Annual Report
2017-18

ICAR– Directorate of Medicinal and Aromatic Plants Research
(ISO 9001:2015 Certified)
Boriavi, Anand – 387 310, Gujarat, India
On the cover:

- Piper longum
- Gloriosa superba
- Swertia chirayita
- Chlorophytum borivilianum
- Commiphora wightii
- Garcinia cambogia
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It gives me immense pleasure to present the Annual Report for the year 2017-18 of ICAR-DMAPR, during which the Directorate has marched ahead with better visibility and recognitions through its significant contributions not only towards awareness and creation of new knowledge but also through its commitment towards society including farmers and stakeholders.

The Indian Government is committed to the welfare of farmers and doubling farmers’ income by 2022. To achieve this goal, the Government has taken up various farmers friendly programmes to direct the benefits of structural changes and good growth to reach farmers, poor and other vulnerable sections of our society and to uplift the underdeveloped regions. As far as medicinal and aromatic plants are concerned, ₹ 2 billion are allocated for organized cultivation of highly specialized medicinal and aromatic plants and said that the organic farming by Farmer Producer Organizations (FPOs) and Village Producers’ Organizations (VPOs) in large clusters, preferably of 1000 hectares each will be encouraged. In this direction to support the doubling the farmers income by 2022, the ICAR-DMAPR has taken strong initiative with suitable plan in research and extension activities to help the medicinal and aromatic plants farmers and stakeholders.

The ICAR-DMAPR has taken initiative in developing superior varieties, technologies and patent. Directorate has filed one patent application “A Phosphorus Enriched Vermicompost Composition and its Method of Preparation”. DMAPR released 03 varieties (Vallabh Ashwagandha 1, Vallabh Isabgol 1 and Vallabh Isabgol 4). Five germplasm were registered at NBPRGR for specific trait; in senna INGR 17079 for a small pod size and INGR17080 for broad pod and leaves; in ashwagandha INGR17056 for a revolute leaf type and INGR17057 for yellow young leaf plant type and in isabgol INGR17055 was registered extended bract mutant.

Directorate has conducted several training in Medicinal and Aromatic plants sector. Two major (twenty five days) programmes were conducted by Directorate, first training on “Gardner” (AGR/Q0801) was conducted for 25 unemployed youth during January 22 -
February 15, 2018 which was funded by the Directorate of Areca nut and Spices Development (DASD), Calicut, Kerala and supported by Agriculture Skill Council of India (ASCI), New Delhi. Second training on “Essential Oil Extraction” (AGR/Q0902) for 25 unemployed youth was organized from February 16 –March 12, 2018 under central sector scheme (CSS). Programmes on Mera Gaav Mera Gaurav (MGMG) and Swachh Bharat Mission also initiated by ICAR and Government of India were continued at the ICAR-DMAPR during the year 2017-18.

I consider it a privilege to place on the records the encouragement given by Dr. Trilochan Mohapatra, Secretary (DARE) & Director General, ICAR. I am also grateful for the strong support and necessary guidance received from Dr A.K. Singh, Deputy Director General (Hort. Science), Dr. T. Jankiram, ADG (Hort. Science). The visits of dignitaries, to name a few, Sh. V. V. Vaghasiya, Hon’able Minister, Agriculture & Urban Housing Development, Government of Gujarat, Gandhinagar; Dr. H. S. Gupta, Formerly Director General, Borlaug Institute for South Asia, New Delhi; Prof. P. Das, Formerly Director, Regional Plant Resource Centre, Bhubaneswar and Dr. N. P. Singh, Director, ICAR-NIASM, Baramati during last one year, immensely benefitted the ICAR-DMAPR family in terms of their valuable comments. I appreciate and thanks the effort made by all the scientists of this Directorate as well as AICRP-MAP& B. I express my appreciation to editorial team and Directorate family for compiling and brining out this report in time. Help rendered by my colleagues, Dr. Geetha K. A. and Dr. Raghuraj Singh in compilation of the results are also specially acknowledged.

Jai Hind !

P. Manivel

Anand

6th June, 2018
# Abbreviations Used

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<th>Description</th>
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<td>AAU</td>
<td>Anand Agricultural University/ Assam Agricultural University</td>
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<td>AICRP - MAPB</td>
<td>All India Coordinated Research Project on Medicinal and Aromatic Plants &amp; Betelvine</td>
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<td>BAU</td>
<td>Bihar Agricultural University/ Birsa Agricultural University</td>
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<tr>
<td>BCKV</td>
<td>Bidhan Chandra Krishi Vishwa Vidyalaya</td>
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<tr>
<td>B:C ratio</td>
<td>Benefit cost ratio</td>
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<tr>
<td>CCSHAU</td>
<td>Chaudhary Charan Singh Haryana Agricultural University</td>
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<tr>
<td>cfu</td>
<td>Colony-forming units</td>
</tr>
<tr>
<td>CTAB</td>
<td>Cetyl trimethyl-ammonium bromide</td>
</tr>
<tr>
<td>DAP</td>
<td>Days after planting</td>
</tr>
<tr>
<td>DAS</td>
<td>Days after sowing</td>
</tr>
<tr>
<td>DAT</td>
<td>Days after transplanting</td>
</tr>
<tr>
<td>DST</td>
<td>Department of Science and Technology</td>
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<tr>
<td>DUS</td>
<td>Distinctiveness uniformity and stability</td>
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<tr>
<td>ICAR - DMAPR</td>
<td>Directorate of Medicinal and Aromatic Plants Research</td>
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<tr>
<td>ETL</td>
<td>Economic Threshold Limit</td>
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<td>FWB</td>
<td>Fresh Weight Basis</td>
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<td>FYM</td>
<td>Farm Yard Manure</td>
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<td>GAP</td>
<td>Good Agricultural Practices</td>
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<td>GC-MS</td>
<td>Gas Chromatography and Mass Spectrometry</td>
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<tr>
<td>ha</td>
<td>Hectare</td>
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<td>HPLC</td>
<td>High Performance Liquid Chromatography</td>
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<tr>
<td>HPTLC</td>
<td>High Performance Thin Layer Chromatography</td>
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<td>IBA</td>
<td>Indole Butyric Acid</td>
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<td>ICM</td>
<td>Integrated Crop Management</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>IDM</td>
<td>Integrated Disease Management</td>
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<td>IGKV</td>
<td>Indira Gandhi Krishi Vishwavidyalaya</td>
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<td>IIHR</td>
<td>Indian Institute of Horticultural Research</td>
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<tr>
<td>ISSR</td>
<td>Inter Simple Sequence Repeat</td>
</tr>
<tr>
<td>IW/CPE</td>
<td>Irrigation Water/Cumulative Pan Evaporation</td>
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<tr>
<td>JNKVV</td>
<td>Jawaharlal Nehru Krishi Vishwa Vidyalaya</td>
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<td>KAU</td>
<td>Kerala Agricultural University</td>
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<tr>
<td>LC-MS/MS</td>
<td>Liquid Chromatography–Mass Spectrometry</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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<tr>
<td>LER</td>
<td>Land Equivalent Ratio</td>
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<td>MAP</td>
<td>Medicinal and Aromatic Plants</td>
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<td>MPKV</td>
<td>Mahatma Phule Krishi Vidyapeeth</td>
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<tr>
<td>N ha⁻¹</td>
<td>Nitrogen per hectare</td>
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<tr>
<td>NAIP</td>
<td>National Agricultural Innovation Project</td>
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<tr>
<td>NDUAT</td>
<td>Narendra Dev University of Agriculture and Technology</td>
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<tr>
<td>NPK</td>
<td>Nitrogen-phosphorous-potash</td>
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<td>OUAT</td>
<td>Orissa University of Agriculture and Technology</td>
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<tr>
<td>PDA</td>
<td>Photo diode array</td>
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<tr>
<td>Plant ha⁻¹</td>
<td>Plant per hectare</td>
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<td>PDI</td>
<td>Percent Disease Index</td>
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<td>PDKV</td>
<td>Dr. Punjabrao Deshmukh Krishi Vishwavidyalaya</td>
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<td>PPV &amp; FRA</td>
<td>Protection of Plant Varieties &amp; Farmers’ Rights Authority</td>
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<td>PSB</td>
<td>Phosphate Solubilising Bacteria</td>
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<tr>
<td>q</td>
<td>Quintal (100 kg)</td>
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<tr>
<td>RDF</td>
<td>Recommended Dose of Fertilizers</td>
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<tr>
<td>RAPD</td>
<td>Random Amplified Polymorphic DNA</td>
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<tr>
<td>RAU</td>
<td>Rajendra Agricultural University</td>
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<tr>
<td>RDF</td>
<td>Recommended Dose of Fertilizer</td>
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<td>RIL</td>
<td>Recombinant Inbreed Line</td>
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<td>RVSKVV</td>
<td>Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya</td>
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<td>SSR</td>
<td>Simple Sequence Repeats</td>
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<tr>
<td>t</td>
<td>Tonne (1000 kg)</td>
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<tr>
<td>TLC</td>
<td>Thin Layer Chromatography</td>
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<tr>
<td>TNAU</td>
<td>Tamil Nadu Agricultural University</td>
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<td>TSP</td>
<td>Tribal Sub Plan</td>
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<tr>
<td>UBKV</td>
<td>Uttar Banga Krishi Vishwa Vidyalaya</td>
</tr>
<tr>
<td>UUHF</td>
<td>Uttarakhand University of Horticulture and Forestry</td>
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<tr>
<td>VAM</td>
<td>Vesicular Arbuscular Mycorrhiza</td>
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<tr>
<td>YSPUHF</td>
<td>Dr. Y.S. Parmar University of Horticulture and Forestry</td>
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<tr>
<td>YSRHU</td>
<td>Dr. Y. S. Rajasekhara Reddy Horticulture University</td>
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SUMMARY

ICAR Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR) and its outreach program All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine (AICRP-MAPB) are engaged in research on Medicinal and Aromatic plants and Betelvine. Salient research findings of 2017-18 are presented below:

ICAR-DMAPR

ALOE (Aloe barbadensis)

SSR markers were validated for diversity analysis of aloe germplasm.

A thick root phenotype (TRP) was identified from the in vitro raised aloe plants.

ASHWAGANDHA (Withania somnifera)

One hundred and twenty-two accessions were characterized for agro-morphological characters. Accessions, IC0210601, IC0262388, IC0385221, IC0510842, IC0510841, RVA-100 and AWS-1 recorded high root yield (more than 1500 kg ha⁻¹). Accession IC0510841 was indentified for extra-large leaf.

DWS-37 (IC0623444; INGR17056): A revolute leaf type and DWS-127 (IC0623445; INGR17057) a plant type with yellow young leaf were registered as trait specific germplasm at ICAR-NBPGR, New Delhi.

Vallabh Ashwagandha-1 (DWS 132) a new ashwagandha variety developed through pure line breeding was recommended as a superior variety for cultivation by the Institute Research Committee. The variety is suitable for cultivation in Madhya Pradesh, Gujarat, Rajasthan and other parts of the country.

Exploration the EST/TSA databases of ashwagandha for mining new SSR markers by MISA identified a total of 89414 SSRs. Among the SSR motifs found, hexamer (75.50 %) were abundantly found, followed by trimers (13.55%), tetramers (5.64%), dimers (4.05%) and pentamers (1.28%). Over 4800 SSR markers were designed out of which 54 SSRs were validated.

A total of 140 germplasm lines and 328 breeding lines of ashwagandha were screened for leaf blight disease. Twelve germplasm lines and 36 breeding lines were found moderately resistant to resistant for Alternaria leaf blight.

Experiment conducted to study the impacts of repeated foliar application of growth retardants/ promoters on the biomass allocation and major withanolide content in W. Somnifera revealed significant effect on the studied parameters under the influence of these treatments. Plants under repeated ethrel application (@ 500mg l⁻¹) during 60-120 days after sowing (DAS) had restricted phenological progression and reduced berry weight (68%) as compared to the control at 160 DAS. It resulted in reduction (29%) in total biomass yield but accumulated more withaferin in roots (48%), stem (65%) and berry (20%) as compared to the control at 180 DAS. Application of 500 mg l⁻¹ succinic acid increased root dry weight by 13% along with more accumulation of withaferin (54%) and 12-deoxy withastramonide(47%) in roots at 180 DAS.
Study of the effect of different organic nutrients sources on yield and quality of ashwagandha revealed the highest fresh (1505 kg ha⁻¹) and dry (767 kg ha⁻¹) root yields as well as total withanolide content (0.947 mg g⁻¹) under the treatment receiving castor cake+ microbial consortium. Regarding individual withanolides, the results showed that a significant increase in the root withaferin-A content in plants treated with different combinations of organic manure and microbial consortia compared with the other treatments. In all the treatments, in general, the application of inorganic fertilizers showed comparable or sometime better withanolide-A content as compared to the application of organic manure alone.

**BAEL (Aegle marmelos)**

Ninety-eight bael accessions were evaluated and the highest fruit yield was observed in DAM - 25 (123.37 kg tree⁻¹), imperatorin content was higher in DAM - 124 (2.99 mg g⁻¹) and essential oil content in fresh leaves was higher in DAM - 161 (6.50 g kg⁻¹). Accessions, DAM-124, DAM-92, DAM-10, DAM-36, DAM-161 DAM-17, DAM-25 and DAM-71 were most distinct and rich in fruit yield, fresh leaf yield, essential oil yield and imperatorin content, therefore, suitable for cultivation and industrial purposes.

**BASIL (Ocimum basilicum)**

Germplasm characterization revealed three different calyx coloured plant types i.e., light purple (GAB-1), dark purple (EC0338780) and green (EC0338784-1).

A unique line Rudra-2 was identified which was a dwarf type with early flowering compared to the semi-dwarf line, DOB-4. Accession Sant-1 had closed canopy architecture and DOB-8W was most vigorous type with high biological yield (66400 kg ha⁻¹).

**GILOE (Tinospora cordifolia)**

In *T. cordifolia*, mini cuttings (single bud with intermodal stem portion on both side) techniques was proved as the best propagation method for commercial multiplication.

**GUGGUL (Commiphora wightii)**

Study of genetic diversity vis-a-vis reproductive behavior of guggul conducted using molecular markers showed that the trend of genetic variation was not strictly correlated to the geographical locations, but was related to the reproductive behaviour of the populations. The diversity was somewhat low in Rajasthan populations where only apomictic populations are distributed. Populations of maximum genetic diversity along with sexual forms were found distributed in Gujarat populations.

**ISABGOL (Plantago ovata)**

The inheritance of leaf color (light and dark green), leaf curling (curly and normal), leaf hairiness (glossy and hairy) and plant height (tall and dwarf) was studied in Isabgol using F₂ population derived from a cross between two mutants DPO-401 and DPO-324.

DPO-9 (IC0623443; INGR17055): an extended bract mutant of isabgol was registered as trait specific germplasm at ICAR-NBPGR, New Delhi.
Vallabh Isabgol-1 (DPO-1) a new high yielding medium duration (120-125 days) variety developed through mutation breeding was recommended for variety release during XVI Group Meeting of All India Coordinated Research project on Medicinal and Aromatic Plants & Betelvine (AICRP-MAP&B) held at MPUAT, Udaipur during 11-14 November, 2017. The mean seed yield of Vallabh Isabgol-1 was 1025 kg ha\(^{-1}\) as compared to 826.6 kg ha\(^{-1}\) of GI-2.

DPO-4 (Vallabh Isabgol-4), a new variety developed through mutation breeding was identified as a superior variety for cultivation by the Institute Research Committee. Its seed yield ranged from 886 to 947 kg ha\(^{-1}\) and under favourable conditions and good management the yield reaches up to 1300 kg ha\(^{-1}\).

One hundred and sixty recombinant inbred lines (RIL) developed from DPO-185 x DPO-14 cross for downy mildew disease resistance mapping were advanced from F\(_5\) to F\(_7\).

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.

Screening for downy mildew resistance showed that among the total of 225 breeding lines, 75 germplasm lines and 160 isabgol RILs, 12 germplasm lines, 27 breeding lines and 50 RILs were moderately resistant to resistant for downy mildew.

Transcriptome analysis was carried out by next generation sequencing (NGS) data of leaves of downy mildew resistant (DPO-185) and susceptible (DPO-14) mutants to understand the host-plant resistance of downy mildew.

Whole genome sequence of downy mildew disease causing fungal pathogen *Peronospora plantaginis* of DMAPR isolate was also carried out using NGS to decipher genes involved in fungal pathogenesis.

Field experiments conducted to study the effect of enriched organic fertilizer on yield and quality of isabgol revealed that application of FYM, vermicompost, castor cake, RDF and enriched organic fertilizer increased the seed yield up to 9.7, 12.6, 13.1, 17.4 and 24.1%, respectively over the control. Maximum husk yield was recorded with application of 2.5 t ha\(^{-1}\) enriched organic fertilizer. Quality parameters like swelling factor and mucilage% were also significantly improved by the application of enriched organic fertilizer.

Integrated disease management module tested for soil borne diseases particularly for wilt and downy mildew diseases showed that among the chemical and bio fungicides, ridomil MZ @ 0.25% spray was most effective and among the bioproducts neem leaf extract @ 10% solution was effective in managing the downy mildew disease. Combination of seed treatment of 2% Bavistine with soil amended by *Trichoderma* spp. and neem cake was most suitable for reducing wilt disease management.

**KALMEGH (Andrographis paniculata)**

A new plant type- DMAPR AP 35-1 was identified from DMAPR AP 35. At reproductive stage the new plant type had a feathery canopy (*mayur*= peacock canopy). The new plant type has very late and
shy flowering also.

Sixty-three germplasm accessions were evaluated for yield and other agronomic traits and it was found that fresh herbage yield ranged from 756 to 8085 kg ha⁻¹ and dry herbage yield ranged from 244.00 to 1769.00 kg ha⁻¹. Accessions IC0342135, EC0415019, IC0520354 and IC0470905 recorded maximum dry herbage yield (more than 1500 kg ha⁻¹).

Twenty reference varieties were maintained during the kharif season.

Characterization of long and short variants of Ent-CPS (Ent-copalyl diphosphate synthase) which is a key enzyme of labdane related diterpene biosynthesis of kalmegh was carried out.

Twenty six genotypes were evaluated under rain-fed condition during early and later growth stages. The result revealed that late season rain-fed condition caused nearly 40% reduction in total biomass. Andrographolide content was also found affected by the water deficit stress caused due to rain-fed condition.

It was found that methanol and ethanol were superior solvents for extraction of major diterpenoid lactones and water was found superior for extraction of flavonoids. Concentration of individual analytes viz., andrographiside, neoandrographolide, andrographanin, 14-deoxy,11-12 didehydroandrographolide, apigenin and 7-O- methylwogonin was also measured from these extracts.

Variation of three andrographolides namely andrographolide, neoandrographolide and andrograpanin were analysed in 15 samples of A. paniculata collected from different regions of India and nine marketed herbal formulations containing A. paniculata. Andrographolide in the 15 samples was in the range of 4.23+ 0.1-1.11+ 0.07 %; neoandrographolide was in the range of 1.15+0.02-0.03+0.0 % and andrograpanin was quantified in eight samples which varied from 0.11+ 0.00 to 0.37+ 0.02 %.

Study of ovicidal and larvicidal effects of andrographolide against human hookworm (Ancylostoma duodenale) revealed significant ovicidal and larvicidal properties of andrographolide against field isolates of A.duodenale which can be developed as a potential therapeutic choice.

KOKKUM (Garcinia spp.)

UPLC-PDA method was developed for the quantification of α, β & γ mangostin and xanthochymol & isoxanthochymol in the extracts of Garcinia cowa, G. cambogia, G. indica, G. mangostana, G. morella, G. pedunculata and G. linoceroide.

The extracts of Garcinia fruits exhibited significant cytotoxic properties and growth inhibitory action (GI₅₀, µg/ml) in sulforhodamine (SRB) assay in human breast cancer cell line (MCF-7), human ovarian cancer cell line (PA-1), human cervical cancer cell line (HeLa), hepatoma cell line (Hep-G2) and colon cancer cell lines (colo-205).

Hypolipidemic activity of G. Indica fruit was tested by using fruit juice in rodents based on “Cafetaria diet” (CF) model.

MADHUNASHINI (Gymnema sylvestre)

Total 44 genotypes were evaluated for their physiological efficiencies during post rainy season
in sub-tropical region of Gujarat. Genotypes were categorized into different groups considering over all mean values of different photosynthetic parameters. Genotype DGS-2 and DGS-18 having superior values in maximum physiological parameters can be very useful in crop improvement program focused on biomass maximization in gymnema.

A paired-end de novo deep transcriptome sequencing of leaf, flower and fruits differing in gymnemic acid content was performed on Illumina Hiseq 2500 platform. Pathway mapping based on master assembly using KEGG database revealed probable candidate genes involved in gymnemic acid biosynthesis. A putative pathway of the gymnemic acid biosynthesis was also proposed. The present study provided an important resource for future molecular and functional genomics studies in Gymnema sylvestre.

MANDOOKAPARNI (Centella asiatica)

LC-MS/MS was applied for quantitative determination of four different triterpenoids (asiaticoside and madecassoside) and their aglycones (asiatic acid and madecassic acid) in the leaves of Centella extracted by different solvents from non-polar to polar, viz., petroleum ether, chloroform (CHCl3), ethyl acetate (EtOAc), acetone, ethanol, methanol and water.

SENNA (Cassia angustifolia)

Two germplasm accessions viz., DCA-121(IC0610825, INGR17079): with small pod size and DCA-124 (IC0610826; INGR17080): plant type with broad pods and leaves were registered as trait specific germplasm at ICAR-NBPGR, New Delhi.

Ten hybrids were generated to study genetics of leaf type, plant habit and leaf shape in the species. Interspecific hybridization of Cassia angustifolia with C. holosericea and C. italica was also attempted for introgression of novel traits such as pest resistance into C. angustifolia.

The Intron Length polymorphism (ILP) in the genes involved in sennoside biosynthesis was also carried out.

Differential expression of caDXS gene was observed in different plant parts viz., in the leaf (young and mature), pod (young and mature) and flowers and genotypes viz., Sona, DCA-80 and DCA-149.

Profiling of sennosides A and B in leaf extracts of 15 senna species and related genera carried out using a RP-HPLC showed that three species viz., Senna tora, Cassia javanica and S.occidentalis could be considered as potential alternative sources of sennosides A and B.

TULSI (Ocimum sanctum)

A simple and cost-effective method was developed for DNA isolation. In this method there was no requirement of liquid nitrogen and deep freezer for leaf sample storage and for DNA isolation. DNA isolated from Tulsi leaves with this method was successfully tested for the random primers (RAPD & ISSR) and gene specific primers (SSR & metabolic pathway genes) amplification.

Twenty two SSR primers pairs were synthesized. These primer pairs were validated using O. sanctum genomic DNA and can be used for the genetic diversity analysis in tulsi.
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AICRP MAP&B

**ALOE (Aloe barbadensis)**

Floral biology of aloe was studied at PDKV, Akola.

At PDKV Akola, four consecutive years' study revealed that significantly higher number of leaves, leaf length and leaf width was recorded at 60 × 60 cm spacing. Application of vermicompost @ 2.5 t ha⁻¹ recorded significantly highest leaf weight and gel recovery. The highest net monetary returns (net return and B: C ratio) were recorded with 60 × 30 cm spacing and 5 t ha⁻¹ vermicompost.

**ASALIO (Lepidium sativum)**

Four genotypes ULS-1, ULS-2, ULS-6 and ULS-9 were found to be statistically at par for seed yield with the check GA-1 (1919.67 kg ha⁻¹) at MPUAT, Udaipur. In another trial, accessions ULS-6, ULS-8, ULS-9, ULS-11 and ULS-12 exhibited higher mean seed yield over the local check ULS-15 (2267 kg ha⁻¹) at MPUAT, Udaipur.

Application of RDF (NPK: 50:50:30 kg ha⁻¹) along with biofertilizers (PSB+AZB) recorded maximum seed yield, however, maximum net return and B: C ratio was obtained with ½ RDF (NPK: 25:25:15 kg ha⁻¹)+ PSB at JNKVV, Jabalpur.

At MPUAT, Udaipur, two hand weeding at 25 DAS and 50 DAS and application of pendimethalin 0.75 kg ha⁻¹ followed by one hand weeding (HW) recorded minimum weed intensity. Both the treatments recorded significantly higher seed, straw and biological yield as compared to the other treatments. RVSKVV, Mandsaur concluded that three hand weeding along with one hoeing performed the best in respect to plant growth and seed yield.

Three consecutive years’ study at YSPUHF, Solan revealed that line sowing performed better than broadcasting while sowing of seeds during last fortnight of October at 30 × 15 cm spacing recorded maximum growth and seed yield.

At JNKVV, Jabalpur, treatment of *Trichoderma* fortified FYM+ Azotobactor+ spray of 0.15% azadirachtin at 15 days intervals was the best for managing the leaf blight and enhancing the seed yield. At Udaipur, IDM modules comprising of seed treatment with (carbendazim 12%+ mancozeb 63%)-75WP @0.30% plus three foliar sprays with tebuconazole 25EC @ 0.10% first at initiation of disease followed by 15 days interval were found effective for the management of leaf spots as well as effective in increasing yields of seeds and mucilage content.

**ASHTAVARGA (Malaxis acuminata)**

*Solan selection* recorded the distinct morphological characters consistently for the fourth year at YSPUHF, Solan.

**ASHWAGANDHA (Withania somnifera)**

An Advanced evaluation trial (AVT-I) with eleven promising genotypes were conducted to identify
promising lines for higher yield and quality. Across locations, maximum dry root yield was recorded
in HWS8-18 (606.78 kg ha⁻¹) which was followed by IWS3 (573.72 kg ha⁻¹) and UMS10 (572.83 kg ha⁻¹)

Maintenance breeding of varieties Jawahar Ashwagandha-20, Jawahar Ashwagandha -134 and Raj
Vijay Ashwagandha- 100 was undertaken at RVSKVV, Mandsaur.

Study on interaction of application of nimbecidine (0.15% azadirachtin) followed by Trichoderma
asperellum @ 106-9cfu ml⁻¹ and Pseudomonas fluorescens @ 106-9cfu ml⁻¹ reduced Alternaria leaf
blight incidence to 28.4% at JNKVV, Jabalpur.

At MPUAT, Udaipur an integrated disease management module under organic farming was
evaluated against root rot and foliar diseases. Seed treatment with carbendazim+ mancozeb @ 2.5
g followed by soil drenching with carbendazim+ mancozeb @ 0.2% recorded the lowest seedling
mortality due to damping off disease at RVSKVV, Mandsaur.

**BACH (Acorus calamus)**

Twenty seven germplasm were evaluated for morphological characters at AAU, Jorhat.

Four lines along with check (Symbolia) were evaluated for yield and quality across locations, mean
rhizome yield (kg ha⁻¹) was maximum in APAc-5 (2782.66).

At KAU Trichur, application of inorganic fertilizer NPK @ 45:12.5:12.5 kg ha⁻¹ recorded the highest
rhizome yield of 1772 kg ha⁻¹ during first year and 1944 kg ha⁻¹ during second year. Among organic
treatments, the plants which received FYM @ 15 t ha⁻¹ gave the highest rhizome yield of 1428 kg ha⁻¹
during first year and 1573 kg ha⁻¹ during second year which was at par with vermicompost @ 7.5 t ha⁻¹.

Maximum number of sprout, fresh weight of shoot, root and rhizome per plant were recorded under the
application of RDF through inorganic fertilizers followed by castor cake @ 2.5 t ha⁻¹ at UBKV, Kalimpong.

**BASIL (Ocimum basilicum)**

An Initial Evaluation Trial (IET) with two entries (two each from Anand) and GAB-1 as a check was
conducted for yield and quality. Across locations, GAB-1 (check) recorded the highest green leaf
yield (7637.6 kg ha⁻¹) which was followed by AOB5 (7450.0 kg ha⁻¹) and AOB4 (7030.9 kg ha⁻¹).

Another Initial Evaluation Trial (IET) with five entries was conducted for yield and quality. Across
locations, Rahuri-1 recorded the highest green leaf yield (8785.2 kg ha⁻¹) which was followed by
MOB13 (8413.5.0 kg ha⁻¹) and MOB19 (8119.21 kg ha⁻¹).

**CHIRAYITA (Swertia chirayita)**

Application of organic manures along with biofertilizers was found quite promising in improving
total herbage yield at UBKV, Kalimpong. Maximum total biomass was recorded under the application
of FYM 5t ha⁻¹+ vermicompost 2t ha⁻¹+ PSB which was at par with RDF through inorganic fertilizers.

**DAVANA (Artemesia pallens)**

At MPKV, Rahuri, it was found that seed treatment of Bacillus subtilis+ soil application of Trichoderma
viride+ Bacillus subtilis and seed treatment with B. subtilis+ soil application of T. harzianum+ B.
*B. subtilis* were the most effective treatments for the management of wilt disease of davana.

**DODI** (*Leptadenia reticulata*)

At AAU, Anand consecutive three years’ experiment data showed that application of nitrogen @ 200 kg ha⁻¹ along with phosphorus @ 25 kg ha⁻¹ was optimum for maximum biomass yield (14814 kg ha⁻¹), net returns (₹ 458626 ha⁻¹) and BCR (2.63).

**DWARF MARIGOLD** (*Tagetes minuta*)

Three consecutive years study conducted at YSPUHF Solan, revealed that seedling transplanting was better than broadcasting while the transplanting of seedling at 30 × 45 cm spacing was found to produce maximum plant growth, biomass and essential oil yield.

**GLORY LILY** (*Gloriosa superba*)

Floral biology was studied and hybridization technique was standardized at TNAU, Coimbatore. Thirty two accessions were also collected from different parts of Tamil Nadu.

Spraying *B. subtilis* @ 0.2% on 30 and 60 days after planting was effective in managing the leaf blight disease which recorded the lowest disease intensity of 16.2% at TNAU.

**HARDE** (*Terminalia chebula*)

Forty one accessions were screened at BAU, Ranchi. Better scion and root stocks were also selected from the germplasm collection.

**ISABGOL** (*Plantago ovata*)

Thirty one accessions were evaluated at MPUAT, Udaipur.

Advanced varietal evaluation trial (AVT-II) was conducted at five locations with an objective to identify high yielding varieties. The entry MIB124 (UI-124) recorded maximum seed yield (1053.38 kg ha⁻¹) across the locations followed by DTPO11-1 (1033.41 kg ha⁻¹) and DPO267-3 (973.15 kg ha⁻¹). Over the seasons and location, entry DPO267-3 recorded maximum seed yield (kg ha⁻¹) (1080.03) which was followed by MIB124 (UI-124) (1053.38), DTPO11-1 (1031.37), DTPO6-6 (1014.60) and MIB5 (1004.83).

Screening of 10 promising genotypes against downy mildew, bacterial blight, leaf spot blight and root rot revealed that five genotypes were resistant against the diseases at MPUAT, Udaipur.

Maintenance breeding of released variety *viz.*, JI-4 was undertaken at RVSKVV, Mandsaur.

At Dr. YSRHU, Venkataramannagudem, application of chlorothalonil in combination with two sprays of potassium salt of phosphorus acid was found to be effective in reducing downy mildew incidence.

**KALIJEERI** (*Vernonia anthelmintica*)

Consecutive three years' study at AAU, Anand recorded the highest seed yield with application of FYM @ 10 t ha⁻¹ along with 50 kg N ha⁻¹, followed by treatment combination of application of castor
cake @ 1.5 t ha⁻¹ with 50 kg N ha⁻¹.

**KALMEGH (Andrographis paniculata)**

Advanced evaluation trial (AVT-I) with ten test entries and three checks was conducted at 13 locations with an objective to identify superior varieties with high yield and quality. Across locations, DMAPRAP35 recorded maximum dry biomass yield (4245.30 kg ha⁻¹) which was followed by DMAPRAP13 (4244.73 kg ha⁻¹).

Study on spacing and planting time revealed that seedlings planted at 30 × 20 cm spacing recorded highest dry herbage production (8670 kg ha⁻¹) at BCKV Kalyani. Similarly seedling planted at 1st June recorded highest canopy spread.

Application of mustard cake @ 1.5 t ha⁻¹, along with treatment of biofertilizers (Azotobacter+ PSB) and soil application of *Jivamrut* exhibited maximum dry herbage yield of kalmegh at OUAT, Bhubaneswar.

Study at PDKV, Akola revealed that the highest fresh and dry foliage yield were recorded under treatment containing vermicompost @ 7.5 t ha⁻¹ with 80:30:50 kg ha⁻¹ NPK (half N with full P & K as basal and remaining half N in three equal splits at 25, 40 & 60 DAS). Application of vermicompost (7.5 t ha⁻¹) recorded maximum herbage yield (131.56 q ha⁻¹) over the other organic sources at DRPCAU, Pusa. RVSKVV, Mandsaur; concluded that application of nitrogen @150 kg ha⁻¹ and sulphur @ 40 kg ha⁻¹ resulted in the highest herbage yield.

**LONG PEPPER (Piper longum)**

At OUAT, application of FYM @ 20 t ha⁻¹ (100 % substitution of recommended dose of nitrogen) resulted in maximum fresh and dry weights of catkin (2382.53 and 481.03 kg ha⁻¹), number of catkins per plant (168.65) and piperine yield (6.56 kg ha⁻¹). However, piperine content of long pepper was not influenced by application of organic manures.

**MADHUNASHINI (Gymnema sylvestre)**

Qualitative and quantitative characterization of 12 germplasm accessions was undertaken at BAU, Ranchi.

At JNKVV, Jabalpur cuttings treated with 750 ppm IBA solution and planted in the month of August showed maximum survivability.

Foliar application of neem seed kernel extract @ 5% showed maximum efficacy in terms of minimum number of leaf webbers and loopers per plant, per cent defoliation and maximum herbage yield (1.98 kg plant⁻¹), followed by *B. thuringiensis* @ 750 g ha⁻¹ at TNAU, Coimbatore.

**MAKOI (Solanum nigrum)**

Floral biology and breeding behaviour of the crop were studied at Dr. YSRHU, Venkataramannagudem.

**MANDOOKAPARNI (Centella asiatica)**

At DRPCAU, Pusa, soil incorporation of FYM inoculated with *T. harzianum* combined with sapling
treatment with the same bio-agent was most effective in suppression of stolon rot.

**NEEL (Indigofera tinctoria)**

At KAU, Trichur consecutive three years study showed that application of FYM @ 5 t ha⁻¹+ NPK @ 45:60:45 kg ha⁻¹ was optimum for maximum herbage yield and indican content.

**OPIUM POPPY (Papaver somniferum)**

Eighty five accessions were evaluated at MPUAT, Udaipur.

Advanced varietal trial (AVT-II) with six test entries and two checks (Chetak Aphim and JOP540) was conducted with an objective to identify superior varieties with high yield and quality. Across locations, maximum latex yield (79.67 kg ha⁻¹) was recorded in UOP20 which was followed by chetak aphim (77.75 kg ha⁻¹).

UOP-69, UOP-80, UOP-79 and UOP-99 were found good as general combiners for latex yield, seed yield, effective capsules per plant, capsule husk yield, seed harvest index and morphine content at MPUAT, Udaipur.

At RVSKVV, Mandsaur, application of vermiculture @ 5 t ha⁻¹+ *Trichoderma*+ sulphur+ zinc+ boran+ RDF recorded maximum plant height (116 cm), capsule (3.2) per plant, seed yield (1500 kg ha⁻¹) and latex yield (69.0 kg ha⁻¹).

Disease management by spraying Copper hydroxide+ streptocycline (0.3%+140 ppm) at rosette stage recorded the lowest stem rot intensity at RVSKVV, Mandsaur. At MPUAT, Udaipur soil application of neem cake manure+ farm yard manure @ (250g m⁻²) supplemented with *Trichoderma* formulation @ (5%)+ seed treatment with neem oil @ (3%) followed by drenching with cow urine: neem leaves: garlic clove fermented product @ 10% at 30 and 60 DAS and 3 sprays of the fermented product @ 5% at 30, 45 and 60 days after sowing was found best to control root rot and downy mildew diseases of opium poppy.

**SAFED MUSLI (Chlorophytum borivilianum)**

Initial evaluation trial (IET) was conducted at six locations with an objective to identify superior varieties with high yield and quality. Across locations, GAS-1 recorded maximum dry root yield (288.71 kg ha⁻¹) which was followed by RSM414 (269.61 kg ha⁻¹).

Maintenance breeding of released varieties viz., JSM-405, RVS and M-414 was undertaken through clonal propagation at MPUAT, Udaipur.

Spraying of carbendzim+ mancozeb @ 0.25 % was effective in reducing anthracnose disease of safed musli at RVSKVV, Mandsaur. At MPUAT, Udaipur soil application of neem cake mixture (250g m⁻²) supplemented with *Trichoderma* talc based formulation (10⁶cfu g⁻¹) (5%)+ seed treatment with neem oil (3.0%) plus three sprays of three foliar sprays of cow urine: neem leaves: garlic clove fermented product @ (5%) 1st at appearance & 2nd, 3rd 15 days interval or three sprays with garlic bulb extracts @ 10% was found as the best treatment to control root rot and anthracnose disease of safed musli.
SARPAGANDHA (*Rauvolfia serpentina*)

Seventy five accessions of sarpagandha were characterized for agro-morphological characters at OUAT, Bhubaneshwar.

At JNKVV, Jabalpur soil application of FYM @ 10t ha\(^{-1}\) + 3 sprays of mancozeb 75%WP at 15 days interval was effective in reducing *Cercospora* leaf spot incidence.

SATAVARI (*Asparagus racemosus*)

Planting on ridges and furrow with application of 10 t ha\(^{-1}\) FYM recorded significantly higher number of roots per plant (69.42), root length (26.61 cm), root diameter (11.47 cm), fresh weight (17942 kg ha\(^{-1}\)) and dry root yield (1974 kg ha\(^{-1}\)) of satavari at PDVK, Akola. At DRPCAU, Pusa, combined application of vermicompost (2 t ha\(^{-1}\))+ mustard cake (1 t ha\(^{-1}\)) inoculated with mixture of PSB @ 5 kg ha\(^{-1}\) and *Azospirillum* @ 2 kg ha\(^{-1}\) recorded significantly higher root yield (14563 kg ha\(^{-1}\)).

SENA (Cassia angustifolia)

Initial evaluation trial (IET) with four test entries and three checks was conducted at four locations with an objective to identify superior varieties with high yield and quality. Across locations, DCA-96 recorded maximum herbage yield (10594.09 kg ha\(^{-1}\)) which was followed by A16-18 (9507.46 kg ha\(^{-1}\)).

At MPKV, Rahuri seed treatment with *B. subtilis* (5g kg\(^{-1}\) of seed) followed by soil application of *T. viride* + *B. subtilis* enriched FYM (5g kg\(^{-1}\)) recorded the lowest wilt incidence. At MPKV, Rahuri, spraying of datura leaf extract significantly reduced *Alternaria* leaf spot disease with the highest fresh leaf yield (8263 kg ha\(^{-1}\)) as well as marketable dry leaf yield (1818 kg ha\(^{-1}\)).

TULSI (*Ocimum sanctum*)

Two consecutive years’ study at AAU, Anand recorded maximum fresh herbage (2018 kg ha\(^{-1}\)), dry herbage (585 kg ha\(^{-1}\)) and oil yield (38.91 kg ha\(^{-1}\)) under the application of FYM @ 15 t ha\(^{-1}\). Integration of FYM with different levels of chemical fertilizers recorded higher plant growth and herbage yields as compared to application of fertilizers alone at BAU, Islampur. Application of vermicompost @ 2 t ha\(^{-1}\) inoculated with PSB @ 5 kg ha\(^{-1}\) and *Azospirillum* @ 2 kg ha\(^{-1}\) produced significantly higher fresh herbage yield (16920 kg ha\(^{-1}\)) at DRPCAU, Pusa. Maximum herbage yield (5600 kg ha\(^{-1}\)) and seed yield (1850 kg ha\(^{-1}\)) was recorded when 40% N requirement was supplemented with vermicompost at RVSKVV, Mandsaur.

BETELVINE (*Piper betle*)

Sixty germplasm lines and 20 hybrids were characterized for 11 qualitative and six quantitative traits at ICAR IIHR, Bengaluru.

Ten inter varietal crosses, twelve crosses between varieties and hybrids and three inter-hybrid crosses were carried out at Bengaluru. Fruit setting was observed in all the crosses.

Hy 07-36 and Hy 06-4 recorded higher leaf yield per vine (129 and 103 leaves per vine) under shade net conditions at ICAR-IIHR, Bengaluru.
Screening of betelvine hybrids against whitefly was carried out in boreja at BCKV, Kalyani and among the nine hybrid lines, PBH- 08-23, PBH-06-8 and PBH-07-24 harboured comparatively less number of flies (around 15-16 flies vine-1).

Application of neem cake @ 2.5 t ha⁻¹ recorded higher leaf length & breadth and higher number of leaves per vine than application of FYM or RDF, however it was at per with application of neem cake at 1.5 t ha⁻¹ at AAU, Jorhat. At BAU, Islampur, application of zinc sulphate @ 30 kg ha⁻¹ in soil resulted in maximum yield of marketable leaves per vine (79.41).

Demonstration of Integrated disease management (IDM) technology (field sanitation+ first application of 1 % Bordeaux mixture at pre-monsoon stage+ application of Trichoderma plus @ 12.5kg ha⁻¹ one month after application of 1% Bordeaux mixture+ second application of 1 % Bordeaux mixture two months after first application+ application of RDF of NPK was conducted in farmers’ field at BCKV, Kalyani and OUAT, Bhubaneswar. The results showed that the IDM technology of the centres were significantly superior to the farmers’ practice in decreasing disease incidence and also recorded higher betel leaf yield.
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.)
• Lemongrass [Cymbopogon flexuosus (Nees ex Steud.) W. Watson]
• Palmarosa [Cymbopogon martinii (Roxb.) Wats.]
• Safed musli (Chlorophytum borivilianum Sant. & Fern.)
• Senna (Cassia angustifolia Vahl)
Organisational Structure

Institute Management Committee

DIRECTOR

Research Advisory Committee

Institute Research Committee

Research

Outreach Programmes (Headquarters)

Central Facilities

Administration

- Genetic Resources Management
- Crop Improvement
- Crop Production
- Crop Protection
- Phyto Chemistry
- Post Harvest Management
- Biotechnology

- All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine

- Agricultural Knowledge Management Unit
  - Central Instrumentation Facilities
  - Library
  - Farm
  - Active Gene Bank
  - Quality Control Laboratory
  - PME Cell

- Establishment
  - Finance
  - Cash and Bill
  - Purchase
  - Store
  - Security
  - Estate Management
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), Bhubaneswar
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 Viswavidyalaya (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
2. Dr. YSRHU, V.gudem
3. AAU, Jorhat
4. BCKV, Kalyani
5. BAU, Ranchi
6. CCSHAU, Hisar
7. UUHF, Bharsar
8. IGKV, Raipur
9. ICAR - IIHR, Bengaluru
10. JNKVV, Jabalpur
11. KAU, Trichur
12. MPUAT, Udaipur
13. MPKV, Rahuri
14. NDUAT, Faizabad
15. OUAT, Bhubaneswar
16. PDKV, Akola
17. BAU, Islampur
18. DRPCAU, Pusa
19. RVSKV, Mandsaur
20. TNAU, Coimbatore
21. YSPUHF, Solan
22. CAU, Pasighat
23. BLU, Jodhpur
24. BUAT, Banda
25. SKUAST, Kashmir
26. SKUAST, Kashmir

ICAR-DMAPR, Anand, Headquarters
## BUDGET PROFILE

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Research Achievements
Research Achievements

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 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.

Germplasm diversity analysis

11,524 set of genomic SSR markers were putatively detected from aloe genome sequence using MISA (http://misaweb.ipk-gatersleben.de/). Out of these SSRs, 100 primers were selected for molecular characterization of aloe germplasm lines. (Project 02: Genetic improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigator: Mr. Manish Kumar Mittal)

Mass multiplication through micropropagation

Plants were raised through tissue culture which were healthy, free from virus, bacteria and fungi. Rate of multiplication was faster than the conventional production through suckers. Mass multiplication through micropropagation was also attempted using the explants from inflorescence peduncle using in-house standardized media i.e., half strength MS media supplemented with growth regulators, sucrose 3% and agar-agar @ 0.6% with a pH 5.7. Over 100 healthy plants were produced for commercial cultivation.

A thick root phenotype (TRP) was identified from in vitro regenerated plants of high aloin content line. The root thickness of TRP was 2.5-3.0 mm compared to the normal root (0.70-0.90 mm) at 30 days from the root initiation. Root length of TRP was short (2.5-3.0 cm) compared to the normal plants (8.0-10 cm). However, no change in the shoot growth was noticed. Further investigations are needed to understand the basis of the TRP. (Project 02: Genetic improvement of medicinal and
aromatic plants through conventional breeding and biotechnological approaches; Investigators: Mrs. Parul M. Purohit, Dr. R. Nagaraja Reddy and Dr. P. Manivel)

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.

Characterization and evaluation of germplasm

One hundred and twenty two accessions were characterized for agro-morphological characters. Variations were observed for leaf shape, leaf colour, flower colour and berry colour. The accessions also showed variation for leaf length (6.28-11.20cm), leaf width (3.64-6.10cm), root length (10.50-27.40cm), root diameter (6.31-20.90mm), number of secondary roots (1.20-4.0), dry root weight per plant (0.96-13.74g) and plant height (34.64-92.60cm). Superior accessions for high root yield were identified. Dry root yield ranged from 233-2000 kg ha⁻¹. Accessions, IC0210601, IC0262388, IC0385221, IC0510842, IC0510841, RVA-100 and AWS-1 recorded high root yield (more than 1500 kg ha⁻¹). A germplasm accession (IC0510841) with extra-large leaf was also observed. (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

DWS-37 (IC0623444; INGR17056): A revolute leaf type and DWS-127 (IC0623445; INGR17057) plant type with yellow young leaf were registered as trait specific germplasm at the national genebank, ICAR-NBPGR, New Delhi. (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).

Pure line breeding

A pure line breeding programme was initiated during 2007 using the natural variability observed
in the open pollinated seed production plot of ashwagandha variety JA 134. Three hundred and twenty seven pure lines were developed based on selection of distinct morphological variation in leaf, stem, and berry characters. The pure lines were evaluated for DUS characters and root yield besides the alkaloids content. (Project 02: Genetic improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. Nagaraja Reddy)

**Development of high yielding ashwagandha cultivar DWS-132**

Vallabh ashwagandha-1 (DWS 132) a new ashwagandha variety developed through pure line breeding was recommended as a superior variety for cultivation by the Institute Research Committee (IRC) meeting held on 26th July 2017. DWS-132 has recorded 589.4 kg ha⁻¹ dry root yield which was 3.69, 3.69 and 3.18% higher over the check varieties JA 20, RVA 100 and JA-134, respectively. It has orange coloured berries that can be used as an important marker trait for varietal identification. It is suitable for cultivation in Madhya Pradesh, Gujarat, Rajasthan and other parts of the country. The nucleus seeds of DWS-132 were produced during the current year for conducting FLD at farmers’ field in the coming year. (Project 02: Genetic improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy)

**Gene based SSR markers developed**

SSR markers are the most popular molecular markers for crop improvement and are frequently used in fingerprinting of cultivars, genetic diversity studies, mapping QTL and marker assisted breeding of crop plants. Despite the reported medicinal importance of ashwagandha, availability of gene based SSR markers is sparse. Exploration of the EST/TSA databases of ashwagandha was undertaken for mining new SSR markers. MISA SSR search tool identified a total of 89414 SSRs in 45584 sequences (61.1% of the total sequences), suggesting an average frequency of 1 SSR per 0.74 kb and 1.0 per 1.96 EST of ashwagandha transcriptome sequence analyzed. Analysis of SSR motifs in these sequences revealed 23117 (50.71%) ESTs had more than one SSR and 11027 (24.19%) had SSR motifs in non-interrupting compound formation. Among the SSR motifs found, hexamer (75.50%) were abundantly found, followed by trimers (13.55%), tetramers (5.64%), dimers (4.05%) and pentamers (1.28%). Over 4800 SSR markers designed, 54 SSRs were validated. (Project 02: Genetic improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy)

**Screening of germplasm for leaf blight disease**

Identification and exploration of elite lines for leaf blight resistance breeding based on the observations in ashwagandha was made when the symptoms of the disease appeared. The observations were made based on disease rating scale of 0-9. A total of 140 germplasm lines and 328 breeding lines of ashwagandha were screened for leaf blight disease. Twelve germplasm lines and 36 breeding lines were found moderately resistant to resistant for Alternaria leaf blight. (Project 2: Genetic improvement of medicinal and aromatic through conventional breeding and biotechnological approaches; Investigators: Dr. R.P. Meena and Dr. P. Manivel)
**Physiological interventions to modify functional partitioning**

An experiment was conducted to study the impacts of repeated foliar application of growth retardants/promoters on the biomass allocation and major withanolide content in ashwagandha. Plants under repeated ethrel application (@ 500mg l) during 60-120 days after sowing (DAS) restricted phenological progression and reduced berry weight by 68% as compared to the control at 160 DAS and resulted in reduction (29%) in total biomass yield but accumulated more withaferin in roots (48%), stem (65%) and in berry (20%) as compared to the control at 180 DAS. Application of paclobutrazol (PBZ) (@500 mg l$^{-1}$) caused reduction in stem weight by 22.2% at 180 DAS whereas application of 500 mg l$^{-1}$ succinic acid increased root dry weight by 13% along with more accumulation of withaferin (54%) and 12-deoxy withastramonide (47%) in roots at 180 DAS. Plants under repeated ethrel application (@ 500 mg l) were delayed in progression of the growth stage till 155 DAS and had restricted berry growth (7.5 g plant$^{-1}$) as compared to the maximum berry weight of 32.3 g plant$^{-1}$ in plants received PBZ @500 mg l$^{-1}$ treatment. *(Project 4: Integrated water and nutrient management and physiological manipulation for improving productivity of medicinal and aromatic plants; Investigators: Dr. K.A. Kalariya and Dr. Narendra Gajbhiye).*

**Root yield and bioactive principles of ashwagandha improved by local microbial consortia in organic nutrient management practices**

Field experiments were conducted for two consecutive years (2016-17) to study the effect of different organic nutrients sources on yield and quality of ashwagandha. The treatment comprised of different organic manures (FYM, vermicompost and castor cake) and microbial consortia along with recommended doses of fertilizer (RDF) and the control. Application of the organic nutrient source invariably improved root yield and bioactive principle in ashwagandha. The yield parameters (root girth, root length, fresh and dry root yield) of ashwagandha were significantly affected by the treatments containing organic manures and microbial consortium alone or in combination. The highest fresh (1505 kg ha$^{-1}$) and dry (767 kg ha$^{-1}$) root yields as well as total withanolide contents (0.947 mg g$^{-1}$) were recorded under the treatment received castor cake+ microbial consortium followed by application of vermicompost+ microbial consortium. Regarding individual withanolides, the results showed that a significant increase in the root withaferin-A content in those plants which were treated with different combinations of organic manure and microbial consortia compared with the other treatments. Differences in 12-Deoxy withastramanolide content was not conspicuous but the maximum amount was recorded with the application of castor cake and vermicompost. In all the treatments, in general, application of inorganic fertilizer showed comparable or sometime better withanolide-A content as compared to the application of organic manure alone. However, combination of organic manure with microbial consortia had the highest withanolidecontent. A positive correlation coefficient (< 0.01) was found between dry root yield and withanolide content ($r = 0.34$ - $0.64$). The study indicated that castor cake and vermicompost could be promising nutrient source for production of quality medicinal herb by improving soil properties. *(Flagship project: Standardization of organic farming practices for important...*
medicinal plants; Investigators: Dr. B. B. Basak and Dr. Narendra Gajbhiye)

BAEL (Aegle marmelos)

It is a member of family Rutaceae and it is a moderate sized, armed tree, 6 to 7.5 m tall. It is commonly found in deciduous forests all over India. It can be propagated by seeds and through vegetative means. Natural regeneration by seed is not adequate. The seed does not retain viability for long and regeneration by root-suckers appears to be the chief mode of propagation in nature. The fruit is used in chronic diarrhoea, dysentry, stomach ache and diabetics. It also act as a tonic for heart and brain. Root is one of the constituent of the popular ayurvedic drug combination of ‘dasmoola’. The roots are astringent, bitter and febrifuge. They are useful in diarrhea, dysentry, dyspepsia, stomachalgia, cardiopalms, seminal weakness, vomiting, intermittent fever and swellings.

Identification of elite accession for commercial cultivation

Evaluation of 98 bael accessions showed wider diversity in terms of plant height, plant spread, stem girth, fruit shape, fruit size, number of fruits per tree, other fruit characters, gum and seed weight, imperatorin and essential oil contents. The highest fruit yield was in DAM - 25 (123.37 kg tree⁻¹), imperatorin content was higher in DAM - 124 (2.99 mg g⁻¹) and essential oil content in fresh leaves was higher in DAM - 161 (6.50 g kg⁻¹). First ten principal components (PCs), contributed 97.21% of the total variability and the highest variation was contributed by the first component (31.71%), followed by second (20.01%), third (9.55%) and fourth components (7.67%). A dendrogram generated from morphometric data grouped all 98 accessions into 5 major clusters. Accession namely, DAM-124, DAM-92, DAM-10, DAM-36, DAM-161 DAM-17, DAM-25 and DAM-71 were most distinct and rich in fruit yield, fresh leaf yield, essential oil yield and imperatorin content; therefore, suitable for cultivation and industrial purposes. (Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Dr. P. L. Saran and Dr. Narendra Gajbhiye).

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 is largely determined by their chemical components present in the essen. 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.
Trait specific germplasm lines identified

Calyx colour is an important morphological marker for identification of basil genotypes. The calyx colour of GAB-1, a released variety in basil has light purple colour. In contrast, dark purple (EC0338780) and green (EC0338784-1) calyx colored types were identified. The genotype EC0338784-1 is a selection from EC0338784 which has purple green calyx colour. (Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. R. Nagaraja Reddy and Dr. P. Manivel).

Selection of dwarf and compact morphotypes for high density plantation

A unique line Rudra-2 was identified which is a dwarf plant type with early flowering compared to the semi-dwarf line, DOB-4. Accession Sant-1 had closed canopy architecture and DOB-8W was most vigorous type with high biological yield (66400 kg ha⁻¹). Overall, Rudra-2 and Sant-1 were found unique and superior accessions; therefore, can be used further in crop improvement programme and also suggested for commercial cultivation as new selections for high density plantation. (Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. P.L.Saran)

GILOE (Tinospora cordifolia)

Gilo 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. Leaf is used for the treatment of gout, jaundice and rheumatism. Raw drug is mainly obtained from the wild habitats of the species. 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.

**Standardization of an easy and cost-effective way of multiplication**

The experiment was carried out to determine a commercially viable technique for multiplication of *Tinospora cordifolia* in open field condition using variable numbers of nodes per cutting. The result showed that three and four noded cuttings were significantly superior in growth and survival parameters but involved more planting/stock materials. Therefore, to reduce the planting stocks, cuttings with one node with and without intermodal stem part were evaluated. Single bud cuttings with intermodal stem area at both sides showed significantly higher growth and survival percent in comparison to only nodal bud without intermodal stem portion and nodal bud with intermodal stem portion at one side. Among all the tested techniques, four buds’ technique was nearly found superior in growth parameters but not significant with three buds, which was proven for higher survival percent. However, single bud cutting technique involved minimum cost and economically proven superior for one-hectare plantation as compared to traditional techniques. The present study indicated that for *T. cordifolia*, mini cuttings (bud with intermodal stem portion on both side) techniques is the best propagation method for commercial multiplication. *(NMPB project: Standardization of propagation techniques and QPM production of selected medicinal plants; Investigator: Dr. P.L. Saran)*

**GUGGUL (Commiphora wightii)**

The species belongs to Burseraceae family. The species is endemic to arid region of India and found in wild form in the drier parts of Madhya Pradesh, Rajasthan and Gujarat. It is a small tree or shrub grows up to 3–5 m height. The gum is highly effective in the treatment of obesity, arthritis and other diseases. The oleo-gum resin is extracted from the main stem through a process known as ‘tapping’ by local people. Extraction of the oleo-gum resin leads to certain death of the plant. The species is not under cultivation and wild populations are the sole source of oleo-gum resin extraction. Hence the species survival is threatened in its natural habitat and it is enlisted under the ‘critically endangered’ category in the IUCN Red Data Book. It is propagated by either seeds or stem cuttings.

**Molecular marker analysis of genetic diversity in relation to reproductive behaviour**

Genetic diversity vis-a-vis reproductive behaviour of guggul was conducted by including accessions of Gujarat and Rajasthan. Gujarat is the only place in India where sexual populations of the species are distributed. RAPD and ISSR markers were used since genome sequence information is lacking in the species. Twenty four RAPD primers and 16 ISSR primers amplified a total of 185 and 128 reproducible
DNA fragments, respectively with fragment sizes ranged from 200 to 3,000 bp. RAPD analysis showed higher polymorphism (80%) in comparison to ISSR (69%). Jaccard’s coefficient of similarity showed that pair-wise genetic similarity coefficients ranged from 46 to 98.3% in RAPD analysis, whereas it ranged from 47.8 to 98.6% in ISSR analysis. The results showed that the trend of genetic variation was not strictly correlated to the geographical locations, but was related to the reproductive behaviour of the populations. The diversity was somewhat low in Rajasthan populations where only apomictic populations are distributed. Populations of maximum genetic diversity along with sexual forms were found distributed in Gujarat populations, especially in Kutchh, Dwarka, Jamnagar and Porbandar populations. Hence the study indicated these areas as the original areas of the species distribution from where it was spread to the other parts of Gujarat and Rajasthan. (NASF project: Molecular and genetic analyses of guggul for the identification of genes governing adventive embryony; Investigators: Ashok Kumar Bishoyi, Aarti Kawane, Anjai Sharma and Geetha K.A.)

**Molecular marker based discrimination study of Commiphora species**

*Commiphora agallocha*, *C. caudata*, *C. stocksiana* and *C. wightii* are the four *Commiphora* species reported from India of which *C. wightii* has been extensively used in Ayurveda for its excellent medicinal values. A study was conducted to discriminate the four *Commiphora* spp. using molecular markers. Random Amplified Polymorphic DNA (RAPD) and Inter Simple Sequence Repeats (ISSR) markers were used for the study considering the fact that no or very little genomic information is available in the genus. One hundred and twenty RAPD and 25 ISSR primers were screened initially from which 25 RAPD and 18 ISSR primers were used for final analysis. The cluster analysis indicated that *C. agallocha* was genetically distant from the other three species *i.e.*, *C. wightii*, *C. stocksiana* and *C. caudata*. Both RAPD and ISSR markers were able to generate 62 and 42 species specific markers, respectively. The specific molecular markers identified can be converted to Sequence Characterised Amplified Regions (SCAR) which would be helpful for molecular taxonomic study. This investigation would also be helpful to develop an insight into the genetic relationship of the limited number of *Commiphora* species distributed in India. (NASF project: Molecular and genetic analyses of guggul for the identification of genes governing adventive embryony; Investigators: Ashok Kumar Bishoyi, Aarti Kawane, Anjai Sharma and Geetha K.A.)

**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 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 1,00,000 ha. A number of high yielding varieties are available in the crop for cultivation.
Genetics of morphological characters

Inheritance patterns of leaf color (light and dark green), leaf curling (curly and normal), leaf hairiness (glossy and hairy) and plant height (tall and dwarf) were studied in isabgol using F2 population derived from a cross between two mutants DPO-401 and DPO-324. Hybrid (F1) had light green leaves, no leaf curling, hairy leaf and tall plant type. F2 segregation analysis revealed that, there were two genes (Lr1 and Lr2) with duplicate gene action controlling leaf color in isabgol. Curly leaf showed 3:1 F2 ratio indicating it is controlled by single recessive gene (cl). There were two genes (H1 and H2) controlling the leaf hairiness with single dominant gene either of H1 or H2 producing the leaf hairy phenotype. Plant height was controlled by two genes (Dw1 and Dw2) with single dominant gene either of Dw1 or Dw2 developing the tall plant height phenotype in Isabgol. The expression of these visible markers is independent of environment and therefore, they can be used as markers in linkage map construction, and also be used effectively as phenotypic tags in marker assisted selection. (Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P.Manivel and Dr. R. Nagaraja Reddy).

Germplasm registration

DPO-9 (IC0623443; INGR17055): an extended bract mutant of Isabgol was registered as trait specific germplasm at the national genebank, ICAR-NBPGR, New Delhi. The trait can be used as a morphological marker character for the identification of superior varieties. (Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigator: Dr. R. Nagaraja Reddy and Dr. P. Manivel).

A superior variety Vallabh Isabgol-1 identified

Vallabh Isabgol-1 (DPO-1) a new high yielding medium duration (120-125 days) variety developed through mutation breeding was recommended for variety release during XVI Group Meeting of All India Coordinated Research project on Medicinal and Aromatic Plants & Betelvine (AICRP-MAP&B) held at MPUAT, Udaipur during 11-14 November, 2017. The mean seed yield of Vallabh Isabgol-1 was 1025 kg ha-1 as compared to 826.6 kg ha-1 of GI-2. Under favourable conditions and good management, yield of up to 1200 kg ha-1 can be obtained. It also has higher swelling factor (11.83 cc g-1) and mucilage yield (9.21 g kg-1 seed) than the existing variety GI-2 (11.72, 8.96 g kg-1 seed). Vallabh Isabgol in contrast to GI-2 is having semi erect growth habit with height of 30-40 cm (medium), leaves are dark green with medium pubescence, compact spike arrangement with compressed flower arrangement in the spike. This variety is suitable for isabgol growing areas of Gujarat, Rajasthan, Madhya Pradesh, Utter Pradesh, Haryana and Delhi. The large-scale trials conducted in farmers’ fields of Gujarat and Rajasthan are encouraging and getting popular among the farmers. (Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy).
**Front line demonstration of Vallabh Isabgol-1**

Vallabh Isabgol-1 a new variety developed at the directorate was demonstrated to farmers at Gujarat and Madhya Pradesh. Front line demonstration (FLD) was laid at Tharad and Sidhpur in Gujarat and Mandsaur in Madhya Pradesh. (*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*)

**Maintenance of reference varieties for DUS testing**

During the 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 of Isabgol were sown and maintained in the field gene bank of ICAR-DMAPR. (*PPVFRA project: Development of DUS Guidelines and Strengthening of DUS test centres for laboratory and field facilities, digitalization and training in medicinal, aromatic and seed spices crops; Investigators: Dr. Aarti Kawane and Dr. Geetha K.A.*)
**Identification of high yielding isabgol cultivar– DPO-4**

DPO-4 (Vallabh Isabgol-4), a new variety developed through mutation breeding was identified as a superior variety for cultivation by the Institute Research Committee during IRC meeting held on 26th July 2017. Its seed yield ranges from 886 to 947 kg ha⁻¹ and under favourable conditions and good management the yield reaches up to 1300 kg ha⁻¹. The crop matures within 110-120 days. The leaves are light green as compared to dark green leaves of its parent GI-2, and long spike whereas GI-2 has medium spike length. *(Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy).*

**Mapping population advanced**

The one hundred and sixty recombinant inbred lines (RIL) developed from DPO-185 x DPO-14 cross for downy mildew disease resistance mapping were advanced from F₅ to F₇. RILs and parents showed variation for days to flowering, maturity, leaf colour and resistance to downy mildew. *(Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy).*

**Screening of germplasm for downy mildew resistance**

Screening for downy mildew resistance was done when the symptoms of the disease appeared. Observations were made based on disease rating scale of 0-9. A total of 225 breeding lines, 75 germplasm lines and 160 RILs were screened and about 12 germplasm lines, 27 breeding lines and 50 RILs were found moderately resistant to resistant for downy mildew. *(Project 2: Genetic improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R.P. Meena and Dr. P. Manivel)*

**Downy mildew resistance genes explored**

Transcriptome analysis was carried out by next generation sequencing (NGS) of leaves of downy mildew resistant (DPO-185) and susceptible (DPO-14) mutants to understand the host-plant resistance. A total of 33.47 million reads were generated from downy mildew (DM) infected (DPO14 and DPO-185) and control (uninfected) leaf samples which were assembled de novo and annotated. The assembly using Trinity yielded 38,803, 40,175, 45,451 and 39,533 non-redundant transcript contigs, respectively in DPO-14 (infected), DPO-14 (uninfected), DPO-185 (infected) and DPO-185 (uninfected) samples. More than 90% coding sequences (CDS) predicted were annotated using BLAST search. Isabgol transcriptome showed the highest similarity to *Seasamum indicum* (41-59%) followed by *Erythranthe guttata* (10-13%). CDS, encoding Pathogen Associated Molecular Pattern (PAMP)-triggered immunity (PTI), Effector-triggered Immunity (ETI), Cell wall degrading enzymes, Phytohormone signalling and Phenylpropanoid biosynthesis pathways involved in host-pathogen interaction were identified in addition to the identification of several R-genes enriched in response to downy mildew infection. Expression of genes encoding *Auxin transporter protein 1* (*AUX1*), *Beta-D-xylosidase 1* (*BXL1*), *Chalcone and stilbene synthase* (*TT4*), *Ethylene response factor 1* (*ERF1*), *Chalcone and stilbene synthase* (*CHS/ TT4*), *Pathogen related protein 1* (*PR1*) and *Ethylene*
responsive factor (ERF) involved in plant defense quantified accordingly using RT-qPCR. *(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)*.

**Fungal Pathogenesis genes explored**

Whole genome sequence of downy mildew disease causing fungal pathogen *Peronospora plantaginis* Underwood of DMAPR isolate was done using NGS to decipher genes involved in fungal pathogenesis. A total of 37.47 million reads were generated and reference guided assembly in to 4015 scaffolds and 10744 contigs. A total of 12,688 CDS were predicted using Gene Mark software. Candidate pathogenicity related genes, RxLR effector family candidate, Crincklers (CRN family candidates), Elicitin-like protein, Pectin esterase, Cytochrome P450s, Pectate lyases, NPP1-like (Necrosis-inducing like proteins), Putative cutinase, Aspatic protease, Serine protease, Cysteine protease, Lipase, Phospholipase and ATP-Binding Cassette (ABC) transporter were identified. *(DST-SERB project: Dissection of pathogenesis genes of Peronospora plantaginis Underwood. a fungal pathogen causing Isabgol downy mildew disease; Investigators: Dr. P. Manivel and Dr. R. Nagaraja Reddy)*.

**Enriched organic fertilizer for improving yield and quality**

Field experiments were conducted for two consecutive years to study the effect of enriched organic fertilizer on yield and quality of Isabgol. The enriched organic fertilizer was prepared from waste biomass from distillation waste 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. The enriched organic fertilizer was compared with conventional organic manures (FYM, vermicompost and castor cake) and recommended dose of fertilizers (RDF). Total dry matter yield was significantly higher under application of different organic fertilizer and RDF than the control. Application of FYM, vermicompost, castor cake, RDF and enriched organic fertilizer increased the seed yield up to 9.7, 12.6, 13.1, 17.4 and 24.1%, respectively over the control. Maximum husk yield was recorded with application of enriched organic fertilizer @ 2.5 t ha⁻¹. Quality parameters like swelling factor and mucilage% were also significantly improved by the application of enriched organic fertilizer. *(Institute flagship project: Standardization of organic farming practices for important medicinal plants; Investigator: Dr. B. B. Basak)*

**Integrated disease management of soil borne diseases**

Integrated disease management module was tested for soil borne diseases particularly for wilt and downy mildew diseases. The experiments were conducted in RBD statistical design with three replications and ten treatments including control. Three sprays of different formulations were applied at fifteen days interval. Among the chemical and all bio fungicide, ridomil MZ @ 0.25% spray was found most effective and among the bioproducts neem leaf extract @ 10% solution was effective in managing the downy mildew disease. In another experiment for wilt disease management, combination of seed treatment @ 2% Bavistine with soil amended by *Trichoderma* spp. and neem cake was observed most suitable and significantly reduced the disease incidence.
In the treated plots the seed yield was also recovered more than the control plots. *(Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R.P. Meena).*

**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.

**Evaluation of germplasm**

Sixty-three germplasm accessions were evaluated for yield and other agronomic traits. Significant variations were observed for plant height and herbage yield. Plant height ranged from 31.0 to 68.0 cm, fresh herbage yield ranged from 756 to 8085 kg ha⁻¹ and dry herbage yield ranged from 244.00 to 1769.00 kg ha⁻¹. Accessions IC0342135, EC0415019, IC0520354 and IC0470905 recorded maximum dry herbage yield (more than 1500 kg ha⁻¹). *(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).*

**Evaluation of promising lines for high yield and quality**

Initial evaluation trial (IET) with 11 test entries and two checks (INGR07041, AK-1) was conducted at ICAR-DMAPR, with an objective to identify superior varieties with high yield and quality. The data showed that the plant height was significantly higher in entry AL 1 (74.10 cm), which was at par with AAP 16 (73.00 cm) and DMAPR AP 13 (69.73 cm). Plant spread was significantly superior in the entry DMAPR 13 (137.50 cm) which was at par with the check variety i.e., AK 1 (116.33 cm). Differences in the collar diameter were non-significant among the entries. Number of primary branches per plant was significantly higher in DMAPR AP 35 (44.33) which was however, at par with DMAPR AP 13 (43.67), NDKL 11 (41.00), DMAPR AP 18 & NDKL 10 (39.33) and AAP 36 & AL 1(38.67). Fresh and dry herbage yield was significantly higher in DMAPR AP 13 (13074.10 kg ha⁻¹; 7228.94 kg ha⁻¹). However, entries DMAPR AP 35 (11192.07 kg ha⁻¹), AK 1 (10652.02 kg ha⁻¹), DMAPR AP 18 (10594.78 kg ha⁻¹) and AAP 16 (10111.03 kg ha⁻¹) were at par with DMAPR AP 13 in the case of fresh herbage yield. Andrographolide content (%) ranged from 1.21 (DMAPR AP 13) to 1.68 (INGR 07041) among the entries. Andrographolide yield was significantly higher in DMAPR AP 35 (93.05 kg ha⁻¹), which was at par with DMAPR AP 13 (87.57 kg ha⁻¹), DMAPR AP 18 (86.48 kg ha⁻¹), NDKL 10 (84.85 kg ha⁻¹) and MAP 2 (81.68 kg ha⁻¹). *(Project 2: Genetic...*
Improvement of medicinal and aromatic plant through conventional breeding and biotechnological approaches; Investigators: Dr. Geetha K.A. and Dr. Narendra Gajbhiye

**A new plant type identified**

A new plant type- DMAPR AP 35-1 was identified from DMAPR AP 35. Up to vegetative stage, both DMAPR AP 35 and the new morphotype looked similar and at reproductive stage the new plant type attained a feathery canopy (*mayur*= peacock canopy). The new plant type had very late and shy flowering also. Anthesis (first flower opening in a season) occurred at 110-120 days after transplanting. The morphotype was first identified in 2016 and selfed seeds collected and sown during 2017 also showed the same morphotype (PPVFRA project: Development of DUS guidelines and strengthening of DUS Test Centres for laboratory and field facilities; Investigators: Dr. Anjali Sharma, Dr. Aarti Kawane, Dr. Narendra Gajbhiye and Dr. Geetha K.A.).

**Maintenance of reference varieties**

Guidelines for kalmegh DUS testing developed by the Directorate were notified by the Protection of Plant Varieties and Farmers' Right Authority (PPVFRA) during 2016. The major characteristics finalized 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); leaf andrographolide content (low, medium, high). Accordingly 20 reference varieties were identified and maintained during the kharif season 2017. (PPVFRA project: Development of DUS guidelines and strengthening of DUS Test Centres for laboratory and field facilities; Investigators: Dr. Aarti Kawane and Dr. Geetha K.A.)
Characterization of long and short variants of Ent-CPS

Ent-CPS (Ent-copalyl diphosphate synthase) is a key enzyme of labdane related diterpene biosynthesis. In kalmegh, two variants of this enzyme are expressed but the functional analysis of their protein products remains unknown. In this study, homology models of Ent-CPS variants were developed and models were further evaluated. Quality of modelled proteins were tested by Ramachandran plots and active site was mapped using Autodock. Finally, models were analysed by MD simulations using GROMAC for 4 ns. Results of these analyses showed that C-terminal domain affects the conformation of active site residues which involve in substrate binding. Thus, short isoforms may be unable to form product or inactive. (Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)

Screening of genotypes for rain-fed condition

Twenty six genotypes were evaluated under rain-fed condition during early and later growth stages. The result revealed that late season rain-fed condition caused nearly 40% reduction in total biomass in kalmegh. Andrographolide content on dry weight basis was affected by the water deficit stress caused due to rain-fed condition. Rain-fed during mid-season reduced andrographolide content to 1.25% and during the late season to 1.45% as compared to well-watered crop which had andrographolide content of 1.55%. Gaseous exchange parameters were also studied in the 26 genotypes in field condition. The mean net photosynthetic rate ($P_n$) was 20.7 and 18.0 μmolCO$_2$ m$^{-2}$S$^{-1}$ during 60-65 and 90-95 days after transplantsing, respectively. The stomatal conductance (gs), intercellular CO$_2$ concentration (Ci) and transpiration rate (E) were reduced with advancement of the growth stage. The highest intrinsic water use efficiency was in genotype AP 55 and the lowest
was in AP 25 and AP 39. *(Project 4: Integrated water and nutrient management and physiological manipulation for improving productivity of medicinal and aromatic plants; Investigator: Dr. K.A. Kalariya).*

**Standardization of solvents for improving extraction of major active ingredients**

Dried powder of aerial parts of kalmegh was extracted by different polarity solvents viz., petroleum ether, chloroform, ethyl acetate, methanol, ethanol, acetone and water. The result showed that the extraction yield (%) was highest in water extraction (39.01%) followed by methanol (29.61%), ethanol (22.95%), acetone (11.43%), ethyl acetate (8.85%), chloroform (6.79%) and petroleum ether (3.17%). It was also found that methanol and ethanol were superior solvents for extraction of major diterpenoid lactones and water for extraction of flavonoids. Concentration of individual analytes was measured from the extracts. The andrographolide content was highest in chloroform extract (161.08 µg mg⁻¹). Andrographiside was found highest in acetone extract (42.18 µg mg⁻¹). Neoandrographolide was recorded highest in acetone extract (23.08 µg mg⁻¹). Andrographanin was higher in ethyl acetate extract (0.54 µg mg⁻¹). 14-deoxy,11-12 didehydroandrographolide was found highest in methanol extract (17.8314 µg mg⁻¹) followed by acetone extract i.e., 15.67 µg mg⁻¹; Apigenin was higher in ethyl acetate extract (2.48 µg mg⁻¹) followed by acetone extract (2.12 µg mg⁻¹) and 7-O- methylwogonin was found higher in petroleum ether extract (0.18 µg mg⁻¹). *(Project 06: Bio-prospection, quality and post harvest technology of medicinal and aromatic plants; Investigator: Dr. Narendra Gajbhiye).*

**Variation in andrographolide in samples from different regions of India and its herbal formulations**

Variation of three andrographolides namely andrographolide, neoandrographolide and andrograpanin were analysed in 15 samples of *A. paniculata* collected from different regions of India and nine marketed herbal formulations containing *A. paniculata*. Extracts were prepared in methanol by refluxing method. The extract yield (%) ranged from 10.99 to 21.68 with mean value extract yield of 15.15+ 2.81. For marketed herbal formulations the extract yield (%) was in the range of 7.59-28.53 with mean value extract yield of 15.50+ 6.84%. HPLC-PDA method was used for identification and quantification of the andrographolides in the extract samples. Andrographolide was quantified (%) in all the 15 samples and it was in the range of 4.23+ 0.1-1.11+ 0.07. Similarly, neoandrographolide was also quantified in all the 15 samples and it was in the range of 1.15+0.02- 0.03+0.0 %. Andrograpanin was quantified in eight samples only and it varied from 0.11+ 0.00 – 0.37+ 0.02 %. *(Project 06: Bio-prospection, quality and post harvest technology of medicinal and aromatic plants; Investigator: Dr. Satyanshu Kumar).*

**Ovicidal and larvicidal effects of andrographolide against human hookworm**

Ovicidal and larvicidal effects of andrographolide against human hookworm (*Ancylostoma duodenale*) were studied. Ethanolic and methanolic extracts of *A. paniculata* showed highest activity in inhibition of egg hatching with the lowest ED50 (median effective dose) values while ethyl acetate extract had the highest activity against larval motility. Andrographolide component showed significant inhibitory effects both on egg hatching and larval growth. Andrographolide exhibited significant ovicidal and larvicidal properties against field isolates of A.duodenale and
can be developed as a potential therapeutic choice. (Project 06: Bio-prospection, quality and post harvest technology of medicinal and aromatic plants; Investigator: Dr. Satyanshu Kumar).

Schematic diagram for the study of ovicidal and larvicidal effects of andrographolide from leaves of Andrographis paniculata against field isolates of human hookworm (Ancylostoma duodenale)

**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. The leaves are dark green with shining surfaces. Male, female and biseaxual flowers are separately seen in the same or different plants. Male flowers are arranged in clusters and female and bisexual are found solitary or in clusters. Fruit is ball shaped berry with 4-10 vertical grooves in the outer fleshy rind. Fruits turn yellow coloured on ripening. Seeds are 4-10, covered with fleshy, white or red aril. The trees flowers in December to February and fruits in March to August. The fruits are edible and the rind is savour in taste. The dried rinds are valued as a condiment in Kerala. The
leaves, fruits and seed oil are medicinal and are used for the treatment of ulcers, inflammations, bleeding piles, diarrhoea, dysentery and indigestion. The fruit pulp extract is used for treating obesity. A decoction of the fruit rind is given in rheumatism and bowel complaints. The seeds yield edible fat which can also be used as kokkam butter which is commonly prepared from G.indica. It is propagated by seeds, stem cuttings and grafts.

**Method development and quantification of targeted compounds in *Garcinia* extracts**

UPLC-PDA method was developed for the quantification of three xanthones i.e., α, β and γ mangostin and two polisoprenylated benzophenones (PIBs) i.e., xanthochymol and isoxanthochymol in the extracts of *Garcinia* cowa, *G. cambogia*, *G. indica*, *G. mangostana*, *G. morella*, *G. pedunculata* and *G. linoceroide*.

![HPLC-PDA chromatogram of five standard mixtures](image)

Process was also developed for the isolation of xanthochymol and isoxanthochymol from the extracts of fruit rinds of *G. indica*, α-mangostin from *G. mangostana* and cambogin and camboginol from extracts of fruit rinds of *G. cambogia*. (ICAR Network project: High Value Compounds/Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh).

**Cytotoxic activity: Growth inhibition (GI⁵₀) determination of selected extracts of *Garcinia***

Four extracts (hexane, chloroform, ethyl acetate and methanol) of eight *Garcinia* species were screened using sulforhodamine(SRB) assay in human breast cancer cell line (MCF-7), human ovarian cancer cell line (PA-1), human cervical cancer cell line (HeLa), hepatoma cell line (Hep-G2) and colon cancer cell lines (colo-205). The extracts exhibited significant cytotoxic properties and growth inhibitory (GI⁵₀, µg/ml) in SRB assay (ICAR Network project: High Value Compounds/Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh).

**Garcinia seed oil as source of solid fat and stearic acid**

Seeds of *Garcinia* species are rich sources of oils with medicinal and nutritional values. *Garcinia* species were characterized for stearate (n-octadecanoic acid, C₁₈₀ CH₃(CH₂)₁₆ COOH, melting point 69.6°C) in their seed oil. The study showed that seed oils of *Garcinia* species had high stearic acid (>50%). *Garcinia* species of high oleic acid was also identified (>70 %) (ICAR Network project: High Value Compounds/Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh).
Validation of *G. indica* fruit juice as a hypolipidemic agent in rodent model

Hypolipidemic activity of *G. indica* fruit was tested by using fruit juice in rodents based on “Cafetaria diet” (CF) model. After 4 weeks of treatment with *Garcinia* fruit juice, it was observed that there was significant decrease in body weight of the CF treated rodents as compared to non-treated CF group as well as Orlistat (a drug designed to treat obesity) treated CF group. Treatment with *Garcinia* fruit juice for 4 weeks caused a significant decrease in glucose intolerance. This data was comparable to group treated with orlistat suggesting that *G. indica* fruit juice has potential to improve glucose sensitivity. However, CF group and high fat group were glucose intolerant.

On administration of *G. indica* fruit juice for 30 days, there was significant decrease in serum total cholesterol, serum tryglycerides and LDL-cholesterol and increase in HDL-cholesterol. It suggested that dyslipidemic rat model was reverting back to normal phenotype. These data when compared to standard drug showed similar result. CF treated group and high-fat treated group both showed significant alteration in lipid profile. Also, there was significant increase in SGPT (Serum glutamic pyruvic transaminase) activity suggesting liver toxicity due to CF diet treatment as compared to the control. Upon the administration of *G. indica* fruit juice, there was significant decrease in its activity. However, there was no significant change in high-fat treated group. Significant increase in serum creatinine level in CF treated group was recorded and the level decreased upon *G. indica*
fruit juice treated group. In case of high-fat treated group, there was significant increase in serum creatinine level.

Upon the treatment of *G.indica* fruit juice, HMG-CoA reductase activity was reduced thus indicating a decreased cholesterol biosynthesis. Ideal decrease in activity was seen on treatment with orlistat. High-fat group did not show significant change suggesting no change in HMG-Co reductase activity. On administering *G.indica* fruit juice, a significant increase in LCAT activity was observed as compared to the CF group. This activity was not increased in case of orlistat treated group. While high-fat treated groups showed decrease in LCAT (cholesterol acyltransferase) activity. No significant change was observed in *G.indica* fruit juice treated group as compared to high-fat treated group.

CF treated group showed significant increase in transcript level of the lipid metabolizing enzyme, acetyl Co-a Carboxylase (ACC) level as compared to the control. There was marked decrease in its level due the treatment of *G.indica* fruit juice for 30 days. The data was similar to the orlistat treated group. High-fat diet treated group did not show significant change in ACC level as compared to control group. (Project 06: Bio-prospection, quality and post harvest technology of medicinal and aromatic plants; Investigator: Dr. Satyanshu Kumar).

**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.

**Study of physiological efficiencies of genotypes**

Gymnema is a slow growing plant and no report is available on gaseous exchange and chlorophyll fluorescence parameters. Total 44 genotypes were evaluated for their physiological efficiencies during post rainy season in sub-tropical region of Gujarat. Genotypes were categorized into low, medium and high groups considering over all mean values of different parameters. Seven genotypes were identified with higher photosynthetic rate (*P*$_{n}$). Eight genotypes had maximum photochemical efficiency (F’$_{v}$/F’$_{m}$) and seven genotypes had maximum actual efficiency of PSII (F’/F’$_{m}$’). The correlation matrix revealed that the *P*$_{n}$ was strongly positively correlated with *g*$_{s}$, F’$_{v}$/F’$_{m}$, *Φ*$_{psii}$ and ETR. Genotype DGS-2 and DGS-18 having high values in maximum physiological parameters will be very useful in crop improvement program focused on biomass maximization in gymnema. (Project 01: Conservation, characterization and utilization of genetic resources of medicinal and
aromatic plants for sustaining production; Investigator: Dr. K.A.Kalariya)

**Deep sequencing-based de novo transcriptome analysis revealed biosynthesis of gymnemic acid**

Madhunashini extract is used to cure the most important lifestyle disease; the diabetes mellitus. Indians first used madhunashini to treat diabetes as early as 2,000 years ago. Triterpene saponins having anti-diabetic property from madhunashini leaves belonging to oleanane and dammarene classes are collectively known as gymnemic acid. Presently, transcriptomic and genomic resources are not available in *G. sylvestre*. A paired-end de novo deep transcriptome sequencing of leaf, flower and fruits differing in gymnemic acid content was performed on Illumina Hiseq 2500 platform using 2x150bp chemistry produced 60.95, 56.99 and 45.82 million raw reads which were submitted to the National Centre for Biotechnology Information’s (NCBI) Sequence Read Archive (SRA) databases. Raw reads were assembled into 112583, 203145 and 138343 unigenes for leaf, flower and fruit, respectively from which coding DNA sequences (CDSs) were predicted. Total of 71676, 99643 and 92770 CDSs were annotated against NCBI’s non-redundant, Uniprot, Eukaryotic Orthologous Groups of proteins(KOG) and Pfam protein databases for leaf, flower and fruit respectively. The top hit species distribution revealed that majority of the hits were found to be against the species *Coffeacanephora*. The most enriched category with maximum CDSs count in KOG classification was “signal transduction mechanisms”, the most abundant domain identified was “protein kinase” and most abundant transcription factor family enriched was bHLH(basic helix-loop-helix). The Blast2GO was used to compare and determine the GO annotations. 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 287 CDSs encoding genes involved in gymnemic acid pathway. Based on the available information from the master assembly, a putative pathway of gymnemic acid biosynthesis was proposed. Comparative analysis revealed significant differences in tissue specific gene expression. The present study provided an important resource for future molecular and functional genomics studies in *Gymnema sylvestre*. (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 and Dr. A. P. Trivedi)

**MANDOOKPARNI (Centella asiatica)**

It is a member of family Apiaceae. It is a prostrate, slightly aromatic, perennial herb commonly found as a weed in crop fields. The species is widely distributed in India and is commonly known as Brahmi in North India. The flowers are pinkish to red in color, born on small umbels. Leaves are used as vegetable in eastern and southern parts of India. It is used for the treatment of leprosy, skin diseases and to improve memory. It is also used against cholera, leucorrhoea and kidney troubles. Asiaticoside, indocentelloside and thankuniside are the major active ingredients. It is propagated both by runners as well as by seeds. Humus rich soil and partial shade are suitable for cultivation.
Standardization of solvents for improving extraction of major active ingredients

LC-MS/MS was applied for quantitative determination of the four different triterpenoids [asiaticoside (AS) and madecassoside (MS)] and their aglycones [asiatic acid (AA) and madecassic acid (MA)] in the leaves of *Centella* extracted by different solvents from non-polar to polar, viz. petroleum ether, chloroform (CHCl3), ethyl acetate (EtOAc), acetone, ethanol, methanol and water. It was found that methanol, ethanol and acetone were superior solvents for extraction of the four triterpenoids as compared to the other solvents used. The results revealed that all the triterpenoids were present at higher concentration in ethanol, followed by methanol, acetone, EtOAc, water, CHCl3 and petroleum ether. The individual quantified values for the different triterpenoids in the different solvent extracts were in the order: ethanol > methanol > acetone >EtOAc> water > petroleum ether > CHCl3 for AS and MS, ethanol > methanol > acetone >EtOAc> petroleum ether > CHCl3 > water for AA, and EtOAc> acetone > methanol > ethanol > CHCl3 > petroleum ether > water for MA. (Project 06: Bio-prospection, quality and post harvest technology of medicinal and aromatic plants; Investigator: Dr. Narendra Gajbhiye).

**SENN** (*Cassia angustifolia*)

Senna 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. 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, antisyntetic, 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 registration and identification of trait specific germplasms**

Two-germplasm accessions viz., DCA-121 (IC0610825, INGR17079): with small pod size and DCA-124 (IC0610826; INGR17080): A plant type with broad pods and leaves were registered as trait specific germplasm at ICAR-NBPGR, New Delhi. Five germplasm accessions viz., DCA-243 broad leaf plant type, DCA-149, a dwarf plant type, DCA-214-1 plant type with dark green leaves with small pods, DCA-225 early flowering plant type, DCA-153 light green plant type and DCA-84 dark green plant type with ovate round leaf shape with pubescent curved pods were also identified. (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).
Multilocation trial of superior lines

Initial evaluation trial (IET) with four test entries and three checks was conducted at four locations with an objective to identify superior varieties with high yield and quality. Across locations, DCA-96 recorded maximum dry herbage yield (10594.09 kg ha⁻¹) which was followed by A16-18 (9507.46 kg ha⁻¹). (Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel)

Hybridization work and induction of polyploidy

Ten hybrids were generated to study genetics of leaf type (broad and narrow), plant habit (semi spreading and erect) and leaf shape (acute and attenuate).

Interspecific hybridization of Cassia angustifolia with Cassia holosericea and Cassia italica was attempted for introgression of novel traits such as pest resistance into C. angustifolia. Successful (100%) hybridization between C. angustifolia with C. holosericea was observed. Seed set was normal in F₁ and F₂ seeds. F₂ plants showed segregation for plant height, pod shape and other phoenological traits.

Two senna plants with profuse flowering but lacking pod formation developed by induction of polyploidy were advanced. (Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel)

New molecular markers developed

Exploration was undertaken to study the Intron Length polymorphism (ILP) in the genes involved in sennoside biosynthesis. Over 210 ILP markers were designed to amplify intronic regions of 27 genes involved in the biosynthesis of sennosides using transcriptome information. More than 90% of ILP markers showed amplification in senna. (Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigators: Dr. R. Nagaraja Reddy and Dr. P. Manivel)

Relative expression of CaDXS gene studied

The relative gene expression of caDXS gene with respect to the expression of GAPDH, Actin, EFF-1α genes (endogenous control) was studied in the leaf (young and mature), pod (young and mature) and flowers of genotypes Sona, DCA-80 and DCA-149. Differential expression of caDXS gene was observed in different plant parts and genotypes of senna. (Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. R. Nagaraja Reddy)

Morpho-anatomical characterization and chemical profiling of Cassia and related genera

Morphological and anatomical characterization of 15 species viz., Senna alata (L.) Roxb., S. alexandrina Mill., S. auriculata (L.) Roxb., Chamaecrista absus (L.) H.S.Irwin&Barneby, Cassia fistula
(L.), *C. javanica* (L.), *Chamaecrista mimosoides* (L.) Greene, *S. occidentalis* (L.) Link, *S. polyphylla* (Jacq.) H.S. Irwin & Barneby, *C. pumila* (Lam.) K. Larsen, *C. renigera* Benth., *S. surattensis* (Burm.f.) H.S. Irwin & Barneby, *S. siamea* H.S. Irwin & Barneby, *S. tora* (L.) Roxb and *S. uniflora* (Mill.) H.S. Irwin & Barneby were carried out. Profiling of sennosides A and B in the extracts of leaves of selected species were also carried out using a RP-HPLC method. Selected species could be differentiated on the basis of their habit, morphological and anatomical characters. Based on the sennosides content, three species, i.e., *S. tora*, *C. javanica* and *S. occidentalis* could be considered as potential alternative sources of sennosides A and B. (ICAR Network project: High Value Compounds/Phytochemicals; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh)

**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.

### Development of a simple method for the preservation of leaf samples and DNA isolation

Existing methods of DNA isolation renders problems in downstream analysis in plant species having high contents of secondary metabolites and glands. Members of lamiaceae such as tulsi and basil have peltate glands and secondary metabolites in leaves. Presence of such compounds probably hinders downstream analysis involving enzymatic reactions such as PCR. Collection of leaf sample and storage of collected material until DNA isolation require costly methods such as use of liquid nitrogen, deep freezer and others. Use of liquid nitrogen in DNA isolation further increases the cost of analysis. To overcome these problems, a simple and cost-effective method is developed. In this method there is no requirement of liquid nitrogen and deep freezer for leaf sample storage and for DNA isolation. Thus, it is a cost-effective method. Second, plant originated enzyme inhibitors such as phenolic compounds and essential oils which can hinder PCR reactions are removed at first step in the method during the lysis by non-active absorbents. DNA isolated from tulsi leaves with this method was successfully tested for the random primers (RAPD & ISSR) and gene specific primers (SSR & metabolic pathway genes) amplification. (Project 03: Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants; Investigator: Dr. Manish Kumar Suthar)

### Development of g-SSR markers

Genomic sequencing database of *Ocimum sanctum* comprising 229838 sequences were collected. This database was searched for identification of repeat sequences using MISA. A total of 7637
SSR motifs were identified in this database. Primers were synthesized for these repeat sequences using their flanking sequences. Initially 22 primer pairs were synthesized. These primer pairs were validated using *O. sanctum* genomic DNA. These will be used as SSR markers for the diversity analysis of the species. *(Project 02: Genetic Improvement of medicinal and aromatic plants through conventional breeding and biotechnological approaches; Investigator: Dr. Manish Kumar Suthar).*

**Other Experiments**

**Incorporation of medicinal plants in high value cropping system**

In a two year field experiment, in high value cropping system of middle Gujarat plain (Anand) production potential and profitability of conventional cropping systems (paddy - kalkatti tobacco - fallow, paddy - wheat - fallow, banana -fallow - fallow, banana+ yam - fallow - fallow and bajra - potato - fallow) and alternative cropping systems (kalmegh - kalkatti tobacco –bhuiaml, kalmegh - wheat –bhuiaml, safedmusli-potato - bajra and (safed musli+ pigeonpea) - asalio–bhuiaml) indicated that there is little scope of integration of medicinal plants for increasing productivity and profitability. However, each cropping system varied significantly in terms of productivity and profitability. The mean annual net returns were highest from the (safed musli+ pigeonpea) - asalio–bhuiaml system and second highest from the safed musli+ potato+ bajra cropping system. *(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 and Dr. Ajoy Saha)*

**Potassium enriched compost from low-grade silicate mineral and distillation waste biomass**

An attempt was made to recycle waste biomass and mineral powder (waste mica) as an alternative source of potassium (K) through composting technology. Two different waste biomass, isabgol straw and palmarosa distillation waste along with two levels of waste mica (2 and 4% as K) were used for preparation enriched composts. A notable decrease of C: N ratio was observed at the end of the composting (150 days) as an indicator of compost maturity. The mature composts were evaluated for K supplying capacity through laboratory leaching and soil incubation study. Significantly higher water soluble K released initially followed by a sharp decrease up to 21 days of leaching thereafter gradually decreased up to 35 days of leaching. Water soluble K was released from K enriched (mica charged) compost significantly higher than the ordinary compost throughout the leaching period. Soil incubation study also revealed that application of K enriched compost greatly improved the available K (water soluble and exchangeable) pools in K deficient soil which indicated that a considerable amount of K release during composting. This study demonstrates that K enriched compost developed from waste biomass and mica can be an effective technology for recycling organic waste as well as low-grade mineral powder. The enriched compost is a promising alternative source of K for crop production and maintenance of soil K which can reduce dependency on costly imported commercial fertilizer and consequently decreases the expense of huge foreign exchange. Moreover, this is an energy efficient, low-cost environmental-friendly approach for proper utilization and value addition to both organic and inorganic waste. *(DST-SERB Project: Evaluation of potassium availability from unconventional sources for sustainable farming*
Development of nucleic acid based RT-PCR assay for detection of cucumoviruses associated with antamul (*Tylophora indica*) and kuppi (*Acalypha indica*)

*Tylophora indica* and *Acalypha indica* were found infected with symptoms of yellow chlorotic rings or irregular yellow spot and in severe condition necrotic rings on the vines of the crop. The symptomatic leaf tissues were processed following the standard leaf dip procedure and spherical virus particles ranging from 28-32nm size were observed under the electron microscopy. To identify the causal virus of the genus *Cucumovirus*, a set of novel degenerate primers (RM07F/CMV-ATYCAYGGHGGTTATGAYATGGG and RM07R/CMV-CRAYRATYTTATASGTCATRAT) was designed and used for polymerase chain reaction (RT-PCR) to amplify ~410bp of the RdRp genomic region. The sequence result showed 97-98% sequence identity with the *Cucumber mosaic virus*. Both the medicinal herbs may serve as an alternate host for the virus. *(Project 5: Integrated pest and disease management in medicinal and aromatic plants; Investigator: Dr. R.P. Meena).*

Method development for identification and quantification of three marker compounds from *Ageratum conyzoides*

A TLC method was developed for identification of three marker compounds in extracts and formulations of jangli pudina (*Ageratum conyzoides*). HPLC-PDA method was also developed for identification and quantification of the three marker compounds in extracts and formulations. Using this method, three marker compounds were identified and quantified in extracts of *Ageratum conyzoides* and formulations made from the extracts. *(NASF Project: 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; Investigator: Dr. Satyanshu Kumar).*

HPLC-PDA chromatogram of (A) standard mixture of three marker compounds (B) extract of *Ageratum conyzoides* (C) formulation
Microencapsulation of herbal extracts

Microencapsulation process was developed for kalmegh (*Andrographis paniculata*) and senna (*Cassia angustifolia*) extracts. HPLC analysis confirmed that andrographolide and neo-andrographolide were retained in the microencapsulated product from *A. paniculata* and sennoside A and B were retained in the microencapsulated product from extracts of *C. angustifolia*. Fruit juice of *Garcinia* was also microencapsulated to increase its shelf life. *(Project 06: Bio-prospection, quality and post harvest technology of medicinal and aromatic plants; Investigator: Dr. Satyanshu Kumar)*

Method development and quantification of phyllanthin and hypophyllanthin in extracts of *Phyllanthus* species

A rapid and validated HPLC-PDA method was also developed for identification and quantification of phyllanthin and hypophyllanthin in extracts of *Phyllanthus* species. Using this method, phyllanthin and hypophyllanthin were identified and quantified in 42 extracts of seven *Phyllanthus* species namely *P. amarus*, *P. debilis*, *P. maderaspatensis*, *Preticulatus*, *Purinaria*, *P. virgatus* and *P. tenellus*. Phyllanthin and hypophyllanthin were present in *P. amarus* and *P. debilis* only. It was found that the contents of phyllanthin and hypophyllanthin were higher in *P. amarus* as compared to *P. debilis*. *(NMPB Project: Standard operating protocols of post-harvest management for five selected medicinal plants (Desmodium gangeticum, Gymnema sylvestre, Leptadenia reticulata, Phyllanthus amarus and Eclipta alba; Investigators: Dr. Satyanshu Kumar and Dr. Raghuraj Singh)*.

Fig. HPLC-PDA chromatogram of standard mixture of phyllanthin and hypophyllanthin (B) and hexane extract of *Pamuras*

Agricultural Knowledge Management Unit (AKMU)

- **Institute website:**
  Institute website was updated regularly with fresh news, thought of the day and all day to day information viz., recruitment advertisement, tender, bulletins, annual reports etc. of the Directorate by event launcher. The ICAR DMAPR web site had already linkage to all important links of ICAR, FMS/MIS, OAJP, NAIP, NMPB, Networking of herbal garden of India, MAPAI, National Portal, Farmers portal, ICAR MAIL, AEBAS Dashboard, ICAR Circular, Institute intranet, Institute Guest House etc. Institute website is in bilingual English-Hindi and received more than 76,358 hits in the last one year.
• **Registration of five New herbal garden:**

Networking of Herbal Gardens of India is an online NMPB project, launched and maintained by our Institute.

• **National Knowledge Networking (NKN):**

Under this NKN Project our institute received 100mbps internet connection which was managed and shared with more than 110 STATIC IP and wifi router nine shared with DHCP for the full-fledged internet usage for official purpose through local area network and wifi by server management.

• **Online Examination Center:**

ICAR-DMAPR have well structured online examination center with 105 computers, two HP servers with server 2012, 20 KVA UPS, dedicated 180 KV Generated set which was managed by AKMU. During this year two examinations were conducted successfully on 23.04.2017 (Ph.D. entrance Exam) and another during 16-21st May, 2017 (ICAR-ARS NET Examination).

• **IT Based application usages:**

In the route of paperless office management, computer, software and internet facilities were provided to all the staff including accounting, clerical, FMS/MIS, PERMISNETii, eprocurement, etendering, ERP, PIMIS, etc with high speed internet facility by NKN Project. More than 70-75 Computers were managed securely by security software in the main building for the institute staff through AKMU. All the facilities for internet, intercom and networking were provided through AKMU.

• **Aadhar Enabled Biometric Attendance System:**

Biometric attendance system and AEBAS (Aadhaar Enabled Biometric Attendance System) are in operation online through attendance.gov.in for monitoring the attendance and regularity of staff working hours.

• **Seminar hall Auditorium and display system:**

For the institute achievements and the display of medicinal and aromatic crops identifying images, taxonomical details and usage of the medicinal crop in bilingual were displayed in the Institute entrance TV display. AKMU supported and managed Auditorium and Seminar hall for meetings, trainings, farmer meets, stake holder meets, summer schools, functions, students and scholars visits for knowing the Institute and institute functional showcase sort video of wealth of India, GACP etc. Audio and video management were managed by AKMU. Hundreds of farmers enjoyed honorable Prime Minister Shree Narendra Modi’s speech in auditorium on 17.03.2018.

Agricultural Knowledge Management Unit main functions for providing institute staff IT facility and successful usages of computer and related peripheral with internet facilities, which was carry forward successfully entire year. AKMU manage institutes google accounts for storing events in digital form of event in high resolution photographs and videos. Managed twitter accounts for focusing institute achievements and events.
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.

Floral biology and breeding behaviour

PDKV, Akola: Inflorescence of Aloe is bright coloured, cylindrical raceme with tubular flowers grown from the center of the rosette of the leaves. The number of flowers in a raceme ranged from 61 to 139. The length of fully developed raceme ranged from 89 to 136 cm. The flowers are bisexual, with perianth of 6 lobes, six stamens and the ovary is superior. Flower opening was indicated by appearance of longitudinal split at the apex of perianth tube and it widens up to the middle of the bud and slowly one after another or simultaneously the tepals of the bud separated and six stamens and stigma became visible. Maximum anthesis (opening of flower) was observed from 09.00 to 10.00 am at relative humidity (RH) of 60-61 % and temperature range of 38.3-32.9°C. The bursting of pollen from anther i.e. dehiscence was maximum between 10.00 am to 11.00 am and relative humidity and temperature were 66-61% and 38.3-32.9°C, respectively at the time of peak pollen bursting. The bees and sunbird are responsible for pollination. The time between anthesis and dehiscence was nearly 1.00 hour.

Effect of spacing and organic manures on growth and yield

PDKV, Akola: A field experiment was conducted to study the effect of different plant spacing and organic manure application on growth and yield of aloe consecutively for three years. Non-significant differences were recorded in pooled means of number of leaves per plant, leaf length and leaf thickness of aloe whereas, leaf width showed significant differences. Significantly higher
pooled means of number of leaves, leaf length and leaf width were at 60 × 60 cm spacing followed by 60 × 45 cm spacing. Application of vermi-compost @ 2.5 t ha⁻¹ per hectare recorded significantly highest leaf weight and gel recovery, whereas gel: peel ratio was comparatively higher with application of 5 t vermicompost per hectare. Interaction effect was found non-significant except in the case of peel weight and gel: peel ratio. However, planting of aloe at 60 × 30 cm spacing recorded significantly higher leaf yield (90.87 t ha⁻¹). Application of vermicompost @ 2.5 t ha⁻¹ recorded significantly higher leaf yield (67.54 t ha⁻¹) followed by application of vermicompost @ 5 t ha⁻¹ (65.86 t ha⁻¹) and FYM @ 10 t ha⁻¹ (65.82 t ha⁻¹), however, these treatments were at par. Similar results were also noticed with gross monetary returns. Significantly highest net monetary return was recorded at spacing 60 × 30 cm and application of vermicompost @5 t ha⁻¹.

**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 lobed 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.

**Evaluation of germplasm**

**MPUAT, Udaipur:** A total of 15 accessions were evaluated for yield and quality characters. The result showed that five accessions i.e., ULS-6, ULS-8, ULS-9, ULS-11 and ULS-12 exhibited higher mean seed yield over the local check ULS-15 (2267 kg ha⁻¹) and over grand mean of the experiment (2081 kg ha⁻¹). Seed yield for the trial ranged from 1433 kg ha⁻¹ (ULS-10) to 2592 kg ha⁻¹ (ULS-9). Six accessions had significantly higher oil content and four accessions had significantly higher mucilage content over the check GA-1 (21.50% and 10.0 cc g⁻¹).

**Evaluation of selected entries for yield and quality**

**MPUAT, Udaipur:** Eight promising entries identified from germplasm stock of the project were evaluated along with two checks (GA-1 and ULS-15). The observations for plant height, number of branches per plant and seed yield (kg ha⁻¹) were recorded for all the entries. The observations on days to 50% flowering, days to maturity and DUS (distinct, uniform and stable) traits were recorded. Four entries ULS-1, ULS-2, ULS-6 and ULS-9 were found to be statistically at par for seed yield with the check GA-1 (1919.67 kg ha⁻¹). These best performing entries also showed better plant stand ability among the tested entries. The days to 75% maturity ranged from 102 to 113 days. The oil content analysis of four entries viz., ULS-8, ULS-9, ULS-19 and ULS-20 exhibited significance over the check ULS-15 (local control) (20.15%) and mucilage content analysis of two entries viz., ULS-3 and ULS-6 also exhibited significance over the check ULS-15 (11.2%).
Effect of inorganic and biofertilizers on growth and yield

**JNKVV, Jabalpur:** A field experiment was conducted to study the effect of recommended dose of chemical fertilizers (RDF) and biofertilizer in different combinations on growth and yield of asalio. The results showed that the various treatments have marked influence on plant height and yield of the crop. The plant height ranged from 84.87 to 93.93 cm, number of branches from 14.67 to 17.73, seed yield from 1600 to 1925 kg ha$^{-1}$. Among the various treatments, treatment combination of ½ RDF (NPK: 25:25:15 kg ha$^{-1}$)+ PSB was found to have maximum seed yield (1925 kg ha$^{-1}$) with maximum net return of ₹ 40775 ha$^{-1}$, and C: B ratio 3.40 followed by application of 50% RDF+ PSB+ AZB i.e., ½ RDF (NPK: 25:25:15 kg ha$^{-1}$)+ PSB+ AZB with Net Return of ₹ 38000/- ha$^{-1}$ and B: C ratio 3.23.

Integrated weed management

**MPUAT, Udaipur:** An experiment was conducted with objectives to identify appropriate weed management practice for control of weeds in asalio and to arrive at an economically viable recommendation to maximize productivity of asalio. The treatments comprised of four herbicides i.e., Pendimethalin, Oxyflurofen, Oxadiargyl and Isoproturon with and without hoeing along with 2 hand weeding and weedy check. The result showed that two hand weeding at 25 DAS and 50 DAS and application of Pendimethalin @ 0.75 kg ha$^{-1}$ followed by one hand weeding recorded minimum weed intensity and dry matter. Consequently the seed (2060 and 2020 kg ha$^{-1}$), straw (8840 kg ha$^{-1}$, 8720 kg ha$^{-1}$) and biological yield (10910 kg ha$^{-1}$, 10740 kg ha$^{-1}$) were statistically at par and superior over rest of the weed control treatments. However, in terms of economics, application of Pendimethalin @ 0.75 kg ha$^{-1}$ proved to be the best weed control treatment (B: C of 2.80).

**RVSKVV, Mandsaur:** Field experiment was conducted to study the effect of different weeding methods and their intensity on growth and yield parameters of asalio. The data revealed that the highest seed yield (1800 kg ha$^{-1}$) was recorded in treatment comprised of three hand weeding at 25+ 35+ 45 DAS+ One hand cum hoeing at 30 DAS and the lowest (850 kg ha$^{-1}$) was in control. The highest number of branches (17.0) and plant girth (7.8 mm) was also found better in this treatment.

Effect of sowing method, time of sowing and plant spacing on growth and productivity

**YSPUHF, Solan:** The experiment comprised of 24 treatments of sowing methods, sowing dates and plant spacings. The experiment was conducted for three years and the pooled analysis of the experiment revealed that line sowing performed better than broadcasting. It was also observed that among the different sowing times, sowing during last fortnight of October month at 30 × 15 cm spacing gave maximum pooled mean plant height (79.71 cm), number of branches plant$^{-1}$ (13.74), seed yield ha$^{-1}$ (9530 kg), 1000 seed weight (3.08 g) and straw yield per plant (14.07 g).

Evaluation of bioagents and a bio-formulation for management of Alternaria leaf blight

**JNKVV, Jabalpur:** An experiment with seven treatments as soil application of bioagents and foliar application of azadirachtin was carried out from 2014-17 for the management of Alternaria leaf blight of asalio. Minimum disease incidences (33.3, 39.0, 41.0 %) were recorded in the treatment of application of Trichoderma fortified FYM+ Azotobacter+ spray of 0.15% azadiractin at 15 days intervals which was followed by treatment of application of FYM+ PSB+ spray of 0.15% azadiractin
at 15 days intervals during 2014-15, 2015-16 & 2016-17. However, the highest seed yield (1625 kg ha\textsuperscript{-1}, 1441 kg ha\textsuperscript{-1}, 1341 kg ha\textsuperscript{-1}) was recorded in treatment of application of \textit{Trichoderma} fortified FYM+ Azotobacter+ spray of 0.15% azadirachtin at 15 days intervals over the control (1258 kg ha\textsuperscript{-1}, 908 kg ha\textsuperscript{-1}, 903 kg ha\textsuperscript{-1}) during the three years’ of study.

On the basis of pooled analysis, all the treatments were found highly suppressive towards the disease but enhanced the seed yield with exception of application of FYM+ Azotobacter+ spray of 0.15% azadirachtin at 15 days intervals. The lowest disease incidence (37.77%) was recorded in application of \textit{Trichoderma} fortified FYM+ Azotobacter+ spray of 0.15% azadirachtin followed by application of FYM+ PSB+ spray of 0.15% azadirachtin (42.44%). The highest (1469 kg ha\textsuperscript{-1}) seed yield was recorded in application of \textit{Trichoderma} fortified FYM+ Azotobacter+ spray of 0.15% azadirachtin.

**Management of foliar diseases**

**JNKVV, Jabalpur:** An experiment was conducted with fungicides to manage the foliar disease of asalio. All the treatments significantly reduced the disease incidence and enhanced the seed yield. The disease incidence ranged between 34.25 and 60.25 percent while the seed yield varied from 1393 to 953 kg ha\textsuperscript{-1} under different treatments. The minimum disease incidence (34.25%) and maximum seed yield (1393 kg ha\textsuperscript{-1}) were recorded in seed treatment with carbendazim 12%+ mancozeb 63% @ 0.30% along with three foliar sprays with tebuconazole 25EC @ 0.10% first at initiation of disease followed by 15 days interval. The highest disease incidence (60.25%) and the lowest seed yield (953 kg ha\textsuperscript{-1}) was recorded in the control.

**Development of effective management practices for downy mildew and leaf spot diseases**

**MPUAT, Udaipur:** Integrated disease management modules against downy mildew and leaf spot disease of asalio were evaluated under artificial inoculated condition during the crop growth season. Downy mildew disease did not appear in experiment and nearby growing fields of asalio whereas, leaf spot disease was observed frequently. Among the modules, seed treatment with (Carbendazim 12%+ Mancozeb 63%) -75WP @ 0.30% plus three foliar sprays with tebuconazole 25EC @ 0.10% was found the best effective treatment with minimum leaf spots disease (8.04%) and maximum disease control (90.67%), along with increased seed yield (1889 kg ha\textsuperscript{-1}) and percentage of mucilage content (15.50). This was followed by treatment comprising of seed treatment with (carbendazim 12%+ mancozeb 63%)-75WP @0.30% plus three foliar sprays with mancozeb 75WP @ 0.25% which showed 23.22 per cent leaf spot, 73.08 per cent of disease control and 1565 kg ha\textsuperscript{-1} seed yield and increased mucilage content (14.88%). However, among the modules, treatment comprising of seed treatment with (carbendazim 12%+ mancozeb 63%)-75WP @0.30% plus three foliar sprays with Copper oxychloride @ 0.30% was found moderately effective against leaf spot disease (PDI-31.75 and 32.96%) compared to the rest of the treatments and control (PDI-86.28%). The treatment comprising of seed treatment with (carbendazim 12%+ mancozeb 63%)-75WP @ 0.30% plus three foliar sprays with (ametoctradin 22.7 %+ dimethomorph 17% SC) @ 0.1% was not found effective against leaf spots and resulted in maximum disease (66.11%) and minimum disease control (23.25%) compared to the rest of the treatments.
Management of foliar diseases

RVSKVV, Mandsaur: The experiment was conducted on management of foliar diseases of asalio. Among the six treatments, dry seed treatment with carbendazim 12%+ mancozeb 63% 75 WP @ 0.30% plus three foliar sprays with metalaxyl 72 MZ WP (mancozeb 64%+ metalaxyl 8%) @ 0.25% first sprays at initiation of disease followed by 15 days interval resulted in minimum disease incidence (DI) (18.16%) and higher seed (2284.90 kg ha⁻¹) yield over the control (DI 39.88% & seed yield of 1499.48 kg ha⁻¹).

Chemical evaluation of germplasm lines

RVSKVV, Mandsaur: Fourteen germplasm lines of asalio were evaluated for oil content and fatty acid composition of seed oil through gas chromatography. The study revealed that asalio seed oil was a very good source of unsaturated fatty acids. The oil content of the germplasm under study ranged from 18.02% (MLS 10-12) to 22.10 (MLS 10-21). The total unsaturated fatty acids ranged from 70.72% (MLS 10-22) to 85.12% (MLS 10-09). The highest linolenic acid (Omega 3) present was 47.48% in MLS 10-09 followed by 46.80% in MLS 10-05. These lines with high unsaturated fatty acids can be taken for further work.

ASHTAVARGA (Malaxis acuminata)

It is an orchid belonging to family Orchidaceae. The species is endemic to India distributed in the pine forests at an altitude of 1800-2300 m. Flowering occurs in the species during July-August. Flowers are yellowish-green in color. This terrestrial species, commonly called as Jeevak or Rishbhak is known for its great therapeutic importance as its dried pseudobulbs are important ingredient of 'Ashtavarga' drugs used in the preparation of an ayurvedic medicine ‘Chyavanaprash’. The raw drug is used to cure tuberculosis and is a great aphrodisiac. It can be propagated by seeds as well as by dormant apical bud from the underground part in the month of April. Due to over exploitation for therapeutic usages, the species status in nature is critically endangered.

Evaluation of germplasm

YSPUHF, Solan: Eight wild populations (collected from its natural distribution areas of Himachal Pradesh) and one morphotype (named as Solan selection; selection made by the Solan centre) were further evaluated for morphological features. The plants of Solan selection was characterised by greenish basal sheath (at the base of the shoot in contrast to purplish in wild type), yellowish green floral buds (in contrast to purplish in wild type), yellow coloured flowers without any purple tinge on their surface (purple tinge in wild type) and pseudo bulbs covered by green sheath (purplish in wild type). The above distinct characters of plants of Solan selection were consistently observed during the growing season of the fourth growing season and hence Solan selection is a candidate strain for registration as unique germplasm in Malaxis acuminata. Among all the populations studied, Solan Selection recorded maximum growth and yield parameters also.
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 entries**

An advanced evaluation trial (AVT-I) with 11 promising entries of ashwagandha (early maturing group i.e., annual type) were tested at PDKV, Akola; AAU, Anand; ICAR-DMAPR, CCSHAU, Hisar; ICAR-IIHR, RVSKVV, Mandsaur; IGKV, Raipur and MPUAT, Udaipur to identify promising lines for higher yield and quality. Across locations, maximum dry root yield was recorded in HWS8-18 (606.78 kg ha⁻¹) which was followed by IWS3 (573.72 kg ha⁻¹) and UMS10 (572.83 kg ha⁻¹). The trial will be repeated next year as AVT-II.

**Collection, maintenance and evaluation of germplasm**

**MPUAT, Udaipur:** A total of 74 lines of annual types (early maturity) were evaluated along with 3 checks in augmented design. The observations were recorded for individual line for morphological metric traits viz., plant height, number of primary branches, root length, root diameter and dry root yield also with other observations viz., days to 50% flowering, days to 75% maturity and total alkaloid content. The observations on non metric traits viz., root type (woody/starchy), berry color (yellow/red) and plant type (erect/spreading) were also recorded. A total of 11 lines exhibited higher dry root yield over the best check RVA-100 (472 kg ha⁻¹). It ranged from 111 to 639 kg ha⁻¹.

**Evaluation of promising lines**

**MPUAT, Udaipur:** Seventeen genotypes (identified as promising from genetic stocks maintained at the centre) were planted along with 3 checks (JA-20, JA-134 and RVA-100. All the test genotypes were annual type (early maturing). It is revealed from the analysis that the test entries UWS-10, UWS-23, UWS-37 and UWS-66 exhibited significantly higher dry root yield over the best check JA-20 (297.67 kg ha⁻¹).

**Maintenance breeding**

**RVSKVV, Mandsaur:** Maintenance breeding of varieties Jawahar Ashwagandha-20, Jawahar Ashwagandha -134, Raj Vijay Ashwagandha- 100 was undertaken through selfing and single plant selection method and purity was maintained by rouging of off type plants.
Evaluation of manure, bioagents and bioformulation against *Alternaria* leaf blight

**JNKVV, Jabalpur:** A field trial was conducted for management of leaf blight of ashwagandha caused by *Alternaria alternata* for the last three years with two main plot treatments of bioformulation (NSKE and 0.15% azadirachtin) and six sub-plot treatments (manure and bioagents in different combinations). The result showed significant effect of spray of nimbicide (0.15% azadirachtin) over neem seed kernal extract (NSKE) for reducing the disease incidence and enhancing the root and seed yields. The lower disease incidence (31.10%, 48.22%, 48.28%) but higher root (453 kg ha⁻¹, 399 kg ha⁻¹, 338 kg ha⁻¹) and seed (559 kg ha⁻¹, 469 kg ha⁻¹, 433 kg ha⁻¹) yields were recorded over the years under nimbicide (0.15% azadirachtin) spray during 2014-15, 2015-16 & 2016-17, respectively.

The effect of soil application of different bioagents (individually or in combination) fortified manure also significantly reduced the disease incidence but enhanced the dry root and seed yields during the experimental years. The lowest disease incidence (30.2%, 39.33%, 42.0%) but the highest dry root yield (550 kg ha⁻¹, 485 kg ha⁻¹, 445 kg ha⁻¹) and seed yield (608 kg ha⁻¹, 520 kg ha⁻¹, 481 kg ha⁻¹) were recorded under treatment combination of *Trichoderma asperellum* @ 10⁶ cfu ml⁻¹ + *Pseudomonas fluorescens* @ 10⁶ cfu ml⁻¹ during the experimental years.

The interaction of bio-fungicide with bioagents/ bioagent fortified manure was also found significant in reducing the percent disease incidence and enhancing the dry root and seed yields. The lowest disease incidence (28.6%, 38.0%, 40.3%) was observed in azadirachtin x *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ treatment during the three experimental years, respectively. The root yield (540, 508 kg ha⁻¹) was maximum in azadirachtin x *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ treatment and NSKE x *T. asperellum* @ 10⁶ cfu ml⁻¹ treatment during 2014-15 and 2015-16, however during 2016-17, root yield was highest in application of NSKE x *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ treatment. The highest seed yield (650 kg ha⁻¹, 556 kg ha⁻¹, 503 kg ha⁻¹) was recorded in azadirachtin x *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ treatment throughout the studied period which was followed by and NSKE x *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ and azadirachtin x *T. asperellum* @ 10⁶ cfu ml⁻¹ treatments.

From the result of pooled analysis, it was evident that the lowest (44.59%) disease incidence but higher root (406 kg ha⁻¹) and seed (488 kg ha⁻¹) yields were recorded in azadirachtin 0.15% spray over NSKE treatment. However, the treatment of *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ and *T. asperellum* @ 10⁶ cfu ml⁻¹ were found equally and highly suppressive (37.17% & 39.83%) towards the *Alternaria* leaf spot disease. The root and seed yields under *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ were the highest in comparison to the other treatments. The combination of *T. asperellum* @ 10⁶ cfu ml⁻¹ + *P. fluorescens* @ 10⁶ cfu ml⁻¹ incorporated as soil application and spray of azadirachtin @ 0.15% were found highly suppressive (35.6%) towards the disease but promoted root (496 kg ha⁻¹) and seed (570 kg ha⁻¹) yields.

**Integrated disease management of root and foliar diseases through organic modules**

**MPUAT, Udaipur:** Integrated disease management organic modules against root rot and leaf...
spots/blight of ashwagandha were evaluated under sick plot and inoculated condition. Among the organic modules, in-furrow soil application of neem cake mixture (100g m\(^{-2}\)) 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 (17.62, 18.75%) and leaf spots (19.43, 22.77%) with higher yields of seed (540, 518 kg ha\(^{-1}\)) and dry roots (428, 442 kg ha\(^{-1}\)) with increased alkaloid content which were statistically significant compared to the rest of the organic modules and control. Among the chemical treatment modules, seed treatment with (carbendazim 12%+ mancozeb 63%)-75WP @ 0.30% plus drenching and three foliar sprays of tebuconazole 25 EC @ 0.1% first at initiation of disease followed by 15 days interval was most effective with minimum incidence of root rot (8.50%) and leaf spots (9.48%) and increased yields of dried roots (547 kg ha\(^{-1}\)), seed (607 kg ha\(^{-1}\)) and alkaloid content compared to organic treatment modules and chemical treatment comprising of seed treatment with (carbendazim 12%+ mancozeb 63%)-75WP @ 0.30% plus drenching and three foliar sprays with mancozeb 75WP @ 0.25%.

**Analysis of antioxidant activity and total alkaloid content in root parts of genotypes**

**MPUAT, Udaipur:** Analysis of antioxidant activity by DPPH method and total alkaloid content in ashwagandha genotypes root powder was found to be varied from 0.18 to 1.71 mg ml\(^{-1}\) and 0.08% to 0.96%, respectively. Maximum antioxidant activity was recorded in germplasm UWS-59 (1.71 mg ml\(^{-1}\)) and minimum was in UWS-37(0.18 mg ml\(^{-1}\)). Similarly, the highest total alkaloid content was in UWS-22 (0.96%) and the lowest was in (0.08%) UWS-59.

**BABCHI (*Psoralea corylifolia*)**

The species belongs to family Fabaceae and it is an erect annual herb extensively used in indigenous system of Medicines for curing leucoderma, leprosy and psoriasis. It grows throughout the plains of India, especially in the semi-arid regions of Rajasthan and Eastern districts of Punjab, adjoining Uttar Pradesh. It is also found throughout India in Himalayas, Dehra Dun, Bengal, Bombay, Bihar, Deccan, and Karnataka. This plant is also widely distributed in the tropical and subtropical regions of the world, especially China and Southern Africa. The oily pericarp of the seed contains important coumarins compounds viz., psoralen and isopsoralen. It has antimicrobial, antifeedent and insecticidal activities also. The crop is propagated by seeds. The plant thrives well in areas with low to medium rainfall during the summer months and on a variety of soils ranging from sandy, medium loam to black cotton in dry tropical regions of India.

**Study of occurrence of diseases**

**MPKV, Rahuri:** Severe infection of powdery mildew was noticed in babchi. Initially small white pustules were observed on lower leaves and in due course of time, entire leaf was covered with powdery mildew. It spread from lower leaves to upper leaves. The size of conidia ranged from
32.3 to 40.6 µm (avg. 36.5 µm) long and 13.9 to 18.2 µm (avg. 16.3 µm) width. The conidia and conidiophores were hyaline. Conidiophores were cylindrical in shape. The mycelium was septate and hyaline. The pathogen was identified as *Erysiphe cichoracearum*.

**Management of leaf eating caterpillar**

**MPKV, Rahuri**: Efficacy of different biopesticides against *Papilio demoleus* was studied. Results revealed that pre treatment count of number of larvae per plant ranged from 6.20 to 8.47 per plant. At three days after treatment (DAT), significant reduction in leaf eating caterpillar population per plant was observed in all the treatments as against 8.13 larvae per plant in untreated control. Maximum reduction in leaf eating caterpillar population (3.13 larvae plant⁻¹) was observed in treatment with chlorpyriphos @ 0.05% followed by azadirachtin (10000 ppm) @ 3 ml l⁻¹ (4.80 larvae per plant) and karanj oil @ 1% (5.80 larvae per plant). At seven days after treatment (DAT) chlorpyriphos @ 0.05% (2.33 larvae per plant) recorded superior insect control compared to all the other treatments as against 7.40 larvae per plant in untreated control. Similar trend was observed at 14 DAT where foliar application of chlorpyriphos @ 0.05% recorded superiority with mean leaf eating caterpillar population of 1.80 larvae per plant against 8.67 leaf eating caterpillar larvae per plant in the untreated control. Maximum seed yield was also obtained in chlorpyriphos @ 0.05% treated plots (1178 kg ha⁻¹) followed by treatment of *Bacillus thuriengenesis* @ 2 g l⁻¹ (1027 kg ha⁻¹) and azadirachtin (10,000 ppm) @ 3 ml l⁻¹ (981 kg ha⁻¹) as against 682 kg ha⁻¹ seed yield in untreated the control plot.

**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.

**Evaluation of promising lines for yield and quality under MLT**

Four lines (APAc-2, APac-4, APAc-5 and APAc-9) along with check (Symbolia) were evaluated for yield and quality at AAU, Jorhat, UBKV, Kalimpong; BCKV Kalyani, IGKV, Raipur, YSPUHF, Solan, KAU, Trichur and YSRHU, Venkataramannagudem. Across locations, mean rhizome yield (kg ha⁻¹) was maximum for APAc-5 (2782.66) which was followed by APAc-2 (2420.08) and APAc-9 (2387.05). The trial failed at Trichur center and Data was recorded at the Kalimpong center. The trial will be conducted next year as AVT-II.
**Germplasm evaluation**

**AAU, Jorhat:** Twenty-seven clones were evaluated for various morphological characters and yield parameters. Maximum leaf length was observed in JAC-25 (92.02 cm) while minimum was recorded in JAC-7 (32.03 cm). Leaf breadth varied from 0.72 cm (JAC-26) to 1.86 cm (JAC-17). Significant variation was observed in leaf breadth among the germplasm. Number of leaf ranged from 6.66 to 9.33. No significant variation of leaf veins was recorded among the germplasm. Maximum rhizome length (22.87 cm) was recorded in JAC-6 while minimum was observed in JAC-22 (8.83 cm). Rhizome width ranged from 3.43 cm (JAC-22) to 6.26 cm (JAC-11) which was closely followed by JAC-6 (6.18 cm). Maximum rhizome weight was found in JAC-4 (56.33 g plant⁻¹) followed by JAC-6 (54.95 g plant⁻¹) while minimum was recorded in JAC-21 (22.33 g plant⁻¹).

**Standardization of organic nutrient management practices**

**KAU, Trichur:** An experiment was conducted to standardize organic nutrient management in bach for optimum growth and economic yield consecutively for two years. Different sources of organic manures like FYM, vermicompost, neem and castor cake were applied at various doses along with recommended dose of chemical fertilizers (RDF) for comparison. Among the different organic manures tried, FYM at 15 t ha⁻¹ gave taller plants during first and second year of study (18.85 and 20.06 cm). However, it was statistically at par with plants supplied with vermicompost at 7.5 t ha⁻¹. Absolute control plots recorded the shorter plants (11.31 and 12.66 cm) at the time of harvest. As compared to organic manures, application of RDF through inorganic nutrients resulted in better plant height during both the years of study (21.14 and 24.93 cm). Among the organic treatments, plants which received FYM @ 15 t ha⁻¹ gave the highest rhizome yield in both the years (1428 kg ha⁻¹, 1573 kg ha⁻¹). However, among all the treatments, plants which received NPK @ 45:12.5:12.5 kg ha⁻¹ recorded the highest rhizome yield during both the years (1772 kg ha⁻¹, 1944 kg ha⁻¹).

**UBKV, Kalimpong:** Field experiments were conducted to standardize organic nutrients (FYM @ 10t ha⁻¹, FYM @15t ha⁻¹, neem/castor cake @ 1.5 t ha⁻¹ and neem/castor cake @ 2.5 t ha⁻¹) along with RDF through inorganic fertilizers and absolute control in bach for optimum growth and economic yield. Results revealed that there were no significant differences among the treatments in case of fresh and dry weights of leaf, root and rhizome.

**Survey, surveillance and cataloguing of diseases**

**BCKV, Kalyani:** Occurrence of four diseases namely, basal rot caused by *Sclerotium rolfsii*, leaf spot (*Cercospora* sp.), leaf tip rot/blight (*Colletotrichum* sp.) and rust caused by *Uromyces acori* was observed on bach at Kalyani, Nadia, West Bengal. The basal rot pathogen attacked the base of the leaves resulting gradual drying of total leaves. In severe infection, white mat of mycelia and occasionally sclerotia of the pathogen were found to cover the base of leaves. The leaf spot disease was characterized by dark brown to black necrotic lesions surrounded by yellow hallow with lighter grey centre covered with white mycelia of the pathogen. Gradually, the lesions became enlarged and coalesced to form blighted areas. Severely blighted leaves turned withered and dried. The conidia were olivaceous brown, septate, size 8.31-73.82µm (Mean 27.95µm ± 11.41) in length and 1.12-2.69 µm (Mean 1.88 µm ± 0.36) in breadth. The leaf tip rot/blight affected leaves
were gradually withered from the leaf tip. The bach rust appeared as brown colour pustules and covered on all over the leaves. The urediospores were subglobose, ellipsoidal or ovoid, yellowish brown, thick wall, sparsely echinulate, size of 21.06-30.32 µm (mean 26.08 µm ± 1.70) in length and 19.63-27.19 µm (mean 23.45 µm ± 1.96) in breadth.

**Incidence of diseases on entries of bach under MLT**

**BCKV, Kalyani:** A trial was conducted at Kalyani to see the performance of different entries of bach provided by the Project Coordinator for MLT. There were total five entries. Percent disease index (PDI) of leaf spot was calculated on a 0-5 scale where 0= no disease; 1= up to 5% leaf area covered; 2= 6-15% leaf area covered, 3= 16-30% leaf area covered, 4= 31-50 % leaf area covered and 5 = above 50% leaf area covered. Percent disease index of leaf rot was calculated on a 0-5 scale where 0= no or a few lesion on leaf; 1= Up to 10% leaf area affected; 2= 11-25% leaf area affected, 3= 26-50% leaf area affected, 4= 51-75% leaf area affected and 5 = above75 % leaf area affected. The occurrence of two diseases **i.e.,** leaf spot (*Cercospora* sp.) and rust (*Uromyces acori*) was recorded. The highest PDI of leaf spot was found on Munipalli (8.77%) followed by Symbolia (6.94%), Nagireddigudem (6.19%), Aihagaripalli (6.15%) and the lowest was on Gaddipalli (5.74%). The highest PDI of rust was found on Symbolia (93.66%) and the other entries were found statistically lower than the Symbolia. Therefore, it was found that all the entries were more or less susceptible to all the diseases and overall, Symbolia was found more susceptible, specially to rust than the other four entries.

**Survey for diseases**

**Dr. YSRHU, Venkataramannagudem:** Among 29 bach accessions, the incidence of *Helminthosporium* leaf spot recorded and evaluated for three years indicated that the mean percent disease index was highest in Symbolia accession (16.83) and the lowest in TNAC 9 (10.01). In multilocation testing trial on *Acorus calamus* there was significant variation among the entries in all the 3 years’ of study. There was no significant variation in *Helminthosporium* leaf spot incidence among treatments in organic farming trial of *A. calamus* in the last two years.

**BASIL (Ocimum basilicum)**

Basil belongs to family Lamiaceae 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 for yield and quality in MLT

An Initial Evaluation Trial (IET) with two entries (two each from Anand) and GAB-1 as a check were tested at AAU, Anand; ICAR-DMAPR; NDUAT, Faizabad; BAU, Islampur; RVSKVV, Mandsaur; DRPCAU, Pusa and MPUAT, Rahuri. Across locations, GAB-1 (check) recorded highest green leaf yield (7637.6 kg ha\(^{-1}\)) which was followed by AOB5 (7450.0 kg ha\(^{-1}\)) and AOB4 (7030.9 kg ha\(^{-1}\)). The trial will be repeated during 2017-18 as AVT-I.

In another trial, an Initial Evaluation Trial (IET) with five entries (four from Mandsaur) and one entry from Rahuri were tested at AAU, Anand; ICAR-DMAPR; NDUAT, Faizabad; BAU, Islampur; RVSKVV, Mandsaur; DRPCAU, Pusa and MPUAT, Rahuri. Across locations, Rahuri-1 recorded the highest green leaf yield (8785.2 kg ha\(^{-1}\)) which was followed by MOB13 (8413.5.0 kg ha\(^{-1}\)) and MOB19 (8119.21 kg ha\(^{-1}\)). The entries MOB-16 (72.670 kg ha\(^{-1}\)) and MOB-13 (61.380 kg ha\(^{-1}\)) recorded the highest oil yield across locations.

Field efficacy of locally available botanical products against lace bug

**DRPCAU, Pusa:** Different locally available botanicals viz., tobacco decoction, neem seed kernel extract (NSKE) and neem oil were tested against lace bug, *Cochlochila bullita*. The different treatments i.e., tobacco decoction @ 5%, NSKE @ 5% and neem oil @ 2% were found superior to the control at post count of 1\(^{st}\), 3\(^{rd}\), 7\(^{th}\) and 14\(^{th}\) day of spraying. But post count of 14\(^{th}\) day revealed that spraying of tobacco decoction @ 5% (15.25) and neem oil @ 2% (13.01) was superior to spraying with NSKE @ 5% (26.00).

**CHIRAYITA (Swertia chirayita)**

The plant belongs to family Gentianaceae. It is an erect annual herb which is distributed in temperate Himalayas from Kashmir to Bhutan. The plant is propagated by seeds. It grows well in moist, temperate forests of Himachal Pradesh. Dried herbage portion is used as raw drug. Flowering occurs in July to October and the raw drug is collected when the capsules are fully formed. The drug is extremely bitter in taste. Chirayita is also known as brown or white chirayita to distinguish it from ‘green chirayita’ which is the dried herbage of Andrographis paniculata. The bitter tonic made from the raw drug improves bile secretion and used for the treatment of bronchial asthma, liver disorders and anaemia. The active ingredient of the raw drug includes ophelic acid, glucosides, etc. The crop requires cold temperate climate for its growth. Nursery raised seedlings are used for propagation; however, its cultivation practices are not yet fully standardized.

**Standardization of organic nutrient management practices**

**UBKV, Kalimpong:** Experiment was conducted to standardize organic nutrient management for optimum growth and economic yield of chirayita. Different sources of organic manures like FYM, vermicompost, neem and castor cake were applied at various doses along with RDF for comparison. The result revealed that maximum plant height (123.90 cm) was recorded with the application of RDF
through inorganic fertilizers at harvesting stage and was significantly better than the other treatments. Fresh and dry areal biomass were more with the application of RDF through inorganic fertilizers and treatment of FYM @ 5t ha⁻¹+ vermicompost @ 2t ha⁻¹+ PSB, respectively and significantly superior to the other treatments. Maximum fresh root biomass was recorded with the application of FYM @ 5t ha⁻¹+ vermicompost @ 2t ha⁻¹+ PSB and RDF through inorganic fertilizers. Dry root biomass was maximum with the application of treatment of FYM @ 5t ha⁻¹+ vermicompost @ 2t ha⁻¹+ PSB.

**DAVANA (Artemisia pallens)**

*Artemisia pallens* is an aromatic herb belonging to the family Asteraceae. The inflorescence of the species bears numerous small yellow flower heads or capitula. It is commercially cultivated for its fragrant leaves and flowers. It grows from seeds and cuttings and reaches maturity in four months. It is mostly grown in Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu states in India. The leaves and flowers yield an essential oil known as oil of Davana. Davanone, davan ether, davana furan and linalool are the major constituents of davana oil. Several species yield essential oil and some are used as fodder, some of them are a source of the anthelmintic chemical santonin.

**Management of wilt disease**

**MPUAT, Rahuri:** Bioagents viz., *Trichoderma viride*, *T. harzianum*, *Pseudomonas fluorescens* and *Bacillus subtilis* alone for seed treatment and their combinations for soil application along with FYM were tested against wilt disease of Davana caused by *Fusarium oxysporum*. Among the bioagents tested, seed treatment with *Bacillus subtilis*+ soil application of *T. viride*+ *B. subtilis* was found to be most effective by recording significantly lowest wilt incidence of 15.87% with maximum disease reduction of 53.70 % over the control.

Differences in herbage yield observed due to different treatments were statistically significant. The treatment comprised of seed treatment with *B. subtilis*+ soil application of *T. viride*+ *B. subtilis* recorded maximum fresh herbage yield (15362 kg ha⁻¹) as well as marketable dry herbage yield (3380 kg ha⁻¹). However, seed treatment with *B. subtilis*+ soil application of *T. harzianum*+ *B. subtilis* was statistically the next best treatment for fresh herbage yield (14781 kg ha⁻¹) and dry herbage yield (3257 kg ha⁻¹). It was found that seed treatment of *B. subtilis*+ soil application of *T. viride*+ *B. subtilis* and seed treatment with *B. subtilis*+ soil application of *T. harzianum*+ *B. subtilis* were most effective for the management of wilt disease of davana.

**Seasonal abundance of economically important insects**

**DRPCA, Pusa:** Insect counting was done at weekly intervals from 37 standard weeks to first standard week. Lace bug peak number was found during 43rd standard week (22-28 October, 2017) at 32.30 and 21.30°C, 86 and 49 per maximum and minimum relative humidity and 1.7mm rainfall. Population started to increase during 38th standard week (17-23 October, 2017) and continued till
January first week in the temperature, humidity and rainfall range, 34.50- 18.90°C (max. temp.), 25.40°C- 9.70°C, 73-51% relative humidity and rainfall 3.40- 0.00 mm, respectively. Correlation study showed that the relative humidity had negative highly significant effect while rainfall had significant effect on population dynamics.

**Damage intensity assessment of insect pest infestation**

**MPKV, Rahuri:** A field experiment was conducted for damage intensity assessment of aphids, jassids and bugs on davana. Spraying of dimethoate @ 1.5 ml l\(^{-1}\) was done for control of sucking pests *i.e.* aphids, jassids and bugs in treated plots, two sprays were taken at fortnightly interval at peak infestation level of the pest and five sprays were given for treated plots for sucking pest complex. It was recorded that 19.72% foliage yield loss by aphids, 7.72% foliage yield loss by jassids and 17.88% foliage yield loss by bugs on davana. It was recorded that 35.98% foliage yield loss was due to sucking pest complex on davana.

**Efficacy of different bio pesticides against aphids**

**MPKV, Rahuri:** Efficacy of different biopesticides against aphids was studied. Experimental results revealed that pre treatment count on aphid population before spraying ranged from 34.93 to 37.47 aphids per branch plant\(^{-1}\). At three day after treatment (DAT), significant reduction in aphid population was observed in all the treatments, while it was 37.93 aphids per branch per plant in untreated control. Maximum reduction in aphids population was observed in azadirachtin (10,000 ppm) @ 3 ml l\(^{-1}\) (27.67 aphids per branch per plant) and NSKE @ 5% (29.67 aphids per branch per plant). At seven days after treatments maximum reduction in aphid population was observed in azadirachtin (10,000 ppm) @ 3 ml l\(^{-1}\) (19.33 aphids per branch per plant) followed by NSKE @ 5% (22.87 aphids per branch per plant). At 14 DAT, maximum aphids population reduction was recorded in *Verticillium lecanii* @ 8 g l\(^{-1}\) (11.73 aphids per branch per plant) followed by *Metarhizium anisopliae* @ 8 g l\(^{-1}\) (12.87 aphids per branch per plant). The same trend of aphid mortality was observed at second spray.

Maximum marketable dry leaf yield was obtained in the treatment of *Verticillium lecanii* @ 8 g l\(^{-1}\) treated plots (2379 kg ha\(^{-1}\)) followed by *Metarhizium anisopliae* @ 8 g l\(^{-1}\) (2115 kg ha\(^{-1}\)) as against 1153 kg ha\(^{-1}\) dry leaf yield in the untreated control.

**DODI (Leptadenia reticulata)**

The plant belonging to family Asclepiadaceae, is a perennial climber. It is distributed in sub Himalayan tracts of India mainly in Punjab, Uttar Pradesh and throughout Deccan peninsula up to 900 m. The plant is galactogogue, cooling, nutritive, aphrodisiac, stimulant, diuretic, and is used as eye tonic. It is also used to cure seminal debility, general weakness, cough, dyspnoea, fever, asthma, constipation, sore throat and gonorrhea. Root and leaf extracts of the species act as antibacterial and anti-fungal agents. It promotes health and vigour, improves voice and alleviates the three doshas, viz., vata, pitta and kapha.
Effect of different levels of nitrogen and phosphorus on dry biomass yield

AAU, Anand: Three years' experiment was conducted to study the effect of different levels of nitrogen and phosphorus fertilizers on growth and yield parameters in dodi. Data showed that application of nitrogen significantly influenced dry biomass yield in all the experimental years as well as on pooled data basis. Significantly higher dry biomass yield (14430 kg ha\(^{-1}\)) was recorded under the application of nitrogen @ 200 kg ha\(^{-1}\) in the year of 2014-15, which was statistically at par with application of nitrogen @ 150 kg ha\(^{-1}\) (13264 kg ha\(^{-1}\)). In the year of 2015-16, the higher dry biomass yield (13480 kg ha\(^{-1}\)) was found under the application of nitrogen @ 200 kg ha\(^{-1}\) which was statistically at par with application of nitrogen @ 150 and 100 kg ha\(^{-1}\) (12589 and 12320 kg ha\(^{-1}\)). Significantly higher dry biomass yield (14052 kg ha\(^{-1}\)) was recorded under the application of nitrogen @ 200 kg ha\(^{-1}\) in the year of 2016-17, which was statistically at par with application of nitrogen @ 150 kg ha\(^{-1}\) (13020 kg ha\(^{-1}\)). Significantly highest value of dry biomass yield (13987 kg ha\(^{-1}\)) was recorded with nitrogen level 200 kg ha\(^{-1}\) on pooled basis. Application of phosphorus significantly effected the dry biomass yield (kg ha\(^{-1}\)) in all the year as well as pooled basis except the year 2014-15. Significantly highest dry biomass yield (12619, 12854 and 12786 kg ha\(^{-1}\)) was recorded with application of phosphorus @ of 25 kg ha\(^{-1}\) in the year of 2015-16, 2016-17 and on pooled basis, respectively. Interaction effect between nitrogen and phosphorus was found non-significant with respect to the dry biomass yield of dodi. From the results it was concluded that significantly highest dry biomass yield of dodi (14814 kg ha\(^{-1}\)), net returns (458626 ₹ ha\(^{-1}\)) and BCR (2.63) were found under application of 200 kg N ha\(^{-1}\) along with 25 kg P ha\(^{-1}\).

Maximum net realization (458626 ₹ ha\(^{-1}\)) and BCR (2.63) were found under application of 200 kg N ha\(^{-1}\) along with 25 kg P ha\(^{-1}\). Hence it is recommended to apply nitrogen @ 200 kg ha\(^{-1}\) (100 kg as basal and 100 kg as top dressing at every cutting) along with @ 25 P\(_2\)O\(_5\) ha\(^{-1}\) as basal for securing higher dry biomass yield and net return.

DWARF MARIGOLD (Tagetes minuta)

It is an aromatic herb belongs to family Asteraceae. The species is native to South America and now naturalized in various parts of the world including India. In India it is grown in Uttar Pradesh, Uttarakhand, Himachal Pradesh and Jammu and Kashmir at an altitude of 1000-2500 m. The species is cultivated for its essential oil and India produces about 3-5 tonnes of the essential oil annually. Leaves, flower heads and seeds contain the major portion of the essential oil. The essential oils are used in pharmaceutical and flavouring industries. The main components identified of the essential oils are β-phelandrene, limonene, β-ocimene, dihydrotagetone, tagetone and tagetenone.

Evaluation of germplasm

YSPUHF, Solan: Thirty-two accessions were evaluated for yield and quality at pre flowering stage and
Crop management under different sowing methods and densities

**YSPUHF, Solan:** An experiment was conducted consecutively for three years comprised of two methods of sowing *i.e.*, direct sowing and seedling transplanting at different plant spacings (30 ×15 cm, 30 × 30 cm, 30 × 45 cm, 45 × 45 cm and 45 × 60 cm). Based on three years’ data, it was concluded that sowing of *Tagetes minuta* through seedling transplanting at 30 × 45 cm spacing recorded maximum plant height (177.8 cm), number of branches (14.6), leaf biomass plant⁻¹ (59.91 g), leaf biomass ha⁻¹ (50.19 kg), essential oil yield from leaf biomass (16.26 kg ha⁻¹) at pre flowering stage. Maximum leaf biomass plant⁻¹ (59.06 g), leaf biomass (45.61 kg ha⁻¹), flower biomass yield (4312 kg ha⁻¹), essential oil yield from leaves (13.40 kg ha⁻¹), essential oil yield from flowers (20.16 kg ha⁻¹), essential oil yield from leaves and flowers (33.55 kg ha⁻¹) at full bloom stage. Gross income (₹ 1,19,180/-), net income (₹ 79,657.5) and B:C ratio (4.32) were also found maximum at 30 × 45 cm spacing.

**GILOE (*Tinospora* spp.)**

Giloe is a member of family Menispermaceae. It is a deciduous perennial climber and is distributed throughout tropical India. The species produces a number 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. Leaf also contains a number of alkaloids. Leaf is used for the treatment of gout, jaundice and rheumatism. Raw drug is mainly obtained from the wild habitats of the species. The plant is not under regular cultivation and it is found growing as a climber on trees in the wild.

**Comparative quality evaluation of different *Tinospora* species**

**KAU, Trichur:** Comparative study of three different *Tinospora* species *i.e.*, *Tinospora cordifolia*, *T. malabarica* and *T. crispa* was conducted. Morphology of *T. cordifolia* and *T. malabarica* are almost alike but the stem and leaves of *T. malabarica* are bigger in size. Scanty tubercle protuberances are more in the papery bark of *T. malabarica* as compared to *T. cordifolia*. In the very young stage, morphological differentiation is very difficult. In the case of *T. crispa* the stem bark is crowded with large blunt protuberances even in very young stages of the plant, hence morphological identification is very easy in *T. crispa*. *T. cordifolia* is found in wide distribution while *T. crispa* and *T. malabarica* are wild and found in limited areas. *T. cordifolia* is preferred by ayurvedic practitioners of Kerala but if not available, *T. malabarica* is used as an alternate drug.

The plant samples were collected and properly identified. The stem portions were cut into
small pieces dried and powdered. Hot methanol extract were prepared and subjected to chemical analysis. Total antioxidant activity, crude fibre content and berberine content were analysed by standard methods. A reference TLC fingerprint was developed by trial and error method (with CHCl₃ : Methanol 17: 1, silica 60F254, UV-L) to differentiate the three species in a single plate.

The three species showed marked variation in antioxidant activity (AOA), berberine content and fibre content also. *T. crispa* showed very high AOA and phenol content followed by *T. cordifolia*. Berberine was found more in *T. malabarica* compared to *T. cordifolia*. Berberine was not detected in *T. crispa*. HPTLC (Butanol:acetic acid:water 12:3:4) and TLC profiles of these three species reflected variations in chemical composition.

Heavy metal analysis of the samples was also carried out using ICP-AES method (Inductively coupled plasma atomic emission spectroscopy). All the three species were free of heavy metals arsenic, cobalt, molybdenum and cadmium whereas the iron, lead, nickel and chromium were found in traces but more in *T. malabarica* followed by *T. crispa*. Fluorescence difference (in colour) was noticed under UV-L for the methanol extract of the three different species reflecting the interspecies variation. GCMSD analysis showed variation in the chemical profile of three different species.

**Quality assessment of traded crude drug Tinospora from different markets of Kerala**

**KAU, Trichur:** *Tinospora* raw drug market samples (30 numbers) were collected from various markets of Kerala. Genuine samples of three species were also collected from the campus and identified and used for the study as reference standards. Stem samples were cut into pieces, dried and powdered. Methanol extracts were prepared and used for developing TLC profiles. A reference TLC profile was developed with genuine samples of three different species of *Tinospora* (*Tinospora cordifolia*, *T. malabarica* and *T. crispa*). The TLC profiles of market samples developed in the same way were compared with the reference fingerprints to assess the genuineness of the market samples. The result revealed that out of thirty samples analysed, 28 samples were found to be that of true type *i.e. T. cordifolia* and the rest two were of *T. malabarica*. No samples proved to be of *T. crispa*.

**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 carried out for collection of *Gloriosa superba* accessions in Tamil Nadu. Sixteen accessions viz., TNGs1, TNGs2, TNGs3, TNGs4, TNGs5, TNGss6, TNGss7, TNGs8, TNGs9, TNGs10, TNGss11, TNGss12, TNGs13, TNGs14, TNGs15 and TNGs16 were collected from Mettupalayam, Vetharanyam, Kovilpatti, Dharapuram, Oddanchatram, Karur, and Dindigul. The accessions were evaluated for growth and yield characters. Among the accessions TNGs-2- Vetharanyam local-1 collected recorded from Vetharanyam recorded the longest branch length (123.33cm), number of leaves (248.22), number of pods per plant (15.78), seed number per pod (39.33), fresh seed yield (86.89 g plant$^{-1}$) and dry seed yield (28.03 g plant$^{-1}$).

**Floral biology and 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 during 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 between the Andhra ecotype and local type was developed. Pollens from the Andhra ecotype (male parent) were dusted on flowers of local type during three colour stage (stigma receptive stage). The F1 seeds were collected and sown to raise the first generation micro tubers.

**Management of leaf blight disease**

**TNAU, Coimbatore:** A field experiment was conducted in the farmers’ field at Vellipalayam, Coimbatore district, Tamil Nadu on the management of leaf blight disease of *Gloriosa superba* caused by *Alternaria alternata*. Spraying with the selected fungicides and biocontrol agents was done at 30 and 60 days after planting. The disease intensity was recorded on 90 days after
planting. The seed yield per hectare was recorded for each treatment. The results revealed that spraying of *Bacillus subtilis* (0.2%) twice at 30 and 60 days after planting was effective in managing the leaf blight disease which recorded the lowest disease intensity of 16.2 per cent. It was found to be at par with spraying of chlorothalonil @ 0.1% twice at 30 and 60 days after planting which recorded 17.4 per cent disease intensity. The highest leaf blight disease intensity of 29.6 per cent was observed in the control. The growth and yield parameters were found to be the maximum in spraying of *B. subtilis* (0.2%) or chlorothalonil (0.1%) twice on 30 and 60 days after planting. The plant height was found to be the maximum in spraying *B. subtilis* (0.2%) twice at 30 and 60 days after planting (126.2 cm) and in the treatment of spraying chlorothalonil 0.1% twice at 30 and 60 days after planting which recorded 121.6 cm plant height. Spraying of *B. subtilis* (0.2%) recorded the maximum yield parameters viz., number of flowers per plant (64.6), number of pods per plant (51.4) and number of seeds per pod (74.7). In the control, plant growth and yield parameters viz., plant height (88.3 cm), number of flowers per plant (32.4), number of pods per plant (21.6) and number of seeds per pod (52.9) were found to be the lowest. The maximum seed yield of 564.2 kg ha⁻¹ was recorded in spraying with *B. subtilis* (0.2%) twice at 30 and 60 days after planting. Spraying chlorothalonil 0.1% twice at 30 and 60 days after planting recorded seed yield of 526.3 kg ha⁻¹. The minimum seed yield of 384.6 kg ha⁻¹ was recorded in the control.

**Development of IDM module for the management of soil borne diseases**

**TNAU, Coimbatore:** A field experiment was conducted in the farmers’ field at Vellipalayam, Coimbatore district, Tamil Nadu on the management of root rot disease of *Gloriosa superba* caused by *Macrophomina phaseolina*. Soil application of biocontrol agent viz., *Trichoderma asperellum* was done at the rate of 2.5 kg ha⁻¹. The tubers were dipped in *Pseudomonas fluorescens* 0.2% or *Bacillus subtilis* (0.2%) or carbendazim 0.1% for 20 minutes. Drenching with biocontrol agents or fungicide was done at 30 days after planting. The disease incidence was recorded at 90 days after planting. The seed yield per hectare was recorded for each treatment. The results revealed that the dipping the tubers in *B. subtilis* @ 0.2% followed by drenching with *B. subtilis* @ 0.2% at 30 days after planting was effective in managing the root rot disease which recorded the lowest disease incidence of 18.9 per cent. It was found to be at par with dipping the tubers in *P. fluorescens* @ 0.2% followed by drenching with *P. fluorescens* @ 0.2% at 30 days after planting which recorded 20.3 per cent disease incidence. The highest root rot disease incidence of 32.7 per cent was observed in the control. The growth and yield parameters were found to be maximum in dipping the tubers in *B. Subtilis* @ 0.2% followed by drenching with *B. subtilis* @ 0.2% at 30 days after planting. The plant growth and yield parameters viz., plant height (118.3 cm), number of flowers per plant (56.2), number of pods per plant (44.8) and number of seeds per pod (67.4) were maximum in treatment of dipping the tubers in *B. subtilis* @ 0.2% followed by drenching with *B. subtilis* 0.2% at 30 days after planting. In the control, plant growth and yield parameters viz., plant height (82.7 cm), number of flowers per plant (35.4), number of pods per plant (23.3) and number of seeds per pod (48.7) were found to be the lowest. Maximum seed yield of 532.8 kg ha⁻¹ was recorded in the treatment of dipping the tubers in *B. subtilis* @ 0.2% followed by drenching with *B. subtilis* @ 0.2% at 30 days after planting. Dipping the tubers in carbendazim @ 0.1% followed by drenching with carbendazim @ 0.1% at 30 days after planting recorded seed yield of 423.7 kg ha⁻¹. Minimum seed
yield of 376.3 kg ha\(^{-1}\) was recorded in the control.

**HARDE (Terminalia chebula)**

The tree belongs to family Combretacea and is about 50-80 feet in height. It has round crown and spreading branches. The fruit or drupe is about 1-2 inches in size. It has five lines or five ribs on the outer skin. Fruit is green when unripe and yellowish grey when ripe. Fruits were collected from January to April, fruit formation started from November to January. The fruit has been extensively used in Ayurveda, Unani and Homeopathic medicine and has become a cynosure of modern medicine. It is one of the three key ingredients in *Triphala*, a natural compound that provides overall support for digestive function and helps ensure that the digestive tract works at optimal levels. It can also be used to treat gastrointestinal and respiratory disorders. The observed health benefits may be credited to the presence of the various phytochemicals like polyphenols, terpenes, anthocyanins, flavonoids, alkaloids and glycosides.

**Collection, characterization and evaluation of germplasm**

**BAU, Ranchi:** Forty one accessions (BTC\(_1\) to BTC\(_{41}\)) were collected from different parts of Jharkhand. Morpho-physical data of fruits such as fruit colour, fruit shape, fruit length (cm), fruit breadth (cm), length/breadth ratio of fruit, number of ribs per fruit, thickness of seed (cm), thickness of pulp (cm), weight of fruits (g), weight of seed (g), weight of pulp (g) and % of pulp per fruits were recorded. On the basis of six parameters namely fruit length, fruit diameter, thickness of pulp, fruit weight, pulp weight and % of pulp per fruit; three accessions i.e., BTC\(_{39}\) - S\(_1\), BTC\(_{40}\) – S\(_2\) and BTC\(_{27}\) – S\(_3\) were selected as scion. On the basis of four parameters namely pulp thickness, fruit diameter, fruit weight and % of pulp per fruit, two accessions i.e., BTC\(_{32}\) - R\(_1\) and BTC\(_{29}\) – R\(_2\) were selected as root stock.

**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 1, 00,000 ha. A number of high yielding varieties are available in the crop for cultivation.
**Advanced varietal evaluation trial (AVT)**

Advanced varietal evaluation trial (AVT-II) of medium maturing group-120 days of isabgol entries was conducted at five locations AAU, Anand; ICAR-DMAPR; RVSKVV, Mandsaur; CCSHAU, Hisar and MPUAT, Udaipur with 12 test entries and five check varieties. The entries UI-89, DPO335, DTPO6-6, DTPO11-1, DPO267-3, DPO253-2, DPO248, MIB5 and MIB1004 were included during 2014-15. The objective of this study was to identify high yielding varieties of isabgol. The entry MIB124 (UI-124) recorded maximum seed yield (1053.38 kg ha⁻¹) across the locations followed by DTPO11-1 (1033.41 kg ha⁻¹) and DPO267-3 (973.15 kg ha⁻¹). Over the seasons and location, the entry DPO267-3 recorded maximum seed yield (kg ha⁻¹) (1080.03) which was followed by MIB124 (UI-124) (1053.38), DTPO11-1 (1031.37), DTPO6-6 (1014.60) and MIB5 (1004.83).

**Evaluation, maintenance and utilization of germplasm**

**MPUAT, Udaipur:** A total of 31 germplasm lines maintained as genetic stock were evaluated along with 3 checks in augmented design. The observations were recorded for individual line for different morphological metric traits; viz., plant height, number of branches per plant, spike length, number of effective spikes per plant and seed yield. The observations on days to 75% flowering, days to 75% maturity and swelling factor were recorded. Thirteen germplasm lines exhibited higher seed yield over the best check UI-89 (600 kg ha⁻¹) and over grand mean of the experiment (604 kg ha⁻¹). Seed yield for the trial ranged from 375 kg ha⁻¹ to 1208 kg ha⁻¹. The husk percent of 11 germplasm were found superior over the check Niharika (31.09%) and none of germplasm was found superior to the checks GI-2 and UI-89 (10.0 cc g⁻¹) for swelling factor.

**In station varietal evaluation trial**

**MPUAT, Udaipur:** Under this trial, eight lines identified as promising from the germplasm evaluation trial of previous year were included for evaluation along with three checks (Niharika, GI-2, UI-89). The objective was to study the performance of these lines with respect to seed yield, husk percentage and other yield attributing characters. The lines UI-6, UI-6-1 and UI-2-1 exhibited statistically higher seed yield over the best check GI-2 (1018.33 kg ha⁻¹). All the lines belonged to medium maturity group including checks. The swelling factor and husk percentage of none of the lines exhibited superiority over the check GI-2 (10.0 cc g⁻¹) and Niharika (34.97%).

**Screening of promising lines for disease resistance**

**MPUAT, Udaipur:** Eight promising lines of isabgol were screened for confirmation of resistance against downy mildew, leaf spots and bacterial blight under sick plot and inoculation condition. Among the eight lines, five lines (UI-124 (MIB-124); UI-2-1 (AMB-2); UI-3-1 (PB-3-1); UI-6-1 (P-6-1) and UI-80 (P-80) showed resistance and two lines (UI-125 (MIB-125); UI-97 (Gumary) were moderately resistant (MR), while GI-2 was found moderately susceptible to downy mildew, leaf spots and bacterial blight of isabgol. Significantly higher seed yield and mucilage content were also recorded in resistant (1079-1639 kg ha⁻¹ and 10.00-10.83 cc g⁻¹) and moderately resistant (731-1312 kg ha⁻¹ and 9.83-10.17 cc g⁻¹) lines compared to susceptible GI-2 (691 kg ha⁻¹ and 9.67 cc g⁻¹).
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. Among the modules against downy mildew, seed treatment with metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with (ametoctradin 22.7%+ dimethomorph 17% SC) @ 0.1% followed by treatment comprising of seed treatment with Metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with Copper hydroxide @ 0.30% resulted in minimum downy mildew disease (10.63; 15.78%) with maximum disease control (87.57; 81.50%) and increased percentage of mucilage content (10.50; 12.00 cc g⁻¹) and was significantly superior compared to the control and rest of the treatments except treatment comprising of seed treatment with metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with ridomil MZ 72 WP (mancozeb 64%+ 8% metalaxyl) @ 0.25% which resulted in 18.60 percent downy mildew with higher seed yield (902 kg ha⁻¹).

However, among the modules against leaf spots, treatment comprising of seed treatment with metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with tebuconazole 25EC @ 0.10% was found most effective against leaf spot disease with minimum disease (9.14%) compared to the rest of the treatments and control. Overall, among the IDM modules tested, treatment comprising of seed treatment with Metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with Copper hydroxide @ 0.30% or seed treatment with metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with ridomil MZ 72 WP (mancozeb 64%+ 8% metalaxyl) @ 0.25% were found effective for management of downy mildew and leaf spots of isabgol.

Integrated disease management organic modules against downy mildew and leaf spots of isabgol were also evaluated at the centre under sick plot and inoculation condition. Among the organic modules, in-furrow soil application of neem cake mixture (100 g m⁻²) 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 downy mildew disease (19.14; 22.24%) and leaf spots (18.60; 22.30%) with higher seed yields (858; 836 kg ha⁻¹) with increased mucilage content (10.67; 10.50 cc g⁻¹) and were statistically superior to the rest of the organic modules and control. Among the chemical treatment modules, seed treatment with metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with ridomil MZ 72 WP (mancozeb 64%+ 8% metalaxyl) @ 0.25% was found most effective against downy mildew (PDI-17.13%) and moderately effective against leaf spots (PDI-9.48%) with maximum yield of seeds (891 kg ha⁻¹) and reduced mucilage content (9.83 cc g⁻¹) compared to the organic treatment modules and chemical treatment comprising of seed treatment with metalaxyl 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with mancozeb 75WP @ 0.25%.

**RVSKVV, Mandsaur:** An experiment on management of downy mildew and leaf spot/blight diseases of isabgol was conducted. Among the seven treatments, dry seed treatment with metalaxyl 35 SD @ 8 gkg⁻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 (17.46%) and higher seed yield (652 kg ha⁻¹) over the untreated control (DI 52.01% and seed yield of 413.67 kg ha⁻¹).
Dr. YSRHU, Venkataramannagudem: An experiment was conducted to manage downy mildew for two years. Potassium dihydrogen phosphate was applied when the disease pressure was low and chemical fungicides when disease pressure was high so as to minimise the pesticide residues. Foliar sprays were initiated after the first disease appearance and subsequent at 15 days intervals. Treatment with captan and mancozeb significantly reduced the per cent disease incidence by 37.85% over control; it was at par with other treatments in which two fungicides were applied. However the treatments with one fungicide alternated with potassium dihydrogen phosphate also reduced the PDI over control and at par. Pooled data analysis revealed that the treatment with captan and mancozeb recorded significantly lowest disease incidence (50.50%) which was at par with other treatments involving two fungicide sprays and also in treatment with captan alternated with two sprays of Potassium dihydrogen phosphate. However all the treatments differed significantly from the control in reducing the percent disease incidence. Pooled analysis of yield data indicated that the seed yield was highest in treatment with chlorothalonil alternated with two sprays of Potassium dihydrogen phosphate (102 g/12 m²) and was at par with the treatments in which one fungicide all alternated with two sprays of Potassium dihydrogen phosphate. Among the treatments with two sprays of fungicides, mancozeb and Copper oxychloride recorded the highest yield and was at par with other treatments except the treatment with captan and mancozeb.

Analysis of soluble fiber content in elite germplasm lines

MPUAT, Udaipur: The analysis of soluble fiber content by AOAC method in 11 germplasm lines analysed yielded soluble fiber content varying from 2.8 to 5.2%. Maximum soluble fiber content was in Niharika (5.2%), followed by UI-89 (4.9%). Minimum soluble fiber content was found in UI-6 (2.8%).

KALIJEERI (Vernonia anthelmintica)

It is a member of family Asteraceae and it is an erect, branched, hispid-pubescent herb to undershrub. It is naturally found throughout India along the roadsides. This annual herb grows up to 70 cm in height. Leaves are ovoid or lanceolate, acute, serrate, pubescent on both sides. Flowers are purplish in corymbose head. Plant pacifies vitiated vata, kapha and used to cure cough, urinary retention, inflammation, fever and leucoderma. The seeds are anthelmintic and used to cure fever, skin diseases, asthma and in kidney troubles. The seeds and leaves are also used for treating leucoderma, abdominal and urinary disorders. The crop is propagated by seeds and grows during winter.

Effect of different organic manures and nitrogen levels on yield

AAU, Anand: Field experiment was conducted to study the effect of different organic manures and nitrogen level on growth, yield of kalijeeri under middle Gujarat plain. Significantly highest seed yield (759, 790, 1031 and 860 kg ha⁻¹) was noted with application of FYM @10 t ha⁻¹ in the year of 2014-15, 2015-16, 2016-17 and on pooled basis respectively, which was followed by application
of vermicompost @ 2.5 t ha\(^{-1}\) (628, 640, 882 and 717 kg ha\(^{-1}\)). Significantly higher stover yield (1576, 1793, 2471 and 1947 kg ha\(^{-1}\)) was recorded with application of castor cake @ 1.5 t ha\(^{-1}\) in all the years as well as in pooled results, which was at par with application of FYM @ 10 t ha\(^{-1}\) (1429, 1697, 2355 and 1827 kg ha\(^{-1}\)). Significantly highest seed yield (714, 732, 970 and 805 kg ha\(^{-1}\)) was obtained with application of nitrogen @ 50 kg ha\(^{-1}\) in years of 2014-15, 2015-16, 2016-17 and pooled basis respectively, which was followed by application of nitrogen @ 25 kg ha\(^{-1}\) (614, 632, 882 and 709 kg ha\(^{-1}\)). The differences in the stover yield were found non-significant in all the three years. Significantly higher stover yield (1767 kg ha\(^{-1}\)) was found under the application of nitrogen @ 50 kg ha\(^{-1}\) which was at par (1660 kg ha\(^{-1}\)) with application of nitrogen @ 25 kg ha\(^{-1}\) on pooled basis.

Maximum net realization (54876 ₹ ha\(^{-1}\)) and BCR (2.15) was found under application of FYM @ 10 t ha\(^{-1}\) along with 50 kg N ha\(^{-1}\) with net realization 37676 ₹ ha\(^{-1}\) and BCR of 1.86. Thus it is concluded that significantly highest seed yield of kalijeeeri (1024 kg ha\(^{-1}\)) with higher net returns (54876 ₹ ha\(^{-1}\)) and BCR (2.15) were found under application of FYM @ 10 t ha\(^{-1}\) along with 50 kg N ha\(^{-1}\) (25 kg as basal and 25 kg as top dressing at 45 DAS) and P\(_2\)O\(_5\) @ 25 kg ha\(^{-1}\) as basal for securing higher seed yield and net return.

**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.

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

Advanced evaluation trial (AVT-I) with ten test entries and three checks (INGR07041, AK-1, AL-1) was conducted at 13 locations viz., RVSKVV, Mandsaur; NDUAT, Faizabad; AAU, Anand; BCKV, Kalyani; IGKV, Raipur; CCSHAU, Hisar; ICAR-DMAPR; AAU, Jorhat, DRPCAUK, Pusa; KAU, Trichur; PDKV, Akola; OUAT, Bhubaneswar and TNAU, Coimbatore with an objective to identify superior varieties with high yield and quality. Across locations, DMAPR AP 35 recorded maximum dry biomass yield (4245.30 kg ha\(^{-1}\)) which was followed by DMAPR AP 13(4244.73kg ha\(^{-1}\)). The trial will be repeated in the next year as AVT-II.

**Standardization of planting density for optimum growth and yield**

**BCKV, Kalyani**: The experiment was conducted to evaluate the performance of the crop growth and
yield under four different plant spacing (30 × 20, 30 × 30, 45 × 30, 45 × 45 cm). The result revealed that the seedlings planted at 30 × 20 cm spacing recorded the highest dry matter production (8670 kg ha⁻¹) which was significantly superior compared to the other spacing of transplanting. The effect of different plant spacing showed that the performance of individual plant was better under wider spacing. However, the yield per hectare was significantly higher at closer spacing. Plant height increased and number of primary branches decreased in low spacing.

**Standardization of organic nutrient management**

**OUAT, Bhubaneswar**: The experiment was comprised of three organic sources (main plot) of nutrients (FYM @15 t ha⁻¹, vermicompost @ 7.5 t ha⁻¹ and mustard cake @ 1.5 t ha⁻¹) with application of four different combinations of biofertilizers and *Jivamrut* (sub-plot). The results revealed that maximum dry herbage yield of kalmegh was obtained with application of mustard cake @1.5 t ha⁻¹ (2261 kg ha⁻¹), however among the biofertilizer treatments, application of Azotobacter+ PSB along with soil application of *Jivamrut* exhibited maximum dry herbage yield (2438 kg ha⁻¹). The andrographolide content was not influenced by the organic management practices. Application of mustard cake @1.5 kg ha⁻¹, along with treatment of biofertilizers (Azotobacter+ PSB) and soil application of *Jivamrut* exhibited maximum dry herbage yield of kalmegh.

**DRPCAU, Pusa**: The experiment was conducted to standardize organic nutrient management in kalmegh for optimum growth and economic yield. Result revealed that among the organic nutrient treatments, plant biomass yield was recorded maximum (13156 kg ha⁻¹) with application of vermicompost @ 7.5 t ha⁻¹ which was recorded significantly higher yield over the rest of the treatments. Maximum plant biomass yield (12687 kg ha⁻¹) was recorded with (Azotobacter+ PSB) among the biofertilizer treatments which was significantly higher over the rest of the treatments.

**Effect of integrated nutrient management**

**PDKV, Akola**: Field experiment was conducted to study the effect of integrated nutrient management on growth, yield and quality of kalmegh. The data on plant height, number of branches, number of pods per plant and seed yield, fresh and dry foliage yields and andrographoloide content were recorded. Application of vermicompost @ 7.5 t ha⁻¹ recorded significantly higher plant height (64.30 cm) and number of branches (37.98) over control. Application of NPK @ 80:30:50 kg ha⁻¹ (Half N with full P & K as basal and remaining half N in three equal splits at 25, 40 & 60 DAS) recorded significantly higher plant height (66.39 cm) and number of branches (36.28). Application of vermicompost @ 7.5 t ha⁻¹ recorded significantly higher fresh and dry foliage yields (7376 and 2996 kg ha⁻¹) which was at par with application of FYM @ 15 t ha⁻¹ (7064 and 2923 kg ha⁻¹). Application of NPK @ 80:30:50 kg ha⁻¹ (half N with full P & K as basal and remaining half N in three equal splits at 25, 40 & 60 DAS) recorded significantly higher fresh and dry foliage yields (7140 and 2963 kg ha⁻¹) which was at par with application of NPK @ 80:30:50 kg ha⁻¹ (half N with full P & K as basal and remaining half N in two equal splits at 25 and 40 DAS). Application of NPK @ 80:30:50 kg ha⁻¹ (half N with full P & K as basal and remaining half N in three equal splits at 25, 40 & 60 DAS recorded significantly higher andrographolide yield per ha (56.88 kg ha⁻¹). Application of vermicompost @ 7.5 t ha⁻¹ recorded significantly higher GMR followed by FYM @ 15 t ha⁻¹. However, these treatments were at par with each other and significantly superior to the control. However, control treatment recorded higher NMR and
B:C ratio. Application of NPK @ 80:30:50 kg ha\(^{-1}\) (half N with full P & K as basal and remaining half N in three equal splits at 25, 40 & 60 DAS) recorded significantly higher GMR. However, significantly higher NMR and B: C ratios were recorded with the application of NPK @ 80:30:50 kg ha\(^{-1}\).

**Effect of different levels of nitrogen and sulphur on growth and yield**

**RVSKVV, Mandsaur**: Field experiment was conducted to study the effect of different levels of nitrogen and sulphur on growth parameters and herbage yield. Result revealed that the highest herbage yields were recorded in application of nitrogen @ 150 kg ha\(^{-1}\) (6500 kg ha\(^{-1}\)) and Sulphur @ 40 kg ha\(^{-1}\) (4000 kg ha\(^{-1}\)). The other characters also showed almost the same trend among the treatments. The experiment was concluded with the remark that application of 150 kg ha\(^{-1}\) N along with 40 kg ha\(^{-1}\) Sulphur was the best for harvesting maximum herbage yield of kalmegh crop.

**Disease incidence on different kalmegh entries**

**BCKV, Kalyani**: A trial was conducted at Kalyani, BCKV to see the performance of 13 entries of kalmegh provided by the Project Coordinator, ICAR-DMAPR. Percent disease index of leaf spot was calculated on a 0-5 scale where 0= no disease; 1= Up to 5% leaf area covered; 2= 6-15% leaf area covered, 3= 16-30% leaf area covered, 4= 31-50 % leaf area covered and 5 = above 50% leaf area covered. Percent disease index of leaf rot was calculated on a 0-5 scale where 0= no or a few lesion on leaf; 1= Up to 10% leaf area affected; 2= 11-25% leaf area affected, 3= 26-50% leaf area affected, 4= 51-75% leaf area affected and 5 = above75 % leaf area affected. Incidence of five diseases was recorded i.e., (a) wart or gall (c.o.- *Synchytrium* sp.), (b) Leaf blight (c.o.- *Rhizoctonia* sp.) (c) root rot (c.o.- *Macrophomina* sp.), (d) pod rot (c.o.- *Fusarium* sp.) and (e) leaf spot (c.o.- *Cercospora* sp.). The incidence of the diseases namely, wart, leaf spot, and root rot were very low in this year. The highest PDI for leaf blight was found in AAP16 (7.43%) followed by Kalyani (local) (6.45%) and both were statistically at par. The lowest was in DMAPRAP-35 (1.25%) followed by DMAPRAP-18 (1.28%), NDKL11 (1.42%), which were at par.

**Identification of a new virus disease**

**OUAT, Bhubaneswar**: Yellowing of leaves, vein clearing, reduced leaves and stunting of plants were observed in kalmegh. Prevalence of whiteflies and typical symptoms suggested the involvement of begomoviruses. The disease was tried to diagnose in collaboration with Advanced Centre for Plant Virology at Division of Plant Pathology, IARI, New Delhi. Using begomoviruses specific coat protein primers and betasatellite specific universal primers, the isolated DNA from the infected plants showed specific amplification. The complete genome of the virus was amplified using rolling circle amplification (RCA). The RCA product and amplified betasatellite DNA were sequenced. In the first attempt, partial genome sequence of the virus and complete sequence of betasatellite DNA were achieved. These sequences were subjected to NCBI BLAST. The partial genome (963 base pairs out of 2.7 kilo base pairs) showed maximum identity of 89% with *Andrographis yellow vein leaf curl virus*. Similarly, in NCBI BLAST of the betasatellite DNA sequences, maximum identity of 95% with *Andrographis yellow vein leaf curl* betasatellite DNA was revealed. In phylogentic study also, the betasatellite DNA sequence clustered with other *Andrographis yellow vein leaf curl* betasatellite DNA sequences. The complete genome sequence of the virus is awaited.
KAUCHA (*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.

**Epidemiological studies on Yellow mosaic disease**

**Dr. YSRHU, Venkataramannagudem:** A trial was conducted to study the effect of weather parameters on *Yellow mosaic virus* (YMV) incidence on two early maturing varieties (Selection-8 and Arka Ashwini), three late maturing varieties (Sel 2, Sel 3 and Arka Dhanvanthri) and with one local variety sown in three different months. Data on disease incidence and weather parameters were recorded at four days interval was statistically analysed. The disease incidence was correlated with white fly population and corresponding weather parameters. Time of onset of disease varied with the time of sowing. In 15th July and 15th August sown crops the disease onset was early and took less time to reach its peak (100%) than 15th June sown crop. There was significant positive correlation between PDI and whitefly population in Sel-3 sown in different months. Positive significant correlation was also found in all the varieties except Arka Dhanavantri sown on 15th June. The significant correlation was found only in Sel-2 and Sel-3. Correlation studies revealed that whitefly population and YMV disease incidence had significant negative correlation with rainfall and non significant correlation with all the other weather parameters in all the varieties sown in August.

LIQUORICE (*Glycyrrhiza glabra*)

The plant belongs to family Fabaceae- Papilionoideae. It is a perennial herb or sub-shrub distributed in sub-tropical and temperate zones. Underground stem (stolon) are used as the raw drug, which contains glycyrrhizin as the principle active ingredient. The plant can be propagated by seeds as well as by stolons. Liquorice, which grows best in well-drained soils in deep valleys with full sun, is harvested in the autumn two to three years after planting. The liquorice stolons and roots are used both in medicines as well as for flavours. It is used to treat cough and gastric and duodenal ulcers, dermatitis, etc. The scent of liquorice root comes from a complex and variable combination of
compounds, of which anethole is up to 3% of total volatiles. Much of the sweetness in liquorice comes from glycyrrhizin, which has a sweet taste, 30–50 times the sweetness of sugar. The sweetness is very different from sugar, being less instant, tart, and lasting longer. The isoflavene glabrene and the isoflavane glabridin, found in the roots of liquorice, are phytoestrogens. The raw drug availability of the species within the country is not sufficient and it is mainly imported from Afghanistan by the industries.

**Analysis of market samples of liquorice roots**

**CCSHAU, Hisar:** Twenty samples of liquorice roots were collected from local markets of different districts of Haryana. The extracts of 20 market samples along with sample from check variety HM-1 were tested by HPLC using standard glycyrrhizic acid ammonia salt. Powdered samples (1 g) of the root powder were boiled with 20 ml 90% ethanol. The solution was filtered and the freshly prepared extract was used for the studies. Standard glycyrrhizic acid ammonia salt was prepared by dissolving 50 mg of the standard in 50 ml of 90% ethanol (1 mg ml⁻¹ or 1000 ppm). Thin Layer Chromatographic (TLC) analysis of 90% ethanolic extract of the liquorice samples and standard glycyrrhizic acid ammonia salt was done for the identification of active ingredient in the standard and samples. Butanol : glacial acetic acid : water with different ratios 3:1:2, 5:1:2, 7:1:2 (all v/v) were used as solvent systems for standardization of TLC profile. The solvent system butanol : glacial acetic acid : water (3:1:2, v/v) gave better spot by exposing the plate to iodine fumes and UV light. The Rf values of spots visualized in 20 market samples of liquorice roots, check variety HM-1 and standard glycyrrhizic acid ammonia salt ranged from 0.63 to 0.65. The Rt values of HPLC chromatographs of market samples matched with the Rf value of variety Haryana Mulhatti-1 and standard glycyrrhizic acid ammonia salt which confirmed the authenticity of market samples.

**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.

**Effect of organic sources of nutrients**

**OUAT, Bhubaneswar:** The experiment was conducted to study the effect of different sources
of organic manures on growth and yield of long pepper. The results revealed that application of different organic manures were effective in increasing the growth and yield of long pepper. However, among the organic manures tried, application of FYM @ 20 t ha\(^{-1}\) (100 % substitution of recommended dose of nitrogen) resulted in maximum values for the traits such as plant height (49.9 cm), number of branches per plant (7.7) diameter of branches (0.41 cm), number of leaves per plant (65.78), fresh and dry weight of catkin (2382.53 and 481.03 kg ha\(^{-1}\)), number of catkins per plant (168.65) and piperine yield (6.56 kg ha\(^{-1}\)). The piperine content of long pepper was not influenced by the application of organic manures. Application of FYM @ 20 t ha\(^{-1}\) in long pepper exhibited higher catkin yield (481.03 kg ha\(^{-1}\)) with B:C of 2.33.

**Identification of diseases**

**OUAT, Bhubaneswar:** In long pepper, typical mosaic and yellowing of leaves were observed. Diseased samples were subjected to electron microscopy. The electron micrograph of the diseased sample indicated the presence of *cucumber mosaic virus* (CMV) in the diseased leaves. The virus genome was amplified in RT-PCR using the coat protein (CP) specific primers. The diseased samples showed positive amplification. The CP gene was cloned and sent for sequencing. Thus RT-PCR detection indicated the association of *Cucumber mosaic virus* (CMV) in the symptomatic plants. However, further confirmation by nucleotide sequencing is needed.

**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 triterpene saponins which are designated as gymnemic acids. The plant is propagated mainly by stem cuttings and also by seeds.

**Exploration and evaluation of germplasm**

**TNAU Coimbatore:** Sixty six accessions (TNG SY1 to TNG SY66) were collected from different parts of Tamil Nadu viz., Kolli hills, Yercaud, Palani hills, Anaikatti, Mettupalayam, Anaimalai, Kuridimalai, Sirumalai, Sathuragiri and Kumbakarai. The accessions were evaluated for growth and yield characters. Among the accessions, Sirumalai local-2 recorded the maximum fresh and dry leaf weight (3.24 and 1.12 kg per plant). The accession had elliptic leaf shape, round base with acute tip and pubescence in leaves. Variations were observed in the germplasm for leaf shape, leaf base, leaf tip, leaf colour and leaf pubescence. Based on leaf shape, the accessions were grouped into ten different groups viz., elliptic (15 accessions), ovate (25 accessions), lanceolate (15 accessions),
oblanceolate (1 accession), elliptic-ovate (1 accession), elliptic-lanceolate (1 accession), ovate-elliptic (1 accession), ovate-lanceolate (1 accession), oblong-ovate (1 accession) and ovate-oblong (1 accession). The accessions were grouped into three groups based on leaf tip viz., acute (40 accessions), acuminate (13 accessions) and attenuate (3 accessions). The accessions were grouped into four groups based on leaf base viz., round (51 accessions), cordate (7 accessions), obtuse (7 accessions) and cuneate (3 accessions). Leaf pubescence was present in 56 accessions and absent in 10 accessions.

**BAU, Ranchi:** Twelve accessions were evaluated for qualitative parameters like (plant habit, color of upper and lower leaf surface, nature of upper and lower leaf surface, shape of leaf tip, shape of leaf base, leaf arrangement, branching pattern, stem colour, stem surface at growth and mature stage) and quantitative traits (branch length, collar diameter, leaf length, leaf breadth, number of nodes per plant, petiole length, petiole thickness, number of leaves per plant, number of primary branches per plant and length of internodes). At 10 months of age, maximum petiole length (1.59 cm) was observed in BGS<sub>5</sub>, maximum petiole thickness (1.52 mm) in BGS<sub>3</sub>, maximum number of leaves per plant (426.4) in BGS<sub>5</sub>, maximum number of primary branches per plant (23.6) in BGS<sub>3</sub> and maximum length of internodes (10.44 cm) in BGS<sub>5</sub>.

**Effect of season and PGR on rooting**

**JNKVV, Jabalpur:** The experiment was conducted with objective to identify a suitable season and PGR dose for successful rooting in cutting of madhunashini. The madhunashini cuttings were planted in three different seasons viz., July, August and September after treatment with IBA 250, 500, 750 ppm and without IBA. The result revealed that both the seasons and PGR treatments had marked influence on rooting of madhunashini. The cuttings prepared and planted in the month of July and September took less time (12.00 days) for bud sprouting as compared to August (13.00 days) planting. The survivability of cutting was observed highest (22.50%) in August month and minimum in July (20.00%). As far as the influence of PGR treatment was concerned, the maximum survivability of cuttings (26.11%) was recorded with 750 ppm IBA treated cuttings followed by 500 ppm IBA treatment(22.78%), whereas, minimum survivability (16.67%) was observed in the control (no hormone treatment). The survivability of cutting was found maximum (28.33%) in August month treated with 750 ppm IBA, whereas, minimum survivability (15.00%) was noticed in July planted cuttings with no IBA treatment.

**Efficacy of biopesticides on the management of leaf webber**

**TNAU, Coimbatore:** A field experiment was conducted to evaluate the bioefficacy of certain promising biopesticides such as neem oil, neem seed kernel extract, *Metarhizium anisopliae*, *Bacillus thuringiensis* and *Beauveria bassiana* on the management of leaf webber (*Bocchoris onychinalis*) of *G. sylvestre*. Chlorpyriphos 20 EC was used as the standard check, along with an untreated check without any treatment. Results revealed that pre-treatment count of leaf webber larvae ranged between 10.07 and 10.73 per plant.

The post treatment counts at one and three days after treatment (DAT) revealed that neem seed kernel extract @ 5 per cent treated plots recorded the lowest number of webbers (6.10 and 1.87 per
plant) followed by neem oil @ 3 per cent with 6.67 and 2.77 webbers per plant, respectively. All the other treatments tested were statistically at par in their efficacy. From fifth day after treatment, *Bacillus thuringiensis* @ 750g ha⁻¹ recorded maximum efficacy followed by neem seed kernel extract @ 5 per cent, neem oil @ 3 per cent, *Beauveria bassiana* @ 2 kg ha⁻¹ and *Metarhizium anisopliae* @ 2 kg ha⁻¹ recording 1.10, 1.33, 1.80, 2.80, 4.13 webbers per plant, respectively. The trend remained the same in subsequent counts with 0.63, 0.73, 0.87, 1.57 and 1.13 webbers per plant at 7 DAT and 0.53, 0.73, 0.80, 0.93 and 2.10 webbers per plant at 14 DAT. However, chlorpyriphos 20 EC (standard check) @ 1.0 l ha⁻¹ was significantly superior to the other treatments with the lowest number of webbers (0.07) at one day after treatment and the webber population was observed to be nil at third, fifth, seventh and fourteenth day counts. The untreated control was significantly inferior with the maximum of 10.6 webbers per plant.

**Efficacy of biopesticides on the management of looper**

**TNAU, Coimbatore:** Efficacy of different biopesticides against looper (*Comostola pyrrhogona*) was studied. Results of the field experiment conducted to evaluate the bio-efficacy of certain promising biopesticides on the management of loopers of *G. sylvestre* revealed that the pre-treatment count of looper ranged between 2.87 and 3.43 per plant, which was statistically non-significant. The post treatment counts at 1 and 3 DAT revealed that among the biopesticides, neem seed kernel extract @ 5 per cent treated plots recorded the lowest number of loopers (1.13 and 0.73), followed by neem oil @ 3 per cent (1.93 and 0.83 loopers per plant) and *Bacillus thuringiensis* @ 750g ha⁻¹ (2.23 and 0.87 loopers per plant). At fifth day after treatment, *Bacillus thuringiensis* @ 2 kg ha⁻¹ recorded maximum efficacy (0.40 loopers per plant) followed neem oil 3 per cent (0.60 loopers/plant) and neem seed kernel extract 5 per cent (0.77 loopers per plant). The trend remained same in the subsequent counts at 7 and 14 DAT. However, chlorpyriphos 20 EC (standard check) @ 1.0 l ha⁻¹ was significantly superior, which registered no loopers even at one DAT and the looper population was observed to be nil at third, fifth, seventh and fourteenth day counts, as against the maximum of 3.77 loopers per plant in untreated control.

**Effect of bio-pesticides on leaf and stem yields**

**TNAU, Coimbatore:** Effect on leaf and stem yields of different biopesticides used in the biopesticides management of insect pests was studied. Results revealed that among the biopesticides tested, neem seed kernel extract @ 5% treated plots recorded maximum dry leaf yield of 0.53 kg plant⁻¹ and dry stem yield of 1.48 kg plant⁻¹ followed by application of *Bacillus thuringiensis* @ 750 g ha⁻¹ (0.48 and 1.26 kg plant⁻¹) and neem oil 3 per cent (0.41 and 1.10 kg plant⁻¹). Chlorpyriphos 20 EC (standard check) @ 1.0 l ha⁻¹ was significantly superior, which yielded 0.76 kg of dry leaves and 2.46 kg of dry stem per plant as against 0.22 and 0.30 kg of dry leaves and stem per plant, respectively.

Thus in *Gymnema sylvestre*, foliar application of neem seed kernel extract 5 % showed maximum efficacy in terms of minimum number of leaf webbers and loopers per plant, per cent defoliation and maximum herbage yield (1.48 kg plant⁻¹), followed by *Bacillus thuringiensis* @ 750 g ha⁻¹ (1.26 kg plant⁻¹).
MAKOI (*Solanum nigrum*)

It belongs to family Solanaceae and is commonly known as Black night shade, Makoi or Deadly nightshade. It possesses medicinal properties like antimicrobial, anti-oxidant, cytotoxic, antiulcerogenic, and hepatoprotective activities. The juice of the fresh herb is sometimes used to treat fever and to allay pain. In large doses, Black nightshade can cause serious, but usually not fatal, poisoning. Externally, the juice or an ointment prepared from the leaves can be used for skin problems and tumors. The fruit has been used for diabetes. An infusion of the plant is used as an enema in infants having abdominal upsets. Freshly prepared extract of the plant is effective in the treatment of cirrhosis of the liver and also serves as an antidote to opium poisoning. It is a potential herbal alternative as anti-cancer agent and one of the active principles reported to be responsible for this action is diosgenin. It is in cultivation in Tamil Nadu and seeds are used for propagation.

**Floral biology and breeding behaviour**

**Dr. YSRHU, Venkataramannagudem:** Floral characteristics such as flower size, style position, pollen size and pollen viability were studied. Flower is regular (actinomorphic), white to pale purple, corolla is white, wheel shaped, 5 lobed, 6-4 mm, wide, calyx is fused, companulate, deeply 5 lobed, stamens with 5 anthers in a conical group, gynoecium is composed of 2 fused carpels, inflorescence is 3-8 flowered cyme, pedunculate. Anthesis (opening of flowers) occurs at sunrise, pollen is released for two days from the day of anthesis and flowers remain as visual flag for 10 days to the pollinators.

MANDOOKAPARNI (*Centella asiatica*)

It is a member of family Apiaceae. It is a prostrate, slightly aromatic, perennial herb commonly found as a weed in crop fields. Mandukparni grows in tropical swampy areas. The stems are slender, creeping stolons, green to reddish-green in color, connecting plants to each other. It has long-stalked, green, rounded apices which have smooth texture with palmately netted veins. The leaves are borne on pericladial petioles, around 2 cm (0.79 in). The species is widely distributed in India. The species is commonly known as brahmi in Northern parts of India. The flowers are pinkish to red in color, born on small umbels. Leaves are used as vegetable in eastern and southern parts of India. It is used for the treatment of leprosy, skin diseases and to improve memory. It is also used against cholera, ulcers, bronchitis, leucorrhoea and kidney troubles. Asiaticoside, indocentelloside and thankuniside are the major glycosides responsible for the medicinal properties. It is propagated both by runners as well as by seeds. Humus rich soil and partial shade are suitable for cultivation.
Integrated management of stolon rot caused by *Fusarium* Clade VII

DRP, Pusa: The study showed that soil incorporation of FYM inoculated with *Trichoderma harzianum* combined with planting material treatment with the same bio agent was most effective in suppression of stolon rot (11.6.0 % disease intensity) and also resulted in maximum herbage yield of 4980 kg ha\(^{-1}\) on fresh weight basis. Likewise soil incorporation of FYM inoculated with *Trichoderma viride* combined with sapling treatment of the same bio agent was also markedly effective in suppression of stolon rot (12.3 % disease intensity) with a herbage yield of 4113 kg ha\(^{-1}\) on fresh weight basis. All the treatments showed significantly lower disease intensity and higher herbage yield as compared to the control.

**NEEL (Indigofera tinctoria)**

It is a shrub belonging to family Fabaceae and grows to a height of about one to two meters. It is annual, biennial, or perennial, depending on the climate in which it is grown. The leaves are pinnate and flowers are pink or violet. The species was one of the original sources of indigo dye. It has been naturalized to tropical and temperate Asia, as well as parts of Africa, but its native habitat is unknown. The plant is also widely grown as a soil improving groundcover and to improve the soil in the same way that the other legume crops. The dye is obtained from processing of the plants’ leaves. The species also has medicinal value especially for removing toxins from the body.

Integrated nutrient management for higher yield and quality

KAU, Trichur: The experiment was conducted consecutively for three years to standardize an effective nutrient management practice for higher yield in neel. The result showed that application of FYM @ 5 t ha\(^{-1}\) + NPK @ 45:60:45 kg ha\(^{-1}\) recorded higher herbage yield of 6413, 6432 and 6932 kg ha\(^{-1}\) during the first, second and third year, respectively. Pooled analysis of three the years' data showed the same trend with higher herbage yield in this treatment. However, it was at par with FYM @ 10 t ha\(^{-1}\) + NPK @ 45:60:45 kg ha\(^{-1}\) with 6364 kg ha\(^{-1}\) pooled herbage yield. The absolute control plots recorded the lowest herbage yield of 1696 kg ha\(^{-1}\), 2400 kg ha\(^{-1}\) and 2310 kg ha\(^{-1}\) respectively during first, second and third years of study. Compared to plots with integrated nutrient management, the yield recorded from the plants which received inorganic fertilizers alone or farmyard manure alone was very low. The pooled average in treatment with farmyard manure alone was 5041 kg ha\(^{-1}\) and that in inorganic manure alone plot was 4570 kg ha\(^{-1}\). The quality of *Indigofera tinctoria* studied in terms of glycoside indican revealed the superiority of absolute control in expressing higher content of indican. This was followed by treatment with farmyard manure alone. Among the integrated nutrient management treatments, FYM @ 5 t ha\(^{-1}\) + NPK @ 60:90:60 kg ha\(^{-1}\) was found to be superior with respect to indican content. Regarding indican yield (per hectare basis) application of FYM @ 5 t ha\(^{-1}\) + NPK @ 45:60:45 kg ha\(^{-1}\), FYM @ 10 t ha\(^{-1}\) + NPK @ 45:60:45 kg ha\(^{-1}\), FYM @ 5 t ha\(^{-1}\) + NPK @ 60:90:60 kg ha\(^{-1}\) and FYM 10 t ha\(^{-1}\) + NPK @ 60:90:60 kg ha\(^{-1}\) were at par and had the higher indican yield (> 40 kg ha\(^{-1}\)). The treatment with FYM 5 t ha\(^{-1}\) + NPK @ 45:60:45 kg ha\(^{-1}\) also...
resulted in better B:C ratio of 2.90 as compared to 2.08 in treatment with FYM alone and 1.69 in treatment with inorganic manures alone.

**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.

**Evaluation of promising lines for higher yield and quality in AVT-II**

Advanced varietal trial (AVT-II) with six test entries and two checks (Chetak Aphim and JOP540) was conducted at three locations *i.e.*, MPUAT, Udaipur; RVSKVV, Mandsaur and NDUAT, Faizabad with an objective to identify superior varieties with high yield and quality. The trial was vitiated at Faizabad. Across locations, maximum latex yield (79.67 kg ha⁻¹) was recorded in UOP20 which was followed by Chetak aphim (77.75 kg ha⁻¹). The trial will be repeated in the next year.

**Evaluation of F₁ hybrids**

**MPUAT, Udaipur:** The centre has initiated the crossing programme in opium poppy during 2014-15 so as to generate variability in the genotypes. For this, eight promising and elite lines identified from the germplasm evaluation over the years were taken as base material. Crossing of these eight lines were attempted in Diallel mating design. Parents UOP-69, UOP-80,UOP-79 and UOP-99 were also good general combiners for latex yield, seed yield, effective capsules per plant, capsule husk yield, seed harvest index and morphine content.Crosses UOP-80 x UOP-20, UOP-53 x UOP-1185, UOP-79 x UOP-60, UOP-79 x UOP-20, UOP-79 x UOP-1185 and UOP-80 x UOP-1185 also showed high per se performance, high heterotic effect and high SCA effect for latex yield, seed yield, capsules per plant, capsule husk yield, seed harvest index and morphine content. The parents and crosses *viz.*, UOP-69, UOP-80,UOP-79, UOP-99 and UOP-80 x UOP-20, UOP-53 x UOP-1185, UOP-79 x UOP-60, UOP-79 x UOP-20, UOP-79 x UOP-1185 and UOP-80 x UOP-1185 were selected for future breeding programme in opium poppy.

**In station varietal evaluation trial**

**MPUAT, Udaipur:** Twenty three promising entries along with 2 checks (Chetak Aphim and JOP-540) were evaluated for latex, seed, and husk yield & other yield contributing traits. Among the
checks, Chetak Aphim was identified as the best check for latex yield and seed yield (22.96 kg ha⁻¹ and 935.33 kg ha⁻¹). Eight genotypes showed their significant superiority for latex yield over the best check (Chetak Aphim). Thirteen genotypes showed their significant superiority for seed yield over the best check (Chetak Aphim). Eleven genotypes exhibited their significant superiority for morphine content over the best check JOP-540 (11.86%). Five genotypes showed their significant superiority for latex yield as well as seed yield over the best check Chetak Aphim (22.96 kg ha⁻¹ and 935.33 kg ha⁻¹). Four genotypes exhibited their significant superiority for morphine content over the check JOP-540 (11.86%) and Chetak Aphim for latex yield (22.96 kg ha⁻¹).

**Maintenance breeding**

**RVSKVV, Mandsaur:** Maintenance breeding of released varieties viz., JA-16, JOP-539 and JOP-540 was undertaken through selfing and single plant selection methods and purity maintained by roughing of off type plants.

**Evaluation, maintenance and utilization of germplasm**

**MPUAT, Udaipur:** A total of 85 germplasm accessions were evaluated along with 2 checks. The observations were recorded for individual accessions for plant height, peduncle length, number of effective capsules per plant, stem diameter, days to 50% flowering, dry latex yield, seed yield, husk yield and morphine content. A total of five accessions exhibited higher dry latex yield over the best check, JOP-540 (30.06 kg ha⁻¹) while overall trial mean was 21.77 kg ha⁻¹. Latex yield ranged 11.39 kg ha⁻¹ to 33.22 kg ha⁻¹. Twenty six accessions exhibited higher morphine content than the check Chetak Aphim (11.91%).

**Effect of integrated nutrient management on growth and latex yield**

**RVSKVV, Mandsaur:** An experiment was conducted to study the effect of organic fertilizer and micronutrient application along with bio control agent on the growth and latex yield of opium poppy crop. The result revealed that the highest latex yield (69.0 kg ha⁻¹) was recorded in application of vermiculture @ 5 t ha⁻¹+ *Trichoderma*+ sulphur+ zin+ boran+ RDF. Seed yield was recorded highest in application of vermiculture @ 5 t ha⁻¹+ *Trichoderma*+ sulphur+ zin+ boran+ RDF (1500 kg ha⁻¹). Application of vermiculture @ 5 t ha⁻¹+ *Trichoderma*+ sulphur+ zin+ boran+ RDF recorded the highest number of capsules (3.2) per plant as well as the highest plant height (116 cm).

**Screening of promising genotypes**

**MPUAT, Udaipur:** Ten promising genotypes of opium poppy were screened for confirmation of resistance against downy mildew, root rot, leaf spots, bacterial blight and powdery mildew. Among the genotypes, six genotypes (UOP-20, UOP-79, UOP-69, UOP-44, UOP-53, UOP-80) showed resistant with lowest disease appearances (11-20%) against downy mildew, root rot, leaf spots, bacterial blight, powdery mildew diseases with higher yield of seed (947-1043 kg ha⁻¹); husk (864-944 kg ha⁻¹) and latex powder (27.36-30.64 kg ha⁻¹) and higher morphine content. However, four genotypes (UOP-35, UOP-60, UOP-04 and UOP-1185) were moderately resistant. Variety Chetak Aphim was found susceptible with maximum disease (50-55%) and low dry latex yield (16.72 kg ha⁻¹), seed yield (643 kg ha⁻¹), husk yield (576 kg ha⁻¹) and morphine content.
Evaluations of integrated disease management modules against diseases

**MPUAT, Udaipur:** Integrated disease management modules against bacterial stem rot and blight diseases of opium poppy were evaluated under sick plot and inoculation condition during *Rabi* season 2016-17. Among the modules, in-furrow soil application of neem cake mixture (100g m$^{-2}$) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus seed treatment with Streptocycline @ 0.035% plus drenching of Copper oxychloride @ 0.3% at 40, 55 and 70 DAS resulted in minimum stem rot (10.47%) and blight disease (12.92%) with maximum control of stem rot (84.27%) and blight disease (82.06) and yielded higher dry latex powder (27.69 kg ha$^{-1}$), seed (783 kg ha$^{-1}$) and capsule husk (706 kg ha$^{-1}$) with higher morphine content and was significantly superior to the control and rest of the treatments except treatment comprising in-furrow soil application of neem cake mixture (100g m$^{-2}$) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus seed treatment with Streptocycline @ 0.035% plus drenching of Copper hydroxide @ 0.3% at 40, 55 and 70 DAS. The IDM module, in-furrow soil application of neem cake mixture (100g m$^{-2}$) 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 or drenching of Copper hydroxide 77 WP @ 0.3% at 40, 55 and 70 DAS was found best in management of bacterial stem rot (80.90-84.27%) and blight disease (78.91-82.06%) of opium poppy.

Integrated disease management modules including organic treatments against downy mildew of opium poppy were also evaluated at the centre under sick plot and inoculation condition. Maximum disease control was recorded in chemical control treatment compared to the organic modules. Among the organic modules, in-furrow soil application of neem cake mixture (100 g m$^{-2}$) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus three foliar sprays of garlic bulb extract (w/v) @10% resulted in minimum downy mildew (15.80%) with maximum disease control (81.53%) and yielded higher dry latex powder (23.06 kg ha$^{-1}$), seed (815 kg ha$^{-1}$) and capsule husk (712 kg ha$^{-1}$) with higher morphine content and was significantly superior to the rest of the organic treatments and control. The chemical module comprising seed treatment with metalaxyl 35 SD @ 8 g kg$^{-1}$ seeds plus three foliar sprays with ridomil MZ 72 WP (mancozeb 64%+ 8% metalaxyl) @ 0.25% was found as the best in management of downy mildew disease with 14.18 per cent downy mildew disease incidence and with significantly maximum disease control i.e., 83.19 per cent and higher yields of dry latex powder (24.70 kg ha$^{-1}$), seed (822 kg ha$^{-1}$) and capsule husk (719 kg ha$^{-1}$) with higher morphine content when compared to the rest of the chemical and organic modules.

**RVSKVV, Mandsaur:** Integrated disease management modules against bacterial stem rot (*Erwinia* spp.) and blight disease of opium poppy were evaluated. Among the integrated disease management modules against bacterial stem rot and blight disease, in furrow soil application of neem cake mixture (100 g m$^{-2}$) enriched with *Trichoderma* + *Pseudomonas* talc based formulation each @ 2.0% at sowing plus seed treatment with streptocycline @ 0.035% plus drenching with Hexaconazol 5Ec @ 0.1% at 40, 55 and 70 DAS resulted in minimum bacterial stem rot disease (21.32%) and higher latex (59.80 kg ha$^{-1}$), seed (1032.22 kg ha$^{-1}$) and capsule husk (962 kg ha$^{-1}$) yields over the control.
Integrated disease management modules against downy mildew of opium poppy were also evaluated at the centre. Among the seven treatments, all the treatments effectively controlled disease incidence over the control, however, seed treatment with metalaxy 35 SD @ 8 g kg⁻¹ seeds plus three foliar sprays with metalaxy 72MZ, (mancozeb 64%+ metalaxyl 8%) @ 0.25% at 35, 55 and 75 DAS recorded minimum disease incidence (20.86%) and maximum latex, seed and husk yields (59.84, 1151.39, 930 kg ha⁻¹).

**PALMAROSA (Cymbopogon martinii var. motia)**

It is an important aromatic grass belonging to family Poaceae. It attains a height of about 1.75 m under favourable growing condition in the forest and up to 2.5 m under cultivation. Essential oil from this species is used in perfumery, cosmetics, pharmaceutical and flavouring industries. Oil is extracted from the floral shoots and aerial parts of 'motia' variety of Cymbopogon martinii. The oil has good demand for export and is very rich in geraniol (75-90%). The oil has high demand in perfumery, soap, cosmetics and blending tobacco products industries in addition to its use in aromatherapy. The species is under cultivation in central, western and southern states of India.

**Analysis of samples from modified mass selection**

**CCSHAU, Hisar:** The essential oil content of 49 promising clones on fresh weight basis (FWB) ranged from 0.17 to 0.60%. Twenty clones recorded oil content better than check Trishna. clone C47 recorded the highest oil content (0.60%) followed by C9 (0.55%), C22 (0.51%), C6 (0.50%), C44 (0.49%), C42 & C46 (0.45%), C17 (0.44%), C10 (0.42%), C11 & C24 (0.40%), C48 (0.39%), C35, C39 & C40 (0.36%), C18 & C25 (0.35%), C1 & C49 (0.34%) and C23 (0.33%) in comparison to 0.32% of check Trishna. Quality analysis of essential oils of these 49 promising clones showed that most of the clones were rich in geraniol content ranging from 77.5 to 86.1 per cent.

**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 “vulnerable” species status. The plant is propagated by the stem disc with the attached fleshy roots as well as by seeds.
Evaluation of promising lines for high yield and quality under MLT

Initial evaluation trial (IET) with one test entry and three checks (GAS-1, JSM405 and RSM414) was conducted at six locations viz., AAU, Anand; PDKV, Akola; ICAR-DMAPR; RVSKV, Mandsaur; MPKV, Rahuri and MPUAT, Udaipur with an objective to identify superior varieties with high yield and quality. The trial was vitiated at AAU, Anand and MPKV, Rahuri. Across locations, GAS-1 recorded maximum dry root yield (288.71 kg ha⁻¹) which was followed by RSM414 (269.61 kg ha⁻¹). The trial will be repeated in the next year as AVT-I.

Integrated disease management of root and foliar diseases

**MPUAT, Udaipur:** Integrated disease management organic modules against root rot and Anthracnose of safed musli was evaluated. Among the organic modules, in-furrow soil application of neem cake mixture (100g m⁻²) 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 significantly higher fasciculated root yields (3559; 3508 kg ha⁻¹) with minimum root rot (21.66, 20.01%) and Anthracnose (21.23; 24.57%) diseases compared to the rest of the organic modules in term of root yield. Among the chemical treatments, 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 by 15 days interval resulted in significantly superior root yield (4316 kg ha⁻¹) with minimum incidence of root rot (11.21%) and Anthracnose (10.75%) diseases. This treatment was also superior to the organic treatments in terms of disease incidence and root yield.

**RVSKV, Mandsaur:** The experiment on management of Anthracnose disease of safed musli was conducted consecutively for three years and the results from pooled mean of three years’ data revealed that the treatment with carbendazim+ mancozeb @ 0.25% recorded minimum disease incidence (37.97%) with significantly higher fasciculated root yield (7796.93 kg ha⁻¹) followed by carbendazim @ 0.15% with disease incidence of 47.70% and fasciculated root yield of 6210.03 kg ha⁻¹. Maximum disease incidence and the lowest fasciculated root yield (1387.49 kg ha⁻¹) were recorded in the control.

**SARPAGANDHA (*Rauvlofia 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 and evaluation of germplasm

**OUAT, Bhubaneswar**: Seventy five accessions were characterized for agro-morphological characters. IC-0615448 recorded maximum leaf length (15.55 cm) followed by IC-0615479 (15.12 cm) and the minimum leaf length was (4.66 cm) in IC-0615444. Maximum leaf breadth was 5.32 cm (IC-0615498) followed by 4.90 cm (IC-0615493) and the minimum leaf breadth was 1.62 cm (IC-0615500). IC-0615447 showed maximum leaf length to breadth ratio of 5.61. Minimum leaf length to width ratio was in IC-0615439 (1.82). Maximum average length of petiole was 1.10 cm (IC-0615466). Minimum average length of petiole was 0.12 cm (IC-0615454). Minimum internodal length was 1.34 cm (IC-0615444 and IC-0615475) and maximum internodal length was 5.84 cm (IC-0615489). 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 had 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 bioagents and micronutrient with organic amendment on leaf spot diseases

**JNKVV, Jabalpur**: Disease management strategy against leaf spot diseases caused by *Alternaria alternata* and *Corynespora cassicola* of sarpgandha was evaluated with combinations of bioagents, micronutrients and organic amendment along with foliar application of non conventional chemicals. Minimum disease incidence (32.66%) was recorded in treatment comprised of *Pseudomonas fluorescens* @ 10^9 cfu ml⁻¹+ neem cake+ ZnSo₄+ 1st spray of cow urine (1:10) followed by 2nd spray of Salicylic acid (1000 ppm) at 15 days interval while *P. fluorescens*+ neem cake+ ZnSo₄+ cow urine spray (1:10)+ Salicylic acid (1000 ppm), *Trichoderma asperellum*+ neem cake+ ZnSo₄+ cow urine spray (1:10)+ Salicylic acid (1000 ppm); *P. fluorescens*+ Bacillus subtilis+ neem cake+ ZnSo₄+ cow urine spray (1:10)+ Salicylic acid (1000 ppm) and *P. fluorescens*+ *T. asperellum*+ neem cake+ ZnSo₄+ neem cake+ ZnSo₄+ cow urine spray (1:10)+ Salicylic acid (1000 ppm) were also equally suppressive towards the *Alternaria* leaf spot disease. The highest root yield (613 kg ha⁻¹) was recorded in *T. asperellum* @ 10^6 cfu ml⁻¹+ neem cake+ ZnSO₄+ 1st spray of cow urine (1:10) followed by 2nd spray of Salicylic acid (1000 ppm) at 15 days interval which was statistically at par with root yield of 607 kg ha⁻¹ recorded in *P. fluorescens* @ 10^6 cfu ml⁻¹+ neem cake+ ZnSo₄+ 1st sprays of cow urine (1:10) followed by 2nd spray of Salicylic acid (1000 ppm) at 15 days interval.

**SATAVARI (Asparagus racemosus)**

The plant belongs to family Liliaceae. It is a creeper and is common throughout India and the Himalayas. It has an adventitious root system with tuberous roots that measure about 1 meter in length, tapering at both ends. 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 planting methods and nutrient sources on crop yield**

**PDKV, Akola:** Field study was conducted to evaluate the influence of planting methods and nutrient sources on root growth, yield and economic returns of satavari. Planting of satavari on ridges and furrow recorded significantly higher number of roots per plant (51.12), root length (20.61 cm), average root diameter (10.59), fresh weight (13384 kg ha⁻¹) and dry root yield (1472 kg ha⁻¹). Application of 10 t ha⁻¹ FYM recorded significantly higher number of roots per plant (53.90), root length (21.55 cm), average root diameter (10.74 mm), fresh weight (13930 kg ha⁻¹) and dry root yield (1499 kg ha⁻¹). Interaction effects between planting methods and organics were found significant in respect of number of roots per plant, root length, average diameter of root and fresh & dry root yields. Planting of satavari on ridges and furrow with application of 10 t ha⁻¹ FYM recorded significantly higher number of roots per plant (69.42), root length (26.61.55 cm), average root diameter (11.47mm) and fresh weight (17942 kg ha⁻¹) and dry root yield (1974 kg ha⁻¹). Planting of satavari on ridges and furrow with application of 10 t ha⁻¹ FYM recorded significantly higher GMR (₹ 3,15,778 ha⁻¹) and NMR (₹ 2,55,583 ha⁻¹). However, planting of satavari crop on ridges and furrow without organics recorded the highest B: C ratio. Planting on ridges and furrow with application of 10 t ha⁻¹ FYM recorded significantly higher number of roots per plant, root length, average root diameter and fresh weight & dry root yield of satavari.

**DRPCAU, Pusa:** Field experiment was conducted to study the influence of organic manures and bio fertilizers on growth and yield of satavari. Result revealed that application of vermicompost @ 2 t ha⁻¹+ mustard cake @1 t ha⁻¹ inoculated with mixture of PSB @ 5 kg ha⁻¹ and *Azospirillum* @ 2 kg ha⁻¹ produced significantly higher root yield (14563 kg ha⁻¹).

**Efficacy of different bio pesticides against fruit borer**

**MPKV, Rahuri:** Efficacy of different biopesticides against fruit borer was studied. Results revealed that pre treatment count of number of fruit borer larvae ranged from 3.40 to 4.78 fruit borer larvae per plant. At three days after treatment (DAT), significant reduction in fruit borer larvae population was observed except in the treatment with *Verticillium lecanii* @ 4 g l⁻¹ and *Verticillium lecanii* @ 8 g l⁻¹ as against 4.60 fruit borer larvae per plant in untreated control. Maximum reduction in fruit borer larvae population was observed in the treatment of Azadirachtin 10,000 ppm 3 ml l⁻¹ (3.27 fruit borer larvae per plant). At seven DAT treatment of *Bacillus thuringiensis* @ 2 g l⁻¹ was found as superior (2.87 fruit borer larvae per plant) to all the other treatments. At fourteen DAT, foliar application of *Beauveria bassiana* @ 8 g l⁻¹ was recorded as superior with mean fruit borer larvae population of 2.07 per plant as against 4.53 fruit borer larvae per plant in the untreated control. There was no effect (no mortality) of spraying of *Verticillium lecani* @ 4 g l⁻¹ and 8 g l⁻¹ on fruit borer larvae per plant on Satavari. The same trend of mortality was observed at second spray. Maximum seed yield was obtained in the treatment *Beauveria bassiana* @ 8 g l⁻¹ (23.08 kg ha⁻¹) as against 11.91 kg ha⁻¹ seed yield observed in the untreated control.
**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 constiveness. 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, splenomegaly, indigestion, malaria, skin diseases, jaundice and anaemia. It is propagated by seeds and normally cultivated as post kharif crop.

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

Initial evaluation trial (IET) with four test entries and three checks (ALFT-2, Sona and KKM-01) was conducted at four locations viz., AAU, Anand; TNAU, Coimbatore; ICAR-DMAPR, MPKV, Rahuri and MPUAT, Udaipur with an objective to identify superior varieties with high yield and quality. The trial was vitiated at Anand, Udaipur and Rahuri. Across locations, DCA-96 recorded maximum herbage yield (10594.09 kg ha\(^{-1}\)) which was followed by A16-18 (9507.46 kg ha\(^{-1}\)). The trial will be repeated in the next year as AVT-I.

**Management of wilt disease**

**MPUAT, Rahuri:** Bioagents viz., *Trichoderma viride*, *T. harzianum*, *Pseudomonas fluorescens* and *Bacillus subtilis* alone as seed treatments and their combinations as soil application along with FYM were tested against wilt disease caused by *Fusarium oxysporum* in senna. Among the bioagents tested, seed treatment (ST) with *B. subtilis*+ soil application (SA) of *T. viride*+ *B. subtilis* was found to be most effective by recording the lowest wilt incidence 20.83% with maximum disease reduction of 62.80% over the control. However, seed treatment with *P. fluorescens* @ 5g kg\(^{-1}\) of seed+ soil application of *T. harzianum*+ *P. fluorescens* @ 5g each kg\(^{-1}\) of FYM and seed treatment of *P. fluorescens* @ 5g kg\(^{-1}\) of seed+ soil application of *T. viride*+ *P. fluorescens* @ 5g each kg\(^{-1}\) of FYM were statistically at par with ST of *B. subtilis* @ 5g kg\(^{-1}\) of seed+ SA of *T. viride*+ *B. subtilis* @ 5g kg\(^{-1}\) of FYM which recorded 23.61 and 25.91% wilt incidence with 57.83 and 53.72% reduction of wilt disease over control. Differences observed in leaf yield were statistically significant among the treatments. The seed treatment with *B. subtilis*+ soil application of *T. viride*+ *B. subtilis* recorded maximum fresh leaf yield (7258 kg ha\(^{-1}\)) as well as dry leaf yield (1669 kg ha\(^{-1}\)). However, treatments of ST of *P. fluorescens* @ 5g kg\(^{-1}\) of seed+ SA of *T. harzianum*+ *P. fluorescens* @ 5g each kg\(^{-1}\) of FYM, ST of *B. subtilis* @ 5g kg\(^{-1}\) of seed+ SA of *T. harzianum*+ *B. subtilis* @ 5g kg\(^{-1}\) of FYM and ST of *P. fluorescens* 5g kg\(^{-1}\) of seed+ SA of *T. viride*+ *P. fluorescens* @ 5g each kg\(^{-1}\) of FYM were statistically at par with this treatment for fresh leaf yield.
Management of leaf spot diseases using botanicals

**MPUAT, Rahuri**: Ten different aqueous plant extracts were tested at 10% concentration against leaf spot disease caused by *Alternaria alternata* in senna. Three sprays of botanicals were taken at an interval of 15 days as soon as disease was noticed. All the plant extracts recorded the lowest leaf spot intensity as compared to the control. Differences observed among the treatments were statistically significant in respect to per cent leaf spot intensity, fresh leaf as well as dry leaf yields. Among the aqueous plant extracts, spraying of datura (*Datura innoxia*) leaf extract recorded significantly lowest leaf spot intensity of *Alternaria* disease (14.57%) with maximum disease reduction of 68.10% as compared to the control (45.67%). However, spraying of datura leaf extract recorded significantly highest fresh leaf yield (8263 kg ha⁻¹) as well as marketable dry leaf yield (1818 kg ha⁻¹).

**TNAU, Coimbatore**: The effect of biocontrol agents and fungicides on management of leaf blight disease caused by *Alternaria alternata* of senna was studied in farmers’ field at Madurai district. The talc based formulations of *Pseudomonas fluorescens* and *Bacillus subtilis* were used for the experiment. Seeds were treated with biocontrol agents viz., *P. fluorescens* @ 10 g kg⁻¹ seed or *B. subtilis* @ 10 g kg⁻¹ seed and by spraying with the same bioagents @ 2 g l⁻¹ at 30 and 60 days after sowing. For comparison, the plants were sprayed with chlorothalonil @ 0.1% at 30 and 60 days after sowing. The results revealed that the seed treatment with *B. subtilis* @ 10 g kg⁻¹ seed followed by spraying with *B. subtilis* 0.2% at 30 and 60 days after sowing was effective in managing the leaf blight disease which recorded the lowest disease intensity of 12.6%. The maximum leaf yield of 564.4 kg ha⁻¹ was also recorded in this treatment.

Management of leaf eating caterpillar using different bio control agents

**MPKV, Rahuri**: Different biocontrol agents were tested against leaf eating caterpillar, *Catopsilia pyranthe*. Results revealed that pre treatment count of number of larvae per plant ranged from 7.40 to 9.13 per plant. Significant reduction in leaf eating caterpillar population per plant was observed in all the treatments at three days after treatment (DAT), as against 9.67 larvae per plant in untreated control. Maximum reduction in leaf eating caterpillar population was observed in the treatment with neem oil 1% (5.93) followed by karanj oil 1% (7.60) and NSE 5% (7.27). Even at seven days after treatment the same trend was observed and neem oil (1%) was superior over all other treatments. Foliar application of *Bacillus thuriengensis* @ 1 kg ha⁻¹ recorded superiority with the mean leaf eating caterpillar population of 2.27 per plant at fourteen days after first spray. The same trend of mortality was observed at second spray.

Maximum dry leaf yield was obtained in *Bacillus thuriengensis* @ 1 kg ha⁻¹ treated plots (1188 kg ha⁻¹) as against 666 kg ha⁻¹ dry leaf yield in the untreated control.

Efficacy of biopesticides in management of pod borer infestation

**TNAU, Coimbatore**: A field experiment was conducted to evaluate the bioefficacy of promising biopesticides such as neem oil, neem seed kernel extract, *Metarhizium anisopliae*, *Bacillus thuringiensis* and *Beauveria bassiana* for the management of pod borer in senna. Chlorpyriphos 20 EC was used as standard check, besides having an untreated check. The results revealed that
the pre-treatment count of pod borer ranged between 2.77 and 3.10 per plant. Among the five biopesticides evaluated, the post treatment counts recorded on 1, 3, 5, 7 and 14 days after spraying revealed that neem seed kernel extract 5 per cent showing maximum efficacy with the least number of pod borer, *Etiella zinckenella* per plant, followed by neem oil 3 per cent, *B. thuringiensis* @ 750 g ha^{-1} and *B. bassiana* @ 2 kg ha^{-1}, which were statistically at par in their efficacy. The pod borer count at one day after treatment (DAT) was as low as 1.23 in neem seed kernel extract @ 5 per cent treated fields. Chlorpyriphos 20 EC (standard check) @ 1.0 l ha^{-1} was significantly superior to all the other treatments, recording the lowest number of pod borer (0.05) at one day after treatment. The order of superiority was maintained in the same way in the post treatment counts on third, fifth, seventh and fourteenth day after treatments. Observations recorded on the efficacy of biopesticides on pod damage by pod borer, *Etiella zinckenella* revealed that *B. thuringiensis* @ 750 g ha^{-1} and neem seed kernel extract 5 per cent showed promising efficacy with the minimum pod damage (4.47 per cent) at 14 DAT, followed by neem oil 3 per cent (5.10 per cent), *M. anisopliae* @ 2 kg ha^{-1} (5.27 per cent), which were statistically at par in their efficacy. *B. bassiana* @ 2 kg ha^{-1} recorded maximum pod damage of 6.27 per cent. However, chlorpyriphos 20 EC (standard check) @ 1.0 l ha^{-1} was significantly superior to all the other treatments, with minimum pod damage of 4.13 per cent as against the maximum pod damage of 13.70 per cent in the untreated control.

**Effect of biopesticides application on leaf yield**

**TNAU, Coimbatore:** Results of field experiment on efficacy of bio-pesticides on leaf yield of senna revealed that neem seed kernel extract 5 per cent treated plots recorded maximum dry leaf yield of 1.40 kg per 24 m^{2} followed by neem oil 3 per cent and *Bacillus thuringiensis* @ 750 g ha^{-1} with the leaf yield of 1.37 kg per 24 m^{2}. *Beauveria bassiana* @ 2 kg ha^{-1} recorded the leaf yield of 1.35 kg per 24 m^{2} and were found to be statistically at par. Among the biopesticides, *Metarhizium anisopliae* @ 2 kg ha^{-1} treated plots yielded minimum leaf yield of 1.32 kg per 24 m^{2}. Treatment of chlorpyriphos 20 EC 1.0 l ha^{-1} was significantly superior among all the treatments yielding 1.44 kg per 24 m^{2} as against 1.24 kg per 24 m^{2} in the untreated control. Thus, foliar application of neem seed kernel extract 5 per cent showed maximum efficacy with the least number of pod borer, *Etiella zinckenella* (0.1 per plant), minimum pod damage (4.47 per cent) and maximum leaf yield (1.40 kg per 24 m^{2}) which was found to be statistically at par with standard chemical check.

**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, sesquiterpenes 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.

**Effect of organic manures on yield and quality**

**AAU, Anand:** Field experiment was conducted to study the effect of organic manures on yield and quality of tulsi consecutively for two years. Based on pooled data analysis, it was found that significantly higher plant height (109.75 cm) was with the application of FYM @ 15 t ha$^{-1}$ which was at par with the applications of castor cake @ 2.5 t ha$^{-1}$, vermicompost @ 7.5 t ha$^{-1}$ and castor cake @ 1.5 t ha$^{-1}$ (108.26, 107.41 and 103.50 cm). Number of branches per plant at harvest was also significantly influenced by application of different manures and significantly higher branches plant$^{-1}$ (18.10) was obtained with application FYM @ 15 t ha$^{-1}$ (18.75) and it was at par with application of castor cake @ 2.5 t ha$^{-1}$ (17.55) and vermicompost @ 7.5 t ha$^{-1}$ (17.54).

Application of FYM @ 15 t ha$^{-1}$ produced significantly higher fresh herbage yield (20.18 t ha$^{-1}$) in pooled basis analysis which was found at par with application of vermicompost @ 7.5 t ha$^{-1}$ (18.71 t ha$^{-1}$) and castor cake @ 2.5 t ha$^{-1}$ (19.50 t ha$^{-1}$). Significantly higher dry herbage yield was found with application of FYM @ 15 t ha$^{-1}$ (5.85 t ha$^{-1}$) which was at par with application of castor cake @ 2.5 t ha$^{-1}$ (5.66 t ha$^{-1}$) and vermicompost @ 7.5 t ha$^{-1}$ (5.42 t ha$^{-1}$). Effect of different level of organic manures was found non-significant with respect to the oil content (%) in both years as well as on pooled basis. Whereas the significantly higher oil yield (35.75 kg ha$^{-1}$) was recorded under application of FYM @ 15 t ha$^{-1}$ in the year 2015-16 which was at par with application caster cake @ 2.5 t ha$^{-1}$ (33.82 kg ha$^{-1}$) and vermicompost @ 7.5 t ha$^{-1}$ (32.61 kg ha$^{-1}$). During 2016-17 also, higher oil yield (42.07 kg ha$^{-1}$) was recorded under application of FYM @ 15 t ha$^{-1}$ which was at par with application of castor cake @ 2.5 t ha$^{-1}$ or 1.5 t ha$^{-1}$ (41.31 kg ha$^{-1}$ and 36.94 kg ha$^{-1}$).

**DRPCAU, Pusa:** A field experiment was conducted with objective to study the effect of organic manures *i.e.*, vermicompost @ 2.5 t ha$^{-1}$, mustard cake @ 1.0 t ha$^{-1}$, neem cake @ 1.0 t ha$^{-1}$, FYM @ 8 t ha$^{-1}$ and bio fertilizers *i.e.*, Azospirillum @ 2 kg ha$^{-1}$, PSB @ 5 kg ha$^{-1}$, Azospirillum @ 2 kg ha$^{-1}$+ PSB @ 5 kg ha$^{-1}$ on growth and herbage yield of tulsi. Result revealed that application of vermicompost @ 2.5 t ha$^{-1}$ inoculated with mixture of PSB @ 5 kg ha$^{-1}$+ Azospirillum @ 2 kg ha$^{-1}$ produced significantly higher herbage yield on fresh weight basis (16921 kg ha$^{-1}$).

**Integrated nutrient management**

**BAU, Islampur:** An experiment was conducted with objective to study the effect of nutrients management on growth and herbage yield of tulsi. The results showed that growth parameters and herbage yields of tulsi were significantly influenced by different nutrient management treatments. Significantly highest plant height (96.20 cm), number of branches plant$^{-1}$ (23.61), fresh herbage yield (14606 kg ha$^{-1}$) and dry herbage yield (3562 kg ha$^{-1}$) were recorded in plots where NPK @ 50:40:30 kg ha$^{-1}$ was applied along with FYM @ 10 t ha$^{-1}$. This treatment was found at par with 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$^{-1}$. All these treatments showed their superiority over the rest of the nutrient management treatments. Growth attributes and herbage yields of tulsi in control
plots were significantly lower than the treatments where inorganic fertilizers was used alone or integrated use of both organic and inorganic sources of nutrients was made. Integration of FYM with different levels of fertilizers produced comparatively higher growth parameters and herbage yields of tulsi than the application of fertilizers alone.

RVSKVV, Mandsaur: Field experiment was conducted to study the effect of different combination of organic manures and chemical fertilizers on herbage and oil yields of tulsi. Result revealed that the highest seed yield (1850 kg ha⁻¹) was recorded in application of 40% N through vermicompost+ rest by RDF and the lowest (750 kg ha⁻¹) in control, though under FYM treatments, the highest seed yield of 1400 kg ha⁻¹ was recorded in application of 20% N through FYM+ the rest by RDF.
**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, Sri Lanka, Pakistan, Malaysia, Thailand, Indonesia, Maldives, Vietnam and Papua New Guinea. In India it is cultivated in an area of about 50,000 ha. Betelvine or betel leaf is associated closely with the old traditions of India and it is considered as a holy plant. 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, diarrhoea, flatulence and to heal wounds, bruises, swellings due to sprains, respiratory disorders, constipations, boils and gum disorders. Recent studies also revealed that the leaf improves immune system and inhibits cancer growth.

**Collection, maintenance and evaluation of germplasm**

**ICAR-IIHR, Bengaluru:** Sixty germplasm lines and twenty hybrids were characterized for 11 qualitative and six quantitative traits. Variability for many traits was noted among the germplasm lines and hybrids. IIHRPBH 09-16 is a Hybrid selection from a poly cross of female clone IC-0617244 and four male clonal pollen IC-0617280, IC-0617281, IIHR BV 58 (CARI 6) and IIHR BV9 (Shirpurkata). The hybrid has light green attractive leaves. It is a very high yielding hybrid with a leaf yield of 90 lakh leaves ha\(^{-1}\) per year. It also possesses resistance to powdery mildew disease.

IIHRPBON 2 is a dwarf hybrid selection from population derived from a cross IC-0617279 and IC-0617280. The plant has dwarf plant stature with very short internodes. Mean plant height of the hybrid is 41 cm with 3.6 cm intermodal length. The plant can be grown in pots and with its dwarf growth habit and is suitable for ornamental potted plant.

IIHR BV 170 (Meetha pan) is a female clone under cultivation producing leaves with sweet taste. The genetic stock has unique sweet tasting leaves with higher chavicol (11%) and eugenol content in leaf essential oil. The clone produces female inflorescence can be used in hybridization programme as female parent to develop hybrids with useful traits.

**Intra and interspecific hybridization**

**ICAR-IIHR, Bengaluru:** The hybridization work in cultivars, germplasm lines and hybrids was continued among the selected parents. Twelve female clones, four male clones, four hybrids (female) and three male hybrids were used in the crossing programme. Ten inter varietal crosses, twelve crosses between varieties and hybrids and three inter-hybrid crosses were carried out. Fruit setting was observed in all the crosses. Fruits of different crosses were harvested and seeds were germinated. The germination per cent in 11 crosses ranged from 2 to 92 and higher germination was recorded in the cross Sirugamani 1/Hy09-13 (92%) followed by Hy 09-16/SwarnaKapoori (82%).
The crosses Gujarat Local/SwarnaKapoori and Hy 06-1/DobbespetAmbadi recorded very low germination per cent (2%). About 650 hybrid seedlings were raised and established in the polyhouse.

Interspecific hybridization between *P. betle* and *Phytophthora* resistant *P. colubrinum* was also being continued. A total of seven betelvine clones and one hybrid were used as female parents. Out of the eight crosses, fruit set was observed in two crosses with Hy 06-4 and Mysore local as female parents. Number of seeds per fruit, seed germination and the establishment of seedlings were very low in interspecific hybrids. The interspecific hybrids raised in previous year (Mysore Local/*P. colubrinum*, Bangla Nagaram/*P. colubrinum*, IIHR BV 96/*P. colubrinum* and Simurali Babna/*P. colubrinum*) were maintained under shade net.

**Evaluation of hybrids under shade net condition**

**ICAR-IIHR, Bengaluru:** Sixteen promising hybrids were evaluated for growth and yield traits under shade net conditions. Orthotropic leaf length varied from 10.28 to 14.00 cm and leaf breadth from 7.14 to 10.80 cm among the hybrids. Leaf petiole length varied from 3.93 to 6.43 cm and Hy 06-4 recorded the longest petiole followed by Hy 08-56 (6.43 and 6.23 cm). Leaf yield per vine varied from 52.75 to 129. Hy 07-36 and Hy 06-4 recorded higher leaf yield per vine (129 and 103 leaves per vine) followed by Hy 06-8 and 08-58 (91 and 77 leaves per vine).

**Standardization of organic farming practices**

**AAU, Jorhat:** A field experiment was conducted to study the effect of organic manures viz. FYM, vermicompost and neem cake on growth and yield of betelvine under Assam condition. One RDF as inorganic fertilizer was included for comparison. Local Assamiya pan was taken for the study. Significant increase in leaf length was observed in all the treatments over the control. Maximum leaf length was observed in application of neem cake @ 1.5 t ha⁻¹ (16.60 cm). Maximum leaf breadth of 14.77 cm was recorded in neem cake application @ 2.5 t ha⁻¹ while minimum (10.57 cm) was in the control. Leaf length/breadth ratio was highest in control (1.22). Number of marketable leaves was significantly increased due to different treatments and the highest number of leaves (118.66 leaves per plant) was recorded in application of neem cake @ 2.5 t ha⁻¹, however it was at par with application of neem cake @ 1.5 t ha⁻¹(113.66 leaves per plant).

**Effect of Zinc sulphate on crop yield**

**BAU, Islampur:** Experiment was conducted to study the effect of Zinc sulphate (ZnSO₄) on growth and yield attributes of betelvine. Application of Zinc sulphate in soil, responded better for production of betel leaves at all doses as compared to the control. Experimental data from the mean of four years revealed that soil application of Zn showed marked influence on number of marketable leaves vine⁻¹, number of branch vine⁻¹ and vine length as well as fresh leaves weight of 100 leaves as compared to control. Significantly higher number of betel leaf was recorded in the application of ZnSO₄ @ 30 kg ha⁻¹ (79.41 marketable leaves vine⁻¹) which was at par with 25 kg ZnSO₄ ha⁻¹ (76.20 marketable leaves vine⁻¹) and both of these treatments exhibited their superiority over rest of the treatments. The higher marketable leaves with application of ZnSO₄ was due to more
branching and vine length on account of adequate supply of micronutrient (zinc) and reduction of *Phytophthora leaf rot* and *Anthracnose leaf spot* disease (29.7% and 39.0%) over the control.

**Evaluation of hybrid lines for resistance to different diseases**

**BCKV, Kalyani:** The incidence of different diseases on nine betelvine hybrids at Kalyani was recorded. Percent disease index of leaf spot was calculated on a 0-5 scale where 0= no disease; 1= Up to 5% leaf area covered; 2= 6-15% leaf area covered, 3= 16-30% leaf area covered, 4= 31-50% leaf area covered and 5 = above 50% leaf area covered. Percent disease index of leaf rot was calculated on a 0-5 scale where 0= no or a few lesion on leaf; 1= Up to 10% leaf area affected; 2= 11-25% leaf area affected, 3= 26-50% leaf area affected, 4= 51-75% leaf area affected and 5 = above 75% leaf area affected. Percent disease incidence and percent disease index were also calculated.

The result showed that there were minor differences among the entries for disease incidence level and none of the entries under observation was completely free from diseases. The average vine mortality was 7.29% (Ghanagette) to 17.20% (PBH-08-23). The highest vine mortality due to foot rot was recorded in the month of October ranging from 12.50% (Ghanagette) to 19.35% (PBH-08-23) and the lowest was in the month of August ranging from 3.13% (Ghanagette) to 16.13% (PBH-08-23). The highest vine mortality was recorded in the month of October by 17.20% on PBH-08-23 and the lowest was on Ghanagette by 3.13% in the month of August. In general, it was noticed that the occurrence of vine mortality was lowest on Ghanagette and highest on PBH-08-23.

The incidence of leaf rot disease caused by *Phytophthora* was maximum in October ranging from 4.69% (Ghanagette) to 9.21% (PBH-06-1). Average percentage of disease severity (PDI) and incidence of leaf rot ranged from 3.58% (Ghanagette) to 7.19% (PBH-06-1) and 6.76% (Ghanagette) to 13.17% (PBH-06-1) respectively. In general, it was noticed that the occurrence of leaf rot was lowest in Ghanagette and highest on PBH-06-1. The incidence of leaf spot disease was maximum in the month of October ranging from 3.38% (Ghanagette) to 8.60% (PBH-06-11) and 10.45% (Ghanagette) to 25.14% (PBH-06-8), respectively. The average percentage of disease severity (PDI) and incidence of leaf spot was recorded from 2.58% (Ghanagette) to 6.88% (PBH-06-11) and 9.35% (Ghanagette) to 20.94% (PBH-06-8) respectively. In general, it was recorded that the occurrence of leaf rot was lowest in Ghanagette and highest on PBH-06-11 and PBH-06-8.

**Integrated management of soil borne diseases**

**BCKV, Kalyani:** A field experiment was conducted to find out the efficacy of different treatments of Bordeaux mixture, *Trichoderma* and *Pseudomonas fluorescens* applied in different combinations with time schedule in view of a broad objective to develop a technology of integrated management of soil borne diseases of betelvine. It was found that diseases were recorded maximum in the month of October in all the cases. The average mortality of vine was maximum (13.50%) in the check and was minimum (5.17) in the Control i.e., recommended practice of one application of Bordeaux mixture (1%) at pre-monsoon+ application of bio-control agent (*T. harzianum /viride*) after one month+ one additional application of Bordeaux mixture(1%) at two months after first Bordeaux mixture application. In case of diseases caused by *Phytophthora* leaf rot, the PDI and
the percentage of diseased leaf were minimum in application of Bordeaux mixture @1% + T. viride + Bordeaux mixture @ 1% i.e., 4.03% and 10.12% against maximum in the check, which were 11.56% and 24.82%, respectively. Similarly, in case of leaf spot disease, the PDI and the incidence on leaf were minimum in application of Bordeaux mixture @1% + T. viride + Bordeaux mixture @1% i.e., 4.46% and 13.65 against maximum in Check, i.e., 26.15% and 68.36%, respectively.

**Demonstration of disease management technology in the farmers’ field**

**BCKV, Kalyani:** Comparative performance of package of practice developed by BCKV and farmers’ practice for disease management in betel vine was studied. The trial was conducted in 12 farmers’ pan barojs at Simurali, Nadia covering an area of 150 m² of each baroj. The disease management technology developed by the centre comprised of sanitation, the application of Bordeaux mixture at pre monsoon, after one month biocontrol agent, one application of Bordeaux mixture 2 month after first Bordeaux mixture application. The farmer’s disease management practice was only sanitation. Disease incidence was recorded in both the treatments. The percent disease incidence of vine death, leaf spot and leaf rot were lower in the management practice developed by BCKV over the farmers’ management practices. In case of farmers’ practice, the average vine death was 20.54%, which was 4.48% in the practice developed by BCKV decreased by 78.20%. The PDI and incidence of leaf spot were 11.51% and 26.90% in farmers’ practice, respectively, and which were 2.22% and 6.24%, respectively, i.e., with a reduction of 80.73% and 76.80%, respectively in the practice developed by BCKV. Similarly, there were a reduction PDI and incidence of Phytophthora leaf rot by 85.19% and 83.31% by following the practice developed by BCKV over farmers’ practice.

**OUAT, Bhubaneswar:** Disease management technology developed by the Centre was demonstrated in the fields of 16 farmers of three coastal district of Odisha namely, Puri, Jagatsinghpur and Kendrapada. Each farmer was supplied with the critical inputs such as Copper sulphate @ 4 kg, Lime@ 4 kg, Trichoderma viride @ 3 kg, neem cake-75 kg and Mustard cke-75 kg for timely management of vine rot, leaf rot, anthracnose(fungal and bacterial) and nematode problems. The results of the demonstration conducted revealed that maximum number of leaves per plant of 33.14 lakhs ha⁻¹ was recorded in treated plots of Sri. Sudhi Ranjan Nayak of Jagatsinghpur district followed by 32.82 lakh ha⁻¹ of Sri Chandan Kumar Maiti of Kendrapada district. The highest fresh weight of 100 leaves (820gm) was recorded in the treated plot of Sri Gagan Kap of Puri district. The C:B ratio was found maximum in the treated plot of Mr. Sudhi Ranjan Nayak (1:1.82). Crop protection demonstration of betelvine disease management package developed by the Centre recorded higher leaf yield and profit with lesser incidences of diseases as compared to farmers’ practice.

**Biology of whitefly**

**BCKV, Kalyani:** Durations and of various life stages of whitefly, Singhiella pallid (Aleyrodidae: Hemiptera) was recorded. The female lay eggs along the margin on the lower leaf surface of tender leaves. The egg is with a stalk, branched at base. After hatching the empty shell, remains permanently attached with the leaf. First instar nymph is elongate-oval in shape with dull in color. After hatching 1st instars moves to short distance and fix itself. The puparium is thin papery whitish in colour. The exuvium of previous instar is attached on dorsum. The adults emerge from pupal
cases leaving the exuvae with ‘T’ shaped slit on the dorsum. The exuvae remain attached with leaves. Male is conspicuously smaller than the female. The colour of the fore wing is black with small whitish patches. The abdomen is dark red in colour. Total duration of egg to adult was about 31-38 days. The nymphal stages took 21-26 days.

**Life history and biology of Erythrina gall wasp**

**BCKV, Kalyani:** Life history and biology of newly invasive *Erythrina* gall wasp (EGW), *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae: Tetrastichinae) were studied in the laboratory. Female EGW had 9-13 ovarioles in an ovary. A three day old female was recorded to have of 78 - 192 ova in a pair of ovary with an average of 131 ova per female. The shape of the egg of EGW was tad pole like with long slender tail and the size ranges from 0.27 - 0.38 mm in length. Eggs were laid on soft tender plant parts by inserting inside the tissue mostly on the underside/ lower side of the leaf. Virgin females when released on young leaves, galls were found to develop indicating that EGW is capable of parthenogenetic reproduction. EGW mostly preferred soft tender leaves which still display juvenile green colour (10 day old leaf and 1.00 - 2.50 mm) for egg laying, and did not lay eggs on the leaf over the age of 30 days. It was observed that the pre-oviposition period ranged from 12 - 24 hours with an average of 20.50 hours, while the oviposition period continued till the death of the female. The incubation period lasted for 3-5 days with an average of 3.53 days.

The larvae of the wasp were apodous, creamy white in colour. On an average the size of full grown larva was 1.53 mm (1.29 - 1.71 mm) and a larval period of 13-17 days (av. 15.27 days). Pupal period lasted for 4-6 days. The pupa was creamy white to yellow in colour which later became darker with black bands on abdomen The size of pupa was 1.51 (1.23 - 1.63 mm). Wasp larvae developed and pupated inside the galls and emerged by tunneling through tissue to the outside. Major eclosion took place during day hours (94.08%). Most of the eclosion happened between 0700 and 1000 hours which accounted for 64.15% of the total eclosion.

The *Erythrina* gall wasp shows dimorphism in body color. The female is yellowish brown, the male is white, and both have dark brown markings. The size of the female ranged from 1.40-2.00 mm and that of male ranged from 1.00-1.70 mm. The total life cycle was completed in 20-28 days with an average of 24.06 days in different seasons of a year. The longevity of the adult male and female was not similar. Females were found to have longer longevity (4 -7 days) with an average of 5.27 days than the males which lives only for 1-3 days with an average of 1.63 days. Female longevity was longer when supplied with supplementary nutrition, but male was not affected. The sex ratio of adults emerged from galls was 4.4 males for one female.

**Studies on differential susceptibility of hybrid lines to aleyrodid flies**

**BCKV, Kalyani:** The screening of betelvine hybrids against whitefly was carried out in *boreja*. Nine lines were evaluated. The results showed that the overall populations of aleyrodid flies were medium (14-26 flies/vine). None of the entries under observation was completely free from fly infestation. Among the nine hybrid lines, PBH- 08-23, PBH-06-8 and PBH-07-24 had comparatively less number of flies (around 15-16 flies / vine). Rest of the six lines recorded higher numbers of flies (>15 flies/vine).
Evaluation of biopesticides against aleyrorid flies

BCKV, Kalyani: Various biopesticides were tested against aleyrorid white flies. The effect of neem oil (0.5%), karanja oil (0.3%), neem oil (0.3%) + karanja (0.2%) and mineral oil (0.3%) along with two synthetic insecticide checks i.e., dichlorvos (0.05%) and imidachloprid (0.3 ml l⁻¹) on betelvine whiteflies (Aleyrodidae: Hemiptera) was evaluated. Since whitefly preferred the undersides of leaves, all leaf surfaces were thoroughly sprayed to ensure uniform distribution of pesticides. Insect populations were estimated at pre-treatment, 5 DAS, 10 DAS and 15 DAS. Differences in abundance of whitefly among the treatments were subjected to analysis of variance. The result showed that the tested pesticides significantly reduced the populations of the whitefly compared to the untreated plot. Imidachloprid (check) was the most effective insecticide against the population of the whitefly. Neem oil or neem+ karanja oil was also suitable for controlling whiteflies. However, mineral oil was found not effective.
Germplasm of medicinal and aromatic plants maintained at ICAR-DMAPR

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Accessions</th>
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<tbody>
<tr>
<td>Aloe spp. (Aloe)</td>
<td>100</td>
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<tr>
<td>Andrographis paniculata (Kalmegh)</td>
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<tr>
<td>Asparagus spp. (Shatavari)</td>
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<td>Cassia angustifolia (Senna)</td>
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<td>Chlorophytum borivilianum (Safed Musli)</td>
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<td>Commiphora spp. (Guggal)</td>
<td>225</td>
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<tr>
<td>Costus speciosus (Keukand)</td>
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</tr>
<tr>
<td>Cymbopogon spp. (Pamarosa &amp; Lemongrass)</td>
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</tr>
<tr>
<td>Desmodium gangeticum (Salaparni)</td>
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<tr>
<td>Gymnema sylvestre (Gudmar)</td>
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<td>Hemidesmus indicus (Anantamul)</td>
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<tr>
<td>Ocimum spp. (Basil, Tulsi, etc)</td>
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<td>Plantago spp. (Isabgol)</td>
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<td>Tinospora cordifolia (Giloe)</td>
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<tr>
<td>Withania somnifera (Ashwagandha)</td>
<td>272</td>
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<td><strong>Total</strong></td>
<td><strong>1884</strong></td>
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(Project 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. P.L. Saran, Dr. N. Reddy, Dr. V. Thondaiman, Dr. Hemlata Bharti, Dr. Akula Chinnapoliah, Mr. Manish Kumar Mittal)

Germplasm enhancement

During the year 2017-18, ten accessions of Desmodium gangeticum were collected from Gujarat and West Bengal region. The collected accessions are under multiplication in the field gene bank for further evaluation studies. Apart from this 71 accessions in different Medicinal and Aromatic Plants including 11 in Aloe (Aloe barbadensis) were explored and collected from Tamil Nadu in collaboration with NBPGR, New Delhi. Other than Aloe, Withania somnifera (8), Andrographis paniculata (4), Gymnema sylvestre (3); Coleus forskohli (3); Mamejo (Enicostemma axillare); (2) Cymbopogon spp. (2); Safed musli (Chlorophytum borivilianum) (1), Senna (Cassia angustifolia) (1) were also collected and documented. (Project 01: Conservation, characterization and utilization of genetic resources of medicinal and aromatic plants for sustaining production; Investigators: Mr. Manish Kumar Mittal; Dr. Thondaiman)

Apart from this, in Costus speciosus survey was conducted in West Bengal, Maharashtra, Gujarat, and Andra Pradesh and 15 accessions each of Hemidesmus indicus and Costus speciosus were collected. The collected accessions are under multiplication for further studies. (NASF project: Chemotyping and molecular profiling of bioactive metabolites in Hemidesmus indicus and Costus speciosus)
Survey and exploration of Gymnema sylvestre was carried out during the current year with collaboration of NBPIGR, Regional Station Akola. Seventeen accessions from Betul, Chhindwara, Seoni and Balaghat districts of Madhya Pradesh were collected. These collections were maintained at nursery for establishment of seedlings for transplanting to the main field. (NMPB funded project: Sustainable production technology of gudmar (Gymnema sylvestre R. Br.) a medicinal plant with antidiabetic compound gymnemagin; Investigator: Dr. Akula Chinapolaiah)

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

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<tr>
<th>Crop</th>
<th>Centre</th>
<th>No. of accessions</th>
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<td>Aloe (Aloe barbadensis)</td>
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<td>CCSHAU, Hisar</td>
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<td></td>
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<td>KAU, Thrissur</td>
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<td></td>
<td>BCKV, Kalyani</td>
<td>02</td>
</tr>
<tr>
<td>Bach (Acorus calamus)</td>
<td>TNAU, Coimbatore</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Dr. YSRHU, Venkataramanagudem</td>
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<tr>
<td></td>
<td>AAU, Jorhat</td>
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<td></td>
<td>UBKV, Kalimpong</td>
<td>7</td>
</tr>
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<td>Ban kakdi (Podophyllum hexandrum)</td>
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<td>12</td>
</tr>
<tr>
<td>Basil (Ocimum basilicum)</td>
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<td>13</td>
</tr>
<tr>
<td>Crop</td>
<td>Centre</td>
<td>No. of accessions</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------------------------------------</td>
<td>-------------------</td>
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<tr>
<td>Bitter snakegourd (<em>Tricosanthes cucumarina</em>)</td>
<td>KAU, Trichur</td>
<td>19</td>
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<td>Brahmi (<em>Bacopa monnieri</em>)</td>
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<td>43</td>
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<td></td>
<td>RAU, Pusa</td>
<td>14</td>
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<tr>
<td>Chitrik (<em>Plumbago</em> spp)</td>
<td>KAU, Trichur</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>TNAU, Coimbatore</td>
<td>45</td>
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<tr>
<td>Chirayita (<em>Swertia chirayita</em>)</td>
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</tr>
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<td>Curcuma spp</td>
<td>AAU, Anand</td>
<td>40</td>
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<tr>
<td>Daruharidra (<em>Berberis aristata</em>)</td>
<td>UUHF, Bharsar</td>
<td>2</td>
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<tr>
<td>Giloe (<em>Tinospora cordifolia</em>)</td>
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<td>07</td>
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<tr>
<td></td>
<td>BCKV, Kalyani</td>
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<tr>
<td></td>
<td>Dr. YSRHU, Venkataramannagudem</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>CCSHAU, Hisar</td>
<td>20</td>
</tr>
<tr>
<td>Glory lily (<em>Gloriosa superba</em>)</td>
<td>TNAU, Coimbatore</td>
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<td>AAU, Anand</td>
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<tr>
<td></td>
<td>MPUAT, Udaipur</td>
<td>16</td>
</tr>
<tr>
<td>Harde (<em>Terminalia chebula</em>)</td>
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<td>Henbane (<em>Hyoscyamus niger</em>)</td>
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<td>Indian valeriana (<em>Valeriana jatamansi</em>)</td>
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<td>Isabgol (<em>Plantago ovata</em>)</td>
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<td>CCSHAU, Hisar</td>
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<td>RVSKVV, Mandsaur</td>
<td>80</td>
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<td>Kalmegh (<em>Andrographis paniculata</em>)</td>
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<td>CCSHAU, Hisar</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>OUAT, Bhubaneshwar</td>
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<td>IGKV, Raipur</td>
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<td>Kaucha (<em>Mucuna pruriens</em>)</td>
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<td>BAU, Ranchi</td>
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<tr>
<td>Kasni (<em>Cichorium intybus</em>)</td>
<td>HAU, Hisar</td>
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<td>Kuth (<em>Picrorhiza kurroa</em>)</td>
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<tr>
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<td>UUHF, Bharsar</td>
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<td>Crop</td>
<td>Centre</td>
<td>No. of accessions</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------</td>
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<td><strong>Lemongrass (Cymbopogon spp.)</strong></td>
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<tr>
<td></td>
<td>NDUAT, Faizabad</td>
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<td><strong>Long pepper (Piper longum)</strong></td>
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<td>AAU, Jorhat</td>
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<td><strong>Lotus (Nelumbo nucifera)</strong></td>
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<td><strong>Madhunashini (Gymnema sylvestre)</strong></td>
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<tr>
<td></td>
<td>BAU, Ranchi</td>
<td>18</td>
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<tr>
<td><strong>Makoi (Solanum nigrum)</strong></td>
<td>Dr. YSRHU, Venkataramannagudem</td>
<td>46</td>
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<tr>
<td></td>
<td>TNAU, Coimbatore</td>
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<tr>
<td></td>
<td>AAU, Anand</td>
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<tr>
<td><strong>Mandookaparni (Centella asiatica)</strong></td>
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<td></td>
<td>RAU, Pusa</td>
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<tr>
<td></td>
<td>UBKV, Kalimpong</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>BCKV, Kalyani</td>
<td>5</td>
</tr>
<tr>
<td><strong>Mentha species</strong></td>
<td>AAU, Anand</td>
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<tr>
<td><strong>Pashanbhed (Berginia ciliata)</strong></td>
<td>UBKV, Kalimpong</td>
<td>17</td>
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<tr>
<td><strong>Neel (Indigofera tinctoria)</strong></td>
<td>KAU, Trichur</td>
<td>22</td>
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<td><strong>Opium poppy (Papaver somniferum)</strong></td>
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<td><strong>Palmarosa (Cymbopogon martinii)</strong></td>
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<tr>
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<td>PDKV, Akola</td>
<td>13</td>
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<tr>
<td><strong>Periwinkle (Catharanthus roseus)</strong></td>
<td>AAU, Anand</td>
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<tr>
<td><strong>Salaparni (Desmodium gangeticum)</strong></td>
<td>KAU, Trichur</td>
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<tr>
<td><strong>Safed musli (Chlorophytum borivilianum)</strong></td>
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<tr>
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<td>12</td>
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<td>MPUAT, Udaipur</td>
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<td>RVSKVV, Mandsaur</td>
<td>24</td>
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<tr>
<td></td>
<td>PDKV, Akola</td>
<td>13</td>
</tr>
<tr>
<td><strong>Sarpgandha (Rauvolfia serpentina)</strong></td>
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<td>37</td>
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<tr>
<td></td>
<td>IGKV, Raipur</td>
<td>12</td>
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<tr>
<td></td>
<td>BAU, Ranchi</td>
<td>38</td>
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<tr>
<td>Crop</td>
<td>Centre</td>
<td>No. of accessions</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Shatavari (Asparagus racemosus)</td>
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</tr>
<tr>
<td></td>
<td>AAU, Anand</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>JNKVV, Jabalpur</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>MPKV, Rahuri</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>NDUAT, Faizabad</td>
<td>24</td>
</tr>
<tr>
<td>Senna (Cassia angustifolia)</td>
<td>AAU, Anand</td>
<td>17</td>
</tr>
<tr>
<td>Sylium (Silybum marianum)</td>
<td>AAU, Anand</td>
<td>10</td>
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<tr>
<td>Tulsi (Ocimum sanctum)</td>
<td>CCSHAU, Hisar</td>
<td>12</td>
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<tr>
<td></td>
<td>AAU, Anand</td>
<td>9</td>
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<tr>
<td>Vetiver (Vetiveria zizaniodes)</td>
<td>CCSHAU, Hisar</td>
<td>50</td>
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<td></td>
<td>KAU, Trichur</td>
<td>37</td>
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<tr>
<td></td>
<td>NDUAT, Faizabad</td>
<td>12</td>
</tr>
<tr>
<td>Wild marigold (Tagetes minuta)</td>
<td>YSPUHF, Solan</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>UBKV, Kalimpong</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3441</strong></td>
</tr>
</tbody>
</table>

**Germplasm of Betelvine being maintained at AICRP MAP&B centres**

<table>
<thead>
<tr>
<th>Centres</th>
<th>No. of accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAU, Jorhat</td>
<td>30</td>
</tr>
<tr>
<td>BAU, Islampur</td>
<td>10</td>
</tr>
<tr>
<td>BCKV, Kalyani</td>
<td>54</td>
</tr>
<tr>
<td>ICAR-IIHR, Bengaluru</td>
<td>121</td>
</tr>
<tr>
<td>JNKVV, Jabalpur</td>
<td>3</td>
</tr>
<tr>
<td>MPKV, Rahuri</td>
<td>28</td>
</tr>
<tr>
<td>OUAT, Bhubaneswar</td>
<td>21</td>
</tr>
<tr>
<td>RAU, Pusa</td>
<td>10</td>
</tr>
<tr>
<td>Dr. YSRHU, Venkataramannagudem</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

Twenty seven explorations were undertaken in various MAP&B crops and collected 238 germplasm accessions in 22 MAP&B species viz., aloe (5), asalio (3), aswagandha (13), bach (10), basil (1), betelvine (10), chirayita (3), daruhaidra (2), tagetus (3), glory lily (32), harde (24), Indian valerian (2), isabgol (10), kalmegh (10), kuth (20), long pepper (4), madhunashini (18), mandonkaparni (3), pashanbhed (7), palmarosa (13), sarpagandha (40) and tusli (3) at various AICRP-MAP&B centres. A total of 3782 accessions are being maintained at various centres.
General Information
COMMITTEE MEETINGS

Institute Research Committee (IRC)

Institute Research Committee (IRC) meeting was held under the chairmanship of Dr. P. Manivel, Director (Acting) on 25.07.2017. Dr. P. Manivel, Member Secretary, IRC appraised the house about the purpose of conducting this IRC and requested the PIs of the project to present the progress of the projects. Accordingly, presentations were made by the scientists for seven main projects and one flagship programme. Progress reports of externally funded projects were also made by the respective PI/Co-PI. The IRC thoroughly reviewed the progress of each project and made suggestions and recommendations for achieving the targeted goals efficiently. The IRC also reviewed the progress made in the externally funded projects which were in operation in the Directorate. One variety in isabgol (DPO-4) and two varieties in ashwagandha (DWS-132 and DWS-135) were recommended as superior varieties at Institute level in the meeting. A special IRC meeting was conducted on 16.03.2018 and work and action plan were formulated on the recommendations of the RAC. Dr. P. Das, Chairman, RAC was the special invitee for the meeting.

Quinquennial Review Team (QRT) meetings

As per the Indian Council of Agricultural Research (ICAR), New Delhi vide Office Order F.No.1 (13)/2016-IA.V dated 14th September, 2017, a Quinquennial Review Team (QRT) was constituted to review the work done during the period from 1.4.2011 to 31.3.2016 of the ICAR Directorate of Medicinal and Aromatic Plants Research (DMAPR), Anand, Gujarat and All India Coordinated Research Project on Medicinal Aromatic Plants & Betelvine (AICRPMAP&B). Dr. H. S. Gupta, Formerly Director General, Borlaug Institute for South Asia (BISA) was the Chairman and Dr. EVS Prakasa Rao, Formerly Head, CIMAP, Bangalore; Dr. Harihar Ram, Formerly Professor, Vegetable Division, GBUAT, Pantnagar; Dr. (Mrs.) Vidya S. Gupta, Formerly Head, Biological Sciences, National Chemical Laboratory, Pune and Dr. A. K. Shasany, Sr. Principal Scientist were the members and Dr. P. Manivel, Principal Scientist & Acting Director, DMAPR was the Secretary.

The QRT review started with a preliminary meeting with Dr. A.K. Singh, DDG (Horticulture.) on 6th October 2017 at KAB II, ICAR, New Delhi. Dr. H. S. Gupta, Chairman QRT and Dr. P. Das, Chairman, RAC of DMAPR, Dr. P. Manivel, Secretary, QRT and Dr. T. Janakiram, ADG (Hort-II) attended the meeting. Subsequently the team visited the ICAR- DMAPR, Anand on 29th November 2017 and reviewed the work progress of ICAR-DMAPR. The performance of AICRP centers were reviewed at four places viz., at TNAU, Coimbatore (04.01.2018), NAAS Complex, New Delhi (18-20 January, 2018), OUAT, Bhubaneswar (06-09 February, 2018) and ICAR-DMAPR, Anand (12-14 March, 2018). The team had in-depth discussion with the Director and Scientists of the Directorate and suggested some
useful areas for improvement of the ongoing research programmes. After the discussion, the QRT congratulated the Director, Scientists and Staff of the Directorate for their significant achievements in research and infrastructure development. The QRT submitted a detailed observations and recommendations in the final report submitted to the ICAR.

Research Advisory Committee (RAC)

The fifteenth RAC meeting of ICAR-Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR) was held on 01st November, 2017 at ICAR-DMAPR, Boriavi, Anand (Gujarat) under the chairmanship of Prof. P. Das, Director, Science Foundation for Tribal and Rural Resource Development, Bhubaneswar, Odisha. The meeting was attended by the following RAC members and special invitees i.e., Dr. Janakiram ADG (HSI), ICAR, New Delhi, Member; Dr. S. Bhaskar ADG (AA&CC), ICAR, New Delhi, Member; Dr. Veena Gupta, Principal Scientist, NBPGR, New Delhi, Member; Dr. N. Ramachandran, Former Head (Plant Pathology), IIHR Bengaluru, Member; Dr. Madhuban Gopal, Emeritus Scientist, ICAR, New Delhi, Member; Prof. Malati G. Chauhan, Former Dean, Gujarat Ayurved University, Jamnagar, Special Invitee; Dr. Vandana D. Modi, Vice President, Cadila Pharmaceuticals, Ahmedabad, Special Invitee and Dr. Geetha K.A., Principal Scientist, ICAR-DMAPR, Anand, Member Secretary. Dr Geetha K A, Member Secretary welcomed the members and special invitees of RAC to the 15th RAC meeting. Prof P. Das, Chairman, RAC appraised the house about the critical role of RAC meetings. He highlighted the growing importance and the thrust put by Government of India on Indian Medicinal and Aromatic plants. The increasing demand of Indian medicinal and aromatic plants world over is indicative of the popularity of our rich and diverse medicinal and aromatic plant resources. It is high time that scientists, related industries and government establishments come together to promote IMAP resources for the benefit of farmers in particular and the country in general. Since quality parameters of the raw drug are of prime importance, fakes and substitutes should be checked out to ensure quality for better acceptability in international markets. Dr. P. Manivel, Director, ICAR-DMAPR, Anand welcomed the members and briefly presented the achievements of DMAPR since last meeting held on April 25, 2016. He also appraised the committee about action taken on the recommendations made by the RAC on April 25, 2016. Thereafter, the achievements made in individual projects during the last one year were presented by Dr. P. Manivel. After thorough discussions on the presentations of different research projects, future research activities of the Directorate were meticulously planned in the meeting. The meeting ended with thanks to the Chair.

Annual Group Meeting of AICRP-MAP&B

The XXV annual group meeting of All India Co-ordinated Research Project on Medicinal and Aromatic Plants & Betelvine (AICRP-MAP&B) was held at the Maharana Pratap University of Agriculture and
Technology (MPUAT), Udaipur, Rajasthan. Dr. T. Janakiram, Assistant Director General (Hort. Science), Indian Council of Agricultural Research (ICAR), New Delhi inaugurated the group meeting on November 11, 2017 at MPUAT, Udaipur. Dr. B.S. Chundawat, Formerly Vice Chancellor, Sardar Krishinagar Dantiwada Agriculture University (SKDAU), Dantiwada, Gujarat was the Chief Guest and Prof. U. S. Sharma, Vice Chancellor, MPUAT, Udaipur was the president of the function. Dr. P. Manivel, Project Co-ordinator, AICRP-MAP&B (acting) and Dr. A.K. Mehta, Director of Research, MPUAT, Udaipur were also present on this occasion. Dr. P. Manivel, presented the research achievements of the AICRP-MAP&B for the past one year and also highlighted the actions taken for the implementation of the technical programme of the project. Dr. T. Janakiram, in his address said that horticulture crops play an important role in doubling the farmers’ income in which medicinal and aromatic plants play vital role. He suggested some future thrust areas of research viz., control of raw drug adulteration, conservation of MAPs and effect of climate change in MAPs. Dr. B.S. Chundawat, in his address said that health care facilities were still lacking in villages; right information on MAP play vital role in ensuring comprehensive healthcare of the village people. Dr. U.S. Sharma, in his address highlighted the importance of MAPs in the economy of Rajasthan. During the 4-days’ deliberations, research achievements and future technical programme of AICRP-MAP&B project was reviewed in different technical sessions such as Crop Improvement, Crop production, Crop protection and Phytochemistry. A new isabgol variety “Vallabh Isabgol-1” developed by the ICAR-DMAPR, Anand was identified for national release. Besides, 39 publications of AICRP-MAP&B centers were released during the workshop. Tamil nadu Agricultural University, Coimbatore and Anand Agricultural University, Anand bagged “The Best AICRP-MAP&B centre award” for the year for their significant research contributions. The workshop was attended by more than 120 participants across India.

**Foundation day celebration**

ICAR-Directorate of Medicinal and Aromatic Plants Research celebrated its 27th Foundation Day on November 24, 2017. The inaugural session of this event was held at the Auditorium of ICAR-DMAPR. Awards were distributed to winners in different activities like sports, punctuality, etc.

**Vigilance awareness week**

The Vigilance Awareness Week was organized at ICAR-DMAPR from October 30th to November 04th, 2017 with the theme “My Vision-Corruption Free India”. An Integrity pledge ceremony was organized on October 30, 2017 for Citizen and Organization by Dr. Raghuraj Singh, Scientist and Co-Chairman of the Organizing Committee in which the Director and all the staff of ICAR-DMAPR took the oath.

A one day workshop was also organized during the Vigilance Awareness Week with the targeted theme on November 03, 2017 by the organizing committee. The Workshop was inaugurated by the
Director, ICAR-DMAPR. The welcome address of the workshop was delivered by Dr. Singh to the participants on behalf of the organizing committee. A lecture on “Brashtachar: Prakaar, Kaaran and Nivaaran” was also delivered by Dr. Singh. He described about different types of corruptions (Brashtachar), their causes (kaaran) and remedies (nivaaran) by emphasizing on different aspects to make corruption free India. After this event, Dr. P. Manivel, Director was invited to address the gathering about the workshop. He mentioned many practical aspects of the life to make corruption free India and emphasized to follow the rules and truth in life and their role in making the organization corruption free. The workshop ended with a vote of thanks proposed by Mr. Vijay Kumar, Administrative Officer and Member Secretary of the Organizing Committee.

**Institute Germplasm Identification Committee (IGIC)**

Field visit of IGIC (Institute Germplasm Identification Committee) was conducted on 12.01.2018 in kalmegh breeding block under the chairmanship of Dr. P Manivel, Director, ICAR-DMAPR, Anand. During the visit, observation and discussion were carried out on verification of unique trait viz. feathery canopy, in accession DMAPR AP 35-1 which was identified from accession DMAPR AP 35 by Dr K A Geetha, Principal Scientist.

**Institute Management Committee (IMC)**

The thirty first and 32nd IMC meetings were organized on 02.08.2017 and 13.03.2018, respectively at ICAR DMAPR.

**Official Language Implementation Committee**

हिन्दी समाधान

निदेशालय की राजभाषा कार्यान्वयन समिति के तत्त्वाधार में 08-14 सितंबर, 2017 के दौरान हिन्दी समाधान हर्षोलास से मनाया गया, जिसके अन्तर्गत हिन्दी के प्रयोग को बढाया देने हेतु अनेक सुचिकर कार्यक्रमों का आयोजन किया गया। इस दौरान हिन्दी निबंध, हिन्दी पत्रलेखन, सामान्य हिन्दी झान, हिन्दी झान प्रशोधक, व्याख्यान व कार्यपात्र प्रतियोगिताओं में आयोजित की गई।

हिन्दी समाधान का प्रारंभ 08 सितंबर, 2017 को हिन्दी पत्रलेखन प्रतियोगिता के साथ प्रारंभ किया गया। हिन्दी समाधान के दौरान हिन्दी दिवस समारोह (14 सितंबर, 2017) को जोर-शोर से मनाया गया। इस अवसर
Institute Technology Management Unit (ITMU)

Patent application filed

<table>
<thead>
<tr>
<th>Application No.</th>
<th>Title of patent</th>
<th>Date of Filing/Registration</th>
<th>Name of Inventors</th>
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<tbody>
<tr>
<td>201811011217</td>
<td>A phosphorus enriched vermi-compost composition and its method of preparation</td>
<td>27.03.2018</td>
<td>Dr. B. B. Basak, Dr. Narendra Gajbhiye, Dr. Ajoy Saha and Dr. P. Manivel</td>
</tr>
</tbody>
</table>
IP generated

- Isabgol leaf transcriptome information has been deposited at the National Center for Biotechnology Information (NCBI) BioProject database (Short Read Archive) under Bioproject number PRJNA382334 with BioSample accessions SAMN06704580, SAMN06704581, SAMN06704582, SAMN06704583 and the Transcriptome Shotgun Assembly (TSA) at DDBJ/EMBL/GenBank under the accession GFNS00000000.

- Two-germplasm accessions viz., DCA-121 (IC0610825; INGR17079): a small pod size genetic stock and DCA-124 (IC0610826; INGR17080): A broad pod and leaves germplasm were registered as trait specific germplasm of senna at the national genebank.

- DPO-9 (IC0623443; INGR17055): An extended bract mutant of Isabgol was registered as trait specific germplasm at the national genebank.

- DWS-37 (IC0623444; INGR17056): A revolute leaf type pure line and DWS-127 (IC0623445; INGR17057): yellow young leaf plant type was registered as trait specific germplasm at the national genebank.

EXTENSION ACTIVITIES

ICAR-DMAPR Tribal Sub-Plan (TSP)

The Directorate is implementing TSP for the “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 tribals about the medicinal plants, their importance and uses in homemade medicines for primary health care and wellbeing. In the year 2017-18, villages of Jambughoda tehsil in Panchmahal district and Chhota Udepur were covered under the TSP activities. To encourage the cultivation of MAPs, the Directorate had distributed seeds and seedlings of medicinal plants to the beneficiary farmers. About 60000 aloe suckers were distributed to the farmers and six Field Demonstration Trials (FLDs) incorporating agroforestry model were given successfully. Based on the demonstration, some innovative tribal farmers have initiated cultivation of Aloevera in Chota Udepur.

Training programme on Conservation, cultivation and post harvest management of medicinal and aromatic plants

A 3-day training programme on Conservation, cultivation and post harvest management of medicinal and aromatic plants was organised at Tamil Nadu Agricultural University (TNAU), Coimbatore during June 28-30, 2017. The training was organised by ICAR-DMAPR with the financial support from
National Medicinal Plants Board (NMPB), New Delhi. The objective of the training programme was for the capacity building and to disseminate the key principles of conservation, cultivation and post harvest management of medicinal and aromatic plants (MAP) to the stakeholders. During the three days deliberations, different aspects of MAP like, conservation, collection, cultivation, pest & diseases management, post harvest management and value addition were covered, keeping in view the GACP as the central theme. A video film on GACP of MAP developed jointly by FAO and DMAPR was shown during the programme. A total of 50 medicinal and aromatic plants cultivating farmers from various districts of Tamil Nadu and 20 officers from agricultural universities and state departments participated in the event.

**Glory lily progressive farmer felicitated**

Mr. V. Tamilarasan, Kappalpatty, Odanchatram Taluk, Dindigul district, Tamil Nadu, a progressive farmer cultivating glory lily (*Gloriosa superba*) was felicitated during the inaugural function of the training program on Conservation, Cultivation and Post Harvest Management of Medicinal and Aromatic Plants organised at Tamil Nadu Agricultural University (TNAU), Coimbatore during June 28-30, 2017 for achieving record high seed yield in glory lily. He could achieve 300 kg seeds per acre with a total income of ₹ 9.00 lakh per acre under dry land cultivation with supported irrigation with the guidance of AICRP-MAP&B centre, DMAC, TNAU, Coimbatore. On behalf of the Directorate and TNAU, Dr. K. Ramasamy, Vice Chancellor, TNAU, Coimbatore presented the certificate of appreciation to the progressive farmer.

**Training on cultivation of remunerative MAPs**

Another one-day farmers training for farmers under transfer of technology programme entitled “Cultivation of remunerative MAPs” during July 22, 2017 at Valasan by the Directorate under central sector scheme (CSS). Seventy-seven participants were selected for the training from different villages of Valasan, Sandesar, Pipadata, Dehedakuva, Vahedav, Padgol, Singdav, Sarsa etc. The farmers and experts were formally welcomed by Ms. Riddhi Patel. Dr. P. L. Saran, Senior Scientist, DMAPR presented an introduction of the scheme along with information on cultivation
practices and economics of MAPs cultivation. Disease management of MAPs was explained by Dr. R.P. Meena and good agricultural practices for MAPs by Dr. K.A. Kalariya. The Dr. P. Manivel, Director, DMAPR, Boriavi delivered a lecture on MAPs seed production as a remunerative venture. The Sarpanches of these villages share their previous experiences of MAP cultivation with the Directorate. The message of “Mera Gaav Mera Gaurav” (MGMG) and Swacch Bharat Mission were also conveyed to the farmers. At the end of the programme vote of thanks was given by Shri. S.B. Prajapati.

Training on cultivation of perennial MAPs

A one-day farmers’ training was organized for MAP farmers under the transfer of technology programme entitled “Cultivation of perennial MAPs” during August 11, 2017 at Khansol by the Directorate under central sector scheme (CSS). Seventy-five participants were selected for the training from different villages of Khansol, Pandoli etc. The training programme was started with the Welcome address by Ms. Riddhi Patel, Senior Research Fellow. Dr. P.L. Saran, Senior Scientist, DMAPR presented an introduction of the scheme along with information on cultivation of perennial MAPs and economics of its cultivation. Disease management of MAP was explained by Dr. R.P. Meena and good agricultural practices (GAP) for MAPs was presented by Dr. K.A. Kalariya and Dr. Raghuraj Singh delivered a lecture on post harvest management practices of MAPs. The Sarpanches of these villages shared their previous experiences of MAP cultivation with the Directorate. The message of “Mera Gaav Mera Gaurav” (MGMG) and Swacch Bharat Mission were also conveyed to the farmers. At the end of the programme vote of thanks was given by Shri. S.B. Prajapati.

Training on cultivation and primary processing of MAPs

One-day farmers training on “Cultivation and primary processing of MAPs” for MAP farmers was organized under transfer of technology programme during August 28, 2017 at Mehashana by the Directorate under central sector scheme (CSS). Seventy-four participants were selected for the training from different villages of Chhathiaarada, Motap, Hebuva etc. The different aspects of MAPs were covered through expert lectures. Dr. P.L. Saran, Senior Scientist, DMAPR presented an introduction of the scheme along with processing and
economics of MAPs cultivation. Organic cultivation of MAPs was explained by Dr. B.B. Basak and good agricultural practices for MAPs by Dr. K.A. Kalariya. Dr. P. Manivel, Director, DMAPR, Boriavi delivered a lecture on seed production and storage. The Sarpanch and progressive farmers shared their previous experiences of MAP cultivation with the Directorate. The message of MGMG and Swacch Bharat Mission was conveyed to the farmers. At the end of the programme, vote of thanks was given by Shri. S.B. Prajapati.

Seminar cum stakeholders meet under Central sector scheme

Two days district level seminar cum stakeholders meet on MAPs was organized during September 14-15, 2017 under Central Sector Scheme, was organized by the ICAR-DMAPR. The aim of the seminar was to provide platform to stakeholders and transfer of technology to farmers through trainings with enhancing knowledge by recent development in MAPs. Two hundred fifty-one farmers participated from Anand as well as from different parts of Gujarat. We have covered all aspects of MAPs viz., cultivation, QPM production, GACP, organic cultivation, improved varieties, PHT, quality primary processing and supply chain/ marketing through presentation by 13 experts, two progressive farmers, three personnel from the Industry along with one field visit. In the end of the programme a panel discussion was also arranged involving farmers, scientific personals, state officer and the traders on a single platform where they exchanged their views and ideas. This helped the farmers to upgrade their knowledge about market availability and economic feasibility. The program was concluded by Dr. P.L. Saran, organizing Secretary, Dr. K.A. Kalariya, Coordinator and Dr. R.P. Meena, Coordinator.

Training on MAPs cultivation in sea affected waste land

One-day tribal farmers training on "MAPs cultivation in sea affected Waste land" was conducted for farmers under transfer of technology programme entitled during December 21, 2017 at Tankari, Jambusar, Bharuch" by the Directorate under central sector scheme (CSS). Fifty-one participants were selected for the training from different villages of Jambusar etc. In this training programme, the farmers and experts were welcomed by Dr. R.P. Meena. Different cultivation aspects
of MAPs were covered through expert lectures. Dr. P.L. Saran, Senior Scientist, DMAPR presented an introduction of the scheme along with information on cultivation of MAPs in sea affected problematic areas. Cultivation practices to be followed in medicinal plants in problematic areas were explained by Dr. K.A. Kalariya. Mr.C.F. Joseph, VIKAS-Centre for Development delivered a lecture on importance of self help groups (SHGs). At the end of the programme, vote of thanks was given by Dr. K.A Kalariya.

**Training on tulsi cultivation and market opportunities**

A One-day farmers’ training cum stake holder meet on “Tulsi cultivation and market opportunities” was organized on January, 05, 2018 at Ravipura, Petlad by the Directorate of Medicinal and Aromatic Plants Research, Anand (Gujarat) under central sector scheme (CSS). Sixty-three participants were selected for the training from Ravipura and nearby villages. Dr. P.L. Saran, Senior Scientist, DMAPR presented an introduction of the scheme along with cultivation practices of tulsi and its market opportunities. Disease management of the crop was explained by Dr. R. P. Meena and good agricultural practices of MAPs by Dr. K.A. Kalariya. The Dr. V. Thondaiman, delivered a lecture on quality planting material (QPM) production of MAPs. Personnels from two private herbal companies viz., Windson Organic Pvt. Ltd. and Patanjali explained market opportunities of MAPs. The messages of MGMG and Swacch Bharat Mission were also conveyed to the farmers. At the end of the programme, vote of thanks was given by Shri. S.B. Prajapati.

**Twenty-five days’ skilled training on “Gardner”**

Twenty-five days’ skilled training on “Gardner” (AGR/Q0801) was conducted for 25 unemployed youth during January 22 - February 15, 2018 by the Directorate. The programme was funded by the Directorate of Arecanut and Spices Development (DASD), Calicut, Kerala and supported by Agriculture Skill Council of India (ASCI), New Delhi. The participants for the skill training were selected from different villages of Boriavi and Anand etc. This training programme was inaugurated by Dr. P. Manivel, Director, ICAR-DMAPR in a formal function and Dr. K.B. Kathiriya, Director of Research & Dean (PG), AAU Anand was the chief guest of the function. Dr. P.L. Saran was the course convener. The programme was conducted including 36 experts, five gardeners along with four field visits.
Twenty-five days’ skilled training on essential oil extraction

Twenty-five days’ skilled training on “Essential Oil Extraction” (AGR/Q0902) for 25 unemployed youth was organized from February 16 –March 12, 2018 by the Directorate under the central sector scheme (CSS). The programme was funded by the DASD Calicut, Kerala and supported by ASCI, New Delhi. The participants for the skill training were selected from different villages of Boriavi, Anand and Ahmedabad. This training programme was inaugurated in a formal function and Dr. Dhaval R. Kathiriya, Director (I.T.) AAU, Anand was the chief guest of the program. The convener of the skilled training course was Dr. P.L. Saran. The programme was conducted by 35 lectures by experts, 20 practicals and 5 field visits.

Training cum awareness program on Protection of Plant Varieties and Farmers’ Rights organised

One-day Training cum Awareness program on Protection of Plant Varieties and Farmers’ Rights Act (PPVFRA) was organised at Savpura village, Tharad, Banaskantha, Gujarat on 19th March, 2018. Different aspects of PPVFRA deliberated in the training included PPVFRA overview, Farmers’ rights and others. A video film on PPV&FRA was shown during the programme.

Mera Gaon Mera Gaurav (MGMG) and Swachh Bharat Mission

Programmes on Mera Gaon Mera Gaurav (MGMG) and Swachh Bharat Mission initiated by ICAR and Government of India were continued at the ICAR-DMAPR during during the year 2017-18.

New joining

Mr. Manjesh G. N., Scientist (Spice, Plantation & MAP) joined ICAR-DMPAR on 16th October, 2017.

Mrs. Priya Phogat, Assistant joined on 31st August, 2017

Distinguished visitors

- Dr. N. P. Singh, Director, ICAR-NIASM, Baramati on June 12, 2018
- Sh. V. V. Varghase, Hon’able Minister, Agriculture & Urban Housing Development, Government of Gujarat, Gandhinagar on October 09, 2017
- Dr. H. S. Gupta, Formerly Director General, Borlaug Institute for South Asia, New Delhi on November 22, 2017 and March 13-15, 2018
- Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), New Delhi on February 03, 2018
- Prof. P. Das, Formerly Director, Regional Plant Resource Centre, Bhubaneswar on November 01, 2017 and March 16, 2018
# Deputation/Meetings attended by the Director

<table>
<thead>
<tr>
<th>Place</th>
<th>Date of Visit</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>Gandhinagar &amp; Ahmedabad</td>
<td>April 06, 2017</td>
<td>गांधीनगर में आयोजित दिवस कृषि के लिए राष्ट्रीय सिद्धांत के बैठक में भाग लेने हेतु । अंतर्राष्ट्रीय उपयोग कृषि के लिए राष्ट्रीय सिद्धांत के बैठक में भाग लेने हेतु ।</td>
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<tr>
<td>ICAR, New Delhi</td>
<td>April 19, 2017</td>
<td>भाकृष्णन - नई दिल्ली में आयोजित सहभागी बैठक में भाग लेने के लिए   ।</td>
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<tr>
<td>NMPB, New Delhi</td>
<td>April 24, 2017</td>
<td>राष्ट्रीय औषधि पादों की योजना एवं प्रोजेक्ट के लिए निर्देशित देने हेतु ।</td>
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<tr>
<td>TNAU, Coimbatore</td>
<td>June 28-30, 2017</td>
<td>तमिलनाडु कृषि विद्यालय, में राष्ट्रीय औषधि पादों को, नई दिल्ली द्वारा प्रायोजित औषधि पोषण पर त्रिदिवसीय प्रशिक्षण कार्यक्रम आयोजित करने हेतु ।</td>
</tr>
<tr>
<td>CIFE, Mumbai</td>
<td>July 08, 2017</td>
<td>भाकृष्णन - CIFE, मुंबई में दिनांक 8 जुलाई, 2017 को सचिव, भाकृष्णन की अध्यक्षता में आयोजित सत्कार अविकार्यवाद की समीक्षा बैठक में भाग लेने हेतु ।</td>
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<tr>
<td>ICAR, New Delhi</td>
<td>July 16, 2017</td>
<td>नई दिल्ली में दिनांक 16.07.2017 को आयोजित भाकृष्णन के 89वें स्थापना दिवस एवं पुरस्कार वितरण समारोह में शामिल होने के लिए।</td>
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<tr>
<td>Chidambaram, Tamil Nadu</td>
<td>August 10, 2017</td>
<td>आयोजित दिनांक 10.08.2017 को आयोजित जीव विज्ञान पर प्रशिक्षण की राष्ट्रीय कार्यशाला के उद्घाटन समारोह में प्रमुख व्यक्ति देने हेतु ।</td>
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<tr>
<td>BCKV, Kalyani</td>
<td>September 06, 2017</td>
<td>आयोजित भारतीय औषधि, सांस्कृतिक पादों एवं पानातन अनुसंधान सम्मेलन परियोजना के, बिधान चंद्र कृषि विश्वविद्यालय, कल्पना का दौर करने हेतु ।</td>
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<tr>
<td>AAU, Jorhat</td>
<td>September 07, 2017</td>
<td>आयोजित भारतीय औषधि, सांस्कृतिक पादों एवं पानातन अनुसंधान सम्मेलन परियोजना के, आसाम कृषि विश्वविद्यालय, जोरहट का दौर करने हेतु ।</td>
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<td>Kolkata</td>
<td>September 9, 2017</td>
<td>कोलकाता में आयोजित एयोनोफार्मिकोलॉजी सोसाइटी के, भारत के चौथे समालन तथा अभियंता पर राष्ट्रीय संगठन में व्याख्या देने हेतु ।</td>
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<tr>
<td>ICAR, New Delhi</td>
<td>September 18, 2017</td>
<td>भाकृष्णन, नई दिल्ली में आयोजित इ.एफ.सी. मीटिंग में भाग लेने हेतु ।</td>
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<tr>
<td>ICAR, New Delhi</td>
<td>September 16, 2017</td>
<td>उप-महानिदेशक (बा. वि.), भाकृष्णन के साथ अध्यक्ष, QRT एवं RAC के साथ प्रशासन बैठक में हिस्सा लेने ।</td>
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<tr>
<td>ASRB, New Delhi</td>
<td>October 11, 2017</td>
<td>कृषि वैज्ञानिक चरण मंडल, नई दिल्ली में आयोजित दिनांक 11.10.2017 को अन्नसेंटर कमिटी से समाधान की कृषि बैठक में भाग लेने हेतु ।</td>
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<tr>
<td>ICAR, New Delhi</td>
<td>November 02, 2017</td>
<td>भाकृष्णन, कृषि अनुसंधान भवन।, नई दिल्ली में आयोजित ITRA परियोजना बैठक में हिस्सा लेने हेतु ।</td>
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<td>MPUAT, Udaipur</td>
<td>November 11-14, 2017</td>
<td>आयोजित महातीर्थ औषधि एवं सांस्कृतिक पादों में अनुसंधान सम्मेलन परियोजना का 25वीं वार्षिक बैठक उदयपुर में आयोजित करने हेतु ।</td>
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<tr>
<td>CAU, Pasighat</td>
<td>December 05-06, 2017</td>
<td>सीरेंडु, पासीभाट में आयोजित अंतर्राष्ट्रीय संगठन में भाग लेने हेतु ।</td>
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<td>New Delhi</td>
<td>December 26-27, 2017</td>
<td>नई दिल्ली में आयोजित NASF परियोजना के द्वारा आयोजित विषविद्यालय लागत समीक्षा की बैठक में भाग लेने हेतु ।</td>
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<tr>
<td>TNAU, Coimbatore</td>
<td>January 01-06, 2018</td>
<td>पी. एच. ए. छात्र की परीक्षा देने हेतु तमिलनाडु कृषि विश्वविद्यालय, कोयम्बटूर जाने हेतु ।</td>
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<td>New Delhi</td>
<td>January 19-20, 2018</td>
<td>नई दिल्ली में QRT बैठक आयोजित करने हेतु ।</td>
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<td>OUAT, Bhubaneshwar</td>
<td>February 07-09, 2018</td>
<td>OUAT, भुबनेश्वर में QRT बैठक आयोजित करने हेतु।</td>
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<tr>
<td>CIMAP, Lucknow</td>
<td>March 06, 2018</td>
<td>सी.एस.आई.आर.- केंद्रीय ओषधीय एवं समांघ पौध संस्थान, लखनऊ की मुलाकात हेतु।</td>
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<tr>
<td>ICAR, New Delhi</td>
<td>March 08-09, 2018</td>
<td>नई दिल्ली में आयोजित भाकृवन्दुप - निदेशक सम्मलेन में भाग लेने हेतु।</td>
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<tr>
<td>Pune</td>
<td>March 25, 2018</td>
<td>बलई नोटी रिसर्च फाउंडेशन, चेनई द्वारा पुणे में आयोजित सम्मलेन में व्याख्यान देने हेतु।</td>
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**Human resource Development**

**Training and Seminar/Symposium attended**

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<thead>
<tr>
<th>Name</th>
<th>Details</th>
<th>Date</th>
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<tr>
<td><strong>Scientific Staff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Satyanshu Kumar</td>
<td>Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR, at ICAR NAARM, Hyderabad</td>
<td>February 15-17, 2018</td>
</tr>
<tr>
<td>Dr. Raghuraj Singh</td>
<td>Training on Advanced Remote Sensing and GIS Applications in Integrated Land Resource Management at ICAR-NBSS and LUP, Nagpur</td>
<td>July 17-29, 2017</td>
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<tr>
<td>Dr. R.P. Meena</td>
<td>Training program on Computational and statistical Advances for analysis of biological data of agriculture at ICAR- IASRI, New Delhi.</td>
<td>March 24–April 13, 2018</td>
</tr>
<tr>
<td>Dr. A Chinapolaiah</td>
<td>Advance Statistical Techniques in Biometrics at ICAR-IASRI, New Delhi</td>
<td>August 10-30, 2017</td>
</tr>
<tr>
<td>Dr. Thondaiman, V</td>
<td>Approaches for Doubling Farmers Income at College of Agriculture, NAU Campus, Bharuch</td>
<td>December 01-17, 2017</td>
</tr>
<tr>
<td>Sh. Manjesh G.N.</td>
<td>FOCARS training at ICAR-NAARM, Hyderabad</td>
<td>July 05-October 04, 2017</td>
</tr>
<tr>
<td></td>
<td>3-months attachment training at CSIR-CIMAP, Bengaluru</td>
<td>December 01, 2017 – February 28, 2018)</td>
</tr>
<tr>
<td><strong>Technical Staff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mrs. Parul Purohit</td>
<td>KOHA for Library Staff of ICAR at ICAR-NAARM, Hyderabad</td>
<td>February 05-09, 2018</td>
</tr>
<tr>
<td>Mr. B K Mishra</td>
<td>Computer Applications (Design and Development of Website/Portal) at ICAR-IASRI,</td>
<td>September 22-27, 2017</td>
</tr>
<tr>
<td>Mrs. S H Nair</td>
<td>ICAR-ERP System, at ICAR-IASRI, New Delhi</td>
<td>July 17-22, 2017</td>
</tr>
<tr>
<td></td>
<td>Computer Applications (Design and Development of Website/Portal), at ICAR-IASRI, New Delhi</td>
<td>September 22-27, 2017</td>
</tr>
<tr>
<td>Mr. S.B. Prajapati</td>
<td>Good Agricultural Practices (GAPs) for Enhancing Resource Use Efficacy and Farm Productivity at ICAR-IARI, New Delhi</td>
<td>December 05-18, 2017</td>
</tr>
<tr>
<td>Name</td>
<td>Details</td>
<td>Date</td>
</tr>
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<tr>
<td>Mr. M. B. Vaghri</td>
<td>National Training on Seed Certification and Marketing at National Seed Research and Training Centre</td>
<td>September 04-08, 2017</td>
</tr>
<tr>
<td>Dr. A. P. Trivedi</td>
<td>Priority Setting, Monitoring and Evaluations (PME) of Agricultural Research at ICAR-NAARM, Hyderabad</td>
<td>October 06-11, 2017</td>
</tr>
<tr>
<td>Mr. R. B. Koli</td>
<td>Behavioural Training and Maintenance of Vehicles at ICAR-CIAE, Bhopal,</td>
<td>February 20-24, 2017</td>
</tr>
<tr>
<td><strong>Administrative Staff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr. Vijay Kumar</td>
<td>Advance Management Development Programme on Public Procurement at National Institute of Financial Management, Faridabad</td>
<td>January 08-12, 2018</td>
</tr>
<tr>
<td>Mr. S.S. Patelia</td>
<td>Enhancing Efficiency and Behavioural Skills for Stenographers Grade III, PA, PS and PPS at CIFE, Mumbai</td>
<td>August 03-09, 2017</td>
</tr>
<tr>
<td>Mr. N.J. Ganatra</td>
<td>Workshop on E Office at Institute of Secretariat Management and Management, New Delhi</td>
<td>September 07-09, 2017</td>
</tr>
<tr>
<td>Mr. S.U. Vyas</td>
<td>National Level Training on Procurement&amp; PFMS at ICAR-CPCRI, Shimla</td>
<td>September 11-15, 2017</td>
</tr>
<tr>
<td><strong>Skilled Supporting Staff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr. C.K. Vankar</td>
<td>National Training on Seed Certification and Marketing at National Seed Research and Training Centre</td>
<td>September 04-08, 2017</td>
</tr>
<tr>
<td><strong>Conference/Seminar/Symposium</strong></td>
<td></td>
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</tr>
<tr>
<td>Dr.B.B. BASAK</td>
<td>3rd International conference on Bioresource and Stress Management (ICBSM) at State Institute of Agriculture Management (SIAM), Jaipur</td>
<td>November 08-10, 2017</td>
</tr>
<tr>
<td></td>
<td>82nd Annual Convention and National Seminar on ‘Development in Soil Science 2017 at Amity University, Kolkata</td>
<td>December 11-14, 2017</td>
</tr>
<tr>
<td></td>
<td>National Seminar on ‘Emerging Techniques in Food Sample Analysis’ at College of Food Processing Technology and Bio energy, Anand Agriculture University, Anand</td>
<td>January 31, 2018</td>
</tr>
<tr>
<td>Dr. Nagaraja R. Reddy</td>
<td>4th International Symposium on Minor Fruits, Medicinal and Aromatic Plants at College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, India</td>
<td>December 05-06, 2017</td>
</tr>
<tr>
<td>Dr. P. Manivel</td>
<td>3rd One Day National Seminar on “Current Regulations on Herbal Drugs and Food Supplements” at Convention Centre, Jamia Hamdard</td>
<td>May 16, 2017</td>
</tr>
<tr>
<td>Dr. Raghuraj Singh</td>
<td>Workshop on “Emerging Applications of Space Technology in Agriculture and Allied Sectors” at SAC Ahmedabad</td>
<td>June 28-29, 2017</td>
</tr>
<tr>
<td></td>
<td>10th NABS Conference on “Recent trends in Life Science: Research, Practices and Application for Sustainable Development” at Bharathiar University, Coimbatore, Tamil Nadu</td>
<td>September 07-08, 2017</td>
</tr>
<tr>
<td></td>
<td>4th International Symposium on Minor Fruits, Medicinal and Aromatic Plants at College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, India.</td>
<td>December 05-06, 2017</td>
</tr>
</tbody>
</table>
### Name Details Date

**Dr. R.P. Meena**
- International conference on “Plant health for human welfare” at Department of botany, University of Rajasthan, Jaipur, Rajasthan.
- November 01-04, 2017

**Dr. Satyanshu Kumar**
- Workshop on “Emerging Applications of Space Technology in Agriculture and Allied Sectors” at SAC Ahmedabad
- June 28-29, 2017

- 3rd International Conference on Natural Products Utilization: From Plants to Pharmacy Shelf at Bansko, Bulgaria
- October 18-21, 2017

- 4th International Symposium on Minor Fruits, Medicinal and Aromatic Plants at College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, India
- December 05-06, 2017

### Awards and recognitions

- Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry) was granted travel grant by Science and Engineering Research Board (SERB), Department of Science and Technology, New Delhi for presenting a research paper “Bio-prospection for laxative principles sennosides from Cassia species” in 3rd International Conference on Natural Products Utilization: From Plants to Pharmacy Shelf, October 18-21, 2017, Bansko, Bulgaria.
- Dr. R.P. Meena bagged the Best oral presentation Award in ISMPP, “International conference on “Plant health for human welfare” during November 01-04, 2017
- Dr. B.B. Basak bagged Golden Jubilee Young Scientist Award 2017 by Indian Society of Soil Science, New Delhi.
- Dr. B.B. Basak bagged Best Oral presentation Award in 3rd International Conference on Bio resource and Stress Management, Jaipur.
- Dr. Hemlata Bharti received Indo-Australian Career Boosting Gold Fellowship-2017 from Department of Biotechnology, Govt. of India for 9 months’ at Commonwealth Scientific and Industrial Research (CSIRO), Canberra, Australia.

### Externally funded projects sanctioned

- Investigation of *Taverniera cuneifolia* (Roth) Ali, as a sweetener for substitute of *Glycyrrhiza glabra* L. in herbal formulations (ICAR-DMAPR: PI: Satyanshu Kumar, Co-PI: Dr. Raghuraj Singh, MSU, Baroda: Dr. P.S. Nagar, Dept. of Botany, The M. S. University of Baroda Vadodara). Funded by NMPB, New Delhi.
- Molecular characterization and biological study on virus and virus like pathogen infecting medicinal and aromatic crops of India. PI: Dr. R. P. Meena. Funded by DST-SERB, New Delhi.

### ICAR-DMAPR RESEARCH PROJECTS

#### Institute funded projects

**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, Senior Scientist (Horticulture); Dr. N. Reddy, Scientist (Plant Breeding); Dr. V. Thondaiman, Scientist (Horticulture); Dr. Hemlata Bharti, Scientist (Horticulture); Dr. Akula Chinnapoliah, Scientist (Horticulture); Mr. Manish Kumar Mittal (Economic Botany and PGR) Dr. Satyanshu Kumar, Principal scientist (Organic Chemistry); Dr. N. A. Gajbhiye, Principal Scientist (Organic Chemistry); Dr. K. A. Kalaria Scientist (Plant Physiology)

**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, Senior Scientist (Horticulture); Dr. N. Reddy, Scientist (Plant Breeding); Dr. V. Thondaiman, Scientist (Horticulture); Dr. Hemlata Bharti, Scientist (Horticulture); Dr. Akula Chinnapoliah, Scientist (Horticulture); 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)

**Project 03:** Understanding the metabolism and biochemistry of active principles in medicinal and aromatic plants.

Principal Investigator: Dr. Nagaraja Reddy, Scientist (Plant Breeding); Co-PI: Dr. Hemlata Bharti, Scientist (Horticulture); Dr. Manish Kumar Suthar, Scientist (Agricultural Biotechnology)

**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. Kalaria Scientist (Plant Physiology); Dr. V. Thondaiman, Scientist (Spices, Plantation & MAPs); Mr. Prince Choyal, Scientist (Plant Physiology)

**Project 05:** Integrated pest and disease management in medicinal and aromatic plants

Principal Investigator: Dr. R.P Meena, Scientist (Plant Pathology); Co-PI: Dr. N A Gajbhiye, Principal Scientist (Organic Chemistry)

**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, Senior Scientist (Organic Chemistry); Dr. B. B. Basak, Scientist (Soil Science); Mr. R.P. Meena, Scientist (Plant Pathology); Dr. Raghuraj Singh, Scientist (Farm Machinery and Power); Dr. A. P. Trivedi, Sr. Technical Officer

**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. Satyanshu Kumar, Principal Scientist; Dr. Geetha, K. A., Principal Scientist (Plant Breeding); Dr. Raghuraj Singh, Scientist (Power and Farm Machinery)
Institute’s Flagship Programme: Organic cultivation of medicinal and aromatic crops

Principal Investigator: Dr. B. B. Basak, Scientist (Soil Science); Co-PI: Dr. Raguraj Singh, Scientist (Power and Farm Machinery)

Externally funded projects

1. PPVFR- Development of DUS guidelines and strengthening of DUS Test Centres for laboratory and field facilities (2006 onwards). Nodal officer Dr. Geetha K.A.

2. DBT- Studies on the Burl: an unresolved woody disorder of mango trees in India (2015-18) Principal Investigator: Dr. P.L. Saran

3. NMPB- Exploration of medicinal and aromatic plants in marginal, degraded and arid regions of India (2016-19). Principal Investigator: Dr. B.B. Basak

4. DBT- Evaluation of unconventional sources of potassium for sustainable farming system (2016-19) Principal Investigator: Dr. B.B. Basak

5. DST-SERB funded transcriptome based discovery of pathways and genes related to resistance against downy mildew disease in isabgol (*Plantago ovata* Forsk) (2015-18) Investigators: Dr. P. Manivel, Principal Scientist (Plant Breeding) & Dr. R. Nagaraja Reddy, Scientist (Plant Breeding)

6. DST-SERB funded 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)


8. GSHTM- 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. Ajoy Saha, Dr. A. P. Trivedi

9. NMPB-Standardization of propagation techniques and QPM production of selected medicinal plants (2017-20) Principal Investigator: Dr. P. L. Saran

10. 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

11. 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 (2016-2019) CCPI: Dr. Narendra Gajbhiye; CoCPI-Dr. Thondaiman

12. 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
13. 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

14. NMPB funded project: Sustainable production technology of gudmar (Gymnema sylvestre R. Br.) a medicinal plant with antidiabetic compound gymnemagin; Principal Investigator: Dr. Akula Chinapalaiah; Co-PI: Dr. Satyanshu Kumar

PUBLICATIONS

ICAR-DMAPR

Research Papers:


**Research paper presented /Abstract published in Conference/Seminar/Symposia, etc.**

**a. Lead papers**


Hemlata Bharti. 2017. Rust In Medicinal Plants. Oral presentation in Plant Microbe Interaction conducted by researchers from the Plant Sciences Division, Australian National University (ANU) & Commonwealth Scientific and Industrial Research Organization (CSIRO) Canberra at ANU Kioloa campus, Australia.

**b. Full length papers:**

Kumar S., Singh R., Kureshi A.A., Kumari P., Dhanani T., Hussain T. Baruah P.C. Talukdar M. and


c. Abstracts


during December 05-06, 2017.

**Popular Articles**

रा म प्रसन्न मीना,ए मनीष कुमार सुधार एवं बृजेश कुमार मिश्र 2017 आर्धिक हड़ताल एवं औषधीय गुणों से भरपूर इसबगोल की खेती


**Book chapters**


**AICRP-MAPB Centres**

**AAU, Jorhat**

**Research papers:**


**IGKV, Raipur**

**Book/booklet:**


**Technical bulletins:**

*Chhattisgarh mei paan ki vyavasayik kheti.* IGKV, Raipur, India, 2017.

**KAU, Thrissur**

**Popular articles:**


**MPUAT, Udaipur**

**Research papers:**


**OUAT, Bhubaneswar**

**Popular article:**


**PDKV, Akola**

**Research Papers:**


**TNAU, Coimbatore**

**Research papers:**

YSPUHF, Solan

Research Papers:

Dr. YSRHU, Venkataramannagudem

Popular articles:

PERSONNEL
ICAR-DMAPR

Acting Director
Dr. P. Manivel, Principal Scientist (Plant Breeding)

Scientific staff:
Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry)
Dr. Geetha K. A., Principal Scientist (Plant Breeding)
Dr. N. A. Gajbhiye, Principal Scientist (Organic Chemistry)
Dr. Parmeshwar Lal Saran, Senior Scientist (Horticulture)
Dr. Nagaraja Reddy R., Scientist (Plant Breeding)
Dr. Biraj Bandhu Basak, Scientist (Soil Science)
Dr. Kuldeep A. Kalariya, Scientist (Plant Physiology)
Dr. Raghuraj Singh, Scientist (Farm Machinery and Power)
Dr. Ram Prasanna Meena, Scientist (Plant Pathology)
Dr. Thondaiman V., Scientist (Spices, Plantation and Medicinal & Aromatic Plants)
Dr. Hemlata Bharti, Scientist (Spices, Plantation and Medicinal & Aromatic Plants)
Dr. Akula Chinapolaiah, Scientist (Spices, Plantation and Medicinal & Aromatic Plants)
Mr. Prince Choyal, Scientist (Plant Physiology) on study leave
Mr. Manish Kumar Mittal, Scientist (Economic Botany and Plant Genetic Resources)
Dr. Manish Kumar Suthar, Scientist (Agricultural Biotechnology)
Mr. Manjesh G.N., Scientist (Spices, Plantation and Medicinal & Aromatic Plants)

Technical staff:
Dr. A. P. Trivedi, Senior Technical Officer
Mrs. P. M. Purohit, Senior Technical Officer
Mr. R. B. Koli, Technical Officer (Driver)
Mr. B. K. Mishra, Senior Technical Assistant, (Lab. Technician)
Mr. S. B. Prajapati, Senior Technical Assistant (Field Assistant)
Mr. S. R. Patel, Senior Technical Assistant (Field Assistant)
Mr. Hasanali M. Khatri, Senior Technical Assistant (Driver)
Mrs. S. H. Nair, Senior Technical Assistant (Computer Assistant)
Mr. J. M. Padhiyar, Technical Assistant (Pump House Operator)
Mr. M. B. Vaghari, Technical Assistant (Field Assistant)
Mr. K. R. Patel, Senior Technician (Tractor Driver)

**Administrative staff:**
Mr. Vijay Kumar, Administrative Officer
Mr. Mangal Singh, Assistant Finance and Accounts Officer
Mr. Raghunadhan K., Assistant Administrative Officer
Mr. Sureshbhai S. Patelia, Private Secretary to the Director
Mrs. R. J. Vasava, Assistant
Mr. N. J. Ganatra, Assistant
Mrs. Priya Phogat, Assistant
Mr. S. U. Vyas, Upper Division Clerk
Mr. V. P. Rohit, Upper Division Clerk
Mr. Raghuveer Prajapati, Lower Division Clerk
Mr. Hayat Ashhar Mohammad, Lower Division Clerk

**Skilled supporting staff**
Mr. C. K. Vankar
Mr. M. A. Saiyed
Mr. J. S. Vasava
Mr. D. M. Parmar
Mr. C. A. Parmar
Mr. R. N. Parmar
Mr. R. B. Bhoi
Mr. L. F. Talpada
Mr. S. B. Bhoi
Mr. A. S. Bhoi
Mr. A.C. Bhoi

**AICRP MAPB**
Project Co-ordinating Cell Headquarter
Dr. P. Manivel, Project Co-ordinator (Acting)
AAU, Anand
Dr. M. A. Patel, Research Scientist (Plant Breeding) till 31st January, 2018
Dr. H.L. Dhaduk, Associate Research Scientist (Plant Breeding) from 1st Feb, 2018
Mr. B. V. Hirpara, Assistant Research Scientist (Agronomy)

AAU, Jorhat
Dr. P. C. Barua, Associate Professor (Horticulture) till 31st December, 2017
Dr. B. K. Saud, Associate Professor (Horticulture) from 01 January, 2018
Mr. Utpal Deka, Assistant Professor (Plant Pathology), till 19th December, 2017
Dr. Pranab Dutta, Assistant Professor (Plant Pathology), from 20th December, 2017

AU, Jodhpur (Voluntary centre)
Ms. Mamta Nehra, Assistant professor (Plant breeding and Genetics)

BAU, Islampur
Dr. S.N. Das, Assistant Professor (Agronomy)
Dr. Prabhat Kumar, Assistant Professor (Plant Pathology)

BAU, Ranchi
Dr. Jai Kumar, Associate Professor (Plant Breeding)
Dr. V. R. Singh, Assistant Professor (Horticulture)

BCKV, Kalyani
Dr. B. K. Das, Professor (Entomology)
Dr. G. Mondal, Associate Professor (Plant Pathology)
Dr. Pran Krishna Thakur, Assistant Professor (Horticulture) from 1st November, 2017

BUAT, Banda (Voluntary centre)
Dr. S.V. Dwivedi, Professor (Vegetable science)

CCSHAU, Hisar
Dr. V. K. Madan, Associate Professor (Phytochemistry)
Dr. Rajesh Kumar Arya, Assistant Scientist (Plant Breeding) from 10th October, 2017
Mrs. Vandana, Assistant Scientist (Agronomy) from 3rd November, 2017

DRPCAU, Pusa
Dr. P. K. Jha, Assistant Professor (SS), (Plant Pathology)
Dr. Udiktumar, Assistant Professor (Horticulture)
Dr. A.K. Rai, Assistant Professor (Entomology)

Dr. YSRHU, Venkataramannagudem
Mrs. P. Rama Devi, Associate Professor (Plant Pathology)
Mrs. D. Aparna, Assistant Professor (Horticulture)
Mrs. P. Sunitha, Assistant Professor (Entomology)

**IGKV, Raipur**
Dr. Alice Tirkey, Scientist (Plant Breeding)
Dr. Yeman Kumar Dewangan, Scientist (Agronomy) till, 8th August, 2017
Dr. A.K. Tiwari, Scientist (Agronomy) from, 9th August, 2017

**CAU, Pasighat**
Dr. T.S. Mehra, Associate Professor (Horticulture)
Dr. Naorem Yaahiphabi Chanu, Assistant Professor (Entomology) from February, 2018
Dr. Helen Soibam, Assistant Professor (Horticulture) from February, 2018
Ms. Nancy Lego, Assistant Professor (Plant Breeding) from February, 2018

**ICAR - IIHR, Bengaluru**
Dr. (Mrs.) Hema Bindu, Principal Scientist (Plant Breeding)
Dr. M.A. Suryanarayana Principal Scientist (Horticulture)
M. R. Rohini, Scientist (Spices, Plantation, Medicinal and Aromatic Plants)

**JNKVV, Jabalpur**
Dr. Vibha, Associate Professor (Plant Pathology)
Dr. C.S. Pandey, Assistant Professor (Horticulture)

**KAU, Trichur**
Dr. M. T. Kanakamany, Professor (Plant Breeding)
Dr. C. Beena, Professor (Phytochemistry)
Dr. P. V. Sindhu, Assistant Professor (Agronomy)

**MPKV, Rahuri**
Dr. R.T. Gaikwad, Associate Professor (Plant Pathology)
Dr. B. Y. Pawar, Assistant Professor (Entomology)
Dr. Sharmila Shinde, Assistant Professor (Horticulture)

**MPUAT, Udaipur**
Dr. A. Joshi, Associate Professor (Phytochemistry)
Dr. Pokhar Rawal, Assistant Professor (Plant Pathology)
Dr. N. S. Dodiya, Assistant Professor (Plant Breeding & Genetics)

**NDUAT, Faizabad**
Dr. S.K. Pandey, Assistant Professor (Plant Pathology)

**OUAT, Bhubaneswar**
Dr. Subash Chandra Swain, Associate Professor (Horticulture)
Dr. Sandeep Kumar, Assistant Professor (Plant Pathology)
PDKV, Akola
Dr. N. K. Patke, Associate Professor (Agronomy) till 1st Feb, 2018
Mr. R. B. Sarode, Assistant Professor (Plant Breeding) till 01st August, 2017
Mr. A.G. Deshmukh, Assistant Professor (Phytochemistry)
Dr. Varsha V. Tapre, Associate Professor (Agronomy) from 2nd Feb, 2018

RVSKV, Mandsaur
Dr. H. Patidar, Professor (Plant Breeding)
Dr. G. N. Pandey, Professor (Plant Pathology)
Dr. S. N. Mishra, Professor (Phytochemistry)
Dr. R.S. Chundawat, Associate Professor (Agronomy)

SKUAST, Kashmir (Voluntary centre)
Dr. S. A. Gangoo, Professor (Forestry)

TNAU, Coimbatore
Dr. G. Thiribhuvanamala, Assistant Professor (Plant Pathology)
Dr. T. Elaiyabharathi, Assistant Professor (Agricultural Entomology)
Dr. L. Nalina, Assistant Professor (Horticulture)

UBKV, Kalimpong
Mr. Bandan Thapa, Assistant Professor (Genetics and Plant Breeding)
Mr. Koushik Roy, Assistant Professor (Agronomy)

UUHF, Bharsar
Dr. R. S. Chauhan, Research Scientist (MAP)
Dr. A. Paliwal, Research Scientist (Plant Breeding)
Dr. S. S. Bisht, Research Scientist

YSPUH&F, Solan
Dr. (Mrs.) Meenu Sood, Assistant Professor (Agronomy)
Dr. Yashpal Sharma, Assistant Professor (Plant Breeding)
Dr. Rajneesh Sharma, Assistant Professor (Biotechnology)
हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agritech with a human touch