yield of madhunashini. The highest survival percentage of transplanted plants (77.78 %) was observed in the treatment receiving 5 t ha^{-1} vermicompost + 5 t ha^{-1} castor cake + 5 t ha^{-1} neem cake + 30:40:40 kg NPK ha^{-1}. Maximum yield of dry leaves (5208.3 kg ha^{-1}) was recorded in 10 t ha^{-1} vermicompost +10 t ha^{-1} neem cake +10 t ha^{-1} castor cake +50:50:50 kg NPK ha^{-1}. However, maximum productivity of leaves and stem was observed in the treatment receiving optimum doses of organic and inorganic fertilizer *i.e.,* 10 t ha^{-1} vermicompost + 10 t ha^{-1} neem cake +5 t ha^{-1} castor cake + 30:40:40 kg NPK ha^{-1}.

Screening of *Gymnema* accessions against leaf webber

TNAU, Coimbatore: Resistance damage rating scale of 0 (no damage); 1 (slight damage, <25% damage), 3 (more damage, 25-50%) and 5 (complete damage, > 50% damage) was developed for *Gymnema* leaf webber**.** As the leaves are economic part in *Gymnema,* the present damage rating scales will be highly useful for identifying the resistance accession/line for future

breeding programmes against leaf webber.

Resistance damage rating scale for *Gymnema* leaf webber developed at TNAU, Coimbatore

Based on the damage rating scale developed, 66 *Gymnema* genotypes were screened to know the level of resistance to leaf webber under field condition and the genotypes were grouped as follows:

Sl. No	Accession number	Resistance level	Damage rating scale
1	Gsy20, Gsy23, Gsy28, Gsy37, DMAPR- Gs	Resistant	0
2	Gsy1, Gsy16, Gsy22, Gsy24, Gsy30, Gsy31, Gsy34, Gsy35, Gsy38, Gsy39, Gsy40, Gsy43, Gsy45, Gsy51, Gsy52, Gsy56, Gsy57, Gsy64	Moderately resistant	1
3	Gsy2, Gsy4, Gsy5, Gsy 9, Gsy10, Gsy11, Gsy12, Gsy13, Gsy14, Gsy18, Gsy19, Gsy21, Gsy24, Gsy32, Gsy33, Gsy42, Gsy44, Gsy47, Gsy50, Gsy53, Gsy54, Gsy55, Gsy60, Gsy61, Gsy66	Susceptible	3
4	Gsy3, Gsy6, Gsy7, Gsy8, Gsy15, Gsy17, Gsy36, Gsy41, Gsy48, Gsy49, Gsy59, Gsy62	Highly susceptible	5

In *Gymnema sylvestre*, assessment of damage intensity caused by leaf webber infestation was recorded as 1.98 kg dry herbage per plant in protected cultivation and 0.93 kg dry herbage per plant in unprotected cultivation.

Eco-friendly IPM modules for Gymnema leaf webber

The experiment was carried out with three treatments *i.e.*, T_1: eco friendly IPM module comprising, soil application of neem cake @ 250kg ha^{-1}; first spray with NSKE 5% @ 2.5ml lit^{-1} followed by second spray with *Beauveria basiana* 5g lit^{-1}, third spray with *Bacillus thuringensis* 5g lit^{-1}, growing cow pea as border crop to encourage natural enemy activity, release of Chrysoperla @10000 grub; T_2: Conventional farmers' practice (Chlorpyriphos 2ml/ litre) and T_3: Control. The results revealed that the population of *Gymnema* leaf webber was significantly low in T1 (5.2 webber $plant^{-1}$) on 14 DAT as compared to T_2 *i.e.,* conventional farmers' practice (15.6 webber $plant^{-1}$) on 14 DAT. Subsequently, the percent defoliation was significantly lower in T_1 (2.9%) than T_2 (5.4%) when compared to the check (10.7%).

OPIUM POPPY (*Papaver somniferum*)

It belongs to family Papaveraceae. opium and poppy seeds are obtained from this species. The

latex collected from the capsule is otherwise known as opium and is medicinally important. Seeds are also used for culinary purposes. Opium is the source of many opiates, including morphine, thebaine, codeine, papaverine and noscapine. The Latin botanical name means, the "sleep-bringing poppy", referring to the sedative properties of the species. Opium poppy is the only species of Papaveraceae that is an agricultural crop grown on a large scale. It is a rabi sown crop and its

cultivation is restricted by the Narcotics Department under licensing system. Seeds of opium poppy are the source of poppy seed oil, a healthy edible oil that has many uses. It is widely grown as an ornamental flower throughout Europe, North America, South America and Asia.

MLT evaluation of promising lines of opium poppy for higher yield and quality

Advanced varietal trial with five test entries (UOP20, UOP79, UOP80, MOP278 and MOP511) and two checks (Chetak Aphim and JOP540) was conducted at three locations Udaipur, Mandsaur and Faizabad with an objective to identify superior varieties with high yield and quality. Across locations, at two locations *i.e.,* Mandsaur and Udaipur, there were no significant differences among the test entries and checks in the case of latex yield. At Faizabad, significantly higher latex yield was in the entry UOP 20 (26.87 kg ha^{-1}) which was however, at par with the checks, JOP 540 and Chetak Aphim. Differences in seed yield were non-significant among the entries in the case of seed yield at Udaipur. At Faizabad, entry MOP 511 had significantly higher seed yield (564.24 kg ha^{-1}) which was at par with entries, UOP 20, and UOP 80 and checks, JOP 540 and Chetak Aphim.

Evaluation, maintenance and utilization of germplasm

MPUAT, Udaipur: A total of 85 germplasm lines maintained as genetic stock were evaluated. The observations were recorded for individual lines for plant height, peduncle length, number of effective capsule per plant, stem diameter, days to 50% flowering, dry latex yield, seed yield husk yield and morphine content. A total of sixteen lines *viz.*, UOP-30, UOP-37, UOP-53, UOP-64, UOP-68, UOP-70, UOP-71, UOP-79, UOP-93, UOP-124, UOP-125, UOP-128, UOP-145, UOP-149 ,UOP-154 and UOP-179 exhibited higher oven dry latex yield over the best check, Chetak Aphim (44.52 kg ha^{-1}) while overall trial mean was (38.38 kg ha^{-1}). Latex yield ranged from 26.03 kg ha^{-1} to 59.21kg ha^{-1}. Nineteen lines exhibited higher morphine content over the check Chetak Aphim (11.89%). In another trial, 15 test entries were evaluated against two checks *viz.*, Chetak Aphim and JOP-540 for latex, seed, and husk yield and other yield contributing traits. Among these test entries, two entries *viz.*, UOP-30 (35kg ha^{-1}) and UOP-35 (35 kg ha^{-1}) were found statistically at par with the best check Chetak Aphim (34 kg ha^{-1}) for latex yield. General mean of this trial for latex yield was 30 kg ha^{-1}. While the latex yield ranged from 25 kg ha^{-1} to 35 kg ha^{-1}. In addition to latex yield, test entry UOP 30 also gave maximum seed yield (1236kg ha^{-1}) but it was statistically at par with the best check Chetak Aphim (1222 kg ha^{-1}). The seed yield of trial ranged from 977 kg ha^{-1} to 1236 kg ha^{-1}, while general mean of the trial was 1131 kg ha^{-1}. The test entry UOP-30 gave maximum husk yield (1102 kg ha^{-1}), but it was at par with Chetak Aphim (1092 kg ha^{-1}). The overall mean of husk yield of this trial was 981 kg ha^{-1} with the range varied from 805 kg ha^{-1} to 1102 kg ha^{-1}.

Maintenance breeding of opium poppy variety

RVSKVV, Mandsaur: Maintenance breeding of all three varieties *i.e.,* Jawahar Aphim -16 (JA-16), Jawahar Opium Poppy -539 (JOP-539) and Jawahar Opium Poppy -540 (JOP-540) were done through selfing and single plant selection methods and purity was maintained by rouging of off type plants.

MPUAT, Udaipur: Maintenance breeding of Chetak Aphim were carried out.

Performance of opium poppy varieties under various level of nutrient application

MPUAT, Udaipur: The experiment was conducted during 2018-19 to study the performance of varieties and fertility level for yield and quality parameters. The growth and yield parameters *viz*., plant height at harvest (90.87 cm), number of effective capsules per plant (3.36), capsule diameter (43.68 mm), latex yield (46.15 kg ha^{-1}), seed yield (1120.3 kg ha^{-1}), husk yield (1123.83 kg ha^{-1}) and morphine content (11.98 %) were observed significantly superior with the genotype Chetak aphim followed by UOP-20 and UOP-80. The fertility level failed to record perceptible variation in growth parameters except plant height at harvest. On the basis of one-year results, it is concluded that Chetak aphim was superior to the other genotypes.

Drip irrigation on growth and yield of opium poppy

RVSKVV, Mandsaur: The field experiment was conducted during 2018-19 to study the effect of irrigation system on growth and yield parameters. Under irrigation systems, maximum plant height (102 cm), seed yield (1150 kg ha^{-1}) and highest latex yield (60 kg ha^{-1}) were recorded under treatment receiving surface flood irrigation and was significantly higher as compared to drip irrigation.

Plant spacing and nitrogen levels on the growth and latex yield

RVSKVV, Mandsaur: Field experiment was conducted during 2018-19 to study the effect of plant density and nitrogen levels on growth and seed yield parameters of opium poppy. The maximum plant height (106.7 cm) and seed yield (1166.6 kg ha^{-1}) were recorded in the treatment receiving 160 kg N ha^{-1} under different plant densities. Among the plant densities tested, maximum latex yield (60.7 kg ha^{-1}) was recorded in plant density of 4 lakhs ha^{-1} and minimum latex yield (56.3 kg ha^{-1}) was in plant density of 7 lakhs ha^{-1}. Maximum plant height (107.7 cm), seed yield (1175 kg ha^{-1}) and latex yield (59.5 kg ha^{-1}) was recorded in the treatment receiving 160 kg N ha^{-1} among the different nitrogen levels.

Evaluations of integrated disease management modules against bacterial blight and stem rot disease

MPUAT, Udaipur: The IDM modules, in-furrow soil application of neem cake mixture (100g sqm^{-1}) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus seed treatment with Streptocycline @ 0.035% plus drenching of Copper oxychloride 50 WP @ 0.3% at 40, 55 and 70 DAS followed by drenching of Copper hydroxide 77 WP @ 0.3% at 40, 55 and 70 DAS was found best in management of bacterial stem rot (Percentage Efficacy of Disease Control- PEDC 81.03%- 86.07%) and blight disease (PEDC 81.75-86.96%) of opium poppy. In-furrow soil application of neem cake mixture (100g sqm^{-1}) individual application of *Pseudomonas* enriched talc based formulation @ 2.0% at sowing or *Trichoderma* talc based formulation at 40, 55 and 70 DAS were moderately effective for management of bacterial stem rot (PEDC-35.82- 45.15%) and blight disease (PEDC- 43.59-49.66%) when compared to the control.

NDUAT, Faizabad: The disease management organic modules against bacterial blight and stem rot disease of opium poppy were evaluated under inoculation condition during 2018-19. Among

the organic disease management modules against bacterial blight disease, the use of neem cake mixture (100g m^{-2}) enriched with *Trichoderma* +*Pseudomonas* @ 2.0% at sowing + seed treatment with Streptocycline @ 0.035% plus drenching with Tebuconazole 25 EC @ 0.1% at 40, 55 and70 DAS resulted in minimum bacterial blight disease (23.39%) with maximum disease control of (68.39%) which ultimately yielded highest dry latex powder (47.77 kg ha^{-1}), seed (1417 kg ha^{-1}) and capsule husk (958 kg ha^{-1}) compared to the untreated inoculated control followed by the use of neem cake mixture (100g m^{-2}) enriched with *Trichoderma* + *Pseudomonas* @ 2.0% at sowing + seed treatment with Streptocycline @ 0.035% plus drenching with Hexaconazole 5 EC @ 0.1% at 40, 55 and 70 DAS which yielded dry latex powder of 43.42 kg ha^{-1}, seed of 1271 kg ha^{-1} and capsule husk of 896 kg ha^{-1} when compared to the untreated inoculated control; while the highest percent disease intensity and lowest disease control were observed in neem cake mixture (100g m^{-2}) enriched with *Trichoderma*+ *Pseudomonas* @ 2.0% at sowing plus seed treatment with Streptocycline @ 0.035% plus drenching with Copper hydroxide @ 0.3% at 40, 55 &70 DAS which yielded dry latex powder of 43.25 kg ha^{-1}, seed of 1375 kg ha^{-1} and capsule husk of 937 kg ha^{-1} when compared to the untreated inoculated control whereas the morphine content ranged from 12.73 to 12.20% as compared 12.20% in the control which indicated that there was no marked difference in morphine content by the treatments.

PASHANBHED (*Bergenia ciliata*)

Bergenia ciliata (Family: Saxifragaceae) commonly known as *pashanbhed,* is a medicinal plant used for the treatment of kidney stones. *B. ciliata* is being used to cure 104 different types of ailments. *B. ciliata* showed high potential in the treatment of gastro-intestinal disorders; it is well known for the treatment of kidney disorders particularly kidney stones. Moreover, *B. ciliata* was reported to possess high antifungal, antiviral, anti plasmodial and antibacterial activities. Pharmacological studies reported that it has good anti-oxidant, anti-inflammatory, anti-tussive, anti-ulcer and anti-neoplastic activities. Variety of secondary metabolites belonging to different classes of compounds such as phenols, alcohols, terpenoids and fatty acid were reportedly isolated from *B. ciliata*. The plant is harvested from the wild for use as a medicine and sometimes also for food.

Studies on reproductive biology

UBKV, Kalimpong:

Flower phenologies were studied in the field for two successive years (2018 and 2019) at 11th Mile, Tirpai in Kalimpong located at 1263 m altitude. Regular field visits were done in the peak flowering time during both seasons. To study the floral phenology, flower buds (N=522 in 2018 and N=625 in 2019) that would open next day were tagged and kept under observation to record anthesis, other floral changes until they senesced. Number of buds opened every 1/2 hour interval was counted and floral changes was also observed in the same way.

The species inhabits mainly on rocky slopes and walls. Anthesis started early morning between 6:30 am and 9:30 am in peak flowering season. Flowering started from early January and lasted till second week of March in 2018. The flowering came late in 2019, which started from late January and ended by last week of March. The maximum number of flower in 2018 was in between 31/01/2018 to 12/02/2018 of January and February and in 2019 it was between 12/02/2019 and 24/02/2019 of February. Freshly opened flowers were pinkish-white to white-pinkish in colour. During senesce the flower colour changed to pale yellowish-brown to brown and finally withered.

Pollination studies conducted revealed maximum fruit set of 90.80% in autogamy (selfing by bagging), while it was 49.50% under controlled xenogamous conditions whereas 42.40% fruit set in flowers subjected to controlled geitonogamy. Maximum seed yield per capsule of 25.80 mg was observed under autogamy (selfing by bagging) pollination, followed by 13.10 mg obtained in flowers subjected to controlled geitonogamy. Minimum seed yield of 6.80 mg per capsule was recorded in flowers subjected to controlled xenogamy.

SAFED MUSLI (*Chlorophytum borivilianum*)

It belongs to family Liliaceae. There are a number of *Chlorophytum* species, which are known under the trade name 'safed musli' of which *C. borivilianum* is the commercially exploited species. The plant is a perennial herb with condensed stem disc. Fasciculated roots contain saponins and are medicinally important. It is used as a general tonic and is a well-known aphrodisiac. The species is naturally distributed in the forest areas of Maharashtra, MP, Rajasthan and Gujarat. Unorganized collection of the species from the natural habitat has caused "critically endangered" IUCN species conservation status. The plant is propagated by the stem disc with the attached fleshy roots as well as by seeds. The cultivation of *C. borivilianum* in India has been carried out in many parts of India *viz*., Chhattisgarh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh.

Collection, maintenance and evaluation of germplasm

PDKV, Akola: Sixteen genotypes were evaluated and the results revealed that fleshy root length per plant recorded highest in genotype AKSM-13 (8.62 cm) followed by AKSA-14 (8.52 cm) and AKSM-08 (8.44 cm) and it was recorded lowest in AKSM-04 (3.80 cm). The dry fleshy root weight per plant was found highest in genotype AKSA-07 (5.80 g) followed by AKSA-08 (5.60 g), AKSA-09 (5.20 g) and AKSA-02 (5.20 g) and it was recorded the lowest in genotype AKSA-04 (3.80 g). Saponin content ranged from 9.01% in AKSM-07 to 8.22% in AKSM-11.

Maintenance breeding of safed musli variety

RVSKVV, Mandsaur: Maintenance breeding of two varieties of safed msuli *viz*., Jawahar Safed Musli - 405 (JSM-405) and Raj Vijay Safed Musli -414 (RVSM-414) was done through

vegetative propagation and purity maintained by rouging of off type plants.

SARPAGANDHA (*Rauvolfia serpentina*)

It is a perennial under-shrub belongs to family Apocynaceae, distributed throughout India. The species attain a height of about 75 cm to 1 m. Roots contain alkaloids (reserpine, desrpidine and reseinamine) which are sedative and used to control high blood pressure. It is also used for the treatment of insomnia, asthma and acute stomach-ache. Ruthless collection of the species from its wild habitats developed stress to the plant stand in its natural habitats and the Government of India has prohibited its collection from the wild. The crop is under cultivation and propagated mainly by seeds. Tropical humid climate is better for a good crop growth. Seedlings are transplanted during the rainy season. The crop is ready for harvesting after about 18 months.

Characterization of germplasm

OUAT, Bhubaneswar: Seventy five accessions of sarpagandha were characterized. The results revealed that IC-0615448 recorded maximum leaf length (15.55 cm) followed by IC-0615479 (15.12 cm) and minimum leaf length (4.66 cm) was recorded in IC-0615444. The highest leaf breadth was recorded in IC-0615498 (5.32 cm) followed by 4.90 cm (IC-0615493) and minimum leaf width was in IC-0615500 (1.62 cm). IC-615447 showed the highest leaf length to breadth ratio (5.61) followed by IC-0615462 (5.23) and the minimum was recorded by IC-0615439 (1.82). The highest length of petiole was 1.10 cm (IC-0615466) followed by 1.06 cm (IC-0615453 and IC-0615483) while minimum length of petiole was observed to be 0.12 cm (IC-0615454). Minimum inter nodal length was found to be 1.34 cm (IC-0615444 and IC-0615475) followed by 2.10 cm (IC-0615468 and IC-0615469) while maximum internodal length was recorded to be 5.84 cm (IC-0615489) followed by 5.67 (IC-0615475). All the accessions exhibited erect growth habit except three accessions such as IC-0615496, IC-0615497 and IC-0615498 which showed semi erect growth habit. All the accessions also showed verticillate type of leaf arrangement and Oblanceolate leaf shape with acute leaf apex. Leaf colour of the accessions varied from dark green to light green.

Effect of planting time and spacing on growth and yield

BAU, Ranchi: Field experiment was conducted to study the effect of transplanting time spacing on growth and yield parameter. The maximum primary root length (74 cm) at harvesting period was recorded from treatment combination of mid May transplantation at spacing level of 30 cm × 40 cm. Similarly, the highest fresh root (7129.2 kg ha^{-1}) and dry root (2844.0 kg ha^{-1}) yields at harvesting period were recorded from treatment combination of mid May transplantation at spacing level of 30 cm × 40 cm.

Effect of integrated nutrient management on growth and yield

BAU, Ranchi: Field experiment was conducted in 2018-19 to study the effect of different

fertilizer treatments on growth and yield parameters. The maximum primary root length (61.75 cm) was recorded in the treatment receiving 10 t ha^{-1} vermicompost + 10 t ha^{-1} neem cake + 5 t ha^{-1} castor cake + 30:40:40 kg NPK ha^{-1} while the maximum secondary root length (46.67 cm) was recorded in treatment receiving 7.5 t ha^{-1} vermicompost + 5 t ha^{-1} neem cake + 7.5 t ha^{-1} castor cake + 40:50:40 kg NPK ha^{-1}. However, the maximum root collar diameter (11.43 mm) was also found in the treatment receiving 7.5 t ha^{-1} vermicompost + 5 t ha^{-1} neem cake + 7.5 t ha^{-1} castor cake + 50:50:50 kg NPK ha^{-1}. The maximum production of fresh root yield (2846.7 kg ha^{-1}) was recorded under combination of organic and inorganic treatments receiving 10 t ha^{-1} vermicompost + 10 t ha^{-1} neem cake + 5 t ha^{-1} castor cake + 30:40:40 kg NPK ha^{-1}. Similarly the higher dry root yield (1455.6 kg ha^{-1}) was recorded in the treatment receiving 7.5a^{-1} vermicompost +5 t ha^{-1} neem cake +7.5 t ha^{-1} castor cake +30:40:40 kg NPK ha^{-1}.

Effect of organic manures on growth

OUAT, Bhubaneswar: Application of FYM @ 20 t ha^{-1} (100% substitution of recommended dose of nitrogen) in sarpagandha recorded maximum plant height, primary branches and LAI at 12 months after planting. Overall, maximum aerial growth was observed under treatment of FYM @ 20 t ha^{-1}) as compared to the rest of the treatments.

SATAVARI (*Asparagus racemosus*)

The plant belongs to family Liliaceae. It is a creeper and is common throughout India and the

Himalayas. The roots are used in Ayurvedic medicine, as an anodyne, aphrodisiac and galactogogue. Satavari is considered to be a main Ayurvedic rejuvenating female tonic for overall health and vitality. In the Ayurveda, A. racemosus is commonly mentioned as a rasayana drug which promotes general well being of an individual by increasing cellular vitality or resistance. The reputed adaptogenic effects of satavari are attributed to its concentrations of saponins. Cultivation of the species is very limited and under cultivation, it is propagated through seeds. Fleshy roots are harvested, peeled and shade dried and used for the drug preparations.

Effect of organic manures and bio-fertilizer on root yield

DRPCAU, Pusa: The field experiment was conducted during 2018-19 to study the effect of organic manures on root yield and quality of satavari. Application of vermicompost (2 t ha^{-1}) + mustard cake (1 t ha^{-1}) inoculated with the bio-fertilizers PSB (5 kg ha^{-1}) and *Azospirillum* (2 kg ha^{-1}) produced significantly higher root yield (16250 kg ha^{-1}) whereas minimum root yield (11280 kg ha^{-1}) was recorded with treatment vermicompost (2 t ha^{-1}) + *Azospirillum* (2 kg ha^{-1}).

Various crop spacing and nutrient management on growth and root yield

IGKV, Raipur: Different crop geometry of satavari influenced significantly the number of branches per plant, root length and number of fleshy roots per plant. Maximum fresh (185.1 q ha^{-1}) and dry root (22.76 q ha^{-1}) yields were obtained with crop spacing of 60 cm × 60 cm

followed by 90 cm × 90 cm and 120 cm × 120 cm. The highest number of branches per plant (16.72), fleshy root length (53.46 cm) , number of fleshy root per plant (294) and fresh root yield (1496.3 g plant^{-1}; 16358 kg ha^{-1}) and dry root (2017 kg ha^{-1}) yields were found with application of FYM (20 t ha^{-1}) and 80:60: 50 kg NPK ha^{-1} which was superior to the other treatments. The study revealed that crop spacing of 60 cm × 60 cm with application of 20 t FYM ha^{-1} and 80:60:50 kg NPK ha^{-1} produced significantly highest dry root yield (2630 kg ha^{-1}) which was superior to the other treatment combination.

Effect of integrated nutrient management on root growth and yield

JNKVV, Jabalpur: The experiment was conducted during 2018-19 to standardize a suitable nutrient dose for maximizing high root yield in satavari. The treatment having integration of 50% recommended dose of NPK + 50% through FYM recorded maximum number of fleshy roots (317 plant^{-1}), maximum fleshy root length (37.4 cm) and fleshy root diameter (16.2 mm), and highest fresh root yield (4690 g plant^{-1}) and dry root yield (748.25 g plant^{-1}). Whereas, the minimum number of fleshy roots (265 plant^{-1}), fleshy root length (28.5 cm), fleshy root diameter (14.7 mm), fresh root yield (4065 g plant^{-1}) and dry root yield (582.75 g plant^{-1}) were recorded with FYM alone (100% N through FYM).

Integrated management of leaf spot of sarpgandha

RPCAU, Pusa: The data on effect of *Trichoderma* as soil treatment and seedling treatment along with foliar spray of neem oil and fungicides on development of leaf spot of sarpgandha revealed that soil incorporation of FYM 10 t ha^{-1} inoculated with *Trichoderma harzianum* formulation (10g kg^{-1} FYM) combined with seedling treatment with *T. harzianum*@ 10g lit^{-1} of water for 10 minutes and foliar spray with neem oil @ 5ml lit^{-1} of water as preventive measure accompanied with one spray of *Propiconazole* or carbendazim 1ml lit^{-1} of water just after appearance of the symptom was found highly effective in controlling the disease development (8.7 %PDI) over the control (29.50% PDI).

SENNA (*Cassia angustifolia*)

It belongs to family Caesalpiniaceae. There are two species of *Cassia viz., C. angustifolia* and *C. acutifolia* (= *C. senna*) which are known under the common name senna. It is cultivated mainly in India and Pakistan. Senna is recognised by British and US pharmacopoeias also. Leaves, tender pods and flowers are medicinally important. The glucosides, sennosides A and B are the major active principles responsible for the therapeutic action of the crop. It is useful in habitual costiveness. It lowers bowels, increases peristaltic movements of the colon by its local action upon the intestinal wall. It is used as expectorant, wound dresser, antidysentric, carminative and laxative. It is also useful in loss of appetite, hepatomegaly, spleenomegaly, indigestion, malaria, skin diseases, jaundice and anaemia. It is propagated by seeds and normally cultivated as post kharif crop.

Evaluation of promising lines of senna

Advance varietal trial II (AVT II) with four test entries and three checks (ALFT-2, Sona and KKM-01) was conducted at four locations *viz*., Anand, Coimbatore, DMAPR and Rahuri. The results showed that at Anand, Coimbatore and Rahuri, the entries showed no significant differences in the case dry leaf yield. At DMAPR, significantly higher dry leaf yield was in A16-18 (7197.53 kg ha $^{-1}$) which was however at par with the checks, KKM 1 and Sona and entries DCA 149 and DCA 96. Total sennosides yield was significantly higher in DCA 96 at Anand (157.88 kg ha^{-1}) and Rahuri (40.36 157.88 kg ha^{-1}), however at Anand it was at par with the checks Sona & KKM 1 and test entries DCA 149 & Rahuri selection. At Rahuri, DCA 96 was at par with DCA 149 and Rahuri selection. At Coimbatore, differences were non-significant among the entries in the case of sennosides yield. None of the entries could outperform the checks across locations.

Eco-friendly IPM modules for *Cassia pod borer, Etiella zinckenella*

TNAU, Coimbatore: Three treatments were used: T_1: Eco friendly IPM module comprising; soil application of neem cake @250kg ha^{-1}, installation of light trap @1 ha^{-1}, release of *Trichogramma chilonis*@ 5cc ha^{-1} at the time of flower initiation and twice at 15 days interval, raising pearl millet as border crop, Ist spray NSKE 5% during flower initiation period, IInd spray with *Bacillus thuringensis* 5g lit^{-1}. @15 DAF; Spinosad 0.5ml litre^{-1} of water (need based- if damage rate crossed more than 10%); T2: Conventional farmers' practice (Chlorpyriphos 2ml/litre) and T_3: Control. The results revealed that the population of senna pod borer was significantly low in T_1 (0.96 borer plant^{-1}.) on 14 DAT as compared to T_2 *i.e.,* conventional farmers' practice (3.9 borer plant^{-1}.) on 14 DAT. Subsequently, the percent pod damage was significantly lower in T_1 (3.97%) than T_2 (7.1%) when compared to the check (8.5%). The pooled results on seed yield revealed significant variations ranging from 837.5kg ha^{-1} in T_1 to 329.5 kg ha^{-1} in untreated check. The economics of seed yield in senna over one year revealed that adoption of IPM module was the best with highest B:C ratio of 2.98 than farmers' practice (1.10). The higher BC ratio in IPM plot is primarily due to no insecticidal application and enrichment of soil with neem cake application and inoculative release of *T. chilonis* @ 5cc ha^{-1} at the time of flower resulted in additional advantage of lesser pod borer damage.

TULSI (*Ocimum sanctum*)

It is an erect highly branched aromatic perennial herb belonging to family Lamiaceae. Two plant types are commonly available, one is with green leaves and the other one is with purple leaves. The species is distributed throughout India and is also under cultivation. Leaves, flowers and occasionally the whole plant are medicinally used to treat heart diseases, leucoderma, asthma, bronchitis and fever. The leaves and tender parts of the shoots are economically important and it yields essential oils. The essential oils obtained have immense value in aroma industry. The chemical constituents of the essential oils are monoterpenes, sesquiterpines and phenols with their alcohols, esters,

aldehydes, etc. Propagation is mainly done by seeds. Seedlings are raised in nursery and transplanted at 4-5 leaf stage seedling at the onset of monsoon. Freshly harvested material is distilled for oil extraction.

Evaluation of promising lines of tulsi for high yield and quality under MLT

The trial with four test entries and one check (Angana) was conducted at seven locations viz., Anand, DMAPR, Faizabad, Islampur, Mandsaur, Pusa and Rahuri with an objective to identify superior varieties with high yield and quality. The trial was failed at Anand, ICAR DMAPR, Faizabad, Mandsaur and Rahuri due to poor seed germination. At the remaining two centres, *i.e.,* Islampur and Pusa, there were no significant differences among the entries in the case of green and dry leaf yield.

Influence of irrigation scheduling on growth, yield and water use efficiency

BAU, Islampur: Field experiment was conducted to study the influence of irrigation scheduling with different IW/CPE ratios on growth and yield attributes of tulsi. Irrigation schedules of treatment receiving IW $_{30\ mm}$/CPE= 1.0 exhibited maximum value of plant height (92.30 cm), number of branches (31.5 plant^{-1}), number of leaf (1920.9 plant^{-1}), plant spread (162.90 cm), green leaf yield (9689.60 kg ha^{-1}) and dry leaf yield (2010.80 kg ha^{-1}) which was found superior to the control (rain fed condition). Scheduling irrigation with different IW/CPE ratio had significant effect on the water use efficiency. Irrigation scheduling with IW $_{30\ mm}$/CPE= 1.0 exhibited highest value of WUE (1.70 kg ha^{-1}mm^{-1}). The result showed that a high WUE may be associated with a high productivity in terms of leaf biomass. The highest gross monetary return (Rs. 201080 ha^{-1}), net monetary return (Rs. 139347 ha^{-1}) and B: C ratio (3.26) were found in case of IW $_{30\ mm}$/CPE= 1.0 where 15 irrigation was given.

Integrated nutrients management on yield and quality

BAU, Islampur: Study was conducted to find out suitable combination of organic and inorganic nutrients for higher growth and herbage yield of tulsi. Maximum fresh herbage yield (14930 kg ha^{-1}) and dry herbage yield (3610 kg ha^{-1}) as well as B:C ratio (4.97) were recorded with the treatment receiving NPK (50 : 40 : 30 kg ha^{-1}) + FYM (10 t ha^{-1}) which was found at par with treatments receiving NPK (40 : 30 : 20 kg ha^{-1}) + FYM (10 t ha^{-1}); NPK (30 : 20 : 10 kg ha^{-1})+ FYM (10 t ha^{-1}) and NPK (50 : 40 : 30 kg ha^{-1}) + FYM (5 t ha^{-1}). Consecutive 4 years' study concluded that application of NPK (50: 40: 30 kg ha^{-1}) + FYM (10 t ha^{-1}) resulted in higher fresh and dry herbage yields but integrated application of NPK (50: 40: 30 kg ha^{-1}) + FYM (5 t ha^{-1}) was more suitable and economical for soil health improvement.

Plant spacing and time of planting on growth and herbage yield

MPKV, Rahuri: A field experiment was conducted to study the effect of time of planting and spacing on plant growth and herbage yield. The treatment of 1st July planting recorded maximum plant height (67.80 cm), number of primary branches (13.74), fresh herbage yield (11337 kg ha^{-1}), dry herbage yield (1780 kg ha^{-1}) and seed yield (212 kg ha^{-1}). In case of spacing, 60 × 45 cm spacing recorded maximum plant height (63.27 cm), number of primary branches (12.11), fresh herbage yield (13811 kg ha^{-1}), dry herbage yield (786 kg ha^{-1}) and seed yield (111 kg

ha^{-1}). Overall, treatment combination of 1st July planting with spacing of 60 × 45 cm recorded maximum fresh herbage yield (17910 kg ha^{-1}) and dry herbage yield (3093 kg ha^{-1}).

Effect of organic manures and bio-dynamic preparations on growth and yield

YSPUHF, Solan: This field experiment was conducted for two years to study the influence of organic manures and bio-dynamic preparations *Ocimum sanctum* (green type). Maximum plant height (87.33 cm), number of branches (26.84 plant^{-1}), fresh biomass (138.16 g plant^{-1}), dry biomass (36.84 g plant^{-1}), fresh biomass yield (10234 kg ha^{-1}), dry biomass yield (2728 kg ha^{-1}), oil yield (18.35 l ha^{-1}), gross income (Rs.218261 ha^{-1}) and net income (Rs.113295 ha^{-1}) were recorded with treatment receiving FYM @ 2 t ha^{-1} + NPK @ 120:60:30 kg ha^{-1} while, maximum B:C ratio (2.62) was found in treatment receiving NPK @120:60:30 kg ha^{-1}.

The same experiment was conducted for two consecutive years (2016 -18) to study the influence of organic manures and bio-dynamic preparations *Ocimum sanctum* (purple type) also. Maximum fresh biomass (137.6 g plant^{-1}), dry biomass (35.5 g plant^{-1}), fresh biomass yield (1019 kg ha^{-1}), dry biomass yield (2632 kg ha^{-1}), oil yield (22.15 kg ha^{-1}), gross income (Rs. 210597.6 ha^{-1}) and net income (Rs. 105632.9 ha^{-1}) with BC ratio (2.01) was obtained in the treatment receiving FYM @ 2 t ha^{-1} + NPK @ 120:60:30 kg ha^{-1}. However, maximum B:C ratio (2.41) was found in treatment receiving NPK @ 120:60:30 kg ha^{-1}.

Plant growth as influenced by nutrient management under peach based agro forestry system

YSPUHF, Solan: Field experiment was conducted for two consecutive years on *Ocimum sanctum* under peach based medicinal agro forestry system applied with organic and inorganic sources of nutrients. *O. sanctum* grown under peach trees with application of NPK @ 120:60:30 kg ha^{-1} recorded the maximum plant height (3.27 cm), number of branches (23.6 plant^{-1}), fresh leaf yield (3020 kg ha^{-1}), dry leaf yield (1119 kg ha^{-1}) and gross income (Rs. 126842 ha^{-1}). However, maximum B:C ratio (6.78) was found in treatment combination of peach + *Ocimum sanctum* + *Jivamrut*.

Integrated management of leaf spot of tulsi caused by *Alternaria alternata*

DRPCAU, Pusa: Soil incorporation of FYM 10 t ha^{-1} inoculated with *Trichoderma harzianum* formulation(10g kg^{-1} FYM) combined with seedling treatment @ 10g lit^{-1} of water for 10 minutes and foliar spray with Copper oxychloride @ 3.0g lit^{-1} of water as preventive measure accompanied with one spray of Copper oxychloride @ 3.0g lit^{-1} of water just after appearance of symptom was found highly effective in controlling the disease development (9.25PDI) over the control (29.25% PDI) with highest herbage yield (12875 kg ha^{-1}).

Plant Genetic Resources

Germplasm of medicinal and aromatic plants maintained at ICAR-DMAPR

Species	Number of Accessions
Aloe spp.*(*Aloe)	108
Andrographis paniculata (Kalmegh)	130
Asparagus spp.(Shatavari)	89
Cassia angustifolia (Senna)	253
Cassia tora (Tora)	79
Chlorophytum borivilianum (Safed musli)	80
Commiphora spp. (Guggal)	225
Costus speciosus (Keukand)	35
Cymbopogon spp. (Pamarosa & Lemongrass)	44
Desmodium gangeticum (Salaparni)	104
Gymnema sylvestre (Madhunashini)	88
Hemidesmus indicus (Anantamul)	39
Ocimum spp (Basil, Tulsi, *etc*)	416
Plantago spp. (Isabgol)	151
Tinospora cordifolia (Giloe)	52
*Withania somnifera (*Ashwagandha)	275
TOTAL	**2168**

(Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. Geetha K.A, Dr. P. Manivel, Dr. Narendra Gajbhiye, Dr. P.L.Saran, Dr. N. Reddy, Dr. V. Thondaiman, Dr. Hemlata Bharti, Dr. Akula Chinnapoliah, Mr. Manish Kumar Mittal)

Germplasm of medicinal and aromatic plants maintained at AICRP - MAPB centres

Crop	Centre	No. of accessions
Aloe (*Aloe barbadensis*)	AAU, Anand	40
	CCSHAU, Hisar	42
	ICAR-IIHR, Bengaluru	42
	NDUAT, Faizabad	24
	PDKV, Akola	17
	IGKV, Raipur	14
	RVSKVV, Mandsaur	10
Ashoka (*Saraca asoca*)	KAU, Thrissur	41
Asalio (*Lepidium sativum*)	AAU, Anand	75
	CCSHAU, Hisar	78
	RVSKVV, Mandsaur	40
	MPUAT, Udaipur	15
Ashwagandha (*Withania somnifera*)	AAU, Anand	75
	CCSHAU, Hisar	78
	ICAR-IIHR, Bengaluru	186
	RVSKVV, Mandsaur	68
	MPUAT, Udaipur	74
	NDUAT, Faizabad	08
	IGKV, Raipur	44
	BCKV, Kalyani	02
Bach (*Acorus calamus*)	TNAU, Coimbatore	13
	YSRHU, Venkataramanagudem	38
	AAU, Jorhat	25
	CAU, Pasigadh	39
	UBKV, Kalimpong	07
Basil (*Ocimum basilicum*)	AAU, Anand	13
Betelvine (*Piper longum*)	AAU, Assam	17
	BAU, Islampur	10
	BCKV, Kalyani	54
	ICAR-IIHR, Bengaluru	118
	JNKVV, Jabalpur	04
	MPKV, Rahuri	28
	RAU, Pusa	62
	Dr. YSRHU, Venkataramannagudem	62
Bitter snakegourd (*Tricosanthus cucumarina*)	KAU, Thrissur	19
Brahmi (*Bacopa monnieri*)	KAU, Thrissur	42
	RAU, Pusa	14

Crop	Centre	No. of accessions
Chitrak (*Plumbago* spp)	KAU, Thrissur	25
	TNAU, Coimbatore	42
Chirayita (*Swertia chirayita)*	UBKV, Kalimpong	31
Curcuma spp	AAU, Anand	40
Daruharidra (*Berberis aristata)*	UUHF, Bharsar	04
Giloe (*Tinospora cordifolia*)	AAU, Anand	07
	BCKV, Kalyani	05
	Dr. YSRHU, Venkataramannagudem	13
	CCSHAU, Hisar	20
	BAU, Ranchi	30
Glory lily	TNAU, Coimbatore	16
Madhunashini (*Gymnema sylvestre*)	JNKVV, Jabalpur	7
	BAU, Ranchi	15
Madhunashini (*Gymnema sylvestre*)	TNAU, Coimbatore	66
Guggal (*Commiphora wightii*)	AAU, Anand	25
	MPUAT, Udaipur	16
Harde (*Terminalia chebula*)	BAU, Ranchi	41
Henbane (*Hyoscyamus niger*)	AAU, Anand	05
Indian valeriana (*Valeriana jatamansi*)	UBKV, Kalimpong	11
Isabgol (*Plantago ovata*)	AAU, Anand	65
	CCSHAU, Hisar	93
	MPUAT, Udaipur	31
	NDUAT, Faizabad	12
	RVSKVV, Mandsaur	80
Kali haldi (*Curcuma caesa*)	CAU, Pasigadh	08
Kalmegh (*Andrographis paniculata)*	AAU, Anand	60
	CCSHAU, Hisar	13
	NDUAT, Faizabad	20
	OUAT, Bhubaneshwar	14
	IGKV, Raipur	257
	BCKV, Kalyani	04
Kasni (*Cichorium intybus*)	HAU, Hisar	20
Kuth (*Picrorhiza kurroa*)	YSPUHF, Solan	03
	UUHF, Bharsar	10
Lemongrass (*Cymbopogon* spp.)	CCSHAU, Hisar	46
	NDUAT, Faizabad	16
Long pepper (*Piper longum*)	KAU, Thrissur	25
	AAU, Jorhat	38

Crop	Centre	No. of accessions
Long pepper (*Piper longum*)	OUAT, Bhubaneswar	51
	BCKV, Kalyani	04
Makoi (*Solanum nigrum*)	Dr.YSRHU, Venkataramannagudem	45
	TNAU, Coimbatore	45
	AAU, Anand	06
Mandukaparni (*Centella asiatica*)	AAU, Jorhat	20
	RAU, Pusa	12
	UBKV, Kalimpong	13
	BCKV, Kalyani	05
Mucuna (*Mucuna pruriens*)	AAU, Anand	20
	BAU, Ranchi	30
	IIHR, Bangalore	102
Mentha species	AAU, Anand	05
Pashanbhed (*Berginia ciliata*)	UBKV, Kalimpong	17
Neel (*Indigofera tinctoria*)	KAU, Thrissur	21
Opium poppy (*Papaver somniferum*)	NDUAT, Faizabad	35
	MPUAT, Udaipur	85
	RVSKVV, Mandsaur	110
Palmarosa (*Cymbopogon martinii*)	CCSHAU, Hisar	65
	PDKV, Akola	13
Periwinkle (*Catharanthus roseus*)	AAU, Anand	6
Salaparni (*Desmodium gangeticum*)	KAU, Thrissur	10
Safed musli (*Chlorophytum borivilianum*)	AAU, Anand	21
	CCSHAU, Hisar	12
	MPUAT, Udaipur	10
	RVSKVV, Mandsaur	24
	PDKV, Akola	13
Sarpgandha (*Rauvolfia serpentina*)	OUAT, Bhubaneshwar	37
	IGKV, Raipur	12
	BAU, Ranchi	33
Shatavari (*Asparagus racemosus*)	CCSHAU, Hisar	24
	AAU, Anand	6
	JNKVV, Jabalpur	14
	MPKV, Rahuri	11
	NDUAT, Faizabad	24
Senna (*Cassia angustifolia*)	AAU, Anand	17
Sylibum (*Silybum marianum*)	AAU, Anand	10

Crop	Centre	No. of accessions
Tulsi (*Ocimum sanctum*)	CCSHAU, Hisar	12
	AAU, Anand	09
Tagetes (*Tagetes minuta*)	YSPUHF, Solan	32
	UBKV, Kalimpong	03
Vetiver (*Vetiveria zizaniodes*)	CCSHAU, Hisar	50
	KAU, Thrissur	37
	NDUAT, Faizabad	12
	TOTAL	**3915**

General Information

Visit of Honorable DDG

Honorable DDG (Hort. Science), Dr. A. K. Singh visited the Directorate on 5th Febuary 2019. During farm visit, he planted sapling of *Saraca indica* at 'Ashok vatika' of the Directorate. Dr. Satyajit Roy, Director (Acting) welcomed him and briefed the activities of the Directorate. The DDG addressed the gathering and expressed his well wishes for the progress of the Directorate for all future endeavours. He also visited differnt laborotaries and interacted with individual scientist discussed about their research activities.

COMMITTEE MEETINGS

Institute Research Committee (IRC)

A midterm review meeting of IRC, ICAR-DMAPR was held on March 15, 2019 at ICAR-DMAPR, Anand under the chairmanship of Dr. Satyajit Roy, Director (Acting), ICAR-DMAPR. The chairman, IRC, ICAR-DMAPR, Dr. Satyajit Roy, Director (Acting), ICAR-DMAPR briefed about the last meeting of IRC held on December 31, 2018. He stressed that activities and outcome of ongoing research projects should be very categorically monitored so that deliverables could be achieved. Thereafter, the presentations were made by scientists for seven main projects and one flagship programme. The meeting ended with the vote of thanks delivered by the Member Sectretary, Dr. Satyanshu Kumar.

Institute Research Committee (IRC) meeting was held under the Chairmanship of Dr. Satyajit Roy, Acting Director, ICAR-DMAPR during December 02-03, 2019. Dr. K. B. Kathiriya, Dean, College of Food Processing Technology and Bio-Energy, AAU Anand; Prof. S.S.Kalamkar, Director, Agro-Economics Research Centre, S.P. University, V.V. Nagar, Anand and Dr. N. K. Kalyanasundaram, Formerly Head, Department of Soil Science, AAU Anand were invited as experts for the meeting. Dr. P. Manivel, Member Secretary (In charge), IRC, welcomed the the Chairman, external experts and the other members of IRC. The meeting

then initiated with introductory remarks of the experts. Dr. K.B. Kathiriya emphasized the need of conservation of genetic resources and importance of maintenance breeding of high yielding varieties. He also suggested to make inventory of individual crops and highlighted that the collected germplasm should be thoroughly screened for its better utilization. Prof. S.S. Kalamkar suggested that efforts should be made for impact assessment of technologies generated at ICAR-DMAPR so that farmers' centric activities could be prioritized. Dr. N.K. Kalyanasundaram specifically highlighted the study areas where medicinal and Aromatic crops are grown so that production related constrains can be attained effectively. Thereafter, the presentations were made by scientists for seven main projects and one flagship programme. Progress reports of externally funded projects were also presented by the respective PI/Co-PI/CCPI. The IRC thoroughly reviewed the progress of each project and made suggestions and recommendations for achieving the targeted goals efficiently. The meeting concluded with the vote of thanks delivered by the member secretary.

Research Advisory Committee (RAC) meeting

Twenty seventh RAC meeting was held during 23rd and 24th December 2019 at ICAR DMAPR under the Chairmanship of Prof. P. Das, Director, Science Foundation for Tribal and Rural Resource Development, Bhubaneswar, Odisha. Dr. T. Janakiram, ADG (Hort II), ICAR, New Delhi; Dr. Satyajit Roy (Acting Director), ICAR DMAPR; Dr. N. Ramachandran, Former Head (Plant Pathology), ICAR-IIHR Bengaluru; Dr. Madhuban Gopal, Emeritus Scientist, ICAR, New Delhi; Dr. Veena Gupta, Head (Germplasm Conservation), ICAR-NBPGR, New Delhi; Mr. Jayansinh, Mafatbhai, Agriculture Entrepreneur; Dr. Vandana D. Modi, Vice President, Cadila Pharmaceuticals, Ahmadabad as special Invitee and Dr. Geetha K.A., Principal Scientist, ICAR-DMAPR, Anand, Member Secretary were the other RAC members who attended the meeting. On December 23rd being observed as National Farmers' day, the RAC visited the field of Mr. Bimalbhai Patel, Isnav Village, Anand who is cultivating brahmi (*Bacopa monnieri*) successfully in an area of 1.5 acre. He has integrated brahmi cultivation with his cow farm which has a biogas plant. The slurry generated from the biogas plant is utilized for Organic cultivation of brahmi. Shri Bimalbhai a progressive farmer, in addition, installed solar panels having 25 KW capacity sufficient for his farm and the surplus energy generated is sold to the feeder GRID for additional income. He is using only herbal formulations for crop protection measures. He has also developed a modified diesel operated harvesting machine for brahmi cultivation and processing which has considerably reduced the cost of cultivation. He is happy with brahmi cultivation instead of his earlier rice cultivation since the crop diversification has resulted in doubling of his income.

He expressed his sincere gratitude to ICAR-DMAPR for the advice, training, technical know-how and encouragement for pursuing the cultivation as well as establishing linkages with the market/Industry to get profitable remunerations. The RAC was impressed by the progressive farmer Bimalbhai's enthusiasm for promoting medicinal crops for enhancing his farm income. The committee suggested instituting special awards for such progressive farmers to encourage spread of medicinal and aromatic plants for additional farm income.

On 24th December, the RAC meeting was held at Committee Room, ICAR DMAPR. The proceedings of the meeting started with the welcome address by Dr. Geetha K.A., Member Secretary, RAC. Prof P. Das, Chairman, RAC gave an introductory remark wherein he stressed World's increasing preferences for plant based products for healthcare, nutrition, dietary supplements, cosmetics and flavoring agents. Dr. T. Janakiram opined that research should be focused on incremental increase in income generation so as to achieve the national goal of "Doubling of Farmers' income" by adopting research targets of value addition, processable varieties, quality assurance, crop diversification based on industry demand, etc. Followed by the introductory remarks of the other RAC members, the member secretary appraised the house about the action taken on recommendations made during the last RAC meeting. The Director, ICAR-DMAPR presented an overview of the Directorate including the Institute's progress for the last one year. In his presentation he also gave a brief introduction about the mandates, thrust areas and achievements of the Institute *viz*., germplasms registered, GAP developed and other major research works done in various MAP crops during the year. After his presentation, individual scientists presented salient research achievements made by them in various Institute and external funded projects as per the recommendation of the last RAC. The contents of the presentations were thoroughly reviewed by the RAC and suggested a number of recommendations. Future research activities of the Directorate were meticulously planned in the meeting for refining the ongoing research programmes.

INSTITUTE TECHNOLOGY MANAGEMET UNIT

Isabgol field day and stakeholders' meet

Isabgol field day and stakeholders' meet was held on March 16, 2019 at the Directorate. Dr. T. Janakiram, Assistant Director General (Hort. Science), Indian Council of Agricultural Research (ICAR), New Delhi; Dr. Jitendra Kumar, Director, Institute of Pesticide Formulation Technology (IPFT), Gurugram; Dr. Niraj Wadhwa, Board Member, Isabgol Processors Association (IPA), Sidhpur and Dr. Satyajit Roy, Director, ICAR-DMAPR, Anand were present in the meet. Dr. Satyajit Roy, Director, welcomed the stakeholders and presented an overview

of the Directorate and research achievements in isabgol. He highlighted new isabgol varieties, good agricultural practices (GAP) and Isabgol seeds standards to the stakeholders.

Mr. Niraj Wadhwa, board member, IPA, said that there was a growing demand for isabgol husk in the bakery industry apart from its medicinal and industrial uses. He emphasized that there was a need for concerted efforts to increase the isabgol production in the country. He appreciated the ICAR-DMAPR in organizing the unique meet to share ideas and challenges in isabgol processing and trade.

Dr. T. Janakiram, in his address emphasized the need to strengthen value chain of isabgol in order the double the income of farmers. He opined that, organic cultivation, good agricultural practices (GAP) certification, use of sensors, technology transfer, market information and value addition of isabgol would ensure more income to the farmers. He suggested to prepare a policy document for isabgol research and development in the country.

Dr. P. Manivel, Principal scientist, ICAR-DMAPR, showcased the new varieties (Vallabh Isabgol-1, Vallabh Isabgol -2 and Vallabh Isabgol -3) developed by the directorate and genetic resources of isabgol to the stakeholders.

The one-day event on Isabgol field day and stakeholders' meet was attended by members from the Isabgol Processors Association, Siddhpur; Isabgol seed industry, Gujarat; State Medicinal Plants Board, Gandhinagar; Space Application Center, Ahmadabad; Pharma industry; National Dairy Development Board, Anand; AICRP-MAP&B centers; Amul, Anand; Institute of Rural management Anand (IRMA) and Scientists of ICAR-DMAPR, Anand. A field visit was arranged in which isabgol varieties and germplasm accessions of the directorate were showcased to the stakeholders. In the end, Dr. R. Nagaraja Reddy, Scientist, ICAR-DMAPR proposed the vote of thanks.

IP generated/Database submitted to NCBI GenBank

1. *Cucumber mosaic virus* isolate TAA_CMV 1a protein mRNA, partial cds. 412 bp mRNA linear (02-SEP-2018) ACCESSION - MG011667
2. *Dickeya zeae* strain ADM19 DNA polymerase III gamma/tau (dnaX) gene, partial cds ACCESSION -MH790975
3. *Dickeya zeae* strain ADM19 isocitrate dehydrogenase (icdA) gene, partial cds. ACCESSION -MH790976
4. *Dickeya zeae* strain ADM19 malate dehydrogenase (mdh) gene, partial cds ACCESSION -MH790977
5. *Alternaria alternata* isolate AWS-1 internal transcribed spacer 1, ACCESSION-MK695680
6. *Alternaria alternata* isolate AWS-1 actin (actin) gene, partial cds. ACCESSION-MK695681
7. *Corynespora cassiicola* isolate ATC-1 internal transcribed spacer 1, ACCESSION-MK027366
8. *Fusarium solani* strain AVARP19 internal transcribed spacer 1, ACCESSION- MH890688.1

Patent filed

Applications/ Registration No.	Name of Innovation/ Technology/ Product	Date of Filling/ Registration	Name of the inventors
201921031374	Standardized extract from Garcinia species exhibiting potential antibacterial activity against methicilin-resistant *Staphylococus aureus*	02.08.2019	Tuhina Banerjee, Satyanshu Kumar, Raghuraj Singh, A. S Negi, Aradhana Singh, Tabaruk Hussain and Ashish Kar

ICAR-DMAPR signed MoU with Navsari Agricultural University

ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat signed a

Memorandum of Understanding with the Navsari Agricultural University (NAU), Navsari, Gujarat in a formal function held on 23rd January 2020 for facilitating training, research and development in partnership mode. In this occasion, Dr.Satyajit Roy, Director, ICAR-DMAPR emphasized that this partnership program would trigger the framing of indigenous technologies of medicinal plants, a step forward in the sustainable collection and cultivation of medicinal and aromatic plants in the country.

Dr. T. R. Ahlawat Associate Director of Research, PI & Nodal officer, Centre for Advanced Agricultural Sciences and Technology (CAAST), NAU expressed his confidence in bringing up the positives through the MoU that would benefit the medicinal farming in the country.

The MoU aims to initiate the knowledge partnership for establishment of secondary agriculture unit to develop skill like latest technologies in different spheres of secondary agriculture, capacity building, competency development, product development and its commercialization for students and farmers.

MOU signed for cultivation of *Taverniera cuneifolia* in Gujarat

A Memorandum of Understanding (MOU) was signed with the ICAR-Directorate of Medicinal and Aromatic Plants Research (DMAPR) as the First Party and the Botany Department of M.S. University of Baroda, Vadodara, Gujarat (BDMSU) as the second Party and Mr. Krupal Barad, S/o Shri Hathaubha Barad Village: Vataman, Mahadevfal, Taluka: Dholka, PIN-382265, District: Ahmedabad (Farmer) as the third party for implementation of the project entitled "Investigation of *Taverniera cuneifolia* (Roth) Ali, as a sweetener for substitute of *Glycyrrhiza glabra* L. in herbal formulations" for cultivation of *Taverniera cuneifolia* in suitable areas of farmers fields of Gujarat.

OFFICIAL LANGUAGE IMPLEMENTATION COMMITTEE

हिन्दी सप्ताह

राजभाषा क्रियान्वयन समिति द्वारा विगत वर्षों की भांति इस वर्ष भी निदेशालय में 14-20 सितंबर, 2019 के दौरान हिन्दी सप्ताह का आयोजन किया गया। इस दौरान हिन्दी निबंध, हिन्दी प्रारूप लेखन, वाद-विवाद व काव्यपाठ प्रतियोगितायें आयोजित की गईं, जिसमें हिन्दी निबंध प्रतियोगिता में नराकास, आणंद के सभी सदस्यों को भी आमंत्रित किया गया था।

हिन्दी सप्ताह की शुरूआत हिन्दी दिवस 14 सितंबर, 2019 को किया गया। हिन्दी सप्ताह के दौरान हिन्दी दिवस समारोह; 14 सितबंर, 2019 को जोर-शोर से मनाया गया। हिन्दी अधिकारी डॉ. राम प्रसन्न मीना ने निदेशालय में हिन्दी सप्ताह का आयोजन करने तथा इस दौरान की जाने वाली प्रतियोगिता के बारे में संक्षिप्त जानकारी देते हुए माननीय कृषि एवं किसान कल्याण मंत्री महोदय जी का एक प्रेरणाप्रद संदेश सभा के समक्ष प्रस्तुत किया और हिन्दी प्रतियोगिताओं में सभी को भाग लेने के लिए आग्रह किया। तत्पश्चात कार्यालय में हिन्दी से संबंधित कार्य पर संक्षिप्त जानकारी प्रस्तुत की। इसके दौरान निदेशालय के वैज्ञानिक, अधिकारी एवं कर्मचारियों ने अपने भाषण में कार्यालय में हिन्दी से संबंधित कार्य में आ रही कठिनाइयों को बताया और उसको दूर करने पर अपने विचार प्रस्तुत किए। निदेशालय के निदेषक एवं राजभाषा कार्यान्वयन समिति के अध्यक्ष डॉ. सत्यजित रॉय ने अपने भाषण में कविता के माध्यम से अपने विचारों को अवगत कराते हुए निदेशालय के सभी कार्मिकों से कार्यालय में हिन्दी से संबंधित कार्य में आ रही कठिनाइयों को दूर करते हूए ज्यादा से ज्यादा हिन्दी में कार्य करने पर जोर दिया।

हिन्दी समापान समारोह 20 सितंबर, 2019 को आयोजित किया गया। डॉ. राम प्रसन्न मीना, हिन्दी अधिकारी ने अपने स्वागतीय भाषण में मुख्य अतिथि महोदय का स्वागत करते हुए उनका लघु जीवन परिचय सभा के समक्ष प्रस्तुत किया। उन्होंने निदेशालय में हिन्दी से संबंधित चल रही गतिविधियों के बारे में भी प्रकाश डाला। स्वागतीय भाषण के पश्चात व्याख्यान व काव्यपाठ प्रतियोगिताओं का आयोजन किया गया, जिनका संचालन व मूल्यांकन मुख्य अतिथि महोदया ने किया। सभी प्रतियोगिताओं में प्रथम, द्वितीय व तृतीय रहे प्रतिभागियों को पुरस्कार मुख्य अतिथि महोदया के कर कमलों द्वारा प्रदान किये गए। पुरस्कार वितरण समारोह के उपरान्त मुख्य अतिथि श्रीमती उमा गोहिल, नगर राजभाषा कार्यान्वयन समिति, आणंदने निदेशालय

में हिन्दी में चल रहे कार्यक्रम की सराहना करते हुए आशा व्यक्त किया की आगे भी इस तरह के कार्यक्रम होते रहेंगे।

समारोह के अंत में डॉ. पी. एल. सारण, प्रधान वैज्ञानिक ने धन्यवाद ज्ञापन प्रस्तुत किया। उन्होंने मुख्य अतिथि, निदेशालय के निदेशक, राजभाषा समिति सदस्यों, विभिन्न प्रतियोगिताओं के प्रतिभागी, कार्यक्रम में सहयोगीजनों, सभी कर्मचारीगण जिन्होंने परोक्ष व अपरोक्ष रूप से अपना सहयोग दे कर इस कार्यक्रम को सफल बनाया, उन सबका आभार व्यक्त किया। राष्ट्रगान के साथ कार्यक्रम का समापन हुआ।

हिन्दी कार्यशालाः

भाकृअनुप-औसपाअनुनि की राजभाषा कार्यान्वयन समिति हिन्दी राजभाषा के उपयोग व प्रसार के लिए सत्त प्रयत्नशील है। वर्ष के दौरान निदेशालय में राजभाषा कार्यान्वयन समिति द्वारा तीन कार्यशालाएं आयोजित की गई।

प्रथम कार्यशालाः दिनांक 28 जून, 2019 को निदेशालय के सभागार में आयोजित की गई। जिसके प्रथम सत्र में मुख्य वक्ता डॉ. रघुराज सिंह ने कार्यालय में हिन्दी का सार्थक प्रयोग विषय पर व्याख्यान दिया। उन्होंने बताया की कार्यालय में किस तरह का सूचना आदान-प्रदान होता है जैसे- टिप्पण, प्रारूपण, संक्षेपण, प्रतिवेदन एवं अनुवाद इत्यादि तथा कार्यालय में प्रयोग करने के लिए विस्तार से बताया।

कार्यशाला के दूसरे सत्र में हिन्दी अधिकारी डॉ. राम प्रसन्न मीना ने कार्यालय में राजभाषा अधिनियम से संबंधित जानकारी देते हुए कार्यालय में हिन्दी को बढ़ावा देने पर जोर दिया। तत्पश्चात वाद-विवाद प्रतियोगिता का आयोजन किया गया, जिसका मूल्यांकन मंचासीन महानुभावों के द्वारा किया गया। इसमें निदेशालय के सभी श्रेणी के कार्मिकों ने भाग लिया। सत्र के अंत में निदेशक महोदय ने विजेता प्रतिभागियों को पुरस्कार राशि से सम्मानित किया। कार्यक्रम के अध्यक्ष डॉ. सत्यजित रॉय ने अपने अध्यक्षीय उद्बोधन में भाषा की भिन्नता का उदाहरण देते हुए कार्यालय में राजभाषा अधिनियम का पालन करने और सरल हिन्दी के प्रयोग पर बल दिया। कार्यक्रम के अंत में श्री बी. के. मिश्र, वरिष्ठ तकनीकी सहायक, भाकृअनुप-औसपाअनुनि, बोरीआवी द्वारा धन्यवाद ज्ञापन प्रस्तुत किया गया और राष्ट्रगान के साथ कार्यशाला का विधिवत समापन हुआ।

द्वितीय कार्यशालाः दिनांक 20 सितंबर, 2019 को हिन्दी के प्रचार-प्रसार में नराकास की भूमिका विषय पर आयोजित की गई। कार्यशाला के प्रथम सत्र में हिन्दी के प्रचार-प्रसार में नराकास की भूमिका विषय पर वक्ता श्रीमती उमा गोहिल ने नराकास की कार्यप्रणाली कार्य की व इसका हिन्दी में प्रचार-प्रसार में योगदान पर विस्तृत जानकारी दी।

कार्यशाला के दूसरे सत्र में डॉ. सत्यांषु कुमार, प्रधान वैज्ञानिक ने हिन्दी के महत्व को बताते हुए कहा कि किस तरह हिन्दी भाषा भारत की संस्कृति का अभिन्न अंग है और साथ ही विदेशों में किस तरह हिन्दी को बढ़ावा दिया जा रहा है, इस पर भी प्रकाश डाला। अंत में डॉ. पी. एल. सारण, प्रधान वैज्ञानिक, भाकृअनुप-औषधीय एवं सुगंधीय पादप अनुसांधान निदेशालय, बोरीआवी ने धन्यवाद ज्ञापन प्रस्तुत किया।

तृतीय कार्यशालाः दिनांक 30 दिसंबर, 2019 सोमवार को हिन्दी को बढ़ावा देने हेतु परिचर्चा विषय पर हिन्दी कार्यशाला

का आयोजन किया गया। कार्यशाला के दौरान निदेशालय के सभी श्रेणी के कार्मिकों ने हिन्दी के प्रति अपने-अपने विचार प्रस्तुत किए और इसके बाद हिन्दी अधिकारी डॉ. राम प्रसन्न मीना ने कर्मिकों के विचार पर विस्तार से चर्चा कर हिन्दी में कार्य करने के प्रति उनके मनोबल को और बढ़ाया। तत्पष्चात कार्यक्रम के अध्यक्ष डॉ. पी. एल. सारण, प्रधान वैज्ञानिक ने अपने अध्यक्षीय उद्बोधन में ज्यादा से ज्यादा हिन्दी का प्रयोग करने पर बल दिया और कहा की यदि हम हिन्दी भाषी नहीं है तो भी हमें हिन्दी बोलने की कोशिश करनी चाहिए, क्योंकि देश में हिन्दी अधिकाधिक बोली जाने वाली भाषा है, जो हमें कभी भी और कही भी जरूरत पड़ सकती है। अतः हमें मातृ भाषा के साथ-साथ हिन्दी भाषा भी सीखनी चाहिए। अंत में धन्यवाद ज्ञापन के साथ कार्यक्रम का समापन हुआ।

संविधान दिवसः समारोह 26 नवंबर, 2019 को निदेशालय के सभागार में मनाया गया।

निदेशालय द्वारा जारी की गई निर्देशिकाओं, दिशानिर्देशों, वेबसाइट से संबंधित जानकारी व दिन-प्रतिदिन आयोजित कीए गए कार्यक्रमों की न्यूजरिपोर्ट का हिन्दी रूपान्तरण व संकलन भी कार्य समिति द्वारा किया जा रहा है।

पुरस्कार

हिन्दी कार्यः 20 हजार शब्द के लिए निदेशालय द्वारा श्री सुरेश पटेलिया, निजी सचिव एवं रघुबीर प्रजापति, कनिष्ठ लिपिक को प्रथम पुरस्कार और श्री बृजेश कुमार मिश्र, वरिष्ठ तकनीकी सहायक को द्वितीय पुरस्कार तथा नराकास, आणंद द्वारा आयोजित हिन्दी प्रतियोगिता में श्रीमती प्रिया फोगाट ने तृतीय पुरस्कार प्राप्त किया। हिन्दी सप्ताह के दौरान आयोजित सभी प्रतियोगिताओं के विजेता प्रतिभागियों को प्रथम, द्वितीय, तृतीय और संत्वना पुरस्कार दिया गया।

International Day of Yoga

International Day of Yoga was organized on June 21, 2019 at ICAR-DMAPR, Boriavi, Anand. In this function, all the scientists, technical and staff members of ICAR-DMAPR were participated.

Group meeting of All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine (AICRPMAP&B)

The XXVIIth annual group meeting of All India Co-ordinated Research Project on Medicinal and Aromatic Plants & Betelvine (AICRP-MAP&B), organized by the Indian Council of Agricultural Research in collaboration with Dr. YSR Horticulture University, Venkataramannagudem was held during 18th to 20th October, 2019. The Inaugural function was held on 18th October and Dr. A. K. Singh, DDG (HS), ICAR, New Delhi was the chief guest of the function. The programme commenced with welcome address by Dr. RVSK Reddy, Director of Research, YSRHU, Venkataramannagudem. Dr. Reddy in his welcome address thanked the ICAR for giving the opportunity to host the group meeting at YSRHU, Venkataramannagudem. He highlighted the achievements made by the university. He also highlighted the importance

of Medicinal and Aromatic plants in the Indian agriculture and livelihood system. Dr. T. Janakiram, ADG (HS I), ICAR, New Delhi presented the prospect of the project and made the house aware about new initiatives taken by the ICAR in the horticulture Sciences such as vertical farming, plastic free nurseries, etc. He also pointed out the post harvest losses during transportation and urged the researchers to take research initiatives to address the problem. He also informed that the QRT report on AICRP on MAPB has been approved in the GB meeting and further action will be initiated to make the MAP sector more vibrant. Dr. Satyajit Roy, Project Coordinator presented the salient research achievements made during the last one year by the various Coordinating centers.

Dr. A. K. Singh, DDG (HS), ICAR, New Delhi during his address congratulated the researchers for bringing out more number of farmers' friendly technologies. He said that the MAP section has great potential and opportunities to cater the demand of MAPs. It would generate employment in rural areas. Only thing is that we have to create more awareness about MAPs among the stakeholders, he opined. He further added that at present global agriculture scenario is changing and MAP can play a vital role indeed. Fourteen publications on MAP from different AICRP MAP&B Centres were released during the occasion. Dr. B.V.K. Bhagwan, Zonal Director, YSRHU, Venkataramannagudem proposed the vote of thanks at the end of the inaugural session.

During the 3-day deliberations, research achievements of AICRP-MAP&B were reviewed and technical programme for the year 2020-21 was finalised in different technical sessions such as Crop Improvement, Crop production, Crop protection and Phytochemistry. The workshop was attended by more than 120 participants across India, Deans and Heads of various departments YSRHU, Venkataramannagudem and Press & Media.

Celebration of 150th Anniversary of Mahatma Gandhi

ICAR-Directorate of Medicinal and Aromatic Plants Research (DMAPR), Anand, Gujarat celebrated 150th Anniversary of Mahatma Gandhi (October 02, 2019). In this context, one week programme of different events (debate, essay writing, quiz competition, painting competition, lectures and stage performace) were organized by a committee constituted by the competent authority. The committee chairman was Dr. Satyanshu Kumar, Principal Scientist and members were Dr. Raghuraj Singh, Scientist; Dr. V. Thondaiman, Scientist; Dr. A.P. Trivedi, STO; Mr. N. J. Ganatra, Assistant Administrative Officer and Sh. Mangal Singh, AF& AO.

Vigilance Awareness Week

The Vigilance Awareness Week 2019 was organized at the Directorate from October 28-November 02, 2019 with the theme "Integrity - A way of Life".

Foundation Day Celebration of ICAR-DMAPR

ICAR-Directorate of Medicinal and Aromatic Plants Research celebrated its Foundation Day on November 24, 2019. The inaugural session of this event was held at the Auditorium of ICAR-DMAPR.

Celebration of the Constitution Day

The Directorate celebrated "Constitution day" on 26.11.2019. Two programs were arranged in this regard *viz.,* "Constitution awareness" program which was conducted in Malataj Village in which approximately 100 farmers participated and took pledge on preamble of the Indian Constitution as per the Council's guidelines; another programme was conducted at the Directorate in which all staff members of ICAR -DMAPR and farmers from nearby villages participated. Dr. Satyajit Roy, Director delivered pledge of Preamble of the Constitution in the central auditorium hall. This was followed by brief information about the genesis and development of Indian constitution by Dr. K.A. Kalariya, Scientist. He pointed out useful information regarding importance of the Indian Constitution especially the preamble. Mr. Ganatra Naresh Jaysinh, Assistant Administrative Officer narrated the details of the Constitutional rights provided by the Indian Constitution. Dr. R.P. Meena, Scientist gave a lecture on fundamental duties prescribed in the Constitution. He also pondered on our duties towards the nation and how one can use the rights provided by the constitution. Dr. Satyajit Roy, highlighted at the end in brief about the importance of "Constitution Day". The programme concluded with the national anthem.

EXTENSION ACTIVITIES

ICAR-DMAPR Tribal Sub-Plan (TSP)

The Directorate of Medicinal and Aromatic Plants Research (DMAPR) has initiated TSP scheme under the theme *"Promotion of medicinal plants cultivation in tribal areas of Gujarat for livelihood and health security"* in the tribal belt of Gujarat. The programme was initiated in 2013-14 with short-term as well as long-term objectives. The short-term objective is to create awareness among the tribal about the medicinal plants their importance and uses in homemade medicines for primary health care and wellbeing. The long-term objective is to promote the cultivation of medicinal plants at commercial scale to uplift the socio-economic

status of the Tribal people. The operational areas under this scheme are selected villages of Panchmahal, Chhota Udepur and Dediapada districts. In previous years, we have distributed planting materials of selected MAPs, small farm equipments including modified iron hoe to different tribal beneficiary farmers. As a part of follow up activities, this year Dr. K. A. Kalariya, Nodal Officer, TSP Scheme had guided and motivated beneficiary tribal farmers to further promote MAPs cultivation.

Mera Gaon Mera Gaurav (MGMG) and *Swachchh Bharat* Mission

MGMG and *Swachchh Bharat* Mission initiated by the ICAR and Government of India are continued at the ICAR-DMAPR. The activities related to these programmes were performed by the ICAR-DMAPR during the year 2019.

Display of inauguration of PM Kisan Samman Nidhi by video conferencing

Honorable Prime Minister Shri Narendra Damodardas Modi inaugurated the PM Kisan Samman Nidhi Sceheme on February 24, 2019. The programme was live displayed in the auditorium of ICAR-DMAPR to farmers, scientists and staff of the Directorate. The arrangements were made for about 100 farmers/participants by Dr. Raghuraj Singh, Scientist; Dr. A.P. Trivedi, Senior Technical Officer; Mr. S.B. Prajapati, Technical Officer, Farm Management and Agricultural Extension Committee and AKMU of ICAR-DMAPR, Anand.

Satavari (*Asparagus adscendens*) cultivation in Gujarat: A success story

Cultivation of medicinal plants is less risky in terms of incidences of wild animals and diseases & insects pests attack and has potential even when grown in degraded and marginal lands. Gujarat is known for tobacco and banana cultivation. With the aim to double the income of farmers and considering shatavari (*Asparagus racemosus*) as a high remunerative crop, Dr. P.L. Saran, Principal scientist from this Directorate promoted several farmers for satavari cultivation for the last four-five years. Mr. Vipulbhai R. Hariyani (Bhadrawadi) was convinced about the profitability of shatavari cultivation during 2015-16. The farmer decided to grow this crop under micro irrigation system. The training activities were financially supported by the DASD, CSS, Calicut, Kerala. Recently, some farmers like Shri Kantibhai (Bhadrawadi), Kalpesh R. Patel (Malataj), Chetanbhai G. Prajapati (Mogar), *etc.*, were also trained and were convinced for shatavari cultivation in this region. Nepali satavari (*Asparagus adscendens*) was selected purposefully due to the richer saponin content and high demand (better returns) and thorny nature (protection from wild animal attack). More over, shatavari cultivation in gravel or sandy soils will play important role for sustainable cultivation. The cultivation is a

profitable venture in such degraded lands due to high B:C ratio (3.75) as compared to traditional crops. On an average, a farmer can get approximately Rs. 3,35,000 net returns per hectare per year. The growers not only fetch remunerative income from this enterprise, but also it provide more employment opportunities to the local people especially in post harvest operations *viz.*, root peeling, drying etc. One of the main objectives of this programme was to establish linkages between growers and the market. Marketing of the dry roots and the dried root powder face problem due to lack of information and skills among the farmers. Efforts have been made and linkages between growers and market (Fresh Mantra Organics LLP, Ahmedabad and Shatras Pvt. Ltd. Surat) were established by this programme.

Exhibition/Farmers' Fair

Field day cum *chalet firte* quiz with DD KISAN

One field day cum *chalet firte* quiz with DD KISAN for MAPs farmers was organized on January 09, 2019 at Pandoli, Petlad by the Directorate and a team from DD Kisan channel. Thirty two participants from different villages of Petlad, participated the programme. Dr. P. L. Saran, Principal Scientist, ICAR-DMAPR welcomed the farmers. Different cultivation aspects of MAPs were covered by experts. Problems/challenges faced by the farmers for cultivation of MAPs were recorded during quiz by DD KISAN team. The success story of brahmi cultivation by Shri Neil Shah was also recorded. Two more stories of brahmi and dodi cultivation were given by Dr. P. L. Saran and Dr. K. A. Kalariya, respectively. At the end of the programme vote of thanks were delivered by Dr. R. P. Meena.

Medicinal and aromatic plants exhibition in Vibrant Gujarat

Medicinal and aromatic plants exhibition stall was established one day before in "Vibrant Gujarat" by Dr. Raghuraj Singh and his team of Farm Management and Agricultural Extension Activities Committee for showcasing of MAPs during 18-22 January, 2019 at Gandhinagar. The

nominated Scientists and Technical Staff explained about different aspects of medicinal and aromatic plants to the visitors and farmers. The queries raised by them were answered in this exhibition about medicinal and aromatic plants cultivation and prospects.

Skill training on "Gardner"

Twenty-five days' skill training on "Gardner" (AGR/Q0801) for 25 unemployed youth was

organized by the Directorate during February 15 - March 11, 2019 under central sector scheme (CSS). The programme was funded by the DASD Calicut, Kerala and supported by ASCI, New Delhi. Twenty five participants were selected from different states of India. The training programme was formally inaugurated by Dr. S. Roy, Director, ICAR-DMAPR, Boriavi. The chief guest was Dr K. B. Kathiria, Director of Research & Dean (PG), AAU, Anand. Dr. P.L. Saran was the organizing secretary and Dr. K.A. Kalariya and Dr. R. P. Meena were the coordinators. There were more than 40 lectures and practical classes with ten field visits for making the training more efficient and successful.

Two days' district level seminar cum stake holders meet on MAPs under central sector scheme

A two-day district level seminar cum stake holders meet on MAPs was organized by the

Directorate during February 06-07, 2019 under Central Sector Scheme, DASD Calicut, Kerala. The aim of the seminar was to provide a platform for awareness of stakeholders with regard to transfer of technology and enhancing knowledge with recent developments in medicinal and aromatic plants sector to farmers through trainers. The programme was chaired by Dr. S. Roy, Director, ICAR-DMAPR, Boriavi and chief guest was Shri B.U. Parmar, Senior Executive Officer and Joint Director, State Horticulture Mission, Gujarat. A total of 201 farmers from Anand as well as from different parts of Gujarat participated the seminar. Various topics under GACP of MAP including improved varieties & QPM production, cultivation practices, PHT, primary processing, quality maintenance and supply chain/marketing were

covered through presentations by subject experts, progressive farmers and industry personnels and also by field visits. At the end of the programme, there was a panel discussion. The program was successfully conducted by Dr. P. L. Saran as organizing secretary and Dr. K. A. Kalariya & Dr. R. P. Meena as coordinators.

***Krishidham* Expo-2019:** ICAR DMAPR participated in *Krishidham* Expo-2019 organized from 15- 17 February, 2019 at ICAR Central Potato Research Institute (CPRI), Regional Station at Modipuram, Meerut, Uttar Pradesh by ICAR-CPRI, Shimla in partnership with HiFi conference and events Pvt Ltd, Noida. In *Krishidham* Expo-2019, over 40 exhibitors participated from the ICAR, state agricultural universities and industries. ICAR-DMAPR stall was one of the best attractions in which Medicinal and Aromatic Plants technologies, raw drugs and scientific literature with display of more than 50 live medicinal and aromatic plants were shown to various stakeholders. In this event large numbers of farmers, researchers press and media visited the DMAPR stall. ICAR-DMAPR bagged the best stall award. Some of the key persons visited the DMAPR stall included Dr. A.K. Singh, Deputy Director General (Horticulture and Crop Sciences), ICAR, New Delhi; Dr. S.K. Chakrabarti, Director, CPRI, Shimla; Dr. A. S. Panwar, Director, ICAR-IIFSR, Modipuram and former Directors of ICAR-CPRI, Shimla. Dr. R. Nagaraja Reddy, Scientist (Plant Breeding) and Mr. S.B. Prajapati, ICAR-DMAPR coordinated in organising the stall at the *Krishidham* Expo-2019.

Medicinal and aromatic plants exhibition in Flower Show of Inner Wheel Club, Anand

Medicinal and Aromatic Plants exhibition stall was established during the Flower Show of Inner Wheel Club, Anand by Dr. Raghuraj Singh, Mr. Manish Kumar Mittal, Mr. S.R. Patel and supporting staff of Farm Section of ICAR-DMAPR, Anand during 16-17 February, 2019 at Shastri Park, Anand. The queries by visitors about medicinal and aromatic plants cultivation and prospects were answered in this exhibition. A lecture was delivered by Dr. Raghuraj Singh, Scientist and OIC Farm on "औषधीय एवं सुगंधित पौधों का कृषि हेतु वर्गीकरण".

Front line demonstrations at farmers' field on MAPs

Under CSS scheme seven FLDs on palmarosa, lemongrass, tulsi, satavari, brahmi, *etc*. were organized and approximately 1.56 lakhs worth of QPM has been distributed to the farmers.

Training imparted

Techniques in Molecular biology to Ms. Nikita Patel, Assistant Professor, Department of Biotechnology, Uka Tarsadia University, Bardoli during August 30 to September 29, 2019.

Transfers/Promotions

- Mr. Ramdeen, Administrative Officer was transferred to ICAR-CTCRI, Thiruvananthapuram on promotion as Senior Adminstrative Officer w.e.f. June 30, 2019.
- Mr. Raghunathan K., Asst. Administrative Officer was transferred to ICAR-CMFRI, Kochi on promotion as Adminstrative Officer w.e.f. August 08, 2019.
- Mr. Naresh Ganatra, Assistant was promoted as Asst. Administrative Officer w.e.f. August 08, 2019.

New Joining

- Mr. Ramdeen, Administrative Officer joined ICAR-DMAPR on transfer from ICAR CIAH, Bikaner on 11.02.2019

Distinguished Visitors

1. Dr. P. L. Saroj, Director, ICAR-CIAH, Bikaner on 03.02.2019
2. Dr. A. K. Singh, DDG (HS), ICAR, New Delhi on 05.02.2019
3. Dr. Gopal Lal, Director, ICAR-NRCSS, Ajmer on 05.02.2019
4. Dr. N. C. Patel, Vice Chancellor, AAU, Anand on 15.02.2019
5. Mr. Kanwal Singh Chauhan, Member, ICAR Governing Body on 25.02.2019
6. Dr. Major Singh, Director, ICAR-DOGR, Pune on 01.03.2019
7. Dr. T. Janakiram, ADG (HS), ICAR, New Delhi on 16.03.2019
8. Dr. Jitendra Kumar, Director, IPFT, Gurugram on 16.03.2019
9. Mr. Anand Sherkhane, Addl. Development Commissioner, Ministry of MSME, Govt. of India, New Delhi on 20.07.2019
10. Dr. P. Das, Director, Science Foundation for Tribal and Rural Resource Development, Bhubaneswar, Odisha on 23rd and 24th December 2019
11. Dr. T. Janakiram, ADG (HS), ICAR, New Delhi on 24th December 2019

TRAINING AND CAPATITY BUILDING

Training programmes organized

Name of program	Beneficiaries
Promotion of medicinal plants cultivation for livelihood and health security of SCs in Gujarat at Nani Devti Village on 26.06.2019 under SCSP	50
Promotion of medicinal plants cultivation for livelihood and health security of SCs in Gujarat, at DMAPR, Boriavi on 29.06.2019 under SCSP	50
Cultivation of MAPs was conducted on 11.10.2019 at Golana, Anand, Gujarat under SCSP	50
Cultivation of MAPs" was conducted on 26.09.2019 at Valasan, Anand, Gujarat under SCSP	100

Name of program	Beneficiaries
Live webcast of Hon'ble PM addresses on inaugural ceremony of *Pashu Arogaya Mela* on conducted by ICAR-DMAPR, Anand, Gujarat on *11.09.2019*.	75
One day farmer's training on "Cultivation of remunerative MAPs" during November 26, 2019 at Malataj Village under Central Sector Scheme.	100
Other state farmers and students' exposure visits/tours	2122

TV talks

Title	Expert	Covered by
Experts byte on isabgol and ashwagandha cultivation	Dr. P. Manivel, Principal Scientist (Plant Breeding)	DD Kisan, New Delhi
Experts byte on brahmi cultivation	Dr. P.L. Saran, Principal Scientist (Horticuture)	DD Kisan, New Delhi
Experts byte on shatavari cultivation	Dr. P.L. Saran, Principal Scientist (Horticuture)	DD Kisan, New Delhi
Experts byte on tulsi cultivation	Dr. P.L. Saran, Principal Scientist (Horticuture)	DD Kisan, New Delhi
Successful farmer story on brahmi cultivation	Dr. P.L. Saran, Principal Scientist (Horticuture)	DD Kisan, New Delhi
Experts byte on *Integrated Pest and disease Management in MAPs*	Dr. R.P. Meena	DD Kisan, New Delhi
Experts byte on cultivation of Safed musli	Sh. Manjesh, G.N.	DD Kisan, New Delhi
Experts byte on cultivation of Kalmegh	Sh. Manjesh, G.N.	DD Kisan, New Delhi

Training and Conference/Seminar/Symposium/Workshops attended

Name	Details	Date
Conference/Seminar/Symposium/Workshops		
Training		
Scientific Staff		
Mr. Shivkumara, K.T.	Professional attachment training programme on Bar-coding of Insects species associated with Medicinal and Aromatic Plants in ICAR-NBAIR, Bengaluru	December 01, 2018-February 28, 2019
Dr. Satyanshu Kumar Dr. Raghuraj Singh	6th Convention of Society for Ethnopharmacology, India and National Seminar on Translational Research on Traditionally used Indian Medicinal Plants with special reference to *Tinospora cordifolia* at Jadavpur University, Kolkata.	September 07-08, 2019

Name	Details	Date
Dr. Satyanshu Kumar Dr. Raghuraj Singh	29th APSI Scientist Meet 2019 and International conference on Drug Discovery and Development in Agro-biotechnology and Pharmaceutical Sciences at Smt. N. M. Padalia Pharmacy College, Ahmedabad.	November 23-25, 2019
Dr. B. B. Basak	Elsevier workshop on 'Research Collaboration: Impact on Innovation & Economic Development' at IIT Gandhinagar.	October 17, 2019
	84thAnnual Convention and National Seminar on 'Development in Soil Science 2019' at Anand Agricltural University, Anand.	November 15-18, 2019
	National Conference on 'Value Addition to Crop Residue of Natural Fibres' at ICAR-CIRCOT, Mumbai.	December 04, 2019
Dr. R. Nagaraja Reddy	International conference on "Nextgen Genomics, Biology, Bioinformatics and Technologies conference at Mumbai, India.	September 30-October 02, 2019
	4th ISSE national conference on System for Transforming India: Challenges & Opportunities, Space Application Centre at ISRO, Ahmedabad.	September 26-27, 2019
Scientific staff, ICAR-DMAPR	Conference on Priority setting, Monitoring and Evaluvation (PME) of Agricultural Research Projects at ICAR-DMAPR, Anand.	August 03, 2019
Dr. R. P. Meena	71st Annual meeting and National symposium held on at Department of Mycology and Plant Pathology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP	February 26-28, 2019

Awards and recognitions

1. Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry), ICAR-DMAPR, Anand was awarded Academy of Plant Sciences India, APSI, Silver Jubilee Award 2019.
2. Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry), ICAR-DMAPR, Anand was elected as Fellow of Academy of Plant Sciences India, FAPSI.
3. The Best Poster Award was bagged for the paper entitled 'Biochar complexing with mineral waste: The soils shift from havoc to health' authored by B. Prem Kumar and B. B. Basak in the National Seminar on Secondary Agriculture: Significance and Scope in the Era of Globalization' at Navsari Agricultural University, Navsari during November 27-29, 2019.
4. Dr. Raghuraj Singh bagged the Best Oral Presentation Award for the research paper

entitled 'Profiling of hepatoprotective lignans phyllanthin and hypophyllanthin in extracts of *Phyllanthus* species using a validated RP-HPLC–PDA method' in 29th APSI Scientist Meet and International Conference on Drug Discovery and Development in Agrobiotecnology and Pharmaceutical Sciences during November 23-25, 2019 at Smt. N. M. Padalia Pharmacy College, Ahmedabad.

5. Mr. Pampaniya N. bagged the best Oral Presentation Award for the research paper entitled "Acreage estimation of Isabgol (*Plantago ovata*) using GIS and remote sensing" authored by Dutta S, Reddy N. R., Pampaniya N. and Manivel P. in the National Seminar on Secondary Agriculture: Significance and Scope in the Era of Globalization, Navsari Agricultural University, Navsari, Gujarat, held during November 27-29, 2019.

6. Mr. Sandip patel bagged GYAN scholarship of NGBT to present the paper entitled "RNA seq analysis of leaf transcriptome reveals identification of differentially expressed genes (DEGs) against delayed flowering in Isabgol [*Plantago ovata* (Forsk.)]" authored by Patel S, Reddy N.R., Panchal R., Manivel P. at the 9th International conference on Nextgen Genomics, Biology, Bioinformatics and Technologies Conference (NGBT), Mumbai, India held during September 30-October 02, 2019, Mumbai, India.

7. Teachers Associateship for Research Excellence award was bagged by Dr. Rushikesh G. Joshi, Assistant Professor, Department of Biochemistry and Forensic Science, Gujarat University, Navrangpura, Ahmedabad, Gujarat-380009 from the Department of Science and technology (DST) – Science and Engineering Research Board (SERB), Teachers Associateship for Research Excellence (TARE) under the mentorship of Dr. P. Manivel, Principal Scientist (Plant Breeding).

8. ICAR-Directorate of Medicinal and Aromatic Plants Research (DMAPR) exhibition stall bagged the best display award (First) at the Krishidham Expo-2019 organized by ICAR - CPRI, Regional Station, Modipuram, Meerut, Uttar Pradesh in partnership with HiFi conference and events Pvt Ltd, Noida for its innovative and informative display of technologies.

Externally funded project sanctioned

Inventorization, molecular identification and characterization of *Garcinia* species from northeast India for isolation of polyisoprenylated benzophenones as taxol mimics, DBT, New Delhi. Participating Institutes: ICAR-DMAPR, Anand (PI: Dr. Satyanshu Kumar, Co-PI: Dr. Raghuraj Singh); MS University, Vadodara and Energy Institute, Guwahati.

ICAR-DMAPR RESEARCH PROJECTS

Institute funded projects

1. **Project 01:** Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production. Principal Investigator: Dr. Geetha, K. A., Principal Scientist (Plant Breeding); Co-PIs: Dr. P. Manivel, Principal Scientist (Plant Breeding); Dr. P. L. Saran, Principal Scientist (Horticulture); Dr. R. N. Reddy, Scientist (Plant Breeding); Dr. V. Thondaiman, Scientist (Spices, Plantation and Medicinal & Aromatic

Plants-SPMAP); Dr. Hemlata Bharti, Scientist (SPMAP); Dr. Akula Chinapolaiah, Scientist (SPMAP); Mr. Manish Kumar Mittal, Scientist (Economic Botany and PGR); Dr. Satyanshu Kumar, Principal scientist (Organic Chemistry); Dr. N. A. Gajbhiye, Principal Scientist (Organic Chemistry) and Dr. K. A. Kalaria Scientist (Plant Physiology)

2. **Project 02:** Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches. Principal Investigator: Dr. P. Manivel, Principal Scientist (Plant Breeding): Co-PIs: Dr. Geetha K.A. Principal Scientist (Plant Breeding); Dr. P. L. Saran, Principal Scientist (Horticulture); Dr. R. N. Reddy, Scientist (Plant Breeding); Dr. V. Thondaiman, Scientist (SPMAP); Dr. Hemlata Bharti, Scientist (SPMAP); Dr. Akula Chinapolaiah, Scientist (SPMAP); Dr. Manish Kumar Suthar, Scientist (Agricultural Biotechnology); Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry); Dr. N.A. Gajbhiye, Principal Scientist (Organic Chemistry); Dr. R. P. Meena, Scientist (Plant Pathology), Mr. Manjesh G. N., Scientist (SPMAP) and Mr. Sivakumara. K.T., Scientist (Entomology).

3. **Project 03:** Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants. Principal Investigator: Dr. Nagaraja Reddy, Scientist (Plant Breeding): Co-PIs: Dr. Hemlata Bharti, Scientist (SPMAP); Dr. Manish Kumar Suthar, Scientist (Agricultural Biotechnology) and Mr. Manish Kumar Mittal Scientist (Economic Botany and PGR)

4. **Project 04:** Integrated water, nutrient management and physiological manipulation for improving productivity of medicinal and aromatic plants Principal Investigator: Dr. B. B. Basak, Scientist (Soil Science): Co-PIs: Dr. N A Gajbhiye, Principal Scientist (Organic Chemistry); Dr. R. R. Singh, Scientist (Farm power and Machinery); Dr. K. A. Kalariya, Scientist (Plant Physiology); Dr. V. Thondaiman, Scientist (SPMAP) and Mr. Manjesh G.N., Scientist, (SPMAP).

5. **Project 05:** Integrated pest and disease management in medicinal and aromatic plants Principal Investigator: Dr. R.P Meena, Scientist (Plant Pathology): Co-PIs: Dr. N A Gajbhiye, Principal Scientist (Organic Chemistry), Dr. Satyajit Roy, Principal Scientist (Plant Pathology) and Mr. Sivakumara. K.T., Scientist (Entomology).

6. **Project 06:** Bio-prospection, quality and post-harvest technology of medicinal and aromatic plants. Principal Investigator: Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry); Co-PIs: Dr. N. A. Gajbhiye, Principal Scientist (Organic Chemistry); Dr. B. B. Basak, Scientist (Soil Science); Dr. Raghuraj Singh, Scientist (Farm Machinery and Power) and Dr. A. P. Trivedi, Sr. Technical Officer.

7. **Project 07:** Improving knowledge and skill of stakeholders for improving production of medicinal and aromatic crops Principal Investigator: Dr. Nagaraja Reddy, Scientist (Plant Breeding); Co-PIs: Dr. P. Manivel, Principal Scientist (Plant Breeding); Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry); Dr. Geetha, K. A., Principal Scientist (Plant Breeding); Dr. P. L. Saran, Principal Scientist (Horticulture); Dr. Raghuraj Singh, Scientist (Power and Farm Machinery); Dr. K. A. Kalariya, Scientist (Plant Physiology);

Dr. R. P. Meena, Scientist (Plant Pathology); Dr. A. P. Trivedi, Senior Technical Officer; Dr. Manish Kumar Suthar, Scientist (Agricultural Biotechnology); Dr, Manish Mittal, Sceintist (Economic Botany and PGR) and Mr. Manjesh G. N., Scientist (SPMAP).

8. **Institute's flagship programme:** Organic cultivation of medicinal and aromatic crops Principal Investigator: Dr. B. B. Basak, Scientist (Soil Science): Co-PIs: Dr. N. A. Gajbhiye, Principal Scientist (Organic Chemistry); Dr. R. P. Meena, Scientist (Plant Pathology) and Mr. Manjesh G.N., Scientist (SPMAP).

Externally funded projects

1. PPVFRA- Development of DUS guidelines and strengthening of DUS Test Centres for laboratory and field facilities (2006 onwards). Principal Investigator: Dr. Geetha K. A.
2. ICAR CRP- High Value Compounds/Phytochemicals (2014-2020) PI : Dr. Satyanshu Kumar; Co-PI: Dr. Raghuraj Singh from 2018.
3. NMPB- Exploration of medicinal and aromatic plants in marginal, degraded and arid regions of India (2016-20). Principal Investigator: Dr. B. B. Basak and Dr. A.P. Trivedi, Senior Technical Officer.
4. DST-SERB- Evaluation of unconventional sources of potassium for sustainable farming system (2016-19) Principal Investigator: Dr. B. B. Basak.
5. DST-SERB- Transcriptome based discovery of pathways and genes related to resistance against downy mildew disease in isabgol (*Plantago ovata* Forsk.) (2015-19 Investigators: Dr. P. Manivel, Prinicipal Scientist (Plant Breeding) and Dr. R. Nagaraja Reddy , Scientist (Plant Breeding)
6. DST-SERB- Dissection of pathogenesis genes of *Peronospora plantaginis* Underwood, a fungal pathogen causing isabgol downy mildew disease (2016-2019) Principal Investigator: Dr. P. Manivel, Principal Scientist (Plant Breeding)
7. GSBTM- Unraveling the biosynthetic pathway of active ingredients in diabetes curing tropical medicinal herb Madhunashini (*Gymnema sylvestre*) through transcriptome analysis (2017-2019) Investigators: Dr. K.A. Kalariya, Dr. A. P. Trivedi, Senior Technical Officer.
8. NMPB- Standardization of propagation techniques and QPM production of selected medicinal plants (2017-20) Principal Investigator: Dr. P. L. Saran.
9. NMPB- Development of Training module and felicitation guide for GAP and GCP for medicinal plants Principal Investigator: Dr. P. Manivel; Co-PIs: Dr. P.L. Saran; Dr. B.B. Basak; Dr. Akhula Chinapoliah.
10. NASF- Chemotyping and molecular profiling of bioactive metabolites in *Hemidesmus indicus*and *Costus specious*, adapted to different phytogeographical zones and Identification of candidate genes related to metabolic pathways (2016-2020) CCPI: Dr. Narendra Gajbhiye; CoCPI-Dr. Thondaiman

11. NMPB- Standard Operating protocols of post harvest management of five selected medicinal plants (*Desmodium*, *Gymnema*, *Leptedenia*, *Phyllanthus* and *Ecalipta alba*) Principal Investigator: Dr. Satyanshu Kumar; CoPI - Dr. Raghuraj Singh.
12. NASF- Chemical, structural and functional characterization of identified anti-tick lead phytochemicals and optimization of delivery matrix for effective application of natural formulation for the control of acaricide resistant ticks (2017-2020) CCPI: Dr. Satyanshu Kumar.
13. NMPB- Sustainable production technology of gudmar (*Gymnema sylvestre* R. Br.) a medicinal plant with antidiabetic compound gymnemagin; (2017-2020 Principal Investigator: Dr. Akula Chinapolaiah; Co-PI: Dr. Satyanshu Kumar.
14. NMPB- Investigation of *Taverniera cuneifolia* (Roth) Ali, as a sweetener for substitute of *Glycyrrhiza glabra* L. in herbal formulations (2018-2021) PI : Dr. Satyanshu Kumar; Co-PI: Dr. Raghuraj Singh.
15. NMPB- Breeding of medicinal plants for improved yield and quality (2018-2023) PI:- Dr. R. N. Reddy; CoPIs:- Dr. P. Manivel; Dr. V. Thondaiman
16. ISRO-SAC- Work plans for inventory of Medicinal Plants (2019-2021) PI:- Dr. R. N. Reddy; CoPIs:- Dr. P. Manivel and Dr. B. B. Basak
17. DST-SERB- Molecular characterization and biological study on virus and virus like pathogen infecting medicinal and aromatic crops of India (2018-2021) PI: Dr. R. P. Meena.

PUBLICATIONS

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Research Papers:

Banerjee T., Singh A., Kumar S., Dhanani T., Gajbhiye N.A., Koley T.K., Maurya A. and Filgonae J. 2019. Ovicidal and larvicidal effects of extracts from leaves of *Andrographis paniculata* (Burm. F.) Wall.ex Nees against field isolates of human hookworm (*Ancylostoma duodenale*). Journal of Ethnopharmacology, 235: 489-500.

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Kalariya K.A., Gajbhiye N., Minipara D., Meena R.P., Kumar S., Saha A., Trivedi A. and Manivel

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Kalariya K.A., Minipara D., Saran P.L., Poojara L., Polireddy A.C. and Manivel P. 2019. Photosynthetic efficiency in *Gymnema sylvestre* (Retz.) R.Br. genotypes Vegetos. Plant and Soil, 32: 473–485. https://doi.org/10.1007/s42535-019-00062-z.

Kapadiya T.B., Shivkumara K.T., Meena R.P., Manivel P and Roy S. 2019. Occurrence of two spotted spider mite, *Tetranychus urticae* Koch (Arachnida: Acari: Tetranychidae) on ashwagandha in Gujarat. Journal of Entomology and Zoology Studies, 7(3): 77-79.

Kureshi A.A., Dholakiya C., Hussain T., Mirgal A., Salvi S.P., Barua P.C., Talukdar M., Beena C., Kar A., Zachariah T.J., Kumari P., Dhanani T., Singh R., Manivel P. and Kumar S. 2019. Simultaneous identification and quantification of three xanthones and two polyisoprenylated benzophenones in eight Indian *Garcinia* species using a validated UHPLC-PDA method. Journal of Association of Official Analytical Chemists – JAOAC International. https://doi.org/10.5740/jaoacint.18-0335.

Kureshi A.A., Hussain T., Mirgal A., Salvi S.P., Barua P.C., Talukdar M., Beena C., Kar A., Zachariah T.J., Kumar S., P. Dhanani T., Singh R. and Kumari P. 2019. Comparative evaluation of antioxidant properties of extracts of fruit rinds of *Garcinia* species by *in vitro* assays. Indian Journal of Horticulture, 76: 338-343.

Manivel P., Reddy N.R. and Gajbhiye N.A. 2019. DWS-37 (IC0623444; INGR17056), an Ashwagandha (*Withania somnifera*) germplasm with revolute rolled leaves. Indian Journal of Plant Genetic Resources, 32(2):264-265.

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Manivel P., Reddy N.R., Raju S., Thondaiman V. and Rakesh G. 2019. Exploration and collection of genetic resources of salparni (*Desmodium gangeticum* L.) in India. International Journal of Minor Fruits, Medicinal and Aromatic Plants, 5 (1): 21-28.

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Saran P.L., Patel R., Meena R.P., Kalariya K.A. and Choudhary R. 2019. Mini cutting technique: an easy and cost-effective way of *Tinospora cordifolia* multiplication. Indian Journal of Agricultural Sciences, 89 (2): 206–209,

Smitha G.R., Basak B.B., Thondaiman V. and Saha A. 2019. Nutrient management through organics, bio-fertilizers and crop residues improves growth, yield and quality of sacred basil (*Ocimum sanctum* Linn). Industrial Crops and Products, 128: 599-606.

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Janakiram T., Reddy N.R., Manivel P. and Roy S. 2019. Road map for isabgol promotion in India, ICAR-Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat.

Book Chapters:

Meena R.P. 2019. Wilt diseases of medicinal and aromatic crops and their management. **In:** Wilt Diseases of Crops (2019), Today and Tomorrow Printers and Publisher, New Delhi. India, pp. 123-139.

Saha A., Ghosh R.K. and Basak B.B. 2019. Fate and behavior of pesticides and their effect on soil biological properties under climate change scenario. **In:** Sustainable Management of Soil and Environment, Springer, Singapore, pp. 259-288.

Pal S. and Basak B.B., 2019. Toward conservation agriculture for improving soil biodiversity. **In:** Applied Agricultural Practices for Mitigating Climate Change, CRC Press, *2*, pp.169.

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Ghosh S., Kumar R., Kumar S., Singh R., Srivastava S., Julliet S., Gupta S., Ravindran R., Pandey M.M., Kumar K., Kumar B., Sharma S., Sah S., Verma A., Sharma A.K., Nagar G., Kumar S., Kumar A., K.G., Chigure G., Fular A., Shanmugnath C., Upadhya D., Shakya M. and Bisht N. 2019. Phyto-acaricides-a sustainable solution for acaricides resistance management. **In:** e-book of International Conference on "New age opportunities and challenges for quality, safety and GMPs in herbal drug development" at CSIR-NBRI, Lucknow during February 22-23, 2019, pp.12.

Saha A., Basak B.B., Gajbhiye N.A., Kalariya K.A. and Manivel, P. 2019. Co-application of biochar and chemical fertilizers for improvement of yield and quality of *Andrographis paniculata* and soil health. **In:** Book of Abstract 83rdAnnual Convention and National Seminar on' Development in Soil Science at Anand Agricultural University, Anand.

Reddy N.R. and Manivel P. 2019. Isabgolomics: Where we are, where does it lead to? **In:** Souvenir of 9th International conference on "Nextgen Genomics, Biology, Bioinformatics and Technologies Conference at Mumbai, India during September 30-October 02, 2019.

Patel S., Reddy N.R., Panchal R. and Manivel P. 2019. RNA seq analysis of leaf transcriptome reveals identification of differentially expressed genes (DEGs) against delayed flowering in Isabgol [*Plantago ovata* (Forsk.)]. **In:** Souvenir of 9th International Conference on Nextgen Genomics, Biology. Bioinformatics and Technologies Conference (NGBT) at Mumbai, India during September 30-October 02, 2019.

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Pampaniya N., Dutta S., Reddy N.R., Bhattacharya B.K., Basak B.B., Manivel P. and Roy S. 2019. Site suitability analysis for medicinal plants using RS and GIS. **In:** Souvenir of 4th ISSE National Conference on System for Transforming India: Challenges & Opportunities at Space Application Centre, ISRO, Ahmedabad during September 26 – 27, 2019.

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agricultural University, Navsari, Gujarat during November 27-29, 2019.

Manivel P., Reddy N.R. and Roy S. 2019. Value addition and marketing of isabgol (*Plantago ovata*): challenges and opportunities. **In:** the Souvenir on "National Conference on Climate Smart Agriculture for Livelihood Security: Challenges and Opportunities" at Anbil Dharmalingam Agriculture College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli during September 13-14, 2019.

Singh R., Nagar P.S., Patel J., Dhanani T., Patel V., Pal K., Gajbhiye N. and Kumar S. 2019. Profiling of hepatoprotective lignans phyllanthin and hypophyllanthin in extracts of *Phyllanthus* species using a validated RP-HPLC–PDA method. **In:** Souvenir: 29th APSI Scientist Meet 2019 and International Conference on Drug Discovery and Development in Agro-biotechnology and Pharmaceutal Sciences at Smt. N.M. Padalia Pharmacy College, Ahmedabad during November 23-25, 2019, pp.153.

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AICRP-MAPB Centres

AAU, Anand

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AAU, Jorhat

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Saud B.K., Dutta P. and Goswami S. 2019. Training manual on package and practices of some medicinal plants, Published under ICAR-AICRP on medicinal and Aromatic Plants, and Betelvine Directorate of Research(Agri), AAU, Jorhat, Assam.

Bulletin/Leaflet

- Cultivation practices of Bosc, Published under ICAR-AICRP on medicinal and Aromatic Plants and Betelvine Directorate of Research (Agri), AAU, Jorhat, Assam pp.16.
- Cultivation practices of Brahmi, Published under ICAR-AICRP on Medicinal and Aromatic Plants, and Betelvine Directorate of Research(Agri), AAU, Jorhat, Assam.
- Cultivation practices of Pippali, Published under ICAR-AICRP on Medicinal and Aromatic Plants, and Betelvine Directorate of Research (Agri), AAU, Jorhat, Assam.

BAU, Islampur

Research Paper

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CCSHAU, Hisar

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JNKVV, Jabalpur

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YSRHU, Venkataramannagudem

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PERSONNEL

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Mr. Raghunadhan K., Assistant Administrative Officer (up to August 07, 2019)
Mr. N. J. Ganatra, Assistant (up to August 07, 2019)
Mr. N. J. Ganatra, Assistant Administrative Officer (from August 08, 2019)
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