On the cover:

Flowers of

Swertia chirayita
Papaver somniferum
Gloriosa superba
Acorus calamus
Aloe barbadensis
Chlorophytum borivilianum
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PREFACE

From the time immemorial, India has a rich heritage and long history of using medicinal and aromatic plants (MAPs) in improving the quality of life by using them in medicine, cosmetics, health hygiene, toiletries, fragrance and food supplements. Therefore, R&D of MAPs requires prioritization for efficient management. There is now a broad consensus that cultivation offers the best prospect for conservation of many MAPs currently found depleted in the wild. Conservation and utilization in MAPs should go hand in hand. Conservation by domestication of highly explored species from the forest and improvement in cultivation practices through adoption of Good Agricultural Practices (GAP) would ensure quality assurance. GAP also addresses specific soil and climate requirements for expression of best quality of MAPs. Processing is another area of major concern. For effectiveness of herbal medicines, adequate quantities of bioactive principles are very important. In this direction, a new paradigm was initiated for standardization of post harvest technologies and value addition for MAPs to improve the yield, quality and economic return.

Considering all these points in mind, in the present year also ICAR- DMAPR along with AICRP MAP&B centres focused its attention on the targeted objectives through multi-disciplinary research projects. Dissemination of the technology generated at the Directorate was carried out by bringing publications of extension and technical bulletins, keeping maximum benefits to the farmers, growers and other stakeholders of MAPs in mind. The Directorate also participated in exhibitions so that direct interfacing with the stakeholders could deliver its best possible role to them. The visits of dignitaries, to name a few, Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR; Mr. Chhabilendra Roul, IAS, Additional Secretary, DARE, and Secretary, ICAR; Dr. Alok K. Sikka, DDG (NRM), ICAR, New Delhi and Prof. A. K. Tripathi, Director, CSIR-CIMAP, Lucknow during last one year, immensely benefitted the ICAR-DMAPR family in terms of their valuable comments as well as critical appraisal of the on-going research activities at the Directorate.
I am extremely grateful to Dr. S. Ayyappan, Formerly Secretary, DARE and Director General, ICAR; Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR and Dr. N. K. Krishna Kumar, Deputy Director General (Horticultural Science) for their keen interest in the activities of the Directorate. I am thankful to Dr. T. Janakiram, Assistant Director General (Hort. II) for his personal care in dealing with the matters of our Directorate at the ICAR Headquarters. I take pleasure to acknowledge the valuable contributions of all the scientists of DMAPR and AICRP - MAPB centres for providing inputs to this annual report. Timely support received from Dr. Geetha K.A., Dr. N.A. Gajbhiye, Dr. G.R. Smitha, Dr. V. Thondaiman and Dr. Aarti Kawane in compilation, editing and printing of this volume is gratefully acknowledged. My thanks are due to Mr. Suresh Patelia, PS to the Director; Mr. Vijay Kumar, Administrative Officer; Mr. Mangal Singh, Assistant Finance & Accounts Officer and all the staff from administrative and finance section for their valuable help to bring this annual report printed.

Jai Hind!

Anand

24.06.2016

Jitendra Kumar
## ABBREVIATIONS USED

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AAU</td>
<td>Anand Agricultural University/ Assam Agricultural University</td>
</tr>
<tr>
<td>AICRP - MAPB</td>
<td>All India Coordinated Research Project on Medicinal and Aromatic Plants &amp; Betelvine</td>
</tr>
<tr>
<td>BAU</td>
<td>Bihar Agricultural University/ Birsa Agricultural University</td>
</tr>
<tr>
<td>BCKV</td>
<td>Bidhan Chandra Krishi Vishwa Vidyalaya</td>
</tr>
<tr>
<td>B:C ratio</td>
<td>Benefit cost ratio</td>
</tr>
<tr>
<td>CCSHAU</td>
<td>Chaudhary Charan Singh Haryana Agricultural University</td>
</tr>
<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>
</tr>
<tr>
<td>DUS</td>
<td>Distinctiveness uniformity and stability</td>
</tr>
<tr>
<td>ICAR</td>
<td>DMAPR Directorate of Medicinal and Aromatic Plants Research</td>
</tr>
<tr>
<td>ETL</td>
<td>Economic Threshold Limit</td>
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<tr>
<td>FWB</td>
<td>Fresh Weight Basis</td>
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<tr>
<td>FYM</td>
<td>Farm Yard Manure</td>
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<td>GAP</td>
<td>Good Agricultural Practices</td>
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<tr>
<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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<tr>
<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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<tr>
<td>IBA</td>
<td>Indole Butyric Acid</td>
</tr>
<tr>
<td>ICM</td>
<td>Integrated Crop Management</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>IDM</td>
<td>Integrated Disease Management</td>
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<tr>
<td>IGKV</td>
<td>Indira Gandhi Krishi Vishwavidyalaya</td>
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<tr>
<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>
</tr>
<tr>
<td>JNKVV</td>
<td>Jawaharlal Nehru Krishi Vishwa Vidyalaya</td>
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<tr>
<td>KAU</td>
<td>Kerala Agricultural University</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>LC-MS/MS</td>
<td>Liquid Chromatography–Mass Spectrometry</td>
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<tr>
<td>LER</td>
<td>Land Equivalent Ratio</td>
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<tr>
<td>MAP</td>
<td>Medicinal and Aromatic Plants</td>
</tr>
<tr>
<td>MPKV</td>
<td>Mahatma Phule Krishi Vidyapeeth</td>
</tr>
<tr>
<td>N ha⁻¹</td>
<td>Nitrogen per hectare</td>
</tr>
<tr>
<td>NAIP</td>
<td>National Agricultural Innovation Project</td>
</tr>
<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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<tr>
<td>OUAT Orissa</td>
<td>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>
</tr>
<tr>
<td>PDI</td>
<td>Percent Disease Index</td>
</tr>
<tr>
<td>PDKV</td>
<td>Dr. Punjabrao Deshmukh Krishi Vishwavidyalaya</td>
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<tr>
<td>PPV &amp; FRA</td>
<td>Protection of Plant Varieties &amp; Farmers' Rights Authority</td>
</tr>
<tr>
<td>PSB</td>
<td>Phosphate Solubilising Bacteria</td>
</tr>
<tr>
<td>q</td>
<td>Quintal (100 kg)</td>
</tr>
<tr>
<td>RAPD</td>
<td>Random Amplified Polymorphic DNA</td>
</tr>
<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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<tr>
<td>RIL</td>
<td>Recombinant Inbreed Line</td>
</tr>
<tr>
<td>RVSKVV</td>
<td>Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya</td>
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<tr>
<td>SSR</td>
<td>Simple Sequence Repeats</td>
</tr>
<tr>
<td>t</td>
<td>Tonne (1000 kg)</td>
</tr>
<tr>
<td>TLC</td>
<td>Thin Layer Chromatography</td>
</tr>
<tr>
<td>TNAU</td>
<td>Tamil Nadu Agricultural University</td>
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<tr>
<td>TSP</td>
<td>Tribal Sub Plan</td>
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<tr>
<td>UBBKV</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>
</tr>
<tr>
<td>YSPUHF</td>
<td>Dr. Y.S. Parmar University of Horticulture and Forestry</td>
</tr>
<tr>
<td>YSRHU</td>
<td>Dr. Y. S. Reddy Horticulture University</td>
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</tbody>
</table>
ICAR Directorate of Medicinal and Aromatic Plants Research (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 findings of 2015-16 are presented below:

**MEDICINAL AND AROMATIC PLANTS**

**ALOE (Aloe barbadensis)**

Twenty four genotypes of Aloe were evaluated at NDUAT, Faizabad and the highest leaf yield was recorded in genotype IC-112279.

At PDKV, Akola, floral biology including anthesis, time of anthesis and pollen dispersal was studied.

At CCSHAU, Hisar, it was found that combinations of three irrigations and planting on ridges produced the highest leaf yield (318.93 q ha⁻¹).

**ARJUN (Terminalia arjuna)**

Study of six market samples of Arjunarishta at PDKV, Akola detected ellagic acid, gallic acid, ethyl gallate and quercetin in the samples, but arjunetin was not detected in any of the samples.

Comparative studies of five species of *Terminalia* viz., *T. arjuna, T. bellirica, T. chebula, T. tomentosa* and *T. catappa* showed that leaves and fruits of *T. bellirica* contained the highest total phenol content (10.31% & 22.38%), tannins (10.05% & 21.88%) and antioxidant potential (15.46% & 35.73% and antiradical activity with DPPH method).

**ASALIO (Lepidium sativum)**

At PDKV, Akola, study conducted to assess the effect of date of sowing and seed rates on growth and yield showed that significantly higher seed yield ha⁻¹ with crop sowing on 44th MW at a seed rate of 6 kg ha⁻¹ (8.98 and 7.28 q ha⁻¹).

At IGKV, Raipur, effect of different levels of irrigation and nitrogen were tested on growth and yield parameters and it was found that the highest grain yield (15.25 q ha⁻¹) was recorded with irrigation at 25, 50 and 75 DAS and application of 80 kg N ha⁻¹.

At YSPUHF, Solan, effect of FYM and nitrogen application on productivity was studied and it was found that seed yield and net return were significantly increased with application of FYM at 10 t ha⁻¹ and N@ 60 kg ha⁻¹, but the B:C ratio was highest (2.91) in application of 5 t FYM ha⁻¹.
Integrated weed management study conducted at MPUAT, Udaipur revealed that maximum seed yield was recorded in two hand weeding and hoeing at 25 and 50 days after sowing (DAS).

Evaluation of manures, bioagents and bioformulations for management of *Alternaria* leaf blight at JNKVV, Jabalpur revealed that minimum disease incidence (39.00%) and maximum seed yield (14.41q ha⁻¹) were recorded in *Trichoderma* fortified FYM + *Azotobacter* + 2 sprays of 0.15% Azadirachtin.

**ASHOKA (Saraca asoca)**

Process development for catechin enriched extracts was standardized at ICAR-DMAPR.

**ASHWAGANDHA (Withania somnifera)**

At ICAR-DMAPR, Anand, among 129 germplasm accessions received from NBPGR gene bank, 122 accessions were germinated and seeds were multiplied, maintained and also characterized for agro-morphological characters. In another trial, a total of 328 pure lines developed at the Directorate were evaluated for 14 morphological traits, dry root yield and also for leaf blight resistance. Experiment on organic nutrient management showed that application of vermicompost @7.5 t ha⁻¹ and application of *Azotobacter* + PSB + Jivamrut recorded maximum plant biomass and dry root yield.

Phytoplasma infection in Ashwagandha was confirmed using DNA markers.

At IGKV, Raipur, sowing the crop in ridges and furrows method with application of vermicompost @7.5 t ha⁻¹ was superior for obtaining higher dry root yield (10.16 q ha⁻¹).

Evaluation of manures, bioagents and bioformulations against leaf blight at JNKVV, Jabalpur revealed that Nimbecidine (0.15% Azadirachtin) x *Trichoderma asperellum* @ 10⁶ cfu ml⁻¹ + *Pseudomonas fluorescens* @ 10⁶ cfu ml⁻¹ was the best treatment for reducing the *Alternaria* leaf blight and enhancing the root and seed yields.

At ICAR-DMAPR, process for preparation of withanolide enriched extracts from roots of Ashwagandha was standardized.

**BACH (Acorus calamus)**

At AAU, Jorhat, 24 accessions were characterized and highest rhizome weight was recorded in JAC-4.

Trial conducted at BCKV, Kalyani showed that among the five testing entries, maximum rhizome yield was in Aihagaripalli (4.63 t ha⁻¹) with minimum leaf spot incidence (4.90%). However, least disease incidence of basal rot was found in Munipalli (4.99%).
BAEL (Aegle marmelos)

At ICAR- DMAPR, Anand, 46 accessions of Bael were evaluated and maximum fruit yield (133.69 kg tree⁻¹) was observed in accession DEM 24 and highest marmelosin content (6.90 mg g⁻¹) was in accession DEM 14.

BALA (Sida cordifolia)

At KAU, Thrissur, 14 root samples of Bala collected from different places of Kerala were tested for total phenol content which ranged from 0.29 to 1.15%.

BASIL (Ocimum basilicum)

Evaluation of 18 accessions at ICAR-DMAPR, Anand showed that maximum herbage yield was in DOB-8 (321.08 q ha⁻¹), however highest oil content (0.70%) with superior volatile compounds composition was recorded in DOB-1.

BITTER SNAKEGOURD (Trichosanthes cucumerina)

Studies on floral biology were conducted at KAU, Thrissur. Evaluation of 19 accessions showed that herbage yield, fruit yield and total yield on fresh weight basis were significantly higher in TCR TC2 (2051.50 g plant⁻¹, 1767.00 g plant⁻¹, 3818.50 g plant⁻¹).

CHIRAYITA (Swertia chirayita)

At YSPUHF Solan, testing of 97 raw drug samples collected from different Indian markets showed that 45.36% were genuine samples, adulteration/substitution was 54.64% and Andrographis paniculata was found as the major substitute of market samples of S. chirayita.

DODI (Leptadenia reticulata)

Effect of irrigation schedule on dry biomass yield conducted at AAU, Anand showed that significantly higher dry biomass yield (91.68, 113.17 q ha⁻¹) was obtained in irrigation schedule of 1.00 IW/CPE ratio based on two years’ data. Effect of different levels of nitrogen and phosphorus on dry biomass yield showed that significantly higher dry biomass yield was recorded in the application of 200 kg ha⁻¹ nitrogen (144.30 q ha⁻¹) and 25 kg ha⁻¹ phosphorus (131.39 q ha⁻¹), whereas, the interaction effect was found non-significant.

Studies conducted at ICAR-DMAPR, Anand revealed that total yield losses due to sucking pests, Aphids (Aphis nerii), Psyllids (Diaphorina dakariensis) and Red spider mite (Tetranychus sp) was 60.77%. There was a reduction of 15% rutine and 5.3% myrictein contents in the pest infested leaves. It was also found that the mean percent infestation was significantly lower in the IPM module involving basal application of vermicompost (6 t ha⁻¹) + Neem cake (500 kg ha⁻¹) followed by 1 spray of Imidacloprid 17.8 SL at 30 days after planting (DAP) followed by 3 sprays of Azadirachtin (1%) at 45, 60 and 90 DAP.
**GILOE** (*Tinospora cordifolia*)

At BCKV, Kalyani, a detailed study was conducted on white powdery leaf spot disease caused by *Cercosporella tinosporae*.

**GUGGUL** (*Commiphora wightii*)

At ICAR-DMAPR, Anand a total of 53 hybrid seedlings of obligate sexual female and apomictic hermaphrodite were generated for genotyping, phenotyping as well as bulk segregant analysis related to the study of apomixis. Ninety four EST-SSR markers designed from ovule transcriptomes of obligate sexual and apomictic parents were tested among the hybrid progenies.

Protocol for repeated somatic embryogenesis was also standardized in the species.

**INDIAN VALERIAN** (*Valeriana jatamansi*)

June planting at a spacing of 30×45 cm produced more root biomass per unit area at UBKV, Kalimpong.

**ISABGOL** (*Plantago ovata*)

Forty two lines were evaluated at NDUAT, Faizabad and maximum seed yield was obtained in genotype HI-4.

Screening of breeding lines and elite lines for downy mildew was conducted at ICAR-DMAPR, Anand and lines DPO-185, DPO-188, RIL-26, RIL-30, RIL-72 and RIL-111 were identified as highly resistant against downy mildew.

Recombinant inbred lines (RILs) developed from DPO-185 x DPO-14 for Downey mildew disease resistance mapping were advanced from F$_i$ to F$_r$. Fresh hybridizations were also made among different distinct lines for genetic studies.

Organic nutrient management conducted with organic manures, bio-fertilizers and bio-formulations at ICAR-DMAPR, Anand showed that application of castor cake @2.5 t ha$^{-1}$ and Jivamrut was superior in terms of straw and seed yield. Effect of different sources of sulphur on yield and quality showed that application of sulphur @10 kg ha$^{-1}$ was optimum for better seed yield irrespective of sources, however application of sulphur invariably increased husk % and husk yield while bentonite sulphur was found superior over the other sources of sulphur in improving husk % and yield.

At MPUAT, Udaipur, storage studies of Isabgol seeds showed no loss of swelling factor (cc g$^{-1}$) either in air tight or open bags storage conditions in both sun and oven drying methods.
KALIHARI (*Gloriosa superba*)

Among the 12 genotypes evaluated at TNAU, Coimbatore, maximum fresh pod yield was obtained in TNGs-11.

Integrated management of leaf blight disease using fungicides and biocontrol agents conducted at TNAU, Coimbatore showed that spraying *Bacillus subtilis* (0.20%) twice on 30 and 60 DAP was effective in managing the leaf blight disease which recorded the lowest disease intensity of 17.90%, maximum yield parameters viz., number of flowers plant\(^{-1}\) (58.50), number of pods plant\(^{-1}\) (45.90) and number of seeds pod\(^{-1}\) (82.10) and seed yield (518.8 kg ha\(^{-1}\)).

KALMEGH (*Andrographis paniculata*)

At ICAR-DMAPR, Anand, among 93 accessions received from NBPGR gene bank, 66 accessions were germinated and seeds were multiplied, maintained and also characterized for agro-morphological characters.

Thirteen selected lines were evaluated at ICAR-DMAPR and significantly higher dry herbage yield was in DMAPR AP 13 (17.81 t ha\(^{-1}\)). However, andrographolide yield was highest in DMAPR AP 35 (850.83 kg ha\(^{-1}\)). Accumulation of major bioactive compounds viz., andrographolide, neoandrographolide, andrographanin, 14-deoxy,11-12 didehydroandrographolide, andrographiside, 7-O- methylwogonin and apigenin was also studied also in these lines.

Twenty selected lines were evaluated at NDUAT, Faizabad and IC-265622 had better dry herbage yield (61.45 q ha\(^{-1}\)).

In Kalmegh, DUS descriptors finalized at ICAR-DMAPR were notified by the PPVFRA.

Twenty eight genotypes were evaluated at ICAR-DMAPR for their responses to foliar hormone application of 200 ppm GA\(_3\) (as a growth promoter) followed by 100 ppm ethrel (as a stress elicitor) at different days after transplanting and genotypes were selected as per their varied responses. Response of water deficit (WD) stress in combination with signal molecules studied at ICAR-DMAPR, Anand showed stage specific effects of signalling molecules which indicated their scope to further augment the quality of *A. paniculata* under different WD stresses.

It was also found at ICAR-DMAPR, Anand that application of castor cake at 2.5 t ha\(^{-1}\) along with half dose of N (40 kg ha\(^{-1}\) with P30 and K50 as basal and remaining half dose of N (40 kg ha\(^{-1}\)) in two equal splits at 25 and 40 DAS recorded significantly higher dry herbage yield (12.02 q ha\(^{-1}\)). Under organic nutrient management it was found that application of castor cake @ 2.5 t ha\(^{-1}\) and Jivamrut application at 25, 50 and 75 DAT resulted in maximum herbage yield.
At PDKV, Akola, application of vermicompost @ 7.5 t ha\(^{-1}\) recorded significantly higher dry herbage yield (15.41 q ha\(^{-1}\)) whereas, in chemical fertilizer application, NPK@ 80:30:50 kg ha\(^{-1}\) in four splits recorded significantly higher dry foliage yield (15.67 q ha\(^{-1}\)).

Pooled means of three years data also revealed that highest dry herbage yield and andrographolide yield per hectare of Kalmegh were obtained when Kalmegh + Pigeon pea were sown in 1:2 ratio. Kalmegh equivalent yield, land equivalent ratio, GMR, NMR and B:C ratio (2.16) were significantly higher with the treatment of Kalmegh + Pigeon pea row proportion of 3:1.

At KAU, Thrissur, the herbage yield was higher (41.73 q ha\(^{-1}\)) in plots which received combination of FYM + *Azotobacter* + PSB + Jivamrut.

At NDUAT, Faizabad, application of vermicompost @ 15 t ha\(^{-1}\) resulted in maximum fresh (88.66 q ha\(^{-1}\)) and dry (47.83 q ha\(^{-1}\)) biomass yields. Among the biofertilizers, application of *Azotobacter* + PSB (seedling treatment) + Jivamrit (3 sprays at 25, 50 and 75 DAT) recorded maximum fresh (99.50 q ha\(^{-1}\)) and dry (52.75 q ha\(^{-1}\)) biomass yields.

At BCKV, Kalyani, it was found that that seedlings transplanted at 30x20 cm spacing recorded highest dry matter production (133.7 q ha\(^{-1}\)).

At ICAR-DMAPR, Anand, results of post harvest studies revealed that washing of Kalmegh samples before drying and storage resulted in degradation of andrographolide content after 12 months of storage. Among the different drying methods, shade drying of samples helped in retention of andrographolide content. Oven drying (45±2°C) was found best and among the packaging materials used, samples stored in polyethylene containers retained the quality.

**KUTKI (*Picrorhiza kurroa*)**

Studies on post harvest losses at YSPUHF, Solan showed that the losses in picroside-I and picroside-II content were minimum when the raw material was stored under low temperature.

Seventy three market samples were also tested at Solan based on Picrosides content and it was found that among the 73 samples, 70 (95.89%) were genuine samples of *P. kurroa* and three (4.11%) were of unknown species.

**LAL CHITRAK (*Plumbago rosea*)**

Effect of coppicing on yield and quality studied at KAU, Thrissur showed that yield of *P. rosea* could be increased by coppicing plants at 15 months after planting at a height of 30 cm which increased 11.01 q fresh root weight. Highest plumbagin content (0.91 %) was in coppicing at 9 months after planting at 30 cm height.

Storage studies showed that dried roots can be stored either in transparent or non-transparent plastic bottles without much loss of plumbagin content (32-33% loss after 24
Among the three Plumbago species (*P. rosea*, *P. zeylanica* and *P. capensis*), plumbagin content, antioxidant activity and potassium content were found higher in *P. rosea*.

**LEMONGRASS (Cymbopogon flexuosus)**

Variatetal discrimination of nine popular cultivars of *Cymbopogon* was established using RAPD and ISSR markers at ICAR-DMAPR. Identification of sequence polymorphism in barcode region was also detected in six species of *Cymbopogon* viz., *C. citratus*, *C. flexuosus*, *C. pendulus*, *C. nardus*, *C. martini* and *C. winterianus*.

**LONG PEPPER (Piper longum)**

Genetic variation among the selected 15 germplasm was carried out using molecular markers at AAU, Jorhat and cluster analysis showed the grouping of clones was mainly on the basis of geographical locations. Significant increase in the number of spikes per plant was recorded in planting without support and planting at a spacing of 90×60 cm increased the crop growth and yield parameters.

At OUAT, Bhubaneshwar, planting at a spacing of 60×60 cm was found to be significantly superior with respect to fresh weight (624.84 kg ha⁻¹) and dry weight of root (426.94 kg ha⁻¹). Raised bed method of planting was found superior in terms of root length, root diameter, total biomass of plant and fresh and dry weight of roots. Among the different combinations of organic manures tested, application of FYM @ 10 t ha⁻¹ + mustard Cake @ 1 t ha⁻¹ resulted in higher fresh and dry weight of roots with maximum soil organic carbon of 0.42 %.

**MADHUNASHINI (Gymnema sylvestre)**

At TNAU, Coimbatore, application of Chlorpyriphos 20 EC (standard check) @ 1.00 l ha⁻¹ was significantly superior to control leaf webbers and loopers in comparison to different biostaticides tested. However, application of neem seed kernel extract @ 5% recorded maximum dry leaf yield (0.53 kg plant⁻¹) and dry stem yield (1.45 kg plant⁻¹).

**MAKOI (Solanum nigrum)**

Application of Azadirachtin 10000 ppm @ 1 ml l⁻¹ was found to be effective against hadda beetle (*Henosepilachna vigintiopunctata*) at YSRHU, Venkataramannagudem.

**MANDUKAPARNI (Centella asiatica)**

At NDUAT, Faizabad, maximum dry herbage yield (13.15 q ha⁻¹) was obtained with the application of FYM @15 t ha⁻¹. Closer spacing (30×60 cm) was superior for fresh and dry herbage yields. Soil treatment with Carbendazim @ 0.10 % was highly effective in managing the stolon rot with minimum disease severity.
NEEL \textit{(Indigofera tinctoria)}

At KAU, Thrissur, the crop planted under 25\% shade to fully open condition during August/September resulted in higher yield and quality. It was also found that the highest herbage yield (64.32 q ha\(^{-1}\)) was obtained in the application of FYM 5 t ha\(^{-1}\) + NPK @ 45:60:45 kg ha\(^{-1}\), however, the highest indican content was recorded in the control.

PALMAROSA \textit{(Cymbopogon martinii)}

At IGKV, Raipur, interaction effect of nitrogen levels and varieties was studied and the highest oil yield (100.13 q ha\(^{-1}\)) was recorded in variety Jamarosa with the application of N@ 150 kg ha\(^{-1}\).

At ICAR-DAMPR, Anand, 75\% of recommended dose of fertilizers (RDF) recorded highest fresh and dry weights of herbage, however, highest geraniol content was obtained under the application of 75\% RDF + Microbial Consortia.

Potential use of the Palmarosa and Java citronella wastes obtained after hydrodistillation of essential oil were evaluated at ICAR-DAMPR for its use as efficient biosorbent systems and as potential sources of phenolics/antioxidants.

PATCHOULI \textit{(Pogostemon cablin)}

At IGKV, Raipur highest oil yield (35.53 kg ha\(^{-1}\)) and net return (Rs 67,359 ha\(^{-1}\)) were found with 45 x45 cm spacing under Mango tree shade. It was also found that maximum herbage yield (16.30 q ha\(^{-1}\)) and oil yield (39.68 kg ha\(^{-1}\)) were obtained with application of NPK @ 100:50:50 kg ha\(^{-1}\) + 2.5 t ha\(^{-1}\) vermicompost + 20 ppm NAA.

PUDINA \textit{(Mentha arvensis)}

The crop (var. Koshi) recorded significantly highest herbage yield (311.10 g m\(^{-2}\)) when planted at 25\(^{th}\) February at a spacing of 40×20 cm at BAU, Islampur.

PUNARNAVA \textit{(Boerhavia diffusa)}

New disease caused by \textit{Synchytrium boerhaviae} inducing leaf gall on Punarnava was recorded for the first time from West Bengal, India by BCKV, Kalyani.

SAFED MUSLI \textit{(Chlorophytum borivilianum)}

Intercropping of Safed musli with Pigeon pea at 3:1 row proportion was found superior for obtaining higher yield and monetary returns at PDKV, Akola.

SALAPARNI \textit{(Desmodium gangeticum)}

Forty three accessions collected from different parts of India were evaluated at ICAR-DMAPR and accessions with distinct morphological traits were identified.
SARPAGANDHA (*Rauvolfia serpentina*)

At OUAT, Bhubaneshwar, the crop planted at 45x45 cm spacing recorded significantly higher fresh and dry weights of roots per plant, dry root yield ha\(^{-1}\) and seed yield ha\(^{-1}\). Significantly higher total biomass of plant and fresh weight and dry weights of roots were obtained with the application of FYM @ 10 t ha\(^{-1}\) + mustard cake @ 1t ha\(^{-1}\). Maximum available P was also found in this treatment (49.70 kg ha\(^{-1}\)). Raised-bed method of planting resulted in maximum total biomass yield (18.26 q ha\(^{-1}\)) and fresh and dry weights of roots (23.28 q ha\(^{-1}\) and 8.78 q ha\(^{-1}\)).

At IGKV, Raipur, studies on intercropping of Sarpagandha showed that maximum Sarpagandha equivalent yield (17.84 q ha\(^{-1}\)) and highest net return (Rs.88484 ha\(^{-1}\)) were recorded with Sarpagandha + Kalmegh intercropping system.

At JNKVV, Jabalpur, it was found that application of *Pseudomonas fluorescens* @ 10\(^{6}\) cfu ml\(^{-1}\) + *Trichoderma asperellum* @ 10\(^{6}\) cfu ml\(^{-1}\) + Neem cake + ZnSo4 + I\(^{nd}\) spray of Cow urine (1:10) followed by 2\(^{nd}\) spray of Salicylic acid (1000 ppm) at 15 days interval resulted in minimum disease incidence of *Corynespora cassiicola* leaf spot (9.26%). However, minimum disease incidence of *Alternaria* leaf spot was recorded in application of *Pseudomonas fluorescens* @ 10\(^{6}\) cfu ml\(^{-1}\) + Neem cake + ZnSo4 + I\(^{nd}\) spray of Cow urine (1:10) followed by 2\(^{nd}\) spray of Salicylic acid (1000 ppm) at 15 days interval.

At NDUAT, Faizabad, spraying of Mancozeb @ 0.25% resulted in minimum percent disease index (15.65) and maximum root yield (12.94 q ha\(^{-1}\)) comparing to the different botanicals tried to control *Cercospora* leaf spot.

SENNAA (*Cassia angustifolia*)

At ICAR-DMAPR, Anand, six genes involved in drought stress were identified by transcriptome analysis which were confirmed through Reverse Transcriptase-PCR (RT-PCR) and Sanger sequencing for the first time. Genomic region governing 3-deoxy-D-arabino-heptulosonate 7-phosphosphate synthase (DAHPS) which is the first enzyme in the shikimate pathway catalyzing the production of 3-Deoxy-D-arabino-heptosonate-7-phosphahate leading to production of sennosides enzyme was also isolated and named as *CaDAHPS*.

Study of dissipation pattern of Chlorpyriphos 20 EC in Senna at ICAR-DMAPR showed that the initial deposits of Chlorpyriphos was 0.246 µg g\(^{-1}\) and 0.875 µg g\(^{-1}\) in fresh Senna leaves which reached below determination level (BDL) on 3\(^{rd}\) and 7\(^{th}\) DAT at standard and double doses, respectively. In dry Senna leaves, the initial residue levels were high (1.046 and 2.18 µg g\(^{-1}\) at standard and double doses) that reached BDL on 7 and 10 DATs, respectively.

Efficacy of biopesticides on the management of pod borer (*Etiella zinckenella*) was tested at TNAU, Coimbatore and it was found that none of the biopesticides tested could outperform chlorpyriphos 20 EC (standard check) @ 1.00 litre ha\(^{-1}\) in terms of lowest number of pod borer and pod damage (0.10 plant\(^{-1}\)) and leaf yield (585.0 kg ha\(^{-1}\)).
At ICAR-DMAPR, Anand, study of heavy metal contents in commercial market samples of Senna leaves obtained from different locations of India showed that Zn, Cu, Pb, Cd, and Cr, As and Hg were below the permissible limit set by World Health Organization (WHO) in the studied samples.

**TULSI (Ocimum sanctum)**

Evaluation of five accessions at ICAR-DMAPR, Anand revealed that DOS-1 was superior in terms of herbage and oil yields, oil content and Methyl eugenol content.

Effect of organic manures on crop yield and oil quality at AAU, Anand showed that significantly higher fresh (20.09 t ha\(^{-1}\)) and dry (5.76 t ha\(^{-1}\)) herbage yields and oil yield (23.70 kg ha\(^{-1}\)) were obtained with application of FYM @ 15 t ha\(^{-1}\).

Six insect pests were recorded on Ocimum spp. and its occurrences were found throughout the year with maximum population during October- November at BCKV, Kalyani.

**WILD MARIGOLD (Tagetes minuta)**

Thirty two accessions evaluated at YSPUHF, Solan showed that TMHP-32 had maximum oil yield in leaves (17.64 l ha\(^{-1}\)) whereas TMHP-24 (20.70 l ha\(^{-1}\)) had maximum oil yield in flowers. It was also found that closer spacing (30x15cm) gave maximum flower biomass (71.98 q ha\(^{-1}\)).

**OTHER EXPERIMENTS**

Effect of organic nutrient sources on Kalmegh and Ashwagandha and soil fertility and soil biological status studied at ICAR-DMAPR, Anand showed that application of vermicompost @7.5 t ha\(^{-1}\) along with Jivamrut application at 25, 50 and 75 DAP was superior in terms of mineral N, available P and S, microbial biomass carbon and dehydrogenase and fluorescein diacetate activities.

A modified Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) GC-MS based method was standardized for the detection of eleven multi-class pesticides in Ashwagandha, Isabgol, Senna and Kalmegh at ICAR-DMAPR.

**BETELVINE (Piper betle)**

Characterization and evaluation of 40 clones were done at ICAR-IIHR, Bengaluru and variability for many traits was noted in the germplasm. Evaluation of 26 accessions was done at AAU, Jorhat based on different morphological and yield parameters.

Eight selected high yielding clones along with local check (Hirehalli Local) were evaluated at ICAR-IIHR, Bengaluru and maximum leaf yield was recorded in IIHR BV 67 (52.22 lakh leaves ha\(^{-1}\))
Under the multilocation trial (nine Betelvine hybrids), leaf yield was higher in PBH-06-11 and PBH-06-4 at BCKV, Kalyani. At ICAR-IIHR, Bengaluru, higher number of leaves per vine was recorded in Hy 06-4 (126.47) and at YSRHU, Venkataramannagudem, GN Hybrid recorded highest yield which was at par with Swarna Kapoori.

Demonstration of integrated crop management (ICM) technologies developed at BCKV, Kalyani; OUAT, Bhubaneshwar; RAU, Pusa and BAU, Islampur were tested in the respective farmers' field at West Bengal, Odisha and Bihar. Results showed that the ICM technologies developed at the centres were superior to the Farmers' practice in terms of controlling the leaf spot and leaf rot diseases and for obtaining better leaf yield.

Study on disease and insect pests occurrences on 20 Betelvine hybrids lines conducted at BCKV, Kalyani showed that none of the hybrids was completely free from diseases and white fly infestation.

Epidemiology of commonly occurring diseases viz., leaf rot and leaf spot diseases and their management in Maghai pan was studied at BAU, Islampur. It was also found that application of Metalaxyl @ 8% + Mancozeb 64% WP ingredient of fungicide @ 0.20% concentration was significantly superior for controlling Phytophthora leaf spot and for Anthracnose leaf spot, application of Carbendazim @12% + Mancozeb 63% WP ingredient of fungicide @ 0.20% concentration was significantly superior.

Integrated disease management of Betelvine for management of soil born diseases at BAU, Islampur showed that treatment which included sanitation + Bordeaux mixture (1%) as soil drenching before planting and 60 days after planting was superior.

Application of Bordeaux mixture (1%) at pre-monsoon + application of bio-control agent (Trichoderma harzianum/viride) after one month + one additional application of Bordeaux mixture @1% at two months after the first Bordeaux mixture application had the best result for controlling leaf spot and Phytophthora leaf rot at BCKV, Kalyani.

Details of various life stages of Black fly (Aleurocanthus bucktoni Sundararaj & Pushpa) were also studied at BCKV, Kalyani.

**Agricultural Knowledge Management**

The Directorate website, Intranet website and other data bases were updated and maintained regularly.

**GENERAL INFORMATION**

The ICAR-DMAPR held regular meetings of IRC, RAC and IMC to monitor the research and development activities. Various training programmes including one summer school on “Advances in Medicinal and Aromatic Plants Research”, model training course on “Value Addition and Post Harvest Management in Medicinal and Aromatic Crops” and Trainers’ Training programme on “Conservation, Cultivation and Post Harvest Management of Medicinal and Aromatic Plants” were organised. The XXIII group meeting
of All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine was organised to review the work of various centres at ICAR-DMAPR. The technology developed by the Directorate and AICRP MAP&B were displayed in exhibitions at various parts of the country. A brainstorming meeting was organized to discuss about the strategies to be taken for the progress of R&D in Medicinal and Aromatic Plants. One-day panel discussion on “Medicinal and aromatic plants research: A way forward” was also organized. Mera Gaon Mera Gaurav (MGMG) programme at ICAR-DMAPR was officially launched. Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR and Mr. Chhabilendra Roul, IAS, Additional Secretary, DARE, and Secretary, ICAR visited the Directorate. International Women’s Day, Hindi Divas, Hindi workshop, and Foundation day were also celebrated at the Directorate.
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

• Development of appropriate production, protection and processing technologies for important MAP through basic, strategic and applied research.
• Germplasm enhancement of various MAP.
• To act as a National Repository of the genetic resources of selected important MAP.
• To coordinate research under AICRP-MAPB.
• To act as information data bank on MAP.
• Transfer of technologies developed by the ICAR - DMAPR to the farmers through cooperation with the developmental agencies.

Mandate crops

• Aloe (*Aloe barbadensis*)
• Ashwagandha (*Withania somnifera*)
• Giloe (*Tinospora cordifolia*)
• Guggal (*Commiphora wightii*)
• Isabgol (*Plantago ovata*)
• Lemongrass (*Cymbopogon flexuosus*)
• Palmarosa (*Cymbopogon martinii*)
• Safed musli (*Chlorophytum borivilianum*)
• Senna (*Cassia angustifolia*)
Objectives

- To identify plants which need attention of agricultural scientists, to collect, maintain and evaluate the identified plants.
- To carry out basic research on the mandate MAP crops for developing their Good Agricultural Practices (GAP).
- To coordinate the research activities of the centres of AICRP - MAPB located at various agro-climatic zones of India.
- To provide quality planting material and technology developed, testing and refinement by the centres of the AICRP-MAPB and ICAR - DMAPR.
- To develop partnership between the Directorate and private sector, NGOs and farmers’ associations/progressive farmers interested in promoting the MAP cultivation.

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. 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 Viswa Vidyalaya (JNKVV), Jabalpur
10. Kerala Agricultural University (KAU), Thrissur
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. Rajendra Agricultural University (RAU), Pusa
17. Rajmata Vijayraje Scindia Krishi Vishwa Vidyalaya (RVSKV), 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. Reddy Horticulture University (YSRHU), Venkataramannagudem
23. Central Agricultural University (CAU), Pasighat
Centres of AICRP on Medicinal & Aromatic Plants and Betelvine

1. Anand Agricultural University (AAU), Anand
2. Dr. Y. S. R. Horticulture University (APHU), VR Gadep
3. Assam Agricultural University (AAU), Jorhat
4. Birsa Agricultural University (BAU), Ranchi
5. C. C. S. Haryana Agricultural University (CCSHAU), Hisar
6. Uttar Pradesh University of Horticulture & Forestry (UJHP), Bijnor
7. Uttarakhand University of Horticulture & Forestry (UUHF), Berhampur
8. Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur
9. Indian Institute of Horticultural Research (IIHR), Bengaluru
10. Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur
11. Kerala Agricultural University (KAU), Thrissur
12. Mahatma Gandhi University of Agriculture and Technology (MGUAT), Udaipur
13. Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri
14. N. D. University of Agriculture and Technology (NDUAT), Faizabad
15. Orissa University of Agriculture and Technology (OUAT), Bhubaneshwar
16. Dr. P. D. Krishi Vidyapeeth (PDKV), Akola
17. Kirana Agricultural University (AAU), Bhubaneshwar
18. Rajendra Agricultural University (RRAU), Pusa
19. Rajmata Vijay Raje Scindia Krishi Vishwa Vidyalaya (RVSKVV), Mandsaur
20. Tamil Nadu Agricultural University (TNAU), Coimbatore
21. Uttar Banga Krishi Vishwavidyalaya (UBKV), Kalimpong
22. Dr. Y. S. Parmar University of Horticulture and Forestry (YSPUHF), Solan
23. Central Agricultural University (CAU), Parshuram

ICAR-DMAPR Anand Headquarters.
### Budget profile for financial year 2015-16

<table>
<thead>
<tr>
<th>Head</th>
<th>Expenditure (Rs. in Lakhs)</th>
</tr>
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<tbody>
<tr>
<td>Non-Plan Expenditure (including pension)</td>
<td>453.57</td>
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<tr>
<td>Plan Expenditure (including TSP &amp; NEH)</td>
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<td>AICRP on MAP &amp; Betelvine</td>
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<td>Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme (Up-scaling of existing component <em>i.e.</em>, Intellectual Property Right (IPR))</td>
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<td>NASF Project - Molecular and genetic analyses of guggul for the identification of genes governing adventive embryony</td>
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<td>ICAR - Network Research Project on High Value Compounds and Phytochemicals</td>
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<td>ICAR-Extra mural projects</td>
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<td>ICAR-Consortia Research Platform on Agrobiodiversity-Medicinal Plants</td>
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### Externally Funded Projects

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<th>Project</th>
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<td>PPV&amp;FRA Project- Development of DUS descriptors in MAP</td>
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<tr>
<td>Centrally Sponsored Scheme under National Horticulture Mission for Development of Spices and Aromatic Plants</td>
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<td>DST Project-Transcriptome analysis of Senna (<em>Cassia angustifolia</em>) to identify potential genes involved in the biosynthesis of sennosides</td>
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<td>DST Project-“Genetic mapping of Isabgol (<em>Plantago ovata</em>) genome and identification of quantitative trait loci (QTLs) for yield and resistance to Downy mildew”</td>
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<tr>
<td>DST-Studies on the burl: an unresolved woody disorder of mango trees in India</td>
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Medicinal and Aromatic Plants

ALOE (Aloe barbadensis)

It 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. Fruit set starts from December to March. Seeds have very low germination percentage. 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. Suckers are mainly used for propagation.

Evaluation of germplasm

NDUAT, Faizabad: Twenty four genotypes of Aloe were evaluated. Data were recorded on characters viz., number of suckers per plant, leaf length, leaf breadth, number of leaves per plant, leaf weight per plant and leaf yield per hectare. Number of suckers per plant varied from 2.70 to 10.00. Maximum number of suckers per plant was in the genotype IC-471886 (10.00 suckers) followed by the genotype IC-111279 (9.55 suckers) and IC- 283655 (8.15 suckers) and minimum was in the genotype IC-283610 (2.70 suckers). Leaf length varied from 24.50 to 53.90 cm. Maximum number of leaves per plant was observed in the genotype IC-112518 (53.90 cm) followed by the genotype IC-310618 (40.90 cm) and minimum was in genotype IC-112517 (24.50 cm.). Number leaves per plant varied from 7.20 to 14.15 per plant. Maximum number of leaves per plant was in the genotype IC-111279 followed by the genotype IC-112518 and IC-285629 and minimum was in IC-471886. Leaf weight per plant ranged from 0.29 kg plant⁻¹ to 3.89 kg plant⁻¹. Maximum plant weight was noted in genotype IC-112279 followed by IC-112531 (3.43 kg plant⁻¹) and IC- 310618 (3.32 kg plant⁻¹) and minimum was in the genotype IC- 471886. Leaf breadth varied from 2.40 cm to 7.25 cm in the genotypes IC-471886 and IC-112518, respectively. Leaf yield ranged from 95.83 to 1296.99 kg ha⁻¹. The highest leaf yield was in the genotype IC-112279 followed by IC-112531 (1144.16 kg ha⁻¹) and IC-310618 (1106.66 kg ha⁻¹) and minimum was in the genotype IC-471886 (95.83 kg ha⁻¹).
Studies on floral biology

PDKV, Akola: Floral biology was studied in the species and it was observed that the flowers are bisexual, containing both female and male reproductive parts. The flowers had perianth of 6 tepals with six stamens and the ovary is superior, where the tepals and stamens are inserted below the ovary. Maximum anthesis was observed from 08.00 to 09.00 am at RH of 62-67% and temperature range of 27 to 30°C. Anther dehiscence was maximum between 09.00 am and 10.00 am. The time between anthesis and anther dehiscence was nearly 1.00 hr.

Effect of irrigation and planting methods on growth and yield

CCSHAU, HISAR: An experiment was conducted with four levels of irrigation and three planting methods to find out their effect on growth and yield of Aloe. Under irrigation treatments the highest yield of leaves (288.57 q ha⁻¹) was recorded with three irrigations, followed by two irrigations (247.86 q ha⁻¹) and one irrigation (206.74 q ha⁻¹), and the lowest was in rainfed conditions (181.97 q ha⁻¹). The highest gel yield was also recorded in three irrigations treatment (173.15 q ha⁻¹), followed by two irrigations (148.72 q ha⁻¹) and one irrigation (124.04 q ha⁻¹), and the lowest was in rainfed condition (109.18 q ha⁻¹). Among the methods of planting tried, the highest yield of leaves (283.12 q ha⁻¹) was recorded with planting on ridges 9” followed by flat beds (244.59 q ha⁻¹) and the lowest was recorded in raised bed method (218.65 q ha⁻¹). Gel yield (q ha⁻¹) was also affected by planting methods. The highest gel yield (169.87 q ha⁻¹) was recorded in ridge planting followed by flat beds (146.76 q ha⁻¹) and it was the lowest (131.19 q ha⁻¹) in raised bed method of planting. Combination of three irrigations and planting on ridges gave the highest leaf yield of 318.93 q ha⁻¹ followed by combination of two irrigations and planting on ridges (312.79 q ha⁻¹).

ARJUN (Terminalia arjuna)

It is a tree species belongs to family Combretaceae and widely distributed in Central India. It has a buttressed trunk and light brown peeling bark. Leaves are 10-25 cm long and 4-9 cm broad. Leaves are compound in nature. A pair of glands is present on the leaf blade close to the tip of the petioles. The bark of the tree is considered as a cardio-tonic and is prescribed in the form of powder along with milk and sugar or in the form of decoction. The astringent property of the bark is also utilized for the treatment of diarrhea. The bark is used for the treatment of coronary disorders and used in many ayurvedic tonics. It is also applied as paste for curing pimples and other minor skin eruptions. The common adulterants of the raw drug are the barks of other Terminalia spp., Sterculia urens and Lagerstroemia flos-regina.
Evaluation of market samples of *Arjunarishta*

**PDKV, Akola:** Evaluation of market samples of *Arjunarishta* was conducted for testing the presence of specific marker compounds of *Terminalia arjuna*. Six market samples of *Arjunarishta* were evaluated. Under UV@254 nm, there was clear cut detection of ellagic acid (Rf 0.39), gallic acid (Rf 0.44), ethyl gallate (Rf 0.52) and quercetin (Rf 0.56) in *Arjunarishta*, but arjunetin was not detected in any of the samples by any of the detection method used.

**Comparative evaluation of quality parameters of *Terminalia* sp.**

**PDKV, Akola:** Comparative studies of five species of *Terminalia*, viz., *T. arjuna*, *T. bellirica*, *T. chebula*, *T. tomentosa* and *T. catappa* based on total phenols, tannins and antioxidant potential in leaves and fruits were conducted. The study showed that leaves and fruits of *T. bellirica* contained the highest total phenol content (10.31% & 22.38%), tannins (10.05% & 21.88%) and antioxidant potential (15.46% & 35.73% antiradical activity with DPPH method).

**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.

**Effect of sowing dates and seed rates on growth and yield**

**PDKV, Akola:** An experiment was conducted to assess the effect of date of sowing (38th, 40th, 42nd, 44th and 46th meteorological weeks-MW) and seed rates (6, 8 and 10 kg ha⁻¹) on growth and yield of Asalio. Significantly higher plant height was noticed at 44th meteorological week sowing which was at par with 46th meteorological week sowing. Seed rate of 6 kg ha⁻¹ recorded significantly higher plant height. Significantly higher seed yield ha⁻¹ was recorded with sowing on 44th MW and seed rate of 6 kg ha⁻¹ (8.98 and 7.28 q ha⁻¹). Sowing of Asalio on 45th MW (5 to 11 Nov) at 30x10 cm spacing produced significantly higher seed yield (5.85 q ha⁻¹) followed by sowing on 44th MW (29th Oct to
Effect of irrigation and nitrogen levels on growth and yield

IGKV, Raipur: Effect of three levels of irrigation (one irrigation at 25 days after sowing-DAS; two irrigations at 25 and 50 DAS; and three irrigations at 25, 50, 75 DAS) and four levels of nitrogen (20, 40, 60 and 80 kg ha\(^{-1}\)) were tested on growth and yield parameters of Asalio. Maximum seed yield (13.20 q ha\(^{-1}\)) was recorded in treatment of irrigation at 25, 50 and 75 DAS which was at par with irrigations at 25 and 50 DAS. Among N sources, maximum number of branches per plant (8.98) and seed yield (12.41 q ha\(^{-1}\)) were found with application of 80 kg N ha\(^{-1}\) over the treatment of 60 kg N ha\(^{-1}\). The interaction of irrigation and different nitrogen levels significantly influenced the seed yield wherein the highest seed yield (15.25 q ha\(^{-1}\)) was found with irrigation at 25, 50 and 75 DAS and application of 80 kg N ha\(^{-1}\). The maximum gross return, net return and B:C ratio were found with irrigation at 25, 50 and 75 DAS followed by irrigations at 25 and 50 DAS. However, the highest net return (Rs. 41889.00 ha\(^{-1}\)) was found with the application of 80 kg N ha\(^{-1}\).

Effect of FYM and nitrogen application on productivity

YSPUHF, Solan: The experiment was comprised of two levels of FYM (5 and 10 t ha\(^{-1}\)), three levels of nitrogen (20, 40 and 60 kg ha\(^{-1}\)) and three schedules of nitrogen application (1/2 as basal + 1/2 at 25 DAS; 1/2 as basal + 1/4 at 25 DAS + 1/4 at 45 DAS; and 1/3 as basal + 1/3 at 25 DAS + 1/3 at 45 DAS). The results revealed that all the growth and yield parameters viz., plant height, number of branches plant\(^{-1}\), seed yield, 1000 seed weight, etc. were significantly increased with higher levels of FYM application i.e., at 10 t ha\(^{-1}\) compared to application of 5 t ha\(^{-1}\) FYM. Net returns from plots of 10 t ha\(^{-1}\) FYM application was significantly higher (Rs 58,150 ha\(^{-1}\)) than the plots received 5 t FYM ha\(^{-1}\) (52,654 ha\(^{-1}\)), but the B:C ratio was highest in application of 5t FYM ha\(^{-1}\) (2.91) than 10 t FYM ha\(^{-1}\) (2.58). It was observed that with the increase in nitrogen levels from 20 to 60 kg ha\(^{-1}\), there was significant increase in all the growth and yield parameters by 47.51 and 28.73 per cent, respectively over the treatments of 20 and 40 N kg ha\(^{-1}\).

Integrated weed management

MPUAT, Udaipur: An experiment was conducted to find out the appropriate weed management strategy in Asalio with ten different weed management practices. Results revealed that maximum plant height, number of branches, seed yield and crop economics were recorded in the treatment consisting of two hand weeding and hoeing at 25 and 50 days after sowing (DAS) and it was at par with application of herbicides viz., Pendimethalin 0.75 kg ha\(^{-1}\) PE, Oxyfluorfen 125 g ha\(^{-1}\) PE and Oxadiargyl 75g ha\(^{-1}\) PE each in combination with one hand weeding and hoeing at 35 DAS. All these
treatments were found significantly superior to the weedy check (no weeding) with respect to growth and yield.

**Evaluation of manures, bioagents and bioformulations for management of leaf blight**

**JNKVV, Jabalpur:** Effect of bioagents and biofungicides were evaluated against *Alternaria* leaf blight of Asalio. Among the seven treatments, viz., FYM+ PSB+ spray of 0.15% Azadirachtin (Nimbecidine); FYM+ Azotobacter+ spray of 0.15% Azadirachtin (Nimbecidine); *Trichoderma* fortified FYM+ Azotobacter+ spray of 0.15% Azadirachtin (Nimbecidine); *Trichoderma* fortified FYM+ PSB+ spray of 0.15% Azadirachtin (Nimbecidine); FYM+ PSB+ Azotobacter+ spray of 0.15%, Azadirachtin (Nimbecidine); *Trichoderma* fortified FYM+ PSB+ Azotobacter+ spray of 0.15% Azadirachtin (Nimbecidine) and control (FYM), minimum disease incidence (39.00%) and maximum seed yield (14.41q ha\(^{-1}\)) were recorded in *Trichoderma* fortified FYM+ Azotobacter+ 2 sprays of 0.15% Azadirachtin while maximum disease incidence (66.60%) and minimum seed yield (9.08 q ha\(^{-1}\)) were recorded in the control. Effect of FYM+PSB+ Azotobacter and *Trichoderma* fortified FYM+ PSB+ Azotobacter+ 2 sprays of 0.15% Azadirachtin in reducing the disease incidence (51 and 52%) and enhancing the seed yield was found to be statistically at par. Although, the effect of FYM+ Azotobacter+ 2 sprays of 0.15% Azadirachtin in disease suppression was superior to the control, the effect on seed yield was at par. Result also indicated that *Trichoderma* fortified FYM+ Azotobacter+ 2 sprays of 0.15% Azadirachtin was the best treatment followed by FYM+ PSB+ 2 sprays of 0.15% Azadirachtin for reducing *Alternaria* leaf blight and enhancing the seed yield.

**ASHOKA (Saraca asoca)**

The plant belongs to family Caesalpinaceae. It is also a medium sized, evergreen tree, distributed throughout India particularly in humid areas belonging. Its original distribution was in the central areas of the Deccan plateau, as well as the middle section of the Western Ghats in the western coastal zone of the Indian subcontinent. Flowers are orange-yellow and tender shoots are bronze coloured. The plant is considered as sacred tree of Hindus and Buddhists. Asoka bark is widely used in Indian medicines for the treatment of female disorders. Ashoka is also known for many pharmacological activities like anti-cancer, anti-menorrhagic, anti-oxytocic, anti-microbial and have extended uses in ayurveda, unani and homeopathy. It also has many uses like to treat skin infections, CNS disorders, genitor-urinary dysfunctions, etc. The species flowers during December to March. Flowers are also used for the treatment of bleeding piles and skin diseases. The activity of the drug is due to the presence of steroidal compound, tannins and calcium salt. The raw drug is widely adulterated with the bark of *Polyalthia longifolia*. Due to over exploitation
the species status in nature is vulnerable. The tree can be propagated by seeds as well as by layering.

**Plant growth studies**

**KAU, Thrissur:** Studies revealed that in case of Saraca asoca over a period of 6 years of growth, average height and bark thickness increased 1.5 times, average girth increased 1.7 times, average bark phenol content increased 3.5 times and the bark tannin content increased 1.2 times.

**Process development for catechin enriched extracts**

**ICAR-DMAPR, Anand:** Two different methods were compared for preparation of catechins (catechin, epicatechin, epicatechingallate and epigallocatechin gallate and procyanidin B2) enriched fractions from the leaves of Ashoka. Using the selected method, catechins enriched fractions was prepared from the leaves of Ashoka.

**ASHWAGANDHA (*Withania somnifera*)**

The plant belongs to family Solanaceae and is considered a 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 ingredients that attributed to the medicinal property are alkaloids and steroidal lactones.

**Germplasm collection, characterization and evaluation**

**ICAR-DMAPR, Anand:** One hundred and twenty nine accessions were received from NBPGCR gene bank for regeneration and multiplication. Of the 129 accessions, only 122 accessions were germinated and seeds were multiplied and maintained.

**ICAR-DMAPR, Anand:** One hundred and twenty two accessions were characterized for agro-morphological characters. Variations were observed in leaf shape, leaf colour, flower colour and berry colour. The accessions also showed variation for leaf length (3.70-8.20 cm), leaf breadth (1.90-4.30 cm), root length (10.00-33.50 cm), root diameter (0.52-0.40 cm), number of secondary roots (0.70-6.00), fresh root weight per plant (1.8-222.3 g),
days to flower initiation (76-128 days), plant height (29.00-89.00 cm), number of berries per plant (219.20 -543.90), number of seeds per berry (28.00-48.00) and berry diameter (0.49 to 0.67 cm).

**Advancement of generations and selection of advanced breeding lines**

**ICAR-DMAPR, Anand:** A total of 328 pure lines developed from the variety, JA 134 were evaluated for 14 morphological traits and dry root yield in augmented design. Pure lines, DWS 37 with downward curled leaves and DWS 127 with yellow coloured young leaves expressed these traits in this year also. Similarly DWS 10, a male sterile line expressed its male sterility nature this year also. The male sterility in this plant was governed by environmentally sensitive genetic male sterile mechanism. It produced sterile pollens during cooler months (December-February) and later it converted in to male fertile during hotter months (March onwards) at Anand condition. The pure lines were screened for leaf blight resistance and resistance sources were identified.

**Organic nutrient management**

**ICAR-DMAPR, Anand:** The experiment was laid out with four levels of organic manures (Control, FYM 15 t, vermicompost 7.5 t and castor cake 2.5 t ha\(^{-1}\)) and four levels of biofertilizers and bioformulations (Control, Azotobacter+PSB, Jivamrut and Azotobacter+PSB+Jivamrut). Biofertilizers were applied as seedling treatment and Jivamrut was applied along with irrigation water at 25, 50 and 75 days after sowing (DAS). The crop was harvested at 180 DAS from the net plot area, shade dried and the dry root yield was converted to kg hectare\(^{-1}\). The results revealed that application of vermicompost @ 7.5 t ha\(^{-1}\) recorded maximum plant biomass, dry root yield and root length. Among the biofertilizers and bioformulations, application of Azotobacter + PSB + Jivamrut recorded maximum plant biomass, root length and root yield of Ashwagandha.
**Standardization of method of sowing and organic manures**

**IGKV, Raipur:** The experiment comprised of two main plot treatments (flat bed, ridges & furrows) and eight subplot treatments (control, FYM 10 t ha$^{-1}$, FYM 15 t ha$^{-1}$, vermicompost 5 t ha$^{-1}$, vermicompost 7.5 t ha$^{-1}$, castor cake 1.5 t ha$^{-1}$, castor cake 2.5 t ha$^{-1}$ and RDF through inorganic fertilizers (NPK @ 60:40:40 kg ha$^{-1}$). The result showed that the method of sowing and application of various organic manures significantly influenced the plant height (at harvest), plant biomass (at harvest) and dry root yield of the crop. Maximum plant height (45.16 cm), plant biomass (47.32 q ha$^{-1}$), dry root yield (8.89 q ha$^{-1}$) and net return (Rs. 42404 ha$^{-1}$) were found with ridge and furrow method of planting which was significantly superior to sowing the crop on flat bed.

Various organic manures also significantly influenced the plant height (at harvest), plant biomass (at harvest) and dry root yield of the crop. Maximum plant height (50.33 cm), plant biomass (52.34 q ha$^{-1}$) and dry root yield (9.87 q ha$^{-1}$) were found with application of vermicompost @ 7.5 t ha$^{-1}$ which was significantly superior to application of FYM @ 10.0 t ha$^{-1}$ and control. The highest net return (Rs. 53700 ha$^{-1}$) was found with RDF through inorganic fertilizers. The interaction effect between method of sowing and organic manure on dry root yield was found significant. Sowing the crop in ridge and furrow method with application of vermicompost @ 7.5 t ha$^{-1}$ was found superior for obtaining higher dry root yield (10.16 q ha$^{-1}$).

**Molecular detection of Phytoplasma diseases**

**ICAR-DMAPR, Anand:** In the experimental field little leaf, rosette plant appearance and stunted growth symptoms were observed in some of the Ashwagandha plants. The symptomatic samples along with the samples from asymptomatic plants were collected for analysis of the phytoplasma association. Total DNA was isolated following the CTAB protocol (with some modifications) from the symptomatic and asymptomatic plants samples. PCR amplification was performed using the phytoplasma specific primers (16s RNA) designed based on the sequences retrieved from NCBI GenBank. The association of the phytoplasma was confirmed based on the expected size of amplicon which was not amplified in the asymptomatic samples.

**Evaluation of manures, bioagents and bioformulations against leaf blight**

**JNKVV, Jabalpur:** The experiment was conducted in split plot design with Neem Seed Kernal Extract (NSKE) and neem based formulation i.e., Nimbecidine (Azadirachtin 0.3%) as main plot treatments and *Trichoderma asperellum* @ $10^{6}$cfu ml$^{-1}$; *Pseudomonas fluorescens* @ $10^{4}$cfu ml$^{-1}$; *T. asperellum* @ $10^{6}$cfu ml$^{-1}$ + *P. fluorescens* @ $10^{6}$cfu ml$^{-1}$; FYM @ 10 t ha$^{-1}$ + *T. asperellum* @ $10^{6}$cfu ml$^{-1}$; FYM @ 10 t ha$^{-1}$ + *P. fluorescens* @ $10^{6}$cfu ml$^{-1}$ and control as subplot treatments. Observations on percent disease index were recorded at different interval using 0-5 scale. The result showed that NSKE and Nimbecidine (0.15% Azadirachtin) sprays significantly influenced the disease incidence, root and seed yields. The minimum per cent of disease incidence and higher root and
seed yields were recorded in Nimbecidine (0.15% Azadirachitin) spray treatment. It was also found that effect of soil application of different bioagents (individually or in combination) and bioagent fortified manures significantly reduced the disease incidence but enhanced the dry root and seed yields. The lowest disease incidence and the highest dry root yield (14.56 q ha\(^{-1}\)) and seed yield (156.00 kg ha\(^{-1}\)) were recorded with application of \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) + \(P. \ fluorescens \ @ \ 10^{7}\) cfu ml\(^{-1}\) treatment followed by \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) with dry root yield of 13.46 q ha\(^{-1}\) and seed yield of 143.00 q ha\(^{-1}\) and application of \(P. \ fluorescens \ @ \ 10^{6}\) cfu ml\(^{-1}\) with dry root yield of 12.38 q ha\(^{-1}\) and seed yield of 135.50 kg ha\(^{-1}\).

Interaction effect of biofungicide with bioagents fortified manures was significant in reducing the per cent disease incidence and enhancing the dry root and seed yield. The lowest disease incidence (38.0%) was observed in Nimbecidine x \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) + \(P. \ fluorescens \ @ \ 10^{6}\) cfu ml\(^{-1}\) treatment. The next best treatment was NSKE x \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) + \(P. \ fluorescens \ @ \ 10^{6}\) cfu ml\(^{-1}\) which was statistically at par with NSKE x \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) in suppressing the disease incidence. The treatments Nimbecidine x \(P. \ fluorescens \ @ \ 10^{6}\) cfu ml\(^{-1}\) and Nimbecidine x \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) had almost similar effect on disease reduction (44.0 & 44.0%) and on root (4.58 & 4.32 q ha\(^{-1}\)) and seed (49.00 & 46.00 kg ha\(^{-1}\)) yields. From the result, it was evident that the Nimbecidine (0.15% Azadirachitin) x \(T. \ asperellum \ @ \ 10^{6}\) cfu ml\(^{-1}\) + \(P. \ fluorescens \ @ \ 10^{6}\) cfu ml\(^{-1}\) was the best treatment for reducing the Alternaria leaf blight and enhancing the root and seed yields.

**Process for preparation of withanolide enriched extracts**

**ICAR-DMAPR, Anand:** A process was developed for preparation of extracts, rich in concentration of three major withanolide namely withaferin A, 12-deoxywithastramonolide and withanolide A from the roots of Ashwagandha. A simple and rapid HPLC method was also validated for the identification and quantification of these three compounds. The validated HPLC method was applied for quantification of these withanolides in different extracts and also in five market samples of Ashwagandha. Total phenol content was also estimated in the extracts and market samples. Supercritical fluid extraction (SFE) process was optimized for the preparation of extracts from root powder with ethanol as a modifier.
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.

**Collection, characterization, evaluation and maintenance of germplasm**

**AAU, Jorhat:** Two new accessions were added during 2015-16 making the total germplasm collection to 24. Among the collected germplasm, leaf length ranged from 29.83 to 72.70 cm. The highest leaf length was recorded in JAC-10 and the lowest was in JAC-7. Leaf breadth was highest in JAC-17 (1.93 cm) and the lowest was in JAC-4 (0.82 cm). Leaf length: breadth ratio ranged from 25.69 (JAC-17) to 64.91 (JAC-10). No significant variation in number of leaves was found among the accessions which varied from 5.33 to 8.66. Number of veins per leaf lamina was either four or five except in JAC-16 where the number was three. Rhizome length of the accessions ranged from 8.03 cm (JAC-23) to 23.33 cm (JAC-6). The highest rhizome width was recorded in JAC-9 (6.66 cm) followed by JAC-6 (6.26 cm), JAC-17 (6.23 cm) and JAC-11 (6.20 cm). Rhizome weight per plant varied from 20.00g to 54.00g. Rhizome weight was recorded highest in JAC-4 (54.00 g plant⁻¹) followed by JAC-1 and JAC-6 (50.00g plant⁻¹). JAC-21 recorded the lowest rhizome weight of 20.00 g plant⁻¹.

**Multi-location trial**

**AAU, Jorhat:** Five entries of Bach were under multilocation trial (MLT) to identify varieties for high yield. During the second year of planting, plant height ranged from 31.40 cm to 48.87 cm. Highest plant height was recorded in APAc-5 (48.87 cm) while minimum was found in APAc-4 (31.40 cm). Number of leaves per plant was maximum in APAc-5 (9.00) followed by Symbolia (8.50). Rhizome length ranged from 5.78 to 12.73 cm. Maximum rhizome length was recorded in APAc-2 (12.73 cm) followed by APAc-9 (8.75 cm). Minimum rhizome length was found in APAc-5 (5.78 cm). No significant variation in rhizome diameter was found among the entries. APAc-9 recorded maximum diameter of 5.68 cm while minimum was recorded in APAc-4 (4.43 cm).

**BCKV, Kalyani:** Five entries of Bach were under MLT to identify varieties for high yield.
Single node rhizome cuttings were planted in 2015. The rhizomes were harvested after 9 months. It was found that maximum rhizome yield (t ha⁻¹) was in Aihagaripalli (4.63 t ha⁻¹) followed by Munipalli (4.17 t ha⁻¹).

Percent disease index of leaf spot and leaf rot were also calculated on a 0-5 scale among the entries. The occurrence of three diseases was recorded viz., leaf spot, basal rot (c.o. Sclerotium rolfsii) and rust (Uromyces acori). The highest PDI of leaf spot was found in Munipalli (8.31%); and the lowest was in Aihagaripalli (4.90%) followed by Gaddipalli (4.93%), Symbolia (5.80%) and Nagireddigudem (6.08%). The highest PDI of rust was found in Symbolia (91.48%), however, it was at par with the other entries. Therefore, it was found that all the varieties were more or less susceptible to all the diseases and overall, Symbolia (APAC-3) was found more susceptible than the others four entries. The highest PDI of basal rot was found in Aihagaripalli (12.48%) followed by Symbolia (10.61%), which were statistically at par. The lowest PDI was found in Munipalli (4.99%) followed by Gaddipalli (7.01%) and both were at par.

**YSRHU, Venkataramannagudem**: The trial included five entries with Symbolia as check variety. During the first year, no significant differences was observed among the accessions in case of plant height, number of leaves, leaf length, leaf width, distance between leaves and rhizome yield. Stem pigmentation at nodes, leaf characteristics viz., colour, serration and shape and floral characteristics such as flower size, style position, pollen size and pollen viability were studied.

**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, dysentery, 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, dysentery, dyspepsia, stomachalgia, cardiopalms, seminal weakness, vomiting, intermittent fever and swellings.

**ICAR- DMAPR, Anand**: Forty six accessions of Bael were evaluated for yield, yield contributing traits and marmelosin content in dry fruit pulp. Maximum fruit yield (133.69 kg tree⁻¹) was observed in accession DEM 24, followed by accession DEM 8 (72.04 kg tree⁻¹). Highest marmelosin content was in accession DEM 14 (6.90 mg g⁻¹) followed by accession DEM 156 (4.60 mg g⁻¹). Number of fruits was positively correlated (p= 0.01).
with fruit yield \((r = 0.806)\), stem girth \((r = 0.581)\), canopy spread \((r = 0.591)\) and plant height \((r = 0.408)\), while fruit weight was correlated \((p = 0.05)\) with marmelosin content \((r = 0.308)\).

**BALA (Sida cordifolia)**

It is an annual herb belongs to family Malvaceae. There are four other species used in medicine, however, *S. cordifolia* is most widely used. *S. cordifolia* is considered as the source of raw drug, Bala in North India while in South India, *S. rhombifolia* is accepted as the source of the raw drug. All the *Sida* species are widely distributed as a weed in the cultivated fields of tropical and subtropical regions of India. Cultivation on limited scale has been initiated in other species in some parts of India. The root of the species is used as raw drug for the treatment of rheumatism. It imparts strength to the body and useful in treatment of facial paralysis, general debility, sciatica, headache, uterine disorders, etc.

**KAU, Thrissur:** Fourteen root samples of Bala were collected from fourteen different places of Kerala viz., Kodakara, Chalakudy, Kalady, Palakad, Wadakaanchery, Alathur, Pattambi, Kottayam, Valanchery, Kuttippuram, Perinthalmanna, Trivandrum, Kollam and Pathanamthitta. The samples were tested for total phenol content which ranged from 0.29 to 1.15%.

**BASIL (Ocimum basilicum)**

It 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. 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.

**Germplasm evaluation**

**ICAR-DMAPR, Anand:** Eighteen accessions of Basil were collected and evaluated for oil content, herbage yield and yield contributing traits. Eight superior and almost stable
selections viz., AOB-2, AOB-3, AOB-5, DOB-1, DOB-2, DOB-3, DOB-4, DOB-5 and DOB-8 were evaluated for branch colour, leaf colour, flower colour, panicle colour, panicle type, branch type, anther colour, leaf type and plant type. Based on one year evaluation at two locations, maximum plant height was observed in DOB-8 (90.58 cm) followed by AOB-3, DOB-1, DOB-2 and DOB-3, while DOB-4 (55.50 cm) showed minimum plant height. Significantly higher plant spread was observed in DOB-8 (97.67 cm) which was at par with AOB-2, while DOB-4 (41.37 cm) showed lowest plant spread. Significantly higher number of branches per plant was observed in AOB-3 (344.28) followed by AOB-5 and DOB-3, while DOB-4 (95.83) showed minimum number of branches per plant. Maximum number of leaves per plant was observed in DOB-8 (2146.33) which was at par with AOB-5, while DOB-4 (828.17) showed minimum number of leaves per plant. Maximum leaf area (per ten leaves) was observed in DOB-8 (189.53 cm²) which was at par with DOB-1 and AOB-5, while DOB-4 (96.30 cm²) showed minimum leaf area. Maximum herbage yield was in DOB-8 (321.08 q ha⁻¹) which was at par with DOB-2 (296.14 q ha⁻¹) and DOB-3 (297.44 q ha⁻¹), while DOB-4 (270.54 q ha⁻¹) showed minimum herbage yield. Highest oil content (%) in leaf was observed in DOB-1 (0.70) which was at par with DOB-5 (0.61%), while DOB-2 showed minimum oil percent (0.17).

The samples of essential oil were subjected to detailed analysis in order to determine the impact of individual accession on its volatile oil constituents. Several compounds were identified in leaf at onset of flowering (stage-I) and at full flowering (stage-II). Highest share of Sebinenehydrate/Eucalyptol, Linalylformate, Eugenol, Calarene, Spathulenol, Naphthalene and Beta-selinene were found in AOB-3, while significantly highest share of Methyl chavicol was observed in AOB-2 at full flowering stage. Valencene, Beta-caryophyllene, Bicyclohept-2-ene/Methanoazulene and Alphacubebeene had maximum share in AOB-5. In case of d-camphor and Isobornylformate/bornyl acetate, the DOB-1 had maximum content which was at par with DOB-5. Among all the accessions, DOB-4 had the highest Methyl cinnamate content. Maximum share of Delta-3-carene was observed in DOB-5, while Methyl Eugenol and Azulene were maximum in DOB-8. The share of Terpinylformate was highest in DOB-3 which was at par with AOB-3. Overall DOB-1 was superior on the basis of volatile compounds.

**BITTER SNAKEGOURD (Trichosanthes cucumerina)**

The plant belongs to family Cucurbitaceae. It is a large, branched woody climber with tendrils, older part of stem is light gray and younger stem is smooth green with tendrils commonly cleft into 3; leaves palmately 3-5 lobed, dark green above, pale beneath with dark-coloured circular gland scattered along the lower side; flowers unisexual, males in axillary racemes, bracts broadly ovate, many nerved, fringed and gland dotted, female flowers solitary and axillary; fruits globose, red when ripe with 10 orange streaks; seeds
numerous, smooth. The roots are bitter, astringent, acrid, thermogenic, carminativa, emetic and purgative. They are good for hemicrania, carbuncles and gonorrhoea. The fruits are very valuable in curing otitis and also recommended for hemicrania inflammations, weakness of lymphs, vitiated conditions of vata, asthma, epilepsy and leprosy.

Studies on floral biology

KAU, Thrissur: Floral biology of *T. cucumerina* was studied using three accessions viz; TCRTC 1, TCRTC 2 and TCR TC 7. It was found that anthesis of male and female flowers occurred during night time. Anthesis time of male flower ranged from 19.00 hours to 19.57 hours and female flower started from 19.20 to 21.05 hours. In all the accessions, male flowers opened first and male phase lasted for 20 days. After the male phase, the female phase started and it lasted for about 35-40 days.

Collection, characterization and evaluation of germplasm

KAU, Thrissur: Nineteen accessions were evaluated for yield and quality. Data were taken on days to harvest, number of fruits per plant, number of fruits per plant, fruit length and width, herbage yield, fruit yield and total yield. Significant differences were observed in the studied characters among the accessions. TCR TC 2 had significantly lower days to harvest (88.00 days) which was at par with TCR TC 18 (88.50 days) and TCR TC 11 (89.50 days). Number of fruits per plant was significantly higher in TCR TC 8 (47 plant^{-1}), which was at par with TCR TC 4, TCR TC 413, TCR TC 4, TCR TC 418 and TCR TC 410 and fruit weight was significantly higher in TCR TC 7 (76.50 g). Herbage yield, fruit yield and total yield on fresh weight basis were significantly higher in TCR TC 2 (2051.50 g plant^{-1}, 1767.00 plant^{-1}, 3818.50 plant^{-1}) however it was at par with TCR TC 7 in terms of fruit yield per plant (1721.00 plant^{-1}).

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.

Collection, characterization, multiplication and conservation of _Swertia_ spp.

**UUHF, Bharsar:** Fifty plants of _S. chirayita_ from Solan were planted inside net house. Efforts were being made to collect germplasm of this species from Kalimpong during growth season. Study also showed that in _S. ciliata_, seeds become mature during the month of October- November. Mature seeds of _S. ciliata_ were collected from natural populations and seeds were sown to raise seedlings. Seeds of _S. cordata_ also mature during the month of October- November. Mature seeds were collected from natural populations and seeds were sown to raise seedlings. Approximately 30 plants of _S. cordata_ collected from Budhabharsar area of Pauri Garhwal, Uttarakhand were maintained in the field gene bank.

**YSPUHF, Solan:** A survey was conducted for checking the availability of genuine material of raw drug of _S. chirayita_ in market. Ninety seven samples were collected from different Indian markets through 14 AICRP centres of MAP&B. The samples were tested for bioactive compounds in samples. Among the 97 samples, 44 samples were of _S. chirayita_, 52 were of _Andrographis paniculata_ and one was of unknown species. Among the _S. chirayita_ samples, 12 samples contained very low bioactive compound. The study thus showed that genuine samples were 45.36% of the total samples studied, adulteration/substitution was 54.64% and _A. paniculata_ species was found as the major substitute of _S. chirayita_ market samples.

**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 irrigation schedule on dry biomass yield**

**AAU, Anand:** An experiment was conducted with four irrigation schedules comprised of IW/CPE ratios 0.40, 0.60, 0.80 and 1.00 for two years. The pooled analysis showed that significantly higher plant height (163.30 and 172.50 cm), number of shoots plant$^{-1}$ (18.08 and 19.13), length of shoots (167.90 cm) and dry biomass yield (91.68, 113.17 q ha$^{-1}$)}
were in irrigation schedule of 1.00 IW/CPE ratio in both the years. The plant stand was found non-significant in both the years as well as in on pooled analysis. Higher water use efficiency (WUE) was found (6.41 kg ha\(^{-1}\) mm\(^{-1}\)) in treatment 1.00 IW/CPE ratio which was followed by the treatment 0.80 IW/CPE ratio (5.39 kg ha\(^{-1}\) mm\(^{-1}\)) in the second year of experiment while, in the first year and on pooled analysis it was found non-significant.

**Effect of different levels of nitrogen and phosphorus on dry biomass yield**

AAU, Anand: An experiment was conducted with five nitrogen levels (control, 50, 100, 150 and 200 kg N ha\(^{-1}\)) and two phosphorus levels (control and 25 kg P ha\(^{-1}\)). Significantly higher dry biomass yield (144.30 q ha\(^{-1}\)) was found with the application of nitrogen@ 200 kg ha\(^{-1}\) which was statistically at par with application of 150 kg N ha\(^{-1}\) and 100 kg N ha\(^{-1}\) (132.65 and 130.20 q ha\(^{-1}\)). The lowest dry biomass yield of 112.21 q ha\(^{-1}\) was obtained under the control treatment. Application of phosphorus 25 kg ha\(^{-1}\) recorded significantly highest dry biomass yield (131.39 q ha\(^{-1}\)), whereas, the interaction effect of nitrogen and phosphorus levels was found non-significant.

Effect of different levels of nitrogen and phosphorus on soil parameters after harvest of the crop revealed that significantly higher value of nitrogen (280.63 kg ha\(^{-1}\)) was found under application of nitrogen @ of 200 kg ha\(^{-1}\), whereas, soil potash was higher (312.88 kg ha\(^{-1}\)) with application of nitrogen @ 50 kg ha\(^{-1}\). Significantly higher soil organic carbon percentage (0.64) was noted with application of nitrogen @ 150 kg ha\(^{-1}\), which was at par with application of nitrogen @ 200 kg ha\(^{-1}\). Significantly highest value of soil phosphorus (62.99 kg ha\(^{-1}\)) was found with the application of phosphorus 25 kg ha\(^{-1}\). However, interaction effect of nitrogen and phosphorus levels was found non-significant.

**Estimation of qualitative and quantitative yield loss due to sucking pests**

ICAR-DMAPR, Anand: Field experiments were laid out in paired plots to find out the yield loss due to sucking pests, Aphids (*Aphis nerii*), Psyllids (*Diaphorina dakariensis*) and Red spider mite (*Tetranychus* sp) in Dodi. At harvest, the fresh weight of leaves recorded from insecticidal sprayed plots was 7.24 kg per 7.5 m\(^2\) (103.42 t ha\(^{-1}\)) which was significantly higher than the yield from the unsprayed plots i.e., 2.84 kg per 7.5 m\(^2\) (40.57 t ha\(^{-1}\)). The per cent loss of yield caused due to the three sucking pests was found to be 60.77. Chemical analyses were done to find out changes in chemical constituents (rutine and myrictein) of pest infested and normal leaves of *Dodi*. There was a reduction of 15% rutine and 5.3% myrictein contents in the pest infested leaves.

**Evaluation of IPM modules against sucking pests**

ICAR-DMAPR, Anand: Field experiments were carried out to evaluate different IPM modules against sucking pests in Dodi. Mean percent infestation was significantly lower in the IPM module involving basal application of vermicompost @ 6 t ha\(^{-1}\) + Neem cake @ 500 kg ha\(^{-1}\) followed by 1 spray of Imidacloprid 17.8 SL at 30 days after
planting (DAP) followed by 3 sprays of Azadirachtin (1%) at 45, 60 and 90 DAP. This module also recorded maximum number of coccinellid beetles and maximum leaf yield per plot.

**GILOE (Tinospora cordifolia)**

Giloe is a member of family Menispermaceae. It is a deciduous perennial climber and is distributed throughout tropical India. The species produces a 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.

**Studies on white powdery leaf spot disease**

**BCKV, Kalyani:** Study was conducted on white powdery leaf spot disease caused by *Cercosporella tinospora*. At first, infected tissues became pale yellowish spots, usually limited along the vein, appeared on the upper leaf surface. They enlarged and sometimes coalesced to each other forming irregular bigger spots with yellow colour. In advanced stage, spots became brownish at their center part. The lower surface of the yellowish spots was covered with dirty white to faint yellow powdery masses composed of conidiophores and conidia. Severely diseased leaves gradually changed into yellow to brown colour and dried up and eventually defoliated. The disease occurred throughout the year, however it was more severe during the rainy season.

Hyphae were internal, within epidermal and mesophyll layers of the diseased leaves, hyaline to pale colored and septate. Stroma were hypophyllous, within stomata or epidermal layer, pale olive brown. Conidiophores were hyaline, pale brown at the base, septate, simple, flexuous, and arising in clusters from the upper cells of stroma, with distinct but thin scars as sympodial. Conidia were hyaline, straight or curved, obclavate, acute apex with truncate and thickened base, 1-3 septate (mostly 1-2 septa), 16.57-43.00 µm x 6.56-11.54 µm (Mean: 28.69± 6.30 µm x 8.87± 0.95 µm) in size, 3.27± 0.79 in length-breadth ratio and smooth. It formed asc in the ascostroma on PDA medium. Ascostroma were small pseudothecia locules, aparaphysate. There were 8 ascospores in each ascus. The size of asc was 43.17-76.65 µm x 7.78-13.65 µm (Mean: 60.65± 7.37 µm x 10.68± 1.38 µm) and the length-breadth ratio was 5.75± 0.95. Ascospores were hyaline and 2 celled. The size of ascospores was 16.82-24.50 µm x 6.48-9.07 µm
(Mean: 20.44± 2.03 µm x 7.69± 0.76 µm) and the length-breadth ratio was 2.69± 0.44. As described above, the fungus observed on the lower leaf surface of the spot of *T. cordifolia* was proved to be the causal agent of the present disease. The fungus apparently belongs to the genus, conidial stage: *Cercosporella tinosporae* (Lacy and Thirum.) Deighton, and sexual stage: *Mycosphaerella tinosporae* (Ascomycota, Dothideomycetes, Capnodiales, Mycosphaerellaceae) based on its morphological characteristics described above. It was reported from Bihar and MP.

**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 branches are crooked, knotty, aromatic and end in sharp spines. The gum is highly effective in the treatment of obesity, arthritis and other diseases. The gum-resin is used in the form of a lotion for indolent ulcers also. 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 'data deficient' category in the IUCN Red Data Book. It is propagated by either seeds or stem cuttings.

**Raising of progenies to develop segregating population**

**ICAR-DMAPR, Anand:** Crosses between obligate sexual and apomictic parents were continued during this year also. Two female obligate sexual genotypes of DMAPR CW 33 series *i.e.*, DMAPR CW 33F5 and DMAPR CW 33F16 were crossed with the apomictic hermaphrodite genotype *i.e.*, DMAPR CW 32. Flowering season in the species was for about four months in the year *i.e.*, December to March, and peak flowering was observed in February and March. During this period, mature buds were tagged prior to anthesis and the stigma is protected by cotton to avoid unwanted pollens. On the day of anthesis, the flowers were pollinated by freshly collected pollen grains from the male parents. The pollinated flowers were observed for fruit setting at 5, 15, 30, 60 days after pollination. A total of 10095 flowers were pollinated, out of which 94 hybrid fruits were collected. Pollination success was found as 0.96%.

Hybrid seedlings were raised from the fruits collected from the crosses. A total of 32 seedlings were generated from the hybrid seeds (32.98% germination) during this year. At present 53 hybrid seedlings (21 seedlings generated during the last year) of obligate sexual female and apomictic hermaphrodite were maintained. In addition to this, a total of 150 open pollinated seedlings from the obligate sexual female were also developed.
These seedlings will be utilized for genotyping, phenotyping as well as bulk segregant analysis for the study of genetics of apomixis in the species.

Identification and testing of molecular markers

ICAR-DMAPR, Anand: EST-SSR markers were designed from ovule transcriptomes of obligate sexual and apomictic parents developed at ICAR-NRCPB. A total of 94 SSR markers were screened and 37 markers showed amplification out of which 19 showed polymorphism among the parents and their progenies. The SSR markers were tested for their utility in genotyping of segregating populations obtained through biparental crossing. Almost all markers showed amplicon with the guggul parents. Some of the markers showed segregation among the biparental progenies. Preliminary results suggest that the pattern of segregation was not consistent with the Mendelian pattern. Further detailed analysis is needed to confirm the results.

Development of in vitro regeneration protocols

ICAR-DMAPR, Anand: Standardization of different explants, culture media and culture conditions for in vitro regeneration of Guggul was carried out during the current year also. Different types of explants (shoot apex, leaves, fruit wall, ovule, roots, stems, etc.) were collected from healthy plants of selected genotypes [DMAPR CW 33 (Female), DMAPR CW 32 (Hermaphrodite) and DMAPR CW 19 (Male)] grown in the Field gene bank of ICAR-DMAPR.

Both MS medium and Woody plant medium (WPM) supplemented with different concentrations and combinations of growth regulators (auxins, cytokinins, gibberelic acids) such as Indole-3-acetic acid (IAA), 1-naphthalene acetic acid (NAA), 2,4-dichlorophenoxy acetic acid (2,4-D), Dicamba, 2ip, 6-benzylaminopurine (BAP), kinetin (Kn), Zeatin, TDZ and gibberelic acid (GA), sucrose (3%) as carbon source, thiamine (10 mg l\(^{-1}\)) as vitamin source, glycine (20 mg l\(^{-1}\)) as amino acid source, inositol (100mg l\(^{-1}\)) and adenine sulphate (10 to 100 mg l\(^{-1}\)) for initiation of callus. The media pH was adjusted to 5.8 using HCl (0.1N) or NaOH (0.1N). Gelrite (0.3%) was added as gelling agent in the culture media and boiled thoroughly and used after proper sterilization. After aseptic inoculation of the explants, all the cultured tubes and flasks were incubated at 25± 2\(^\circ\)C. Humidity of the culture room was kept at 40 to 50%, under a light intensity of 1600 to 2000 lux and 16 hour light and 8 hour dark period.

All explants responded to callus induction in MS and WPM medium supplemented with 2, 4-D and Kinetin, but organogenesis was not obtained in any of the growth regulator combinations tested. However, when ovule generated calli were transferred to the MS medium with Kinetin, BAP and NAA, somatic embryos were obtained after 9-10 weeks of subculture. Primary somatic embryos upon transfer to fresh medium continued to give rise to secondary embryos, both on the induction medium and also in medium with lower concentrations of cytokinins. Direct somatic embryogenesis was also observed from the epicotyl regions of in-vitro raised seedlings, when cultured on embryogenesis
induction medium.

**Molecular marker based discrimination of Commiphora spp.**

**ICAR-DMAPR, Anand:** Study was conducted to evaluate genetic diversity and species discrimination of four Commiphora species *i.e.*, C. agallocha (Syn. C. madagascariensis Jacq.), C. caudata (Wight and Arn.) Engl., C. stocksiana (Engl.) Engl. and C. wightii (Arn.) Bhandari [Syn. C. mukul (Hook. ex Stocks) Engl.] using molecular markers. RAPD and 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. RAPD primers amplified 264 fragments from which 18 were monomorphic, 109 were polymorphic and 137 were unique, whereas 18 ISSR markers amplified 132 loci out of which 37 loci were polymorphic, 11 were monomorphic and 84 were unique. 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 SCARs 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.

**INDIAN VALERIANA (Valeriana jatamansi)**

It is a perennial herb, 15-60 cm tall, velvet-hairy to hairy. Rhizomes are elongate, with fibrous roots. Stems are 3-6 in number. Leaves at the base are heart-shaped or ovate, toothed or wavy-toothed. Flowers are white which are borne in flat-topped clusters on top of the stems. Upper bracts are linear-lance shaped, about 3 mm long. Stigma is 3-fid. Seed-pods are velvety, shorter than the upper bracts. The species is found throughout the Himalayas, from Afghanistan to SW China, at altitudes of 1500-3600 m. Flowering occurs during March to May. Roots of the species are useful in diseases related to eye, blood, liver and spleen. Leaves are used for the treatment of headache. Roots are also used in aromatic industry. Raw drug is collected mainly from the wild since cultivation is not yet popularized. Since it is a temperate plant, it requires cold weather for proper growth. The plant is propagated by seeds as well as by root stocks.

**Effect of sowing time and spacing on growth and yield**

**UBKV, Kalimpong:** An experiment was conducted with two sowing times (1st week of June and July) and three spacings (30×20, 30×30 and 30×45 cm). Date of transplanting significantly influenced the root biomass only at 6, 12 and 18 months stages, and
significantly more root volume was recorded with the July planting at 6th month and 12th month. However, June planting produced more root biomass at 12, 15 and 18 months of observation. Plant spacing failed to produce any statistically significant difference in root biomass yield at 9th and 15th month. Maximum root biomass was recorded with the spacing of 30×30 cm at 6 month and was at par with 30×45 cm spacing. However, at 12th month, more root production was observed with 30×45 cm spacing and was at par with 30×30 cm spacing and significantly better than the other set of spacings. At 18th month, more root biomass accumulation was registered with 30×45 cm spacing, and statistically superior to the other two set of spacing. Interaction effect produced significant response only at 18 months. Fresh root biomass produced significant response at 21 month stage and failed to produce any response at 24 month stage. However, June planting produced more root biomass per unit area compared to the other set of treatments. Further, spacing of 30×45 cm was significantly superior compared to the rest of the treatments.

**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 production country in the international trade. Country earns on an average Rs. 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.

**Evaluation of germplasm**

**NDUAT, Faizabad:** Forty two lines of Isabgol were evaluated to develop a suitable variety favourable for eastern Uttar Pradesh conditions. The study showed that the length of spikes per plant ranged from 1.12– 2.91 cm. Maximum length of spike was recorded in the line AMB-29 (2.91cm) followed by HI-96 (2.81cm) and DM-11 (2.62 cm) and minimum was in genotype PB- 17 (1.12 cm).

The number of spikes varied from 4.60 to 11.80. The highest number of spikes was noticed in HI-4 (11.80) followed by HI-2009 (10.90) and DM-9 & PB-80 (1060) while, the minimum number of spikes was recorded in Palampur- 2 (4.60).

The seed yield ranged from 1.04 to 6.04 q ha⁻¹. The maximum seed yield was obtained in HI-4 (6.04 q ha⁻¹) followed by HI-2009 (4.79 q ha⁻¹) and PB-80 (4.58 q ha⁻¹). The minimum seed yield was noted in Palampur-2 and Palampur- 3 (1.04 q ha⁻¹).
Screening of breeding lines and elite lines for Downy mildew

ICAR-DMAPR, Anand: Different germplasm lines and recombinant inbred lines (RILs) of Isabgol were screened in artificial epiphytotic condition against Downy mildew disease to evaluate the resistance reaction of these lines. Sporangia were collected from the surfaces of the infected leaves and the inoculums (2x 10^3 ml^-1) of the sporangia prepared with distilled water were sprayed on the plants in evening time. The disease incidence and severity were recorded after the appearance of symptoms on the crop. For recording the disease incidence, scoring scale (0-9) was developed based on the visual observation and the rating was assigned according to the area of leaf covered by the fungal mycelium. Among the lines screened for the Downy mildew disease resistance, DPO-29 DPO-76, DPO-37, DPO-208, RIL-29, RIL-39 and RIL-152 were found highly susceptible lines while DPO-185, DPO-188, RIL-26, RIL-30, RIL-72 and RIL-111 were recorded as highly resistant against Downy mildew.

Hybridization and advancement of generation

ICAR-DMAPR, Anand: Recombinant inbred lines (RIL) developed from DPO-185 x DPO-14 for Downey mildew disease resistance mapping were advanced from F_2 to F_6. Recombinant inbred lines (RILs) and parents showed variation for days to flowering, maturity, leaf colour and resistance to Downey mildew disease. Fresh hybridizations were made among different distinct lines for genetic studies. The F_2 population of DPO-1 (Petaloid mutant) × DPO-1 and the other crosses were studied and advanced. The F_1 plant of petaloid mutant was normal and fertile indicating that petalloidy is governed by recessive gene. Similarly light green leave trait was found to be dominant over dark green leaves.

In M_6 generation, 439 stable mutants (DPO-1 to DPO-439) of the variety GI-2 were evaluated for seed yield in augmented design. Lines identified for distinct traits were narrow leaf (DPO-433); folded leaves (DPO-113); short leaves with dark green colour and curved tip (DPO-401); short leaves with light green colour (DPO-402); yellowish stem (DPO-353); brownish/yellowish leaf tip and resistance to Downey mildew (DPO-185); extended bract mutant (DPO-9); early maturing with extruded corolla and narrow leaves (DPO-147); short inflorescence with short stalk (DPO-352) and cleistogamy (DPO-420). Screening of these mutants for resistance against Downey mildew was also done and resistance sources were identified (DPO-29, DPO-76, and DPO-208).

Multilocation trial

ICAR-DMAPR, Anand: Two trials were conducted. One advanced varietal evaluation trial (AVT-II) for early maturing group (90-100 days) with three test entries DPO-174, DPO-186, DPO-385, and one control INGR 11035 (Early maturing check) and another advanced varietal evaluation trial (AVT-I) for medium maturing group (120 days) with 11 entries, AMB-2 (UI-2-1), MIB124 (UI-124), UI-89, DPO 332, DTPO 6-6, DTPO11-1,
DPO 267-3, DPO 253-2, DPO 248, MIB 5, and MIB 1004 and four check varieties viz., Niharika, GI-2, GI-3 and local checks (RI/89/GI-3/JI-5). Seed yield and morphological characters were recorded.

**Frequency distribution for the traits studied**

**ICAR-DMAPR, Anand:** Trait means for the 10 traits recorded among the recombinant inbred lines (RILs) along with the parents were plotted graphically in frequency distribution diagrams. The histograms obtained showed smooth fitted curves and normal distribution suggesting their polygenic nature. Transgressive segregants were identified among the RILs for various traits viz., six RILs for days to maturity, 8 for seed yield and 50 for Downey mildew resistance had greater values than the parents.

**Structural and cytogenetic investigations of male sterility**

**ICAR-DMAPR, Anand:** Pollen fertility and pollen count were compared in the fertile plants of male sterile population and fertile populations. Pollen fertility was assessed by Fluorescein Diacetate (FDA) staining and pollen count was estimated by haemocytometer method. The study revealed no significant differences between the two populations in terms of pollen count and fertility in male fertile plants.

Tetrads of male sterile plants and male fertile plants were stained by de-stained aniline blue to study the callose wall of the developing tetrads. The study revealed that callose deposition on the tetrad wall was comparable in both male sterile and male fertile lines. It indicated that the male sterility was not due to any abnormality in callose wall i.e. neither premature nor delayed rupture of the callose wall of the tetrad. Histological study of microspore development was also compared in the male sterile and male fertile lines.

**Organic nutrient management**

**ICAR-DMAPR, Anand:** The experiment was conducted with four levels of organic manures (FYM 15 t, vermicompost 7.5 t and castor cake 2.5 t ha\(^{-1}\)) and four levels of bio-fertilizers and bio-formulations (Control, *Azotobacter* + PSB, Jivamrut and *Azotobacter*+ PSB+ Jivamrut). Bio-fertilizers were applied as seedling treatment and Jivamrut was applied along with irrigation water at 25, 50 and 75 days after planting (DAP). The crop was harvested at 110 days after planting and the results revealed that application of organic manures and bio-fertilizers showed variable response to Isabgol. Application of castor cake @ 2.5 t ha\(^{-1}\) was found superior in terms of straw and seed yield. Among the bio-fertilizers and bio-formulations, application of Jivamrut recorded maximum plant straw and seed yield of Isabgol, whereas harvest index was maximum with application of *Azotobacter*+PSB.

**Effect of different sources of sulphur on yield and quality**

**ICAR-DMAPR, Anand:** A field experiment was conducted to evaluate different sources of
sulphur (Single super phosphate -SSP), Gypsum and bentonite sulphur @ 5, 10, and 15 kg ha\(^{-1}\) on yield and quality of Isabgol. Results revealed that application of sulphur @10 kg ha\(^{-1}\) was optimum for the seed yield irrespective of sources. Application of sulphur invariably increased husk percentage and husk yield while bentonite sulphur was found superior to the other sources of sulphur in improving husk percentage and yield. The highest seed yield and husk percentage was recorded under bentonite sulphur application @ 15 kg ha\(^{-1}\) but was not significantly higher than seed yield and husk percentage recorded under bentonite sulphur application @ 10 kg ha\(^{-1}\). Most important quality parameter of Isabgol husk is its swelling factor and application of bentonite sulphur significantly improved swelling percentage over the control and SSP. Sulphur content was found to improve with sulphur application and highest content was found under bentonite sulphur application.

**Post harvest studies of different storage conditions on quality parameters**

**MPUAT, Udaipur:** Storage studies of Isabgol seeds conducted during November 2015 to February 2016 showed no loss in values of swelling factor (cc g\(^{-1}\)) either in air tight or open bags storage conditions in both sun and oven drying methods. However, moisture content of seeds stored in open or closed bags showed a gradual reduction during these months. In both drying methods (sun and oven drying), application of blue silica in air tight bags during storage improved the swelling factor.

**JEEVAK (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:** Regions known as natural distribution areas of the species were repeatedly surveyed and stocks of this species were located from eight spots. Vegetative propagules like pseudobulbs and rhizomes were collected (at least 50 each) and preserved under ambient conditions during the winter period. These propagules corresponding to eight collections were planted in the field. Sprouting of propagules in
the eight collections was observed from 3rd week of May onwards. The data were recorded on sprouting percentage in different collections. Flowering initiation was observed from 2nd week of June, 2015 onwards in all the collections. In one collection, plants with deviant colour pattern were noticed and were isolated and maintained separately. These deviant plants were characterised by greenish basal sheath (at the base of the shoot), buds and flowers without any purple tinge on their surface (as against the normal condition of purple basal sheath and buds and flowers with purple tinge). This colour pattern was so far consistently observed for the last two seasons. The data on leaf, floral characteristics and yield parameters of all the collections as well as colour variants were also recorded.

**KALIJEERA (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 and soil quality**

**AAU, Anand:** An experiment was conducted with four levels of organic manures (control, FYM 10 t, caster cake 1.5 t and vermicompost 2.5 t ha$^{-1}$) and three levels of nitrogen (control, 25 and 50 kg ha$^{-1}$). Result showed that significantly higher number of branches per plant was found with application of FYM @10 t ha$^{-1}$ in the year of 2014-15, 2015-16 and pooled analysis (12.30, 12.40 and 12.40), which was at par with application of vermicompost @ 2.5 t ha$^{-1}$ (11.40, 12.00 and 11.80). Significantly higher number of inflorescences plant$^{-1}$ (57.80, 58.10 and 57.90) was observed with the application of FYM 10t ha$^{-1}$ in year of 2014-15, 2015-16 and pooled analysis, respectively, which was remained at par with application of caster cake @ 1.5 t ha$^{-1}$ (56.20, 55.80 and 56.00) and vermicompost @ 2.5 t ha$^{-1}$ (53.00, 57.20 and 55.10), while, it was the lowest in control (48.50, 50.10 and 49.10). Among the different levels of nitrogen applied, significantly higher number of branches plant$^{-1}$ (11.90, 11.80 and 11.90) and number of inflorescences plant$^{-1}$ (58.10, 57.00 and 57.50) were recorded with treatment of 50 kg N ha$^{-1}$ in both the years and on pooled data analysis, which were at par with application of 25 kg N ha$^{-1}$ (11.10, 11.70 and 11.40) number of branches plant$^{-1}$; 54.20, 55.10 and 54.60 number of inflorescences plant$^{-1}$). However, the interactions between different manures and nitrogen levels were found non-significant.
KALIHARI (*Gloriosa superba*)

The plant belonging to Liliaceae family is a climbing herb commonly found in the forests throughout India up to 2000 m. Stems are slender, arising from a perennial, fleshy tuberous rhizome. 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 a variety of diseases such as gastrointestinal disorders, colic, chronic ulcers, cancer and piles. It is widely cultivated now in Tamil Nadu, Maharashtra and Himachal Pradesh.

**Exploration and collection of germplasm**

**TNAU, Coimbatore:** Survey was carried out for the collection of germplasm in Tirupur and Dindigul districts. Twelve genotypes viz., TNGs1, TNGs2, TNGs3, TNGs4, TNGs5, TNGs6, TNGs7, TNGs8, TNGs9, TNGs10, TNGs11 and TNGs12 were collected from Dharapuram, Oddanchatram, Karur, Paravalasu, Mettupalyam, Kumarapalayam, Jeyankondam, Sagunipalayam, Moolanur and Markampatti. The genotypes were planted during October 2015 and the preliminary data were recorded on growth characters.

Among the genotypes, TNGs8 recorded maximum vine length (175.30 cm) and TNGs2 recorded maximum stem girth (0.85 cm). Number of leaves was found to be highest in TNGs9 (115) among the genotypes. Pod length and pod girth were maximum in TNGs2 (8.02 and 9.55 cm). Fresh pod yield was maximum in TNGs11 (65 g).

**Integrated management of leaf blight disease using fungicides and biocontrol agents**

**TNAU, Coimbatore:** A field experiment was conducted in the farmers' field at Dharapuram, Tiruppur district, Tamil Nadu on management of leaf blight disease of *Gloriosa superba* caused by *Alternaria alternata*. Spraying with respective fungicides and biocontrol agents were done at 30 and 60 days after planting (DAP). The disease intensity was recorded on 90 DAP. The seed yield per hectare was recorded for each treatment. The results revealed that spraying *Bacillus subtilis* (@ 0.20%) twice on 30 and 60 DAP was effective in managing the leaf blight disease which recorded the lowest disease intensity of 17.90%. It was found to be at par with spraying of chlorothalonil @ 0.10% twice at 30 and 60 DAP which recorded disease intensity of 18.70%. The highest leaf blight disease intensity of 33.4% was observed in the control. The growth and yield parameters were found to be maximum in spraying of *B. subtilis* (@ 0.20%) or chlorothalonil @ 0.10% twice at 30 and 60 DAP. The vine length was found to be maximum (118.6 cm) in spraying of *B. subtilis* (@ 0.20%) twice at 30 and 60 DAP and was at par with treatment of spraying chlorothalonil @ 0.10% twice at 30 and 60 DAP.
Spraying of *B. subtilis* (@ 0.20%) recorded maximum yield parameters viz., number of flowers plant$^{-1}$ (58.50), number of pods plant$^{-1}$ (45.90) and number of seeds pod$^{-1}$ (82.10). In control, plant growth and yield parameters viz., vine length (97.6 cm), number of flowers plant$^{-1}$ (39.10), number of pods plant$^{-1}$ (24.70) and number of seeds pod$^{-1}$ (60.40) were found to be the lowest. Maximum seed yield of 518.8 kg ha$^{-1}$ was recorded in spraying of *B. subtilis* (@ 0.20%) twice at 30 and 60 DAP. Spraying of chlorothalonil 0.10% twice at 30 and 60 DAP recorded seed yield of 499.40 kg ha$^{-1}$. The minimum seed yield of 369.20 kg ha$^{-1}$ was recorded in control.

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

**TNAU, Coimbatore:** A field experiment was conducted in the farmers’ field at Dharapuram, Tiruppur district, Tamil Nadu on 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 2.50 kg ha$^{-1}$. The tubers were dipped in *Pseudomonas fluorescens* 0.2% or *Bacillus subtilis* (@ 0.20%) or carbendazim 0.10% for 20 minutes. Drenching with biocontrol agents or fungicide was done at 30 DAP. The disease intensity was recorded on 90 DAP. The seed yield per hectare was recorded for each treatment.

The results revealed that dipping of tubers in *B. subtilis* @ 0.20% followed by drenching with *B. subtilis* @ 0.20% at 30 DAP was effective in managing the root rot disease which recorded the lowest disease incidence (14.80%), that was at par with dipping the tubers in *P. fluorescens* @ 0.20% followed by drenching with *P. fluorescens* @ 0.2% at 30 DAP which recorded 16.10% disease incidence. The highest root rot disease incidence (26.40%) was observed in the control. The growth and yield parameters were found to be maximum in dipping the tubers in *B. subtilis* @ 0.20% followed by drenching with *B. subtilis* @ 0.20% at 30 DAP. The plant growth and yield parameters viz., plant height (122.50 cm), number of flowers plant$^{-1}$ (50.50), number of pods plant$^{-1}$ (42.00) and number of seeds pod$^{-1}$ (75.50) were maximum in the treatment of the dipping the tubers in *B. subtilis* @ 0.2% followed by drenching with *B. subtilis* @ 0.20% at 30 DAP. In the control, plant growth and yield parameters viz., vine length (98.20 cm), number of flowers plant$^{-1}$ (32.50), number of pods plant$^{-1}$ (19.30) and number of seeds pod$^{-1}$ (53.60) were found to be the lowest.

Maximum seed yield of 514.4 kg ha$^{-1}$ was recorded in the treatment of dipping the tubers in *B. subtilis* @ 0.20% followed by drenching with *B. subtilis* @ 0.20% at 30 DAP. Dipping of tubers in carbendazim @ 0.10% followed by drenching with carbendazim @ 0.10% at 30 DAP recorded seed yield of 408.6 kg ha$^{-1}$. Minimum seed yield (364.50 kg ha$^{-1}$) was recorded in the control.
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.

Germplasm regeneration

ICAR-DMPAR, Anand: Ninety three germplasm accessions were received from NBPGR gene bank for regeneration. Of the 93 accessions only 66 accessions were germinated and seeds were multiplied and maintained. The accessions showed variation for branching pattern, leaf shape, leaf surface texture, leaf colour, inflorescence type and capsule shape. The accessions differed widely for number of primary branches (5.00-14.00), leaf lamina length (4.20-10.20 cm), leaf lamina breadth (1.20-3.40 cm), plant height (45.00-87.00 cm) and number of seeds per capsule (6.00-13.00).

Evaluation of germplasm

ICAR-DMPAR, Anand: Thirteen selected lines of *Andrographis paniculata* were evaluated based on morphological parameters (plant height, canopy spread, collar diameter, number of primary branches, length of primary branches, number of secondary branches, length of internode), herbage yield (fresh weight of leaf, stem, herbage and root (g plant⁻¹), dry weight of leaf, stem, herbage and root (g plant⁻¹), leaf stem ratio on dry weight basis and yield (t ha⁻¹) and andrographolide content at different growth stages i.e., days after transplanting (DAT) viz., at 70, 90, 110, 130 and 150 DATs. Significant differences were observed in all the studied characters at different maturity levels among the lines. Based on leaf stem ratio (on dry weight basis), the lines were grouped into two groups, i.e., group 1 which included six lines (DMAPR AP 3,6,10,13,27,37) where leaf portion remained more than 50% up to 70 DAT and group 2 which included seven lines (DMAPR AP 1, 2, 18, 19, 22, 24, 35) where leaf portion remained more than 50% even up to 90 DAT. At 110 DAT, fresh leaf yield was significantly higher in DMAPR AP 35 (5.07 t ha⁻¹) which was at par with DMAPR AP 22 and 24. Dry leaf yield was significantly higher in DMAPR AP 1 (1.77 t ha⁻¹) which was at par with DMAPR AP 35, 13, 18, 19, 22 and 24. Fresh and dry stem yields were significantly higher in DMAPR AP
Fresh herbage yield was also significantly higher in DMAPR AP 13 (17.81 t ha⁻¹) which was at par with DMAPR AP 1, 2, 18, 22 and 35. Dry stem yield was significantly higher in DMAPR AP 13 (7.97 t ha⁻¹) which was at par with DMAPR AP 1. However, andrographolide yield (kg ha⁻¹) was highest in DMAPR AP 35 (850.83), followed by DMAPR AP 18 (839.35). Based on leaf andrographolide accumulation pattern, the lines were grouped into three groups, i.e., group 1 which included only one line (DMAPR AP 13) which attained highest andrographolide content (%) at 70 DAT, group 2 included six lines (DMAPR AP 2, 18, 19, 22, 24 and 35) which attained highest andrographolide content (%) at 90 DAT and group 3 which attained highest andrographolide content (%) at 110 DAT (DMAPR AP 1, 3, 6, 10, 27 and 37).

Accumulation of major bioactive compounds viz., andrographolide, neoandrographolide, andrographanin, 14-deoxy,11-12 didehydroandrographolide, andrographiside, 7-O-methylwogonin and apigenin was studied among the lines. The range of these bioactive compounds in leaves at 70 DAT was: andrographolide 16.28 to 29.75 mg g⁻¹, neoandrographolide 1.43 to 4.95 mg g⁻¹, andrographanin 0.25 to 1.02 mg g⁻¹, 14-deoxy,11-12 didehydroandrographolide 2.32 to 4.40 mg g⁻¹, andrographiside 1.50 to 3.08 mg g⁻¹, 7-O-methylwogonin 0.0054 to 0.0241 mg g⁻¹, apigenin 0.0149 to 0.0370 mg g⁻¹. In the stem, the ranges were: andrographolide 1.61 to 3.09 mg g⁻¹, neoandrographolide 0.390 ± 0.048 mg g⁻¹, andrographanin 0.013 to 0.77 mg g⁻¹, 14-deoxy,11-12 didehydroandrographolide 0.401 to 0.63 mg g⁻¹, andrographiside 0.26 to 0.52 mg g⁻¹, 7-O-methylwogonin 0.167 to 0.320 mg g⁻¹ and apigenin 0.0013 to 0.0018 mg g⁻¹.

**NDUAT, Faizabad:** Twenty selected lines of Kalmegh were evaluated to find out a suitable variety favorable for eastern Uttar Pradesh conditions. The data were recorded on plant height, number of primary branches per plant and fresh as well as dry herbage yields. The plant height varied significantly from 57.20 to 82.40 cm. The highest plant height was in IC-210699 (82.40 cm) followed by IC-210635 (80.25 cm) and IC-211295 (79.55 cm). However, lowest plant height was in IC-471917 (57.20 cm). Number of primary branches per plant ranged significantly from 21.70 to 27.90. Maximum number of primary branches per plant was recorded in IC-210635 (27.90) followed by IC-111291 (27.40) and IC-211295 (26.70). However, minimum number of primary branches per plant was recorded in IC-471912 (21.70). Fresh herbage yield ranged significantly among the 20 lines from 84.72 to 175.95 q ha⁻¹. Maximum fresh herbage yield was obtained in IC-260035 (175.95 q ha⁻¹) followed by IC-265622 (170.22 q ha⁻¹) and IC-471918 (164.38 q ha⁻¹). Minimum fresh herb yield was noted in IC-210699 (84.72 q ha⁻¹). IC-265622 had better dry herbage yield (61.45 q ha⁻¹) as compared to IC-471918 (56.39 q ha⁻¹) and IC-265622 (55.25 q ha⁻¹) while, minimum dry herbage yield was in IC-210699 (25.22 q ha⁻¹).

**DUS descriptors notified**

**ICAR-DMAPR:** In Kalmegh, DUS descriptors were finalized with 15 morphological characters and example varieties were also developed for each character. DUS guidelines
were submitted to the authority and the Task force Committee met for finalization of Kalmegh DUS descriptors on 2nd November, 2015 at ICAR-DMAPR. The Committee thoroughly reviewed the draft guidelines prepared by the centre and recommended modifications in the guidelines. The finalized guidelines were notified by the authority and published in Plant variety Journal (Vol. 10, No. 01) in January 15, 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 23 example varieties were identified.

**MLT evaluation of promising lines for high yield and quality**

**BCKV, Kalyani:** Different promising lines identified at different centres were tested to identify Kalmegh varieties for high yield and quality. Eleven entries including three checks (INGR No. 07041, AK-1 and AL-1) were evaluated at Kalyani. No significant differences were observed in dry herbage yield among the entries. All the entries were screened for incidences of five diseases i.e., wart or gall (c.o.- Synchytrium sp.), leaf blight (c.o.- Rhizoctonia sp.), root rot (c.o.- Macrophomina sp.), pod rot (c.o.- Fusarium sp.), and leaf spot (c.o.- Cercospora sp.) also. However, the incidence of the diseases namely, wart, leaf spot, and root rot were very low in this year. It was found that severities of leaf blight and pod rot were more than the other diseases. The severities of leaf blight and pod rot were recorded from 1.04% (DMAPR AP18) to 9.90% (AAP 16) and 1.33 (DMAPR AP18) to 51.33% (NDKL10), respectively.

**Physiological interventions to enhance herbage yield**

**ICAR-DMAPR, Anand:** Twenty eight genotypes were evaluated for their responses to foliar hormone application of 200 ppm GA, (as a growth promoter) at 30 and 45 days after transplanting (DAT) followed by 100 ppm ethrel (as a stress elicitor) at 60 and 75 DAT. Hormonal application had increased the leaf area per plant from 630 cm² in control to 692 cm². The dry aerial biomass was 34.40 g plant⁻¹ in control and 39.9 g plant⁻¹ in hormonal application Genotypes with high aerial biomass were AP01, AP35 and AP55 in control whereas under hormonal application genotypes AP01, AP20, AP24 and AP49 performed well at 120 DAT. Genotypes AP 1 and AP 35 having higher leaf area and leaf weight at early growth stage consistently gave higher dry biomass yield under control as well as hormone treatment at both 120 DAT and 150 DAT.
Impact of growth regulators on physiology of Kalmegh under water deficit stress

ICAR-DMAPR, Anand: Response of water deficit (WD) stress in combination with signal molecules were studied in pot experiment. Total chlorophylls, total carotenoids and proline content increased due to WD stress at 50 DAT whereas, total chlorophylls and total carotenoids content decreased but, proline content increased at 80 DAT. WD stress had increased activity of antioxidant enzymes like superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX) and guiacol peroxidise (GPX). Ascorbic acid enhanced the APX activity and glutamic acid enhanced GPX activity of leaves under WD stress. WD stress reduced actual efficiency of photosynthesis (Fv'/Fm') and energy utilized for photochemistry (Φµ) at 80 DAT. Leaf andrographolide content decreased at 80 DAT as compared to that of 50 DAT. The signalling molecules showed stage specific effects and glutamic acid and salicylic acid indicated their scope to further augment the quality of A. paniculata under prolonged WD stress.

Effect of date of transplanting on crop growth

BCKV, Kalyani: The crop was transplanted at five different dates on fortnightly intervals between 1st June and 1st August. Seedlings transplanted on 1st June recorded highest canopy spread (65.30 cm) which was significantly superior compared to other dates of transplanting. Transplanting on 1st June recorded about two fold increase in canopy (65.30 cm) over transplanting on 1st August (32.7 cm). Therefore, wider spacing can be recommended for early transplanting of Kalmegh, while, closer spacing should be followed for late transplanting to utilize the space.

Effect of plant spacing on growth and yield

BCKV, Kalyani: The experiment was conducted to evaluate the performance of the crop growth and yield in four different plant spacing (30x20, 30x30, 45x30 and 45x45 cm). 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. Seedlings transplanted at 30x20 cm spacing recorded highest dry matter production (133.7 q ha\(^{-1}\)) which was significantly superior compared to the rest of spacings studied.

Integrated nutrient management

ICAR-DMAPR, Anand: An experiment was conducted with seven levels of organic manures (control; FYM 10 & 15; vermicompost 5 & 7.5; castor cake 1.5 & 2.5 t ha\(^{-1}\)) and seven levels of inorganic fertilizers (@ N\(_{80}\)P\(_{50}\)K\(_{50}\), N\(_{40}\):P\(_{30}\):K\(_{30}\) kg ha\(^{-1}\), N\(_{60}\):P\(_{30}\):K\(_{30}\) kg ha\(^{-1}\), N\(_{80}\):P\(_{30}\):K\(_{30}\) kg ha\(^{-1}\), N\(_{60}\):P\(_{30}\):K\(_{30}\) kg ha\(^{-1}\) with 1/2N and full P & K as basal and remaining half of N at 25 DAS); N\(_{80}\):P\(_{30}\):K\(_{30}\) kg ha\(^{-1}\) (Half N with full P & K as basal and remaining half N in two equal splits at 25 and 40 DAS); N\(_{60}\):P\(_{30}\):K\(_{30}\) kg ha\(^{-1}\) (Half N with full P & K as basal and remaining half N in three equal splits at 25, 40 & 60 DAS). The crop was harvested at 120 days after planting and the results revealed that application of castor cake at 2.5 t ha\(^{-1}\) along with half dose of N (40 kg ha\(^{-1}\)) with P\(_{30}\) kg ha\(^{-1}\)and K\(_{30}\) kg ha\(^{-1}\) as
basal and remaining half dose of N (40 kg ha\(^{-1}\)) in two equal splits at 25 and 40 DAS recorded significantly higher dry herbage yield of Kalmegh (12.02 q ha\(^{-1}\)).

**KAU, Thrissur:** Experiment was laid out with different doses of organic manures and fertilizers *i.e.*, FYM 15 t ha\(^{-1}\), vermicompost 7.5 t ha\(^{-1}\), castor cake 2.5 t ha\(^{-1}\), RDF through inorganic fertilizers as main plot treatments and Biofertilizers (*Azotobacter* + PSB as seedling treatment), Jivamrut (3 spray at 25, 50 and 75 DAP), Biofertilizers (*Azotobacter* + PSB as seedling treatment) + Jivamrut (3 spray at 25, 50 and 75 DAP) as sub plot treatments in split plot design. The result showed that direct effect of main plot treatments was statistically non significant. Among the sub plot treatments combined application of biofertilisers and Jivamrut gave higher yield of 41.53 q ha\(^{-1}\). However, it was statistically at par with individual application of Jivamrut (40.31 q ha\(^{-1}\)). The herbage yield was higher in plots which received combination of FYM + *Azotobacter* + PSB + Jivamrut (41.73 q ha\(^{-1}\)). However, it was at par with all the other treatment combinations except that which received basal application of FYM only (34.93 q ha\(^{-1}\)).

Total phenol content was also tested in the organically and inorganically cultivated plant samples. The result showed that total phenol content was 0.62% in crop grown under application of NPK @ 80:40:20 kg ha\(^{-1}\), 0.65% in application of FYM @ 15 t ha\(^{-1}\), 0.52% in application of vermicompost @ 7.5 t ha\(^{-1}\) and 0.50% in application of caster cake @ 2.5 t ha\(^{-1}\).

**NDUAT, Faizabad:** An experiment was conducted to standardize the production technology for Kalmegh with various treatments of organic manures and biofertilizers with FYM 15 t ha\(^{-1}\), vermicompost 7.5 t ha\(^{-1}\), castor cake 2.5 t ha\(^{-1}\), RDF through inorganic fertilizers as main plot treatments and Biofertilizers (*Azotobacter*+ PSB) (seedling treatment), Jivamrut (3 spray at 25, 50 and 75 DAT), Biofertilizers (*Azotobacter*+ PSB) (seedling treatment)+ Jivamrut (3 spray at 25, 50 and 75 DAT) along with control as sub plot treatments. The observations on plant height, number of branches per plant, plant biomass as fresh and dry at 60 DAT and at maturity were recorded. The plant height did not vary significantly due to use of organic manures however, effect of biofertilizers was found significant. Application of vermicompost @ 7.5 t ha\(^{-1}\) resulted in maximum plant height (65.83 cm) as compared to the other organic manures, however, application of vermicompost @ 15 t ha\(^{-1}\) resulted in maximum number of branches per plant (21.25), fresh biomass yield (88.66 q ha\(^{-1}\)) and dry biomass yield (47.83 q ha\(^{-1}\)). Among the biofertilizers tried, application of *Azotobacter*+ PSB (seedling treatment)+ Jivamrut (3 sprays at 25, 50 and 75 DAT) recorded maximum plant height (69.50 cm), number of branches per plant (22.58), fresh biomass yield (99.50 q ha\(^{-1}\)) and dry biomass yield (52.75 q ha\(^{-1}\)). The interaction effect of both the main and sub plot treatments was non-significant in the case of plant height and fresh and dry biomass yields, however, it was significant in case of number of branches per plant.

**PDKV, Akola:** Application of vermicompost @ 7.5 t ha\(^{-1}\) recorded significantly higher dry herbage yield (15.41 q ha\(^{-1}\)) whereas, in chemical fertilizer application of 80:30:50 kg ha\(^{-1}\) NPK in four splits recorded significantly higher dry foliage yield (15.67 q ha\(^{-1}\)). Interaction
effects were found non-significant.

**Organic nutrient management**

**ICAR-DMAPR, Anand:** An experiment was conducted with four levels of organic manures (FYM 15 t, vermicompost 7.5 t and castor cake 2.5 t ha\(^{-1}\)) and four levels of biofertilizers and bioformulations (control, *Azotobacter*+PSB, Jivamrut and *Azotobacter*+PSB+Jivamrut). Biofertilizers were applied as seedling treatment and jivamrut was applied along with irrigation water at 25, 50 and 75 days after transplanting (DAT). Application of castor cake at 2.5 t ha\(^{-1}\) resulted in maximum plant height, number of branches per plant and herbage yield. Among the bio-fertilizers and bio-formulations, application of *Azotobacter*+PSB+Jivamrut recorded maximum plant height and number of branches per plant, however, dry herbage yield was found maximum with jivamrut application at 25, 50 and 75 DAT.

**Studies on intercropping with Pigeon pea**

**PDKV, Akola:** An experiment was conducted to evaluate intercropping of Kalmegh with Pigeon pea at four row proportions (2:1, 3:1, 2:2 and 1:2) and compared the performance of intercropping with sole Kalmegh and sole Pigeon pea crops. Pooled means of three years data revealed that highest plant height, number of branches per plant, dry herbage yield and andrographolide yield per hectare of Kalmegh were obtained in the treatment where Kalmegh + Pigeon pea was sown in 1:2 ratio. Whereas, the highest plant height and maximum number of branches of pigeon pea were recorded with 3:1 row proportion of Kalmegh + Pigeon pea followed by sole Pigeon pea. However, significantly highest seed yield of Pigeon pea was recorded with sole Pigeon pea crop than any other row proportions of intercropping in the study. Kalmegh equivalent yield, land equivalent ratio (LER), GMR, NMR and B:C ratio (2.16) were significantly higher with the treatment of Kalmegh + Pigeon pea row proportion of 3:1.

**Standardization of post harvest technologies**

**ICAR-DMAPR, Anand:** An experiment was laid out in factorial CRD design with primary processing as main factors (washing and without washing of the samples), drying methods as sub factor (shade, sun, solar and oven drying) and packaging materials as sub-sub factor (gunny bag, Polyethylene (cement) bag, LDPE container, HDPE container and corrugated box). Analysis of different physico-chemical parameters was carried out at immediately after harvest, after drying and during storage (3, 6, 9 & 12 months after storage). The results revealed that washing of Kalmegh samples before drying and storage resulted in degradation of chlorophyll and andrographolide content after 12 months after storage compared to the samples without washing. Among the different drying methods, shade drying of samples helped in retention of green colour and andrographolide content after 12 months after storage, however, the rate of moisture absorption and microbial contamination were more. Oven drying (45±2\(^{\circ}\)C) was found best as in this method of drying, even after 12 months of storage, moisture absorption, degradation of andrographolide content and microbial load were found less. Among the packaging
materials used, samples stored in polyethylene containers retained the quality followed by HDPE and cartons as there was less absorption of moisture content, more colour retention and less microbial contamination.

**Process development for preparation of andrographolides enriched extracts**

**ICAR-DMAPR, Anand:** Process was developed for preparation of extracts, enriched in three andrographolides *viz*., andorgrapholide, neoandrographolide and andrograpanin. Time for preparation of decoction in terms of maximum concentration of andrographolide was also standardized.

**KUTKI (*Picrorhiza kurroa*)**

It is a small perennial herb of family Scrophulariaceae. It grows well in the hilly parts of the North-Western Himalayan region of India and Nepal. Plants are elongated, stout with creeping rootstock and mainly distributed at an altitude of 2700-4500 m. Dried rhizome and roots are used as drug. The leaf, bark and the underground parts of the plant, mainly rhizomes are widely used in Ayurveda since ancient times. It is used either as adulterants or substitute of Indian Gentian (*Gentiana kurroa*). It shows anti-oxidant, anti-inflammatory and immunomodulatory activities and also valued for its hepatoprotective effect. The bitter rhizomes have been used for thousands of years in India to treat people with indigestion and constipation due to insufficient digestive secretion. The plant and its formulations are widely used in therapy of epidemic jaundice.

**Effect of date of sowing/ planting**

**UUHF, Bharsar:** The experiment was carried out to study the effect of date of planting on *Picrorhiza kurroa* consecutively for two years. Maximum plant population, number of leaves per plant and total number of rhizomes per plant were recorded in plants transplanted on 15th July in both the years, however, maximum plant height was recorded in plants transplanted on 15th June in both the years. Maximum total leaf area per plant was recorded in plants transplanted on 15th June in the first year, whereas it was maximum in plants transplanted on 15th July in the second year. The highest fresh weight of leaves per plant was recorded in plants transplanted on 15th June in the first year, whereas it was maximum in plants transplanted on 15th April in the second year. Maximum length of rhizomes per plant was recorded in plants transplanted on 15th July in the first year, whereas it was maximum in plants transplanted on 15th June in the second year. Maximum fresh and dry weights of total rhizomes per plant were recorded in plants transplanted on 15th September in the first year, whereas it was maximum in plants transplanted on 15th June in the second year.
Studies on post harvest losses of Picroside-I and II

**YSPUHF, Solan:** An experiment was conducted by procuring fresh raw material of *Picrorhiza kurroa* from the natural sites. The dried rhizomes at room temperature were stored for 24 months under five different storage conditions viz., gunny bags stored at ambient/room temperature, gunny bags stored under refrigerated condition at 4° to 6°C, gunny bags stored under humid condition (85% relative humidity and 25°C temperature), sealed black poly bags stored at room conditions and sealed transparent poly bags stored at partial light in room conditions. The samples were analysed by HPLC at 2 months intervals for quantitative estimation of Picroside-I and Picroside-II. The results showed that though both picroside-I and picroside-II contents decreased with storage duration under all the storage conditions, storage of the rhizome at maximum humidity (85%) at 25°C recorded complete loss of picroside-I in 14 months and picroside-II in 6 months suggesting that the raw material of *P. kurroa* should not be kept under humid condition after drying. The losses in picroside-I and picroside-II content were minimum when the raw material was stored under low temperature which suggested long term storage of *P. kurroa* under low temperature conditions for maintaining the quality of raw drug in terms of Picroside content.

**YSPUHF, Solan:** Seventy three market samples of *P. kurroa* were collected through 13 AICRP centers to check the quality based on Picrosides content. It was found that among the 73 samples, 70 (95.89%) were genuine samples of *P. kurroa* and three (4.11%) were of unknown species.

**LAL CHITRAK (Plumbago rosea)**

The plant belongs to family Plumbaginaceae and is a perennial shrub of about 1.5 m tall. Flowers are red colored, borne in elongated spikes. The plant flowers throughout the year. It is distributed in the peninsular India, West Bengal and Orissa. Plant pacifies vitiated vata, kapha, diarrhoea, inflammation, fever, nervous palsy, haemorrhoids, skin diseases, irritable bowel disease, amenorrhea and anaemia. The two Plumbago species i.e., *P. rosea* and *P. zeylanica* are commonly used for the same purposes in different traditional medicines. In Ayurveda and Unani medicine, the root is used to promote appetite and stimulate digestive process. The freshly harvested roots are used for the drug preparation.

**Effect of coppicing on yield and quality**

**KAU, Thrissur:** An experiment was conducted with three cutting intervals i.e., 9, 12 and 15 months after planting and at three pruning heights i.e., 15, 30 cm and control (no coppicing) for improving yield and quality. The fresh weight of roots was highest (56.23 q ha⁻¹) in plants coppiced at 15 months after planting, which was at par with the plants
coppiced at 9 and 12 months after planting (51.82 and 50.71 q ha^{-1}). However, the quality was better in plants which received coppicing at 9 months after planting. There was significant reduction in plumbagin content when plants were coppiced at 12 months after planting.

Interaction effect of coppicing stage and height revealed that yield of \textit{P. rosea} could be increased by coppicing plants at 15 months after planting at a height of 30 cm. Compared to the plants with no coppicing, there was 11.01 q increase in fresh root weight in plots with coppicing at 15 months after planting at 30 cm height and 6.92 q increase in plants with coppicing at 15 months after planting at 15 cm height. Among the different treatment combinations, coppicing at 9 months after planting at 30 cm height gave the highest plumbagin content (0.91%). Plants which were coppiced at 12 months after planting recorded the lowest plumbagin content.

**Effect of storage containers on yield and quality**

\textbf{KAU, Thrissur:} Storage studies showed that dried roots can be stored either in transparent or non-transparent plastic bottles without much loss of plumbagin content (32-33\% loss after 24 months). Analysis of active principles in roots of three different \textit{Plumbago} species, \textit{viz.}, \textit{P. rosea}, \textit{P. zeylanica} and \textit{P. capensis} showed variation in their phytochemical constituents. The plumbagin content, antioxidant activity and potassium content were found higher in case of \textit{P. rosea} roots compared to other species.

**LEMONGRASS (\textit{Cymbopogon flexuosus})**

Lemongrass, which is commonly known as Nimbu ghass is an important aromatic grass of Indian origin. The leaves and shoot of the plant is used to extract essential oil which is rich in citral content (75-85\%). Lemongrass oil is one of the most important essential oil produced in the world. The oil is mainly used in the manufacture of perfumes for soaps, hair oils, scents and medicines. There are three types of the lemongrass namely, the East Indian or true lemongrass (\textit{C. flexuosus}), West Indian lemongrass (\textit{C. citratus}) and \textit{C. pendulus} (North Indian or Jammu lemongrass). The oil obtained by the distillation of the grass of \textit{C. flexuosus} is the genuine oil of commercial importance. Presently it is commercially cultivated in Kerala, Assam, Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh and Uttar Pradesh.

**Germplasm collection, characterization and evaluation**

\textbf{ICAR-DMAPR, Anand:} Thirty three accessions of Lemongrass were collected from MAPRS, Odakkali (KAU), Kerala and multiplied at DMAPR, Anand for preliminary evaluation. Among the 33 accessions, OD-355 recorded maximum plant height (100.50 cm), OD-191 recorded highest fresh herbage (355.00 g plant^{-1}) and OD-30
recorded more number of tillers per plant and high oil percentage (1.14%). Two accessions viz., OD-204 and OD-368 showed resistance to phyllody disease and rest of the accessions were susceptible to phyllody.

**Variatel discrimination of Cymbopogon using molecular markers**

ICAR-DMAPR, Anand: The objective of the study was to discriminate nine leading varieties of Cymbopogon spp. using RAPD and ISSR markers. Nine varieties which included seven leading cultivars (OD-19, NLG-84, Pragati, CN-5, RRL-16, Bio-13 and CKP 25) and two elite clones (DMAPR CF 01 & DMAPR CF 02) of Cymbopogon species were taken for the study. Among these, five are, C. flexuosus and one each of C. nardus, C. winterianus, C. pendulus and one is a hybrid of C. khasianus and C. pendulus. Two hundred and twenty decamer RAPD primers (Operon Technologies Alameda, USA) of OPA, OPB, OPC, OPD, OPE, OPG, OPJ, OPN, OPO, OPP and OPT series and 150 synthesized ISSR primers (both 5’ and 3’ anchored) were taken for initial screening. Ninety RAPD primers and 70 ISSR primers were selected from the screened primers for the study since they generated more distinct reproducible amplicons of high resolution. Both RAPD and ISSR analysis were sufficient to discriminate the studied varieties as the marker systems were able to generate unique marker/s which would be used as varietal specific marker/(s) for their identifications. The similar pattern of UPGMA derived dendrogram of RAPD and ISSR analysis revealed the reliability of the markers chosen for the study. Varietal specific markers generated from the study could be utilized for checking adulteration which otherwise adversely affect the quality of the essential oils in Cymbopogon. These markers can also be utilized for the protection of cultivars in the present IPR regime. Moreover, the study provide a molecular marker tool kit in both random and simple sequence repeats for diverse molecular research on the same or related genera.

**Identification of sequence polymorphism in barcode region in Cymbopogon spp.**

ICAR-DMAPR, Anand: Identification of Cymbopogon species is determined by morphological markers, odour of the essential oils and concentration of bioactive compounds present in the essential oil matrices which are highly influenced by environment. Hence it is difficult to distinguish individual Cymbopogon species which causes wrong identification and adulteration at the species level. Therefore in the present study, effort was made to evaluate potential DNA barcodes in six commercially important Cymbopogon species for their individual discrimination and authentication at the species level. Six species of Cymbopogon viz., C. citratus (DC.) Stapf, C. flexuosus (Nees ex Steud.) Wats., C. pendulus (Nees ex Steud.) Wats., C. nardus (L.) Rendle, C. martinii (Roxb.) Wats. and C. winterianus Jowitt ex Bor; collected from different parts of India were used for the present investigation. Four widely used DNA barcoding regions viz., ITS 1 & ITS 2 spacers, matK, psbA-trnH and rbcL were taken for the study. Gene sequences of the same or related genera of the concerned loci were mined from NCBI domain and primers were designed and validated for barcode loci amplification. Out of
the four loci studied, sequences from matK and ITS spacer loci revealed 0.46% and 5.64% nucleotide sequence diversity, respectively whereas the other two loci i.e., psbA-trnH and rbcL showed 100% sequence homology. The newly developed primers can be used for barcode loci amplification in the genus Cymbopogon. The identified Single Nucleotide Polymorphisms (SNPs) from the studied sequences may be used as barcodes for the six Cymbopogon species. The information generated can also be utilized for barcode development of the genus by including more number of Cymbopogon species in future.

**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.

**Collection, characterization, evaluation and maintenance of germplasm**

**AAU, Jorhat:** Studies on genetic variation among selected germplasm was carried out through molecular markers. Based on the morphological and yield characters, 15 local clones along with a check variety “Viswam” were selected for the study. RAPD analysis technique was adopted for the study. Twenty decamer random primers were used to generate RAPD fingerprints of the studied accessions. The PCR products were subjected to 1.80% agarose gel electrophoresis to separate the amplified DNA fragments according to molecular size and visualized under UV light after stained with ethidium bromide. Unweighted Pair Group Method using Arithmetic averages (UPGMA) cluster analysis of RAPD banding pattern was performed and the correlation coefficient of similarity matrix was calculated. The similarity value ranged from 0.587 to 0.862 indicating moderate genetic diversity among the germplasm studied. A dendrogram using average linkage among groups was generated. Grouping
pattern revealed that the germplasm formed four main clusters. The major cluster I consisted of clones PLJ-19, PLJ-18, PLJ-3 and PLJ-20, out of which PLJ-19 and PLJ-3 were very close. Clone PLJ-19 was a collection from Bokakhat, Assam and PLJ-03 from Namgui, Arunachal Pradesh. Cluster II consisted of PLJ-30, PLJ-32, PLJ-28 and PLJ-29. Cluster III comprised of PLJ-09, PLJ-01, PLJ-22, PLJ-17 and PLJ-11. PLJ-01 and PLJ-22 were very close. Both of them were local collections (PLJ-01, Khetri and PLJ-22, Kadamtal). The major cluster IV consisted of two clones PLJ-16 and PLJ-10. The variety “Viswam” which was a collection from Kerela Agricultural University (KAU) did not form any cluster and stood separately. Cluster analysis showed the grouping of clones was mainly on the basis of geographical location with a few exceptions.

**Standardization of planting methods and spacing**

**AAU, Jorhat:** The experiment consisted of planting with or without support and four spacings (40×40, 60×40, 60×60 and 90×60 cm). Planting Long pepper with support significantly increased leaf size, leaf breadth and internodal length. However, leaf length, spike breadth, fresh weight and dry weight of spikes under this treatment were found to be at par with that of planting without support. On the other hand, significant increase in the number of spikes per plant was recorded in planting without support. Planting at a spacing of 90×60 cm increased the growth and yield parameters of Long pepper.

**OUAT, Bhubaneshwar:** The experiment comprised of four different levels of spacing (30x30 cm, 45x45 cm, 60x60 cm, 90x90 cm). The result showed that maximum vine length (81.16 cm) was recorded in 90x90 cm, followed by 60x60 cm and the minimum (57.23 cm) was in 30x30 cm. Significantly higher number of branches per plant (4.06), number of leaves per plant (69.58), leaf length (6.12 cm) and leaf breadth (5.74 cm) were observed in 45x45 cm spacing and the minimum was in 30x30 cm spacing. Maximum diameter of branches (0.51 cm), root length (16.13 cm) and root diameter (0.45 cm) were obtained in 90x90 cm spacing and the minimum was noticed in 30x30 cm spacing. However, Long pepper plants planted at a spacing of 60x60 cm was found to be significantly superior with respect to fresh weight (624.84 kg ha⁻¹) and dry weight of root (426.94 kg ha⁻¹), which was at par with 45x45 cm spacing.

Effect of planting methods (flat bed and raised bed) on growth and yield of the crop was also studied at the centre. The growth parameters such as plant height, number of branches per plant, diameter of branches, number of leaves per plant and leaf length and breadth were not influenced by the method of planting. However, root parameters such as root length, root diameter, total biomass of plant and fresh and dry weight of roots were maximum in raised bed method of planting.

**Integrated nitrogen management**

**AAU, Jorhat:** The experiment was conducted to replenish the nitrogen requirement of the crop through organic means. Two commonly used organic manure viz., Farm Yard Manure (FYM) and vermicompost were taken for the study. Data on leaf length, leaf
breadth and number of spikes were taken. The highest leaf length (6.47 cm) was recorded with 100% N fulfilment through vermicompost followed by application of 50% N through RDF + 50% through FYM. Leaf breadth was minimum (4.74 cm) in 25% N through RDF+ 75% through vermicompost. Maximum leaf breadth was recorded in 100% N through vermicompost (6.21 cm). Significant variation in number of spikes was observed among the treatments. Highest number (96.66) of spikes was recorded in 100% N through vermicompost followed by 25% N through RDF+75% through vermicompost.

Length of spike was recorded maximum (3.87 cm) in 100% N through vermicompost, while minimum (2.82 cm) was in application of 50% N through RDF+ 25% through vermicompost. Fresh weight of the spikes ranged from 0.96 g (50% N through RDF+50% through vermicompost) to 1.32 g (100% N through vermicompost), followed by 100% N through RDF (1.28 g). No significant variation was observed among the other treatments. Maximum dry weight of spike was recorded in application of 100% N through vermicompost (0.46 g) and minimum (0.28 g) was observed in application of 50% N through RDF+ 50% through vermicompost.

Effect of organic manure

OUAT, Bhubaneshwar: The experiment comprised of four treatments with different combinations of organic manures viz., FYM @ 20 t ha⁻¹, mustard cake @ 2 t ha⁻¹, FYM @ 10 t ha⁻¹ + mustard cake @ 1t ha⁻¹ and control (no manure). The physico-chemical characters of the soil of the experimental field were studied before undertaking the experiment. Result showed that significantly higher plant height and number of branches per plant was recorded in the treatment with FYM @ 20 t ha⁻¹ and the minimum was in control (no manure). The stem diameter, number of leaves plant⁻¹, leaf length, leaf breadth, LAI, root length and fresh and dry weight of roots were found maximum with the application of FYM @ 10 t ha⁻¹ + Mustard Cake @ 1t ha⁻¹ and the minimum was in the control. Physico-chemical characteristics of the soil revealed that the maximum organic carbon of 0.42% was estimated in FYM application and the minimum was recorded in the control. The effect on other soil parameters such as pH, electrical conductivity and available N, P and K were found to be statistically non-significant among the treatments.

Post-harvest and storage studies

PDKV, Akola: Various storage conditions/treatments including application of clove oil, neem oil, citronella oil, black pepper oil, Amrit dhara (Ajwain and menthe ark), garlic oil, asafoetida and silica were studied. The initial concentrations of piperine and moisture content were determined and were found to be in the range of 2.93-3.59% and 7.68-8.63%, respectively. The microbial load was also estimated for initial sample and found to be within the permissible limits.
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.

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

**TNAU, Coimbatore:** A field experiment was conducted to evaluate the bioefficacy of some promising biopesticides such as neem oil, neem seed kernel extract (NSKE), *Metarhizium anisopliae*, *Bacillus thuringiensis* and *Beauveria bassiana* on the management of leaf webber. Chlorpyriphos 20 EC was used as the standard check, along with an untreated check without any treatment. Results showed that the pre-treatment count of leaf webber ranged between 8.1 and 8.4 plant\(^{-1}\), which was statistically non significant. The post treatment counts at one and three days after treatment (DAT) revealed that NSKE \(@ 5%\) treated plots recorded the lowest number of webbers (4.40 and 2.10 plant\(^{-1}\)) followed by neem oil 3% with 6.0 and 2.6 webbers plant\(^{-1}\), respectively. All the treatments tested were statistically at par. From the fifth DAT, *B. thuringiensis @ 750g ha\(^{-1}\)* recorded maximum efficacy followed by NSKE @ 5%, neem oil @ 3%, *B. bassiana @ 2 kg ha\(^{-1}\)* and *M. anisopliae @ 2 kg ha\(^{-1}\)* recording 1.00, 1.60, 2.00, 2.10, 4.30 webbers plant\(^{-1}\), respectively. The trend remained the same in subsequent counts with 0.70, 1.10, 1.30, 1.80 and 3.20 webbers plant\(^{-1}\) at 7 DAT and 0.30, 0.80, 0.70, 1.10 and 2.20 webbers plant\(^{-1}\) at 14 DAT. However, chlorpyriphos 20 EC (standard check) \(@ 1.00 l ha\(^{-1}\)\) was significantly superior to the other treatments with the lowest number of webbers (0.20) at one DAT and the webber population was observed to be nil at third, fifth, seventh and fourteenth DATs. The untreated control was significantly inferior with maximum of 9.3 webbers plant\(^{-1}\).

**Efficacy of biopesticides on management of loopers**

**TNAU, Coimbatore:** Results of the field experiment conducted to evaluate the bioefficacy of certain promising biopesticides on management of loopers of *G. sylvestre* revealed that pre-treatment count of looper ranged between 3.10 and 3.50 plant\(^{-1}\), which was statistically non significant. The post treatment counts at 1 and 3 DAT revealed that among the biopesticides, neem seed kernel extract (NSKE) \(@ 5%\) treated...
plots recorded the lowest number of loopers (1.70 and 1.00 plant⁻¹), followed by neem oil @ 3% (1.9 and 1.1 loopers plant⁻¹), Bacillus thuringiensis @ 750 g ha⁻¹ (2.50 and 0.90 loopers plant⁻¹), Beauveria bassiana @ 2 kg ha⁻¹ (2.90 and 1.20 loopers plant⁻¹) and the least being Metarhizium anisopliae @ 2 kg ha⁻¹ with 2.60 and 2.00 loopers plant⁻¹. At fifth DAT, B. thuringiensis @ 2 kg ha⁻¹ recorded maximum efficacy (0.20 loopers plant⁻¹) followed by B. bassiana @ 2 kg ha⁻¹ (0.50 loopers plant⁻¹), NSKE @ 5% and neem oil @ 3% (both recorded 0.70 loopers plant⁻¹), followed by M. anisopliae @ 2 kg ha⁻¹ (1.10 loopers plant⁻¹). The trend remained same in the subsequent counts at 7 and 14 DAT. However, chlorpyriphos 20 EC (standard check) @ 1.00 l ha⁻¹ was significantly superior to the other treatments, which registered the lowest number of 0.10 loopers plant⁻¹ 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 4.20 loopers plant⁻¹ in untreated control.

Results of the experiment on leaf and stem yields revealed that among the biopesticides tested NSKE @ 5% treated plots recorded maximum dry leaf yield of 0.53 kg plant⁻¹ and dry stem yield of 1.45 kg plant⁻¹, followed by B. thuringiensis @ 750 g ha⁻¹ (0.47 and 1.31 kg plant⁻¹), neem oil @ 3% (0.46 and 1.13 kg plant⁻¹), M. anisopliae @ 2 kg ha⁻¹ (0.42 and 0.91 kg plant⁻¹), B. bassiana @ 2 kg ha⁻¹ (0.42 and 0.89 kg plant⁻¹). Chlorpyriphos 20 EC (standard check) @ 1.0 l ha⁻¹ was significantly superior which yielded 0.75 kg of dry leaves and 2.27 kg of dry stem plant⁻¹ against 0.16 and 0.27 kg of dry leaves and stem plant⁻¹, respectively.

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.

Collection, Characterization, evaluation and maintenance of germplasm

YSRHU, Venkataramannagudem: Forty five accessions of Solanum nigrum were
maintained and evaluated for their morphological and agronomical traits. APSn-32, the accession collected from Pandiriramanidi was added to the germplasm during 2014-15. TNSn-50 exhibited purple streak in flower corolla, the character as reported by TNAU was found stable under multi-location testing. Distinct characters like plants bearing red berries with erect growing habit and streak in flower petal were identified and recorded in APSn-25, collected from Shankarghat, UP. Taxonomic identification of the accessions of Solanum nigrum was conducted with the help of BSI, Coimbatore. APSn-12, APSn-6 and APSn-20 were found suitable for leafy vegetable purpose. Among 45 accessions, APSn-23 recorded highest herbage yield followed by APSn-6. TNSn-31 recorded the lowest yield. Highest plant height was recorded in APSn-11 followed by ApSn-20. Number of branches was highest in APSn-23 followed by APSn-12.

**Bio-efficacy of pesticides against Hadda beetle**

**YSRHU, Venkataramannagudem:** Incidence of Coleopteran beetle (Hadda beetle) Henosepilachna vigintiopunctata was recorded during October and treatments were applied two times at fortnight intervals. Among the botanical treatments, Azadirachtin 10000 ppm @ 1 ml l\(^{-1}\) followed by pungam oil @ 3ml l\(^{-1}\) were found to be effective against Hadda beetle.

**MANDUKAPARNI (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. 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.

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

**NDUAT, Faizabad:** The experiment was carried out with six levels of NPK (25:20:15; 50:20:15; 75:20:15 kg ha\(^{-1}\)) and FYM (5, 10 and 15 t ha\(^{-1}\)) along with control. Non-significant differences were observed for plant height. The highest internodal length was observed in application of 15 t FYM ha\(^{-1}\) and the lowest was in 50 kg N + 20 kg P\(_2\)O\(_5\) + 15 kg K\(_2\)O kg ha\(^{-1}\). The petiole length varied from 9.66 to 11.43 cm. Maximum petiole length was observed in application of 15 t FYM ha\(^{-1}\) followed by 10 t FYM ha\(^{-1}\).
and 75 kg $N + 20$ kg $P_2O_5 + 15$ kg $K_2O$ ha$^{-1}$ and the lowest was in application of 50 kg $N + 20$ kg $P_2O_5 + 15$ kg $K_2O$ ha$^{-1}$. Maximum fresh herbage yield (65.77 q ha$^{-1}$) was recorded in 15 t FYM ha$^{-1}$ followed by 10 t FYM ha$^{-1}$ (63.97 q ha$^{-1}$) and 75 kg $N + 20$ kg $P_2O_5 + 15$ kg $K_2O$ ha$^{-1}$ (58.73 q ha$^{-1}$) and minimum was in the control (35.10 q ha$^{-1}$). The dry herbage yield was 7.01 q ha$^{-1}$ and 13.15 q ha$^{-1}$ with 15 t FYM ha$^{-1}$ and control, respectively.

**Effect of spacing and harvesting time on herb yield**

**NDUAT, Faizabad:** Effect of different plant spacing (30×60, 45×60, 60×60 cm) and harvesting time (15th May 15th June and 15th July) on herbage yield of Mandukaparni was studied. The results revealed that maximum plant height was recorded with 60×30 cm and 15th May harvesting, whereas, fresh and dry herbage yields were higher at closer spacing (30×60 cm) and in early harvesting, which were significantly superior to the rest of the treatments.

**Studies on integrated disease management of stolon rot**

**NDUAT, Faizabad:** The results of an experiment conducted during 2015-16 indicated that serious incidence of stolon rot was caused by *Fusarium* sp. The disease first appeared during rainy season. The soil treatment with Carbendazim @ 0.10 % was highly effective in managing the stolon rot with minimum disease severity of 0.92 in 0-4 scale. The second best treatment was soil treatment with *Trichoderma viride* @ 3.50 kg ha$^{-1}$ (1.42) followed by soil treatment with *T. viride* @ 3.00, 2.50 and 2.00 kg ha$^{-1}$ with disease severity 1.67, 1.82 and 2.85, respectively as compared to the control plot (3.68 on 0-4 scales).

Maximum fresh herbage yield (45.86 q ha$^{-1}$) was obtained in soil treatment with Carbendazim followed by soil treatment with *T. viride* @ 3.50, 3.00, 2.50 and 2.00 kg ha$^{-1}$ with yield of 40.74, 39.57, 38.76 and 36.67 q ha$^{-1}$, respectively, as compared to the control plot (32.48 q ha$^{-1}$). Although, maximum yield was obtained in soil treated with Carbendazim, considering the medicinal quality of the plant, soil treated with different doses of *Trichoderma* sp. can be recommended for management of Stolon rot at commercial level.

**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. The leaves are dried and used for the treatment of any type of toxicity, fever, jaundice, arthritis and indigestion. Root is used in abdominal disorders, leucorrhoea and hair loss.

**Effect of shade and planting dates on yield and quality**

**KAU, Thrissur:** An experiment comprising three levels of shade (25, 50% shade and open) and three planting dates (2nd week of August, September and October) was conducted for a period of three years. Crop planted either in August or in September under 25% shade gave the highest herbage yield consecutively for three years. Pooled analysis of indican content confirmed that planting *Indigofera* under fully open condition during the month of August recorded maximum indicant content (1.19 %) followed by planting in September under fully open condition (1.16 %). From the results, it can be concluded that *I. tinctoria* can be planted under 25% shade to fully open condition during August/September for obtaining better yield and quality.

**Effect of combination of organic manures and bio-fertilizers on yield and quality**

**KAU, Thrissur:** An experiment was laid out with different combinations of FYM i.e., 5 t ha⁻¹ and 10 t ha⁻¹ and NPK i.e. NPK @ 30:45:30 kg ha⁻¹, NPK @ 45:60:45kg ha⁻¹ and NPK @ 60:90:60 kg ha⁻¹ to study their effects on crop yield and quality. Result showed that plant height was significantly higher in application of FYM 10 t ha⁻¹ + NPK @ 60:90:60 kg ha⁻¹ (85.98 cm) which was at par with application of FYM 10 t ha⁻¹ + NPK @ 45:60:45 kg ha⁻¹ (98.24 cm) and application of FYM 5 t ha⁻¹ + NPK @ 60:90:60 kg ha⁻¹ (83.24 cm). The highest herbage yield of 64.32 q ha⁻¹ was obtained in application of FYM 5 t ha⁻¹ + NPK @ 45:60:45 kg ha⁻¹. Application of FYM 10 t ha⁻¹ + NPK @ 45:60:45 kg ha⁻¹ and FYM 10 t ha⁻¹ + NPK @ 60:90:60 kg ha⁻¹ were at par with respect to herbage yield. However, the crop which received no manures or fertilizers recorded highest indican content. Combined application of FYM 5 t ha⁻¹ and NPK @ 45:60:45 kg ha⁻¹ can be recommended as an integrated nutrient management package for higher yield and quality of *Indigofera*.

**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.

**Maintenance of working germplasm**

**NDUAT, Faizabad:** Working germplasm (41 genotypes) were evaluated for morphological characters. Significant variations were noticed for the characters taken for the study. Plant height ranged from 95.50 to 127.90 cm. Maximum plant height was observed in ND-11 followed by ND-46 (127.50 cm) and ND-12 (125.50 cm). Minimum plant height was recorded in ND-7. Peduncle length ranged from 19.20 to 30.40 cm. The highest length of peduncle was recorded in genotype JOP-540 (30.40 cm) followed by the genotype ND-45 (29.80 cm) while, the lowest peduncle length was in the genotype ND-4-2 (19.20 cm). Number of stigmatic rays varied from 11.60 to 14.70. ND-42 produced the maximum stigmatic rays (14.70) per capsule followed by the genotypes ND-22 and ND-44 (14.60), while ND 4-1 was having the lowest number of stigmatic rays (11.60). Capsule length ranged from 3.12 to 4.22 cm. ND-89 had the longest capsules followed by ND-48 (4.14 cm) and NOP-4 (4.11cm). However, the shortest capsules were observed in the genotype JA-16 (3.12 cm). Width of capsules varied from 3.11 to 4.60 cm. Maximum capsule width was recorded in NOP-4 followed by ND-45 (4.31 cm) and ND-12 and ND-17 (4.17 cm) while, minimum width of capsule was in JA.- 16 (3.11 cm). Number of leaves per plant varied from 13.70 to 22.90. ND-35 produced maximum number of leaves per plant (22.90) followed by ND-22 (22.60) and ND-10 (21.40) while, ND-24 had the lowest number of leaves per plant (13.70). Leaf length ranged from 17.17 to 25.48 cm. The longest leaf was recorded in genotype ND-4-1 (25.48 cm) followed by genotype ND- 4- 2 (24.95 cm) while, the shortest leaves were found in genotype ND-48 (17.17 cm). Leaf breadth varied from 9.18 to 15.87 cm. The broadest leaf was recorded in genotype ND-4-1 (15.87 cm) followed by genotype ND-6 (14.50 cm) and ND-28 (14.24 cm) while, the narrowest leaves were observed in genotype ND-208 (9.18 cm).

**PALMAROSA (Cymbopogon martinii)**

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. The species is under cultivation
in central, western and southern states of India.

**Effect of integrated nutrient management on herbage and oil yields**

**ICAR-DAMPR, Anand:** The experiment was laid out in split plot design with three main plot treatments (no organics, FYM and crop residue) and seven sub plot treatments (no fertilizers, 50% RDF, 75% RDF, 100% RDF, 50% RDF + Microbial consortia, 75% RDF + Microbial consortia and 100% RDF + Microbial consortia). The first harvest results revealed no significant differences in main plots as well as in sub plots for plant height, number of tillers, plant spread and oil content. Fresh and dry weight of herbage per plant, fresh and dry weights of herbage per ha and geraniol content showed significant differences at sub plot level. The sub plot treatment of 75% RDF recorded highest fresh and dry weights of herbage, however, highest geraniol content was obtained in the sub plot treatment of 75% RDF + Microbial Consortia.

**IGKV, Raipur:** The effect of four nitrogen levels (75, 100, 125 and 150 kg ha\(^{-1}\)) were evaluated in three varieties of Palmarosa (Tawirosa, CN5 and Jamarosa). The different varieties influenced significantly the herbage yield and oil yield of Palmarosa. Maximum herbage yield (285.45 q ha\(^{-1}\)) and oil yield (97.78 kg ha\(^{-1}\)) were found in the variety Jamarosa. The different nutrient levels also significantly influenced the plant height, herbage yield and oil yield. Among the different nutrient levels, maximum herbage yield (232.21 q ha\(^{-1}\)) was found with application of N @150 kg ha\(^{-1}\). Highest oil yield (76.35 kg ha\(^{-1}\)) was found under N application @ 150 kg ha\(^{-1}\) which was at par with N @125 kg ha\(^{-1}\). The interaction of different varieties of Palmarosa with nitrogen level significantly influenced the oil yield. The highest oil yield (100.13 q ha\(^{-1}\)) was found in Jamarosa with application of N @ 150 kg ha\(^{-1}\). Maximum gross return, net return and B:C ratio were found in variety Jamarosa over Tawi rosa and CN-5. However, maximum gross return, net return and B:C ratio were found under the treatment of N @ 150 kg ha\(^{-1}\).

**Study of Palmarosa distillation waste as an effective biosorbent**

**DMAPR, Anand:** The aim of this study was to investigate the potential use of the Palmarosa waste obtained after hydrodistillation of essential oil as a biosorbent. Calcium alginate encapsulated beads were made from the waste material and tested for its ability to remove methylene blue (dye) from aqueous solutions. The prepared beads were characterized by Fourier transform infrared spectroscopy (FTIR). A series of batch experiments were conducted to assess the effects of process variables such as medium pH (2-10), biosorbent dose (1.00- 20.00 g l\(^{-1}\)), contact time (5-1440 min), initial dye concentration (10-150 mg l\(^{-1}\)), and temperature (25-55°C). The study revealed that adsorption increased with increase in contact time, initial solution pH, and adsorbent dose and 10.0 g l\(^{-1}\) was considered as the optimum dose of adsorbent for achieving maximum removal efficiency. The time to reach the equilibrium of dye adsorption onto adsorbent was concentration dependent and equilibrium was achieved within 120 min at
dye concentrations of 10, 25 and 50 mg l\(^{-1}\) and it was 240 min at dye concentrations of 75, 100 and 150 mg l\(^{-1}\). Kinetic analysis showed that pseudo-second-order model had the best fit to the experimental data. The Langmuir model provided the best fit for the experimental data of the equilibrium biosorption of methylene blue on Palmarosa distillation waste encapsulated in calcium alginate beads. Biosorption process was found to be endothermic in nature. To conclude, we show for the first time that palmarosa distillation waste fixed on alginate beads can uptake and adsorb methylene blue very effectively in batch systems and showed great potential for dye removal from aquatic environments.

Similar study was conducted for utilizing distillation waste of Java citronella (C. winterianus Jowitt.) as an activated carbon for the adsorption of cong red dye from water. The preparation of activated carbon from distillation waste of java citronella activated with H\(_3\)PO\(_4\) and its ability to remove the Congo red (CR) dye used in the textile industry in aqueous solution were reported in this study. Batch adsorption experiments were performed as a function of contact time, pH, adsorbent dosage and initial dye concentration and temperature. The experimental results indicated that 0.4 g of activated carbon removed >84% of 10 mg l\(^{-1}\) dye with optimum pH of 7.0. The times to reach the equilibrium of congo red dye adsorption onto activated carbon were determined to be 45 min irrespective of dye concentration. Adsorption data were modelled using the Langmuir and Freundlich isotherms. Freundlich isotherm was obeyed for the adsorption. The dye adsorption followed the pseudo-second-order kinetics model at a dye concentration up to 5 to 30 mg l\(^{-1}\) whereas it followed pseudo-first-order at a dye concentration 50 and 100 mg l\(^{-1}\). This option will make the agro-industrial waste of java citronella plant for textile industrial effluent treatment for environmental cleansing.

**Study of Palmarosa distillation waste as a potential source of phenolics/antioxidants**

ICAR-DMAPR, Anand: Palmarosa waste obtained after essential oil distillation was evaluated for the effect of commonly used extraction techniques and solvents in the antioxidant activities and total phenol and flavonoid contents. The extraction techniques compared were successive, individual and decoction methods in both fresh as well
distillation waste of palmarosa using different solvents viz. petroleum ether, chloroform, ethyl acetate, acetone, methanol and water. The antioxidant activity of all the different solvent extracts was evaluated using antioxidant assay like 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical radical-scavenging abilities. Although the distillation waste showed less antioxidant activity than the fresh original plant, it would be possible to recover appreciable amounts of antioxidants from the hydrodistilled residue. IC₅₀ (µg ml⁻¹) value for DPPH-activity by individual extraction techniques ranged from 59.6-341.2 for fresh plant whereas it was 79.6-631.2 for distillation waste. Successive extraction was found as better technique to extract the antioxidants from the distillation waste than the other techniques evaluated in the present study. IC₅₀ (µg ml⁻¹) value for DPPH-activity by successive extraction technique ranged from 59.6-341.2 for distillation waste whereas it was 79.6-631.2 for individual extraction techniques. The results showed that extracting solvent significantly altered the antioxidant property estimations and methanol was found to be the best solvent for extraction of antioxidants in both individual and successive (except distillation waste) extraction methods. For phenolics and flavonoid extraction, methanol was also found to the best solvent in individual method whereas ethyl acetate was found to be the best solvent for successive extraction. The total phenolic and flavonoid contents ranged from 1.9 to 41.8 mg gallic acid equivalents g⁻¹ of dried extract and 0.99 to 27.6 mg quercetin equivalents g⁻¹ of dried extract, respectively for distillation waste whereas the corresponding value for fresh plant was 3.2 to 57.1 mg gallic acid equivalents g⁻¹ of dried extract and 2.1 to 32.1 mg quercetin equivalents g⁻¹ of dried extract, respectively. The variation in extracting bioactive components among the extracts was probably due to the difference of the nature of the compounds extracted with different solvents. The distillation of palmarosa produced a non-profitable waste and this by-product generated could be valorized and used as a source of natural antioxidants.

Similar study was conducted in Java citronella (C. winterianus Jowitt) also for utilization of the by-product of Java citronella as a source of phenolic/antioxidants. The study showed that the higher extraction yield was obtained by using water and hydro-alcoholic mixture. The extract obtained by both 75% and 50% aqueous methanol showed the highest total phenolic content with a value of 78.4-79.6 and 53.6-54.3 mg gallic acid equivalents g⁻¹ of dried extract in fresh plant materials and distillation waste, respectively. The flavonoid content was higher in 75% aqueous methanolic extract with a value of 36.5 and 25.6 mg quercetin equivalent g⁻¹ of dried extract in fresh plant materials and distillation waste, respectively. The extract obtained by 75% aqueous methanol showed the highest DPPH radical scavenging activity with IC₅₀ value of 64.2 and 144.1 µg ml⁻¹ in fresh plant materials and distillation waste, respectively. Though the finding showed that distillation waste of Java citronella contained moderate antioxidant potential, the findings indicated that these can be utilized as a functional food ingredient or as an antioxidant additive.
PATCHOULI \( (Pogostemon cablin) \)

The plant belongs to family Lamiaceae and is a perennial, branched, aromatic herb with soft, opposite, serrated egg shaped leaves and square stems. The plant grows up to 90-100 cm and flowers during the months of February to March. The oil extracted from the leaves has a fresh green slightly harsh aroma. As the oil ages it may considerably become sweeter and balsamic. Patchouli oil is used as a base in perfumery industry, and it is gaining more importance in aromatherapy. In India the crop is cultivated in coastal areas of South India, West Bengal, Assam, Karnataka and coastal regions of Gujarat. The plant is propagated by rooted stem cuttings.

**Effect of shade and spacing on herbage and oil yields**

**IGKV, Raipur:** Effect of shades (open area as control, under Ber tree, under Mango tree) and spacing viz., 60x60 cm, 60x45, 45x45 cm) on herbage and oil yields of Patchouli was studied. Result showed that plant height was not influenced significantly by the shade or spacing. Significant improvement in herbage yield and oil yield were observed with shade of Mango tree in comparison to shade of Ber tree and open area. Maximum oil yield \( (31.82 \text{ kg ha}^{-1}) \) was found in crop grown under Mango tree which was significantly superior to those of Ber tree \( (27.16 \text{ kg ha}^{-1}) \) and open area \( (21.62 \text{ kg ha}^{-1}) \). Crop spacing of 45x45 cm recorded significantly more oil yield \( (29.0 \text{ kg ha}^{-1}) \) than spacing of 60x45cm \( (27.16 \text{ kg ha}^{-1}) \) and 60cm x 60 cm \( (24.43 \text{ kg ha}^{-1}) \). Among the interaction effects of these two factors, highest oil yield \( (35.53 \text{ kg ha}^{-1}) \) was found with 45 x 45 cm spacing which was significantly superior to 60x45 cm and 60x60 cm, respectively under the shade of Mango tree. Maximum net return \( (\text{Rs. 67,359 ha}^{-1}) \) was found when the crop was grown under Mango tree followed by Ber tree \( (\text{Rs. 55707 ha}^{-1}) \) and open space \( (\text{Rs. 41874 ha}^{-1}) \). However, spacing of 45x45 cm resulted in highest net return \( (\text{Rs. 60550 ha}^{-1}) \).

**Effect of nutrient management and plant growth regulators (PGR) on growth and yield**

**IGKV, Raipur:** Effect of different nutrient applications viz., control (RDF: NPK 150:50:50 kg ha\(^{-1}\)) 100:50:50 kg ha\(^{-1}\) NPK + 2.5 t ha\(^{-1}\) vermicompost and different doses of various PGRs viz., NAA and GA on growth and herbage yield of the crop was studied. Application of various nutrient levels and PGR significantly influenced the plant height, herbage yield and oil yield of the crop. Maximum plant height \( (70.50 \text{ cm}) \), herbage yield \( (16.30 \text{ q ha}^{-1}) \) and oil yield \( (39.68 \text{ kg ha}^{-1}) \) were found with application of 100:50:50 kg ha\(^{-1}\) NPK + 2.5 t ha\(^{-1}\) vermicompost + 20 ppm NAA followed by 100:50:50 kg ha\(^{-1}\) NPK + 2.5 t ha\(^{-1}\) vermicompost + 30 ppm GA. Application of 150:50:50 kg ha\(^{-1}\) NPK + 2.5 t ha\(^{-1}\) vermicompost + 20 ppm GA gave the highest net return \( (\text{Rs. 41121 ha}^{-1}) \) and B:C ratio \( (0.85) \).
PUDINA (*Mentha arvensis*)

It is a herbaceous aromatic perennial herb belongs to family Lamiaceae. The species is native to the temperate regions of Europe and western and central Asia, east to the Himalaya and eastern Siberia, and North America. It has a creeping root stock from which erect branches grows up. The plant reaches a height of about 10–60 cm or rarely up to 100 cm. The crop is cultivated for its essential oil extraction which is widely used in pharmaceutical, cosmetic and flavouring industries. In India, Uttar Pradesh accounts for around 90% of Indian production, with the remaining 10% coming from smaller areas in the Punjab, Rajasthan, etc. In Ayurveda, Pudina is considered as appetizer and useful in gastric troubles. In Europe, it was traditionally used to treat flatulence, digestive problems, gall bladder problems and coughs. The extracts and menthol-related chemicals produced from the crop are used in food, drinks, cough medicines, creams and cigarettes. The chemical constituents of the essential oils mainly include menthol, menthone, isomenthone, neomenthol, limonene, methyl acetate, piperitone, beta-caryophyllene, alpha-pinene, beta-pinene, tannins and flavonoids.

**Effect of time of planting and spacing on growth and yield**

**BAU, Islampur:** An experiment was conducted with five dates of planting (25th January, 5th February, 15th February, 25th February and 5th March) and four spacing (30×20, 30×30, 40×20 and 40×30 cm). The results revealed that *Mentha arvensis* (var. Koshi) recorded significantly highest plant height, number of branches and herbage yield (311.10 g m⁻²) when planted at 25th February at a spacing of 40×20 cm as compared to the other treatments.

PUNARNAVA (*Boerhavia diffusa*)

It is a member of family Nyctaginaceae. It is a diffusely branched, prostrate medicinal herb. The plant is a common weed found in grassland, cultivated field and orchards throughout India up to an altitude of 2000 m in the Himalayas. It is occasionally cultivated in West Bengal. It can be propagated by seeds. The roots are the source of the Ayurvedic drug Punarnava which is laxative, diuretic and cardiotonic. Root is also used to cure biliousness, blood impurities, anaemia, inflammations. The whole plant is used for treating cancer, liver and renal diseases. Roots of *B. erecta* are used to adulterate *B. diffusa*. 
New disease pest reported

BCKV, Kalyani: The species of *Synchytrium* inducing gall on Punarnava was recorded for the first time from West Bengal, India. The disease occurred naturally in the period of June to December and the incidences were recorded 10 to 100% at different places in Kalyani, West Bengal. The disease symptoms on Punarnava appeared on all the aerial tender plant parts including inflorescence. The gall at its very early stage was small, transparent protuberance or bump and then gradually enlarged and transformed into a characteristic of light pink to dark pink gall. The colour of galls showed pink to dark pink from its initial stage to active stage. The galls were either developed isolated or coalesced and sprawled all over the affected area. Average diameter of gall was 459.71 ±170.30 μm (Range: 148-797 μm). Each gall containing single to several yellow, globular sori and/or dark brown, spherical resting spores could be visible by naked eye or very clearly under stereo microscope. Under light microscope, the sori were found to be oval to spherical in shape covering with single layer of cell wall, whereas, the spherical resting spores were enclosed with two distinct walls. Lipid like substances in the resting spores could be noticed on puncturing the wall of spore. The average diameter of the resting spores were 81.23 ± 20.29 μm (Range: 42.06-127.31 μm) and sporangium were 22.60 ± 2.90 μm (Range: 17.09 - 30.66 μm). At the active stage of the disease development, the severely affected parts appeared as curly, deformed, thickened and shortened in shape and size. The inflorescence became deformed and sterile. The diseased plants were, deformed, stunted growth and pink in colour. Finally, the surface of diseased parts turned into roughed, corky, malformed, grey colour and covered with dead tissues.

The species of *Synchytrium* inducing gall on Punarnava was recorded for the first time from India. In 1927, Stevens, reported *Synchytrium boerhaviae* on leaves, petioles and stems of *Boerhavia erecta* in El Roble, Costa Rica. The pathogen was reported as compositely dihomeogallic and placed in the subgenus, *Microsynchytrium*. So, on the basis of similarity, this pathogen is identified as *Synchytrium boerhaviae*.

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 and a whirl of sessile leaves. 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. Raw drug is collected both from wild as well as from cultivation. 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.

**Studies on Intercropping**

**PDKV, Akola:** The experiment was conducted to study the feasibility of intercropping of Safed musli with Pigeon pea at four row proportions (2:1, 3:1, 2:2 and 1:2) and compared with sole Safed musli and sole Pigeon pea crops. Number of fleshy roots per plant, root length, root girth, fresh and dry fleshy root yield and saponin content were maximum under the row proportion of 3:1 of Safed musli + Pigeon pea. Among all the treatments, sole Pigeon pea crop produced maximum seed yield of Pigeon pea. Safed musli equivalent yield and land equivalent ratio were significantly higher under intercropping with row proportion of 3:1 of Safed musli + Pigeon pea. Significantly higher GMR (Rs. 4,68,628/-), NMR (Rs. 3,48,653 ha⁻¹) and B:C (3.87) were recorded with intercropping system of Safed musli + Pigeonpea in 3:1 row proportion followed by sole Safed musli cropping. Hence, intercropping of Safed musli with Pigeon pea at 3:1 row proportion is recommended for obtaining higher yield and monetary returns.

**SALAPARNI (Desmodium gangeticum)**

It is a perennial shrub belongs to family Fabaceae and is an important member of Laghupanchamoola groups of plants coming under Dasamoola group. Dasamoola is a combination of ten medicinal plants in which principally roots are employed. Dasamoola is collectively used in pacify vitiated tridosha, pain, arthritis, fever, cough, bronchitis, general weakness, neuropathy, nerve weakness, urinary tract diseases, boosts immune power, colic pain, intermittent fever, respiratory disease and as an expectorant. D. gangeticum is an erect, branched shrub grows up to 1 meter in height. Flowers white, purple or lilac found in elongated terminal or axillary recemes. Fruits are multi-chambered and are grouped into 6-8 in number which are sticky in nature. When ripe, each fruit separate into one seeded segments. The useful part is the root and it is an important ingredient of more than 50 ayurvedic formulations. The drug is reported to be a good cardio tonic. It is hot, sweet, diuretic, laxative and nerve tonic. It cures burning sensations, fever, cough, difficult breathing, dysentery, thirst and vomiting. The plant is rich in flavonoids, alkaloids and pterocarpanoids which are responsible for its therapeautic activities.

**Characterization and evaluation of germplasm**

**ICAR-DMAVR:** Forty three accessions collected from different parts of India were maintained in field gene bank. Three accessions with distinct morphological traits were identified from the germplasm. They were DDG 6 (prostrate type plant), DDG 15 (tall and erect plant) and DDG 29 (with narrow and long leaves).
SARPAGANDHA (*Rauvolfia serpentina*)

It is a perennial under-shrub belongs to family Apocynaceae, distributed throughout India. The species attain a height of about 75 cm to 1 m with inflorescence arranged in cymes with deep red and white flowers. 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.

**Standardization of spacing**

**OUAT, Bhubaneshwar:** The experiment was carried out to study the effect of different levels of spacing (30x30 cm, 45x45 cm, 60x60 cm and 90x90 cm) on growth and yield of the crop. Result revealed that the plant height (70.23 cm) and number of branches per plant (4.78) were significantly higher in 60x60 cm and was minimum in spacing of 90x90 cm. The plants spaced at 45x45 cm recorded significantly higher number of leaves per plant, leaf length, leaf breadth, root length, fresh and dry weights of roots per plant, dry root yield ha^{-1} and seed yield ha^{-1}, whereas all these parameters were minimum in 90x90 cm spacing.

**Effect of organic manure on crop performance**

**OUAT, Bhubaneshwar:** The experiment comprised of four treatments with different combinations of organic manures viz., FYM@ 20 t ha^{-1}, mustard cake @ 2 t ha^{-1}, FYM @ 10 t ha^{-1} + mustard cake @ 1t ha^{-1} and control (no manure). The physico-chemical characters of the soil of the experimental field were studied before undertaking the experiment. The result showed that significantly higher plant height and number of branches per plant were in the plants received FYM @ 20 t ha^{-1} whereas number of leaves plant^{-1}, root length, total biomass of plant and fresh weight and dry weight of roots were significantly higher in the treatment of FYM @ 10 t ha^{-1} + mustard cake @ 1t ha^{-1}. The results also showed that physico-chemical characteristics of soil such as pH, electrical conductivity, organic carbon, available N and K were found to be statistically non significant among the treatments. However, there was significant variation in the available P in soil within 0-30 cm depth. Maximum available P was estimated (49.70 kg ha^{-1}) in FYM + Mustard cake treatment.
Standardization of planting methods

OUAT, Bhubaneshwar: The experiment was conducted to find out a suitable planting method (flat bed or raised bed) for *R. serpentina*. The result revealed that plant height, number of branches per plant, diameter of branches, number of leaves per plant, leaf length and breadth and seed yield per plant were not significantly influenced by the method of plantings. However, raised bed method of planting recorded maximum total biomass of plant, root length, root diameter and fresh and dry weights of roots.

Studies on intercropping

IGKV, Raipur: An experiment was conducted to evaluate intercropping of Sarpagandha with different crops viz., Soybean, Urd, Til, Kalmegh, Clusterbean, Moong and Groundnut. The result showed that different intercropping systems significantly influenced the plant height, root length, dry root yield and Sarpagandha equivalent yield (SEY). Maximum SEY was found with Sarpagandha+ Kalmegh intercropping system (17.84 q ha⁻¹) followed by Sarpagandha+ Urd intercropping system (15.55 q ha⁻¹). Sarpagandha+ Kalmegh gave highest net return (Rs.88484 ha⁻¹) which was 77% higher than sole crop of Sarpagandha. Intercropping of Sarpagandha+ Kalmegh was followed by Sarpagandha+ Urd intercropping system in terms of yield advantage and economic returns.

Effect of bioagents, micronutrient and organic amendments on leaf spot diseases

JNKVV, Jabalpur: Disease management strategy against leaf spot diseases of Sarpagandha was evaluated with combinations of bioagents, micronutrients and organic amendments. Results showed that minimum disease incidence of leaf spot (9.26%) was recorded in application of *Pseudomonas fluorescens* @ 10⁶ cfu ml⁻¹ + *Trichoderma asperellum* @ 10⁵ cfu ml⁻¹ + Neem cake+ ZnSO₄+ 1ⁿ spray of Cow urine (1:10) followed by 2ⁿ spray of Salicylic acid (1000 ppm) at 15 days interval. However, the least disease incidence of *Alternaria* leaf spot was recorded under treatment *P. fluorescens* @ 10⁵ cfu ml⁻¹ + Bacillus subtilis @ 10⁸ cfu ml⁻¹ + Neem cake+ ZnSO₄+ 1ⁿ spray of Cow urine (1:10) followed by 2ⁿ spray of Salicylic acid (1000 ppm) at 15 days interval (disease incidence 12.46%) and *P. fluorescens* @ 10⁶ cfu ml⁻¹ + Neem cake+ ZnSO₄+ 1ⁿ spray of Cow urine (1:10) followed by 2ⁿ spray of Salicylic acid (1000ppm) at 15 days interval (disease incidence 12.74%), however they were statistically at par.

Management of Cercospora leaf spot

NDUAT, Faizabad: An experiment was laid out to study the efficacy of fungicide and different botanicals against *Cercospora* leaf spot caused by *Cercospora rauvolfiae* of *Rauvolfia serpentina*. Result showed that minimum percent disease index (15.65) was recorded in the treatment with Mancozeb @ 0.25% followed by Neem leaf extract @ 5.0 % (18.47), Garlic bulb extract (21.85) and Tulsi leaf extract (24.90) as compared to control plot (67.43). Maximum yield was obtained in the plot treated with Mancozeb (12.94 q ha⁻¹) and lowest in the control plot (9.15 q ha⁻¹). Neem leaf extract (11.86 q ha⁻¹) was the next best treatment followed by Garlic and Tulsi but keeping in view of the
medicinal value of the species, Neem leaf extract may be recommended for the management of leaf spot of *R. serpentina*.

**SEenna (Cassia angustifolia)**

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

**Mining genes involved in drought tolerance**

**ICAR-DMAPR, Anand:** RNA from two different stages of leaf development was extracted and sequenced separately using Illumina platform. A total of 200 million reads were generated and de novo assembly using Trinity yielded 43,413 transcripts which were further annotated. Out of the total transcripts, 42,280 (95.0%) were annotated by BLASTX against green plant database of NCBI. Highest number of gene ontology (GO) terms were enriched for molecular functions category of these “catalytic activity” (GO: 0003824) (25.10%) and “binding activity” (GO: 0005488) (20.10%) were most abundantly represented. InterProsan was used to see protein similarity at domain level; a total of 33,256 transcripts were annotated against the Pfam domains. Coding DNA sequences (CDS) encoding various drought stress regulated pathways were identified. Six genes encoding MYC2 transcription factor, 9-cis-epoxycarotenoid dioxygenase (NCED), L-ascorbate peroxidase (APX), aminocyclopropane carboxylate oxidase (ACO), Abscissic acid 8'-hydroxylase (ABA) and WRKY transcription factor
involved in drought stress were confirmed through Reverse Transcriptase-PCR (RT-PCR) and Sanger sequencing for the first time. The potential drought stress related transcripts identified in this study provide a good start for further investigation into the drought tolerance in Senna.

Isolation of CaDAHPS gene

**ICAR-DMAPR, Anand:** 3-deoxy-D-arabino-heptulosonate7-heptulosonate7-phosphate synthase (DAHPS) is the first enzyme in the shikimate pathway catalyzing the production of 3-Deoxy-D-arabino-heptosonate-7-phosphohate leading to production of sennosides. Genomic region governing DAHPS enzyme was isolated through homology based approach and named as CaDAHPS. CaDAHPS gene has 5 exonic sequences and length of the gene is approximately 3 Kb than its orthologue in soyabean.

**IPR protection of transcriptome data generated**

**ICAR-DMAPR, Anand:** The pooled leaf transcriptome assembly of senna was deposited at DDBJ/EMBL/GenBank under the accession GEEB00000000. Sanger sequenced products of gene involved in drought stress tolerance in Senna were deposited at the GenBank at National Centre for Biotechnology Information (NCBI) with accessions numbers KU533732 (Transcription factor MYC2), KU533733 (9-cis-epoxycarotenoid dioxygenase), KU533731 (L-ascorbate peroxidase), KU533730 (1-aminocyclopropane-1-carboxylate oxidase), KU366613 (Abscisic acid 8'-hydroxylase ) and KU533734 (WRKY transcription factor 33).

**Dissipation of Chlorpyrifos 20 EC**

**ICAR-DMAPR, Anand:** A field trial was conducted to study the dissipation pattern of Chlorpyriphos 20 EC in Senna and estimation of its half life ($T_{1/2}$). Two sprays of Chlorpyriphos 20 EC were given at two weeks interval i.e., @ 250 g a.i. ha$^{-1}$ and 500 g a.i. ha$^{-1}$. The samples of Senna leaves were collected at 0, 1, 3, 5, 7, 10 and 21 days after Treatment (DAT). Fresh samples were processed by QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) approach. Quantification of Chlorpyriphos residues were done in GCMS. The method gave very good overall mean recoveries in the range of 85.37-103.58%. The LOD and the LOQ were found to be 0.01 and 0.03 $\mu$g g$^{-1}$, respectively. The initial deposits of Chlorpyriphos was 0.246 $\mu$g g$^{-1}$ and 0.875 $\mu$g g$^{-1}$ in fresh Senna leaves which reached below determination level (BDL) on 3rd and 7th DAT at standard and double doses, respectively. In dry Senna leaves, the initial residue levels were high (1.046 and 2.18 $\mu$g g$^{-1}$ at standard and double doses) that reached BDL on 7 and 10 DATs, respectively. The $T_{1/2}$ of Chlorpyrifos in dry Senna leaves was 1.46-2.16 days whereas in fresh leaves it ranged from 1.013 to 1.61 days. The residues in the soil at the time of spraying and harvesting were at BDL in either dose of application.
Efficacy of biopesticides on the management of pod borer

**TNAU, Coimbatore:** A field experiment was conducted to evaluate the bioefficacy of some promising biopesticides such as Neem oil, Neem Seed Kernel Extract (NSKE), *Metarhizium anisopliae*, *Bacillus thuringiensis* and *Beauveria bassiana* for the management of pod borer (*Etiella zinckenella*) in Senna. Chlorpyriphos 20 EC was used as standard check, besides having an untreated check. The results revealed that pre-treatment count of pod borer ranged between 3.0 and 3.5 per plant, which was statistically non significant. Among the five bio-pesticides evaluated, post treatment counts recorded on 1, 3, 5, 7 and 14 days after spraying (DAS) revealed NSKE @ 5% showed maximum efficacy with the least number of pod borer, *Etiella zinckenella* per plant, followed by Neem oil 3%, *B. thuringiensis* @ 750 g ha⁻¹ and *B. bassiana* @ 2 kg ha⁻¹, which were statistically at par in their efficacy. *M. anisopliae* @ 2 kg ha⁻¹ recorded minimum efficacy, harbouring more number of pod borers per plant. The pod borer count at one DAS was as low as 1.10 in NSKE @ 5% treated fields, followed by 1.40, 1.50, 2.30 and 2.40 in neem oil 3%, *B. thuringiensis* @ 750 g ha⁻¹, *B. bassiana* @ 2 kg ha⁻¹ and *M. anisopliae* @ 2 kg ha⁻¹ treated fields, respectively. However, chlorpyriphos 20 EC (standard check) @ 1.00 litre ha⁻¹ was significantly superior to all the other treatments, recording the lowest number of pod borer (0.10 plant⁻¹) at 1 DAS and the untreated control was significantly inferior, recording 3.70 pod borers plant⁻¹. The order of superiority was maintained in the same way in the post treatment counts on third, fifth, seventh and fourteenth DASs.

Observations recorded on the efficacy of biopesticides on pod damage by pod borer revealed that *B. thuringiensis* @ 750 g ha⁻¹ treatment showed promising efficacy with the minimum pod damage (4.87%) at 14 DAS, followed by NSKE @ 5% (4.93%), neem oil 3% (5.40%), *B. bassiana* @ 2 kg ha⁻¹ and *M. anisopliae* @ 2 kg ha⁻¹, which were statistically at par in their efficacy. *M. anisopliae* @ 2 kg ha⁻¹ recorded maximum pod damage of 5.67%. However, chlorpyriphos 20 EC (standard check) @ 1.00 lit ha⁻¹ was significantly superior to all the other treatments, with minimum pod damage of 4.33% as against the maximum pod damage of 14.27% in untreated control.

Results of the experiment on the leaf yield revealed that NSKE @ 5% treated plots recorded maximum dry leaf yield of 576.70 kg ha⁻¹ followed by treatment of *B. thuringiensis* @ 750 g ha⁻¹ (560.30 kg ha⁻¹) and treatment of neem oil @ 3% and *M. anisopliae* @ 2 kg ha⁻¹ (549.70 kg ha⁻¹), however, they were found to be statistically at par. Among the biopesticides, *B. bassiana* @ 2 kg ha⁻¹ treated plots yielded minimum leaf yield (585.00 kg ha⁻¹). The standard check chlorpyriphos 20 EC 1.00 lit ha⁻¹ was significantly superior among all the treatments (585.0 kg ha⁻¹). Leaf yield in the untreated control was 512.70 kg ha⁻¹. Foliar application of NSKE @ 5% showed maximum efficacy with the least number of pod borer (1.10 plant⁻¹), minimum pod damage (4.93%) and maximum leaf yield (576.70 kg ha⁻¹) which was found to be statistically at par with standard chemical check.
Study of heavy metal contents in raw herbal drugs collected from market

ICAR-DMAPR, Anand: Analysis of heavy metals was standardized in Atomic Absorption Spectrophotometer (AAS) and microwave digestion system. The method was standardized successfully to determine heavy metals (Zn, Cu, Pb, Cd, Cr, As and Hg) in 12 commercial market samples of Senna leaves obtained from different locations of India. Zn content in the samples varied from 17.20 to 31.70 ppm while, Cu content varied from 4.20 to 6.80 ppm which was below the permissible limit set by World Health Organization (WHO). Toxic heavy metals like Pb, Cd and Cr were also detected in the market samples but in negligible amount. In case of As and Hg, some of the market samples (Udaipur and Anand) were of below the detection limit. Among the different toxic heavy metals, Pb content was detected higher in different market samples which ranged from 0.17 to 1.00 ppm.

Distribution of sennosides in different plant parts of Senna

ICAR-DMAPR, Anand: Distribution of sennosides in different plant parts of Senna was recorded in 20 selected plants. Using column chromatography, process was optimized for preparation of enriched extracts also. Four compounds were isolated using column chromatography.

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.

Germplasm evaluation

ICAR-DMAPR, Anand: Five accessions viz., DOS-1, AOB-3, AOB-4, DOS-5 and Angna (check) of Tulsi were evaluated for herbage yield, oil content and yield contributing traits. Based on one year evaluation data at two locations, maximum plant height was observed in Angna (69.42 cm) which was at par with DOS-5 and DOS-4 (65.67cm and 65.42cm), while DOS-1 showed minimum plant height (53.42 cm). Highest plant spread
was observed in Angna (83.38 cm) which was at par with DOS-5 (82.71 cm), while DOS-3 (56.25 cm) showed least plant spread. Maximum number of branches per plant was observed in DOS-3 (178.50) which was at par with DOS-1 and DOS-5 (170.00 and 144.83), while DOS-4 (128.83) showed minimum branches per plant. Highest number of leaves per plant was observed in DOS-3 (1239.83) which was at par with DOS-1 (1219.67) and DOS-5 (1068.00), while Angna showed minimum number of leaves per plant (849.67). Maximum green leaf yield was in DOS-1 (174.80 g plant⁻¹), while DOS-4 (122.08 g plant⁻¹) had minimum green leaf yield. Maximum leaf area (per ten leaves) was recorded in DOS-3 (114.03 cm²) which was at par with DOS-1 (110.57 cm²), while DOS-5 showed minimum leaf area (58.11 cm²). Highest oil content (%) was in DOS-3 (0.71) which was at par with DOS-1 (0.66), while, Angna showed minimum oil content (0.35%).

The essential oils of the accessions were subjected to detailed analysis. At full flowering stage, highest Bioclorheptane 2-ol content was found in DOS-3 and DOS-4 (0.11 and 0.11%), Delta-3-carene, Valencene, Azulene, Beta-caryophyllene, Alpha copaene, Naphthalene and Beta-cubebene content (1.36, 15.16, 0.58, 9.46, 2.67, 0.24 and 11.67%) were found in Angna, while highest Methyl chavicol, Methyl eugenol and Camphene (1.25, 88.05 and 0.10%) were observed in DOS-1. Overall, DOS-1 was superior on the basis of leaf yield and oil and Methyl eugenol contents.

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

**AAU, Anand:** Effect of organic manures on crop yield and oil quality was studied with eight treatments i.e., no manure (control), FYM @ 10 t ha⁻¹, FYM @ 15 t ha⁻¹, vermicompost @ 5 t ha⁻¹, vermicompost @ 7.5 t ha⁻¹, caster cake @ 1.5 t ha⁻¹, caster cake @ 2.5 t ha⁻¹, RDF through inorganic fertilizers (75:50:40 NPK kg ha⁻¹). Significantly higher fresh and dry herbage yields (20.09 and 5.76 t ha⁻¹) and oil yield (23.70 kg ha⁻¹) were found with application of FYM @ 15 t ha⁻¹, which was at par with application of vermicompost @ 7.5 t ha⁻¹ where fresh and dry herbage yields and oil yield were 18.61 t ha⁻¹, 5.33 t ha⁻¹ and 21.44 kg ha⁻¹, respectively and application of castor cake @ 2.5 t ha⁻¹ where fresh and dry herbage yields and oil yield were 18.82 t ha⁻¹, 5.39 t ha⁻¹ and 21.06 kg ha⁻¹, respectively. The lowest fresh and dry herbage yields (15.49 and 4.40 tha⁻¹) were recorded with control.
ICAR-DMAPR, Anand: Effect of organic manures on Tulsi was conducted in split plot design with three main plot treatments (no organics, green manuring with Sesbania and crop residue) and seven sub plot treatments (no fertilizers, 50% RDF, 75% RDF, 100% RDF, 50% RDF + Microbial consortia, 75% RDF + Microbial consortia and 100% RDF + Microbial consortia). First harvesting data revealed no significant differences for main plot treatments as well as sub-plot treatments for different growth, yield and quality parameters.

Studies on insect pests

BCKV, Kalyani: Six insect pests were recorded on Ocimum spp. Among them, three were of the order Hemiptera viz., Tingid bug, Cochlochila bulita (Tingidae), Aphid (Aphididae) and Ptyelus sp. (Cercopidae). Others were Leaf folder, Syngamia abruptalis (Lepidoptera: Pyralidae), an Ash weevil, Myllocerus sp. (Curculionidae : Coleoptera) and short horned grasshopper (Orthoptera). Among these, tingid bug, C. bulita was found as a major insect pest. Both adults and nymphs of tingid bug, C. bulita suck the sap from leaves, the leaf margin dried up leading to curling, cupping and withering of whole leaves. Due to heavy infestation, the plants showed a burning appearance. All the species of Ocimum were found as host of this pest and its occurrence was found throughout the year with maximum population during October- November.

WILD 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 annually with a major share comes from Himachal Pradesh. The plant grows to a height of 0.6 m to 2 m. Leaves, flower heads and seeds contain the major portion of the essential oil. The flower heads are attractive in appearance and it can also be grown as ornamental crop in gardens. The essential oils are used in pharmaceutical and flavouring industries. Besides, it is well known for its biocide properties. The main components identified of the essential oils are ß-phelandrene, limonene, ß-ocimene, dihydrotagetone, tagetone and tagetenone.

Collection, characterization, evaluation and maintenance of germplasm

YSPUHF, Solan: Thirty two accessions were evaluated. Maximum plant height of 223.6 cm was observed in TMHP-32 which was at par with TMHP-3, TMHP-6, TMHP-8, TMHP-10, TMHP-12, TMHP-13, TMHP-14, TMHP-24, TMHP-29 and TMHP-30. Minimum plant height (173.3 cm) was observed in TMHP-25. Maximum collar diameter of 16.4 mm was observed in TMHP-13 and minimum diameter of 11.95 mm was in
TMHP-31. Maximum number of branches per plant (7.67) was observed in TMHP-2 and minimum (3) was in TMHP-31. Maximum leaf biomass (68.45 q) per hectare was observed in TMHP-9 and minimum (37.00 q) was in TMHP-30. Maximum oil percentage in leaves was in TMHP-30 (0.34%) and minimum was in TMHP-3 (0.21%). Maximum oil yield per hectare in leaves was in TMHP-32 (17.64 litres) and minimum was in TMHP-3 (9.98). Maximum fresh flower biomass (46.62 q) per hectare was in TMHP-1, TMHP-8, TMHP-27 and minimum was in TMHP-14 (12.95q). Maximum oil percentage in flowers was in TMHP-11 (0.64%) and minimum was in TMHP-16 (0.37%). Maximum oil yield per hectare in flowers was in TMHP-24 (20.70 litre) and minimum was observed in TMHP-14 (5.67 litre). Seeds of ten accessions were submitted to NBPGR for long term storage and to avail IC numbers. Morphometric observations were completed in all the 32 accessions.

Standardization of sowing methods and planting densities

YSPUHF, Solan: The experiment comprised of six treatments on methods of sowing (broadcasting and line sowing) and different plant densities (30x30, 30x45, 45x45 and 45x60 cm). The nutrient status of the experimental field was tested before starting the experiment. The result showed that denser spacing (30x15cm) gave maximum flower biomass (71.98 q ha\(^{-1}\)). The essential oil content from flowers ranged from 0.35% to 1.09%.

Other experiments:

Soil fertility and soil biological status under organic nutrient management practices

ICAR-DMAPR, Anand: In organic nutrient management experiments, different sources of organic manures (farm yard manure, castor cake and vermicompost), biofertilizers [Azotobacter and phosphate solubilizing bacteria (PSB)] and Jivamrut were evaluated in Kalmegh and Ashwagandha. Application of organic sources improved mineral N as well as available P and S in soil. Soil microbial biomass carbon (MBC) as well as dehydrogenase (µg TPF g\(^{-1}\) ha\(^{-1}\)) and fluorescein diacetate (µg fluorescein g\(^{-1}\) ha\(^{-1}\)) were significantly improved by the application of organic nutrient sources. Soil fertility and biological status in terms of mineral N, available P and S, MBC and dehydrogenase and fluorescein diacetate activities were highest with vermicompost @7.5 t ha\(^{-1}\) along with Jivamrut application at 25, 50 and 75 DAP.

Modified QuEChERS and GC-MS based approach for the detection of pesticides

ICAR-DMAPR, Anand: A rapid, multiresidue, multimatrix analytical method for the determination of eleven multi-class pesticides in four medicinal plants (Ashwagandha, Isabgol, Senna and Kalmegh) was developed. Samples were extracted by modified QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) approach followed by gas chromatography-single quadrupole mass spectrometry (GC-MS). The method was subjected to thorough validation procedure in-terms of accuracy, precision, limit of quantification (LOQ), matrix effect, linearity and uncertainty analysis. The mean recovery
for most of the pesticides was in the range of 70–120% with RSD <20% and measurement uncertainties <20% for all the compounds at 0.5 mg kg\(^{-1}\) in all the matrices. The limits of quantification ranged from 0.01 to 0.069 mg kg\(^{-1}\). The proposed method was successfully applied to determine pesticide residues in 52 commercial market samples obtained from different locations in India.

**BETELVINE (Piper betle)**

It is a perennial evergreen dioecious climber, belonging to family Piperaceae. It is a native of Central and Eastern Malaysia and has spread throughout tropical Asia and Malaysia; Madagascar and East Africa at a later date. The plant grows well in shady conditions having moderate temperature with high humidity. The major cultivating countries are India, Bangladesh, Srilanka, Pakistan, Malaysia, Thailand, Indonesia, Maldives, Vietnam and Papua New Guinea. In India it is cultivated in an area of about 50,000 ha. 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.

**Exploration and collection**

**ICAR-IIHR, Bengaluru:** Betelvine growing areas of East Midnapore, West Bengal, Gubbi, Tumkur District, Karnataka and Lenewadi in Jamkhed of Maharashtra were explored and germplasm was collected along with Local Kapoori and Meetha cum Bangla from AICRP MAP&B, Rahuri. A distinct germplasm found in homestead garden in Dobbespet, Tumkur district of Karnataka was also added to the existing germplasm.

**Characterization and evaluation of germplasm**

**ICAR-IIHR, Bengaluru:** Forty germplasm lines were characterized for different qualitative and quantitative traits. Variability for many traits was noted in the germplasm. The data
revealed that IIHR BV67, Sirugamani 1, IIHR BV 53 were profuse flowering types among the female clones. Among the male clones, Swarna Kapoori, Sangli Kapoori and CARI 6 were found to be profusely flowering types. Clones Banavalli, Hirehalli Local, CARI 6 and IIHR BV 96-1 produced dark green colored orthotrophic leaves. It was observed that all the clones had acuminate leaf apex except Banavalli which had acute leaf apex. Leaf shape of the accessions was found to be elliptical, wide elliptical or ovate.

In general Kapoori clones produced narrow leaves whereas broader leaves were observed in Khasi Pan. Plagiotropic leaf length/breadth (l/b) ratio was lowest in Sirugamani 1 (1.15) and maximum in CARI 6 (2.15). Number of plagiotropic shoots per meter length of vine was maximum (12) in CAR I2 and IIHR BV 68. Longer plagiotropic shoots were recorded in Godi Bangla (64.16 cm) followed by Bangla (UP) (63.96 cm) and Nov Bangla (63.24 cm). Number of nodes per plagiotropic shoots varied from 8.4 (IIHR BV 68) to 16.84(CARI 6).

**AAU, Jorhat:** Evaluation of twenty six accessions was done during 2015-16. Except Apb-2, all the other accessions had cordate type leaf. The leaf of Apb-2 was oblong. Leaf lamina was invariably entire and the tip was acute type. Length of petiole varied from 5.10 to 9.10 cm. Apb-8 and Apb-10 had the longest petiole (9.10 cm) followed by Apb-22 (8.10 cm).

Observations on leaf length, leaf breadth, leaf length/breadth ratio and intermodal length were taken. The leaf length of the germplasm ranged from 7.60 cm to 16.93 cm. Highest leaf length was in Apb-15 (16.93 cm) followed by Apb-1 (15.83 cm). Leaf breadth was highest in Apb-1 (13.67 cm) followed by Apb-1 (13.47 cm). Leaf length/breadth ratio was highest in Apb-3 and Apb-10 (1.59) while the minimum was recorded in Apb-7 (0.89). Internodal length ranged from 4.83 cm (Apb-11) to 9.10 cm (Apb-7).

**BCKV, Kalyani:** Germplasm of betelvine collected from different parts of the country was maintained under Boroja structure in two separate places at BCKV. In total, 54 cultivars were maintained at this center. These were Bangla type-36 numbers, Sanchi type- four numbers, Kapoori type-11 numbers and Meetha- 3 numbers. Besides these, 20 hybrid lines were also maintained at this center.

**Yield trial of high yielding clones under Areca nut support**

**ICAR-IIHR, Bengaluru:** Eight selected high yielding clones along with local check (Hirehalli Local) were planted in Areca nut garden with a spacing of 2.7/0.9 m (4115 vines ha⁻¹) during October 2010. Growth and leaf yield were recorded in the fifth year after planting. Maximum leaf yield was recorded in IIHR BV 67 (52.22 lakh leaves ha⁻¹) followed by Sirugamani 1 and Mysore Local (48.59 and 47.42 lakh leaves ha⁻¹). Hirehalli Local recorded the lowest leaf yield (16.19 lakh ha⁻¹) during the year. Result thus showed that IIHR BV 67, Mysore Local, Sirugamani 1 and Godi Bangla were high leaf yielders and these clones are being used in hybridization programme as parents.
Multi-location trial of hybrids

**AAU, Jorhat:** Nine betelvine hybrids viz., IIHRPB 06-1, IIHRPBH 06-4, IIHRPBH 06-8, IIHRPBH 06-11, IIHRPBH 07-24, IIHRPBH 07-36, IIHRPBH 08-20, IIHRPBH 08-23 and IIHRPBH 08-52 collected from ICAR-IIHR were planted along with two local checks i.e., Local Bangla type and Assamiya Pan type in the last week of September, 2014. Data were recorded on vine length, shoot internodal length (Main stem and lateral shoot), number of laterals, lateral length and number of leaves per lateral shoot. Vine length among the hybrids varied from 87cm to 183cm. The highest vine length was found in HY08-23 followed by HY08-20 (160.00cm) while minimum vine length was recorded in HY07-36 (87.00cm). Shoot internode length of the main shoot was recorded highest in HY08-23 (10.46cm) while minimum was noticed in HY07-36 (4.37cm). Significant variation of shoot inter node length of the lateral was observed which ranged from 0.30 cm to 10.00 cm. Maximum shoot inter node length was recorded in HY06-4 (10.00 cm) while minimum was in HY06-11 (0.30 cm).

**BCKV, Kalyani:** Under the multi-location trial of Betelvine hybrids to identify promising hybrids for high yield and quality at Kalyani, the hybrid entries along with four farmers' varieties were evaluated. Result showed that leaf yield was higher in PBH -06-11 and PBH -06-4 among the hybrids.

**ICAR-IIHR, Bengaluru:** Nine hybrids from ICAR-IIHR along with Hirehalli Local (Bangla type) and Swarna Kapoori as two local checks were tested. The data on growth and yield were recorded. There were significant differences for vine length among the entries. Among the hybrids, Hy 06-4 recorded highest vine length (256.00 cm) followed by Swarna Kapoori (237.94 cm). Orthotropic shoot intermodal length was lowest in Hy 06-11 (3.47cm) followed by Hy 06-1 (3.77 cm). Plagiotropic leaf length was highest in Hy 06-11 (15.64 cm) followed by Hy 06-4 (15.38 cm). Highest leaf breadth was observed in Hy 06-11 (9.55 cm) followed Hy 06-4 (9.54 cm). Plagiotropic leaf petiole length was maximum in Hy 08-23 (3.37 cm) followed by Hy 08-20 (2.98 cm). Highest number of plagiotropic shoots per metre of vine was recorded in Hy 07-36 (8.17) followed by Hy 06-1 (8.07). Longest plagiotropic shoot was observed in Swarna Kapoori (40.18 cm) followed by Hy 06-4(40.16 cm) however, both were at par. Higher number of leaves per vine was recorded in Hy 06-4 (126.47) followed by Hy 06-1 (113.00) whereas the check Hirehalli local recorded 83.80 leaves per vine and Swarna Kapoori had 106.70 leaves per vine. No major insect pests or disease pests were observed in the trial. Organoleptic evaluation showed varied levels of pungency from low (Swarna Kapoori) to moderate (most of the hybrids) to high (Hirehalli Local, Hybrids 6-4 and 6-8).

**YSRHU, Venkataramannagudem:** During 2015-16, Tellaku ponnuru recorded highest vine length which was at par with Swarna Kapoori and GN Hybrid. GN Hybrid recorded highest yield which was at par with Swarna Kapoori. Leaf length and width were also highest in GN Hybrid.
Evaluation of hybrid lines for resistance to different diseases and insect pests

**BCKV, Kalyani:** The incidence of different diseases and insect pests on 20 Betelvine hybrids lines maintained at Kalyani was recorded. Percent disease index of leaf spot and leaf rot were calculated on a 0-5 scale. 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 disease. Average vine mortality (from August to October, 2015) due to foot rot was recorded as 3.13-8.60%. The highest vine mortality (12.90%) was recorded in the month of 25th October, 2015 in PBH- 08-64, PBH-06-1, PBH- 07-10 followed PBH-07-4 (12.50%) and it was totally absent in the month of August, 2015 in GN-1 Hybrid, PBH-08-56, PBH-08-45, PBH-06-11, PBH-06-2, PBH-06-8, PBH-06-9 and PBH-07-16. Incidence of leaf rot disease caused by Phytophthora was maximum in October. The average percentage of disease (severity) index (PDI) and incidence of leaf rot recorded from 4.21% (PBH-07-10) to 2.79% (GN-1 Hybrid) and 6.13% (PBH-06-11) to 9.07% (PBH-06-2), respectively. Incidence of leaf spot disease was maximum in the month of October. The average percentage of disease (severity) index (PDI) and incidence of leaf spot recorded ranged from 4.29% (PBH-07-4) to 5.95% (PBH-06-8) and 15.25% (PBH-07-4) to 20.00% (PBH-08-56), respectively.

Screening of these hybrids against whitefly was also carried out. Adult populations from ten vines for each entry were taken at the end of October, 2015. Mean population of aleyrodid flies per vine was calculated (average of 10 vines) and the results showed that the overall populations of aleyrodid flies were medium (12-30 flies vine⁻¹). None of the entries under observation was completely free from fly infestation. Among the 20 lines, PBH- 08-64, PBH-08-10 and PBH- 07-1 harbored comparatively less number of flies (<15 flies vine⁻¹). Rest of the lines recorded higher numbers of flies (>15 flies vine⁻¹).

**Survey for disease occurrences in farmers' field**

**BAU, Islampur:** Survey was conducted for identification of most severe diseases in Magahi pan growing regions of Nalanda, Nawada, Gaya and Aurangabad districts during 2015-16. During the survey Phytophthora foot-rot and Phytophthora leaf rot were found as most severe diseases with 35.70% and 32.50% disease incidences, respectively. Other severe diseases were also noticed viz., Anthracnose leaf spot (29.5%) and bacterial leaf spot (20.00%).

**Epidemiology and management of leaf rot and anthracnose leaf spot**

**BAU, Islampur:** Epidemiology of commonly occurring diseases viz., leaf rot and leaf spot diseases and their management in Maghai pan were studied. The leaf rot (Phytophthora parasitica var. piperrina) was characterized by the presence of circular black or brownish water soaked spots. These spots rapidly increased in size and coalesced with each other, involving a major area in the leaf blade, which rotted when the weather was continuously wet. The central rotten portion of the spot dropped out, leaving a hole with irregular edges. The symptoms developed on any part of the leaves, including tips and margins. If the conditions still continued to be favorable, the rot proceeded to the...
petiole and eventually to the stem. *Phytophthora* leaf rot severity was reported maximum (36.30%) during the month of August. In this month rainfall was high (296.60 mm) as compared to other the months of disease severity period; average temperature varied between 26.6 and 32.9°C with high relative humidity (90.48%). Another disease observed was *Anthracnose* leaf spot (*Colletotrichum capsici*). The diseased leaves were characterized by presence of circular to irregular, light to dark brown lesions on the leaves which were surrounded by yellow hallo. The centre of such spots were later turned straw yellow in colour. The spots often coalesced to form bigger patches. *Anthracnose* leaf spot severity was reported maximum (28.30%) during the month of January. In this month the average temperature varied between 8.70 and 22.00°C that was low as compared to the other months of disease severity, however, relative humidity was observed high (90.90%).

The trial for management of *Phytophthora* leaf rot and *Anthracnose* leaf spot of Magahi Pan included seven treatments for each disease. For *Phytophthora* leaf spot, each fungicide treatment was sprayed when the percent disease index (PDI) varied between 17.70 and 29.00% under natural conditions at the 4th week July. Two sprays were applied at 15 days intervals. All the treatments reduced the *Phytophthora* leaf rot over the control. Application of Metalaxyl @8% + Mancozeb 64% WP ingredient of fungicide at 0.20% concentration was significantly (p=0.05) superior to all the other treatments and reduced 76.3 % disease severity of Phytophthora leaf spot.

For *Anthracnose* leaf spot, each fungicide treatment was sprayed when the percent disease index (PDI) varied between 13.00 and 23.70% under natural conditions at 4th week of November. Two sprays were applied at 15 days intervals. All the treatments reduced the *Anthracnose* leaf spot over the control. Application of Carbendazim 12% + Mancozeb 63% WP ingredient of fungicide at 0.20% concentration was significantly (p=0.05) superior to all the other treatments and reduced 68.8 % disease severity of Anthracnose leaf spot.

**Integrated disease management of soil borne diseases**

**BAU, Islampur:** The result of integrated disease management of Betelvine for management of soil born diseases like *Phytophthora* foot rot, *Sclerotium* wilt and bacterial leaf spot during 2015-16 showed that treatment which included sanitation + Bordeaux mixture @ 1% as soil drenching before planting and 60 days after planting was superior to the control and the other treatments which reduced the disease incidence by 70.40%, 74.70% and 67.70%, respectively.

**BCKV, Kalyani:** A field experiment was conducted to find out the efficacy of Bordeaux mixture, *Trichoderma* and *Pseudomonas fluorescence* in different combinations with time schedule for developing a technology of integrated management of soil borne diseases of Betelvine. The result indicated that the treatment which included one application of Bordeaux mixture (1%) at pre-monsoon+ application of bio-control agent (*Trichoderma harzianum/ viride*) after one month+ one additional application of Bordeaux mixture(1%) at two months after first Bordeaux mixture application had the best result out of the five
treatments by reducing 77.78% vine mortality, 72.10% leaf rot (PDI) and 87.45% leaf spot (PDI). PDI and the percentage of diseased leaf recorded for *Phytophthora* leaf rot were 3.09% and 8.29%, respectively. Similarly, in case of leaf spot disease, PDI and the incidence of disease on leaf were 3.48% and 12.09%, respectively in this treatment. Maximum mortality of vine (26.67%), PDI and percentage of diseased leaf in *Phytophthora* leaf rot (10.08 and 22.70) and PDI and incidence of disease in leaf spot disease (25.17% and 67.86%) were recorded in the control (only sanitation).

**Biology of Blackfly**

**BCKV, Kalyani:** Durations of various life stages of Blackfly (*Aleurocanthus bucktoni* Sundararaj & Pushpa) were studied. The female laid eggs scattered on the lower leaf surface of young leaves. The egg was with a stalk branched at base. After hatching, the empty shell remained permanently attached with the leaf. First instar nymph was elongate-oval in shape, brown in color with two pairs of curved sitae. After hatching, 1st instars moved to short distance and fixed itself. The puparium was perfect black in colour. The exuvium of previous instar was attached on dorsum. The adults emerged from pupal cases leaving black exuviae with 'T' shaped slit on the dorsum. The exuviae remained attached with leaves. Male was conspicuously smaller than the female. The colour of the fore wing was black with small whitish patches. The abdomen was dark red in colour.

**Demonstration of integrated crop management technology in the farmers' field**

**BCKV, Kalyani:** Comparative performance of integrated crop management technology (ICM) developed by BCKV and farmers' practice for disease management in Betel vine was studied in 12 farmers' field at Simurali, Nadia covering an area of 150 m² of each baroja. The disease management technology developed by the center and applied in farmers' baroja was sanitation+ the application of Bordeaux mixture at pre monsoon + after one month, biocontrol agent+ one application of Bordeaux mixture at 2 months after the first mixture application. The farmers' 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 16.11%, which was 4.72% in the technology developed by BCKV i.e., decrease by 70.69%. The PDI and incidence of leaf spot were 10.85% and 26.05%, respectively in farmers' practice and which were 2.59% and 8.07% respectively, i.e., with a reduction of 76.16% and 69.02%, respectively in the practice developed by BCKV. Similarly, there were a reduction of PDI and incidence of *Phytophthora* leaf rot by 80.01% and 73.91%, respectively by following the practice developed by BCKV over farmers' practice.

**BAU, Islampur:** The demonstration trial of ICM practices was conducted at 20 farmers' fields at 12 villages (locations) of four districts (Nalanda, Nawada, Gaya, and Aurangabad) where Magahi pan is in cultivation during 2015-16. The result of the demonstration showed that ICM practices resulted in better yield performances
(43.80-56.30 lakh marketable leaves ha\(^{-1}\)) at all the locations than the farmers' practices (31.3-43.0 lakh marketable leaves ha\(^{-1}\)). The crop under ICM practices had low incidence of foot-rot disease (7.00-23.00%) in comparison to farmers' practices (26.00-39.00%). Similarly ICM practices produced better leaf quality with fresh weight of 100 leaves in higher ranges i.e., 120.00-149.00 g whereas, farmers' practices recorded lower fresh weight of 100 leaves (108.00-131.00 g). Thus, Betelvine growers can increase their marketable leaves per hectare and fresh weight of 100 leaves with lower incidences of diseases like foot-rot by adopting ICM practices.

**OUAT, Bhubaneswar:** Crop protection demonstration of Betelvine disease management package developed by the centre was conducted in 15 farmers' field. The result showed that the crop protection demonstration of Betelvine disease management package developed by the centre recorded higher leaf yield and profit with fewer incidences of diseases as compared to the farmers' practices.

**RAU, Pusa:** The experiment comprised of INM practices of NPK @ 200:100:100 kg ha\(^{-1}\) in the form of organics (vermicompost+oil cake)+inorganic and IDM practices of sanitation+ soil drenching with Bordeaux mixture (1%) followed by incorporation of mustard cake @ 500 kg ha\(^{-1}\) inoculated with *Trichoderma viride* (1 kg *Trichoderma* per 100 kg oilcake) after 30 days and again drenching with Bordeaux mixture (1%) 60 days after 1\(^{st}\) drenching. The ICM/IDM technology of Betelvine cultivation developed by the centre was tested in 30 farmers field at seven different locations in 4 different districts viz., Samastipur, Vaishali, Darbhanga and Begusarai districts of Bihar. The crop performance under ICM practice was found superior at all the locations with maximum marketable leaf yield (40.50 lakh leaves ha\(^{-1}\)) and quite less disease incidence in Darbhanga district. The crop in ICM practice also recorded longer shelf life (15-16 days) of the leaves. The crop under Farmers' practices registered lower yield (maximum 22.50 lakh leaves ha\(^{-1}\)) with higher incidence of *Phytophthora* rot (up to 30.50 %) and shorter shelf life of leaves (10-12 days).

**Agricultural Knowledge Management Unit (AKMU)**

**Institute website**

The institute website (www.dmapr.org.in) has been updated on daily basis.

**Intranet website**

The Directorate intranet website was maintained and published the information such as office circulars, applications forms, documents and other information related to this office. It was updated on daily basis.

**Databases**

Attempts were also continued for updating the software applications such as Digital Herbarium of Medicinal & Aromatic Plants in India, Open Access Journal of Medicinal & Aromatic Plants (www.oajmap.in) and Digital Photo Library of Medicinal and Aromatic Plants, etc.
Germplasm of medicinal and aromatic plants maintained at ICAR-DMAPR, Anand

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<th>Number of Accessions</th>
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### Germplasm of medicinal and aromatic plants maintained at AICRP-MAPB centres

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<td>Tulsi (Ocimum sanctum)</td>
<td>CCSHAU, Hisar</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>AAU, Anand</td>
<td>3</td>
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<tr>
<td>Tagetes (Tagetes minuta)</td>
<td>YSPUHF, Solan</td>
<td>32</td>
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<tr>
<td>Vetiver (Vetiveria zizanioides)</td>
<td>CCSHAU, Hisar</td>
<td>50</td>
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<tr>
<td></td>
<td>KAU, Thrissur</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>NDUAT, Faizabad</td>
<td>12</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>3117</strong></td>
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Germplasm of Betelvine being maintained at AICRP MAPB centres

<table>
<thead>
<tr>
<th>Center</th>
<th>Number of accessions</th>
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<tbody>
<tr>
<td>AAU, Jorhat</td>
<td>26</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>118</td>
</tr>
<tr>
<td>MPKV, Rahuri</td>
<td>28</td>
</tr>
<tr>
<td>OUAT, Bhubaneshwar</td>
<td>21</td>
</tr>
<tr>
<td>RAU, Pusa</td>
<td>10</td>
</tr>
<tr>
<td>YSRHU, Venkataramannagudem</td>
<td>64</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>331</strong></td>
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</tbody>
</table>
Committee meetings

Research Advisory Committee meeting (RAC)

The XIII Research Advisory Committee (RAC) meeting of the Directorate was held at ICAR - DMAPR, Anand under the chairmanship of Dr. S. B. Dandin, Formerly, Vice Chancellor, University of Horticultural Sciences, Bagalkot, Karnataka during 8th to 9th June, 2015. The other members of RAC were Dr. K. C. Dalal, Former Director, NRCMAP; Dr. C. Devkumar, Former Assistant Director General (Education), ICAR, New Delhi; Dr. Jitendra Kumar, Director, ICAR-DMAPR; Dr. S. K. Pareek, Former Principal Scientist, ICAR - NBPR, New Delhi; Shri S. N. Tyagi, Mission Director, GSBTM, Gandhinagar; Dr. A.N. Ganeshamurthy, Head, Division of Soil Science and Agricultural Chemistry, ICAR - IIHR, Bangalore and Dr. Satyanshu Kumar, Principal Scientist and Member Secretary, ICAR-DMAPR. The research activities carried out at the Directorate during the year were thoroughly discussed and also future research activities of the Directorate were meticulously planned in the meeting.

Institute Research Committee meeting (IRC)

Institute Research Committee Meeting (IRC) was held under the Chairmanship of Dr. Jitendra Kumar, Director, ICAR-DMAPR, Boriavi on 14th October, 2015. Dr. P. Manivel, Secretary, IRC, welcomed the Chairman and members of the IRC. The Chairman appraised the house about the purpose of conducting this important meeting. Thereafter the scientists presented the work progress of the ongoing projects. There were totally seven main projects and one flagship programme. Accordingly, the PI's of each project made presentations followed by the presentations of individual scientists who presented their achievements and future targets and discussions were made. 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.

Institute Management Committee (IMC)

Institute management committee meetings (IMC) were held on 28.04.2015 and 26.02.2016, under the Chairmanship of Dr. Jitendra Kumar, Director, ICAR-DMAPR. Various developmental issues and activities were discussed in the IMC meetings.
Extension activities

ICAR-DMAPR Tribal Sub-Plan (TSP)

The ICAR-DMAPR has been implementing Tribal sub-plan (TSP) since its inception in the year 2013-14 for the “Promotion of medicinal plants cultivation in tribal areas of Gujarat for livelihood and health security” in the tribal villages of Dediapada tehsil of Narmada District, Gujarat.

Seeds and planting material of Kalmegh (Andrographis paniculata), Dodi (Leptadenia reticulata), Aloe (Aloe barbadensis), Ashwagandha (Withania somnifera) and Mandukaparni (Centella asiatica) were distributed to the beneficiary tribal farmers under the TSP Plan Scheme of ICAR-DMAPR. Technical know-how was also given to the tribal farmers about the planting, sowing and other cultivation practices of these medicinal plants. Improved sowing-cum-weeding hoes were distributed keeping in view of the practical difficulties to be faced for sowing and weeding on undulated topography and shallow soils in the targeted areas under the scheme. The implement was modified to adjust the row spacing, soil depth and sowing/weeding operations. Villages of Jambughoda tehsil in Panchmahal district were surveyed and new beneficiaries were added during the current year. With the help of an NGO; the VIKSAT, 112 beneficiaries from 7 villages of Bhiloda and 13 villages from Vijaynagar tehsils of Sabarkantha and Arvalli districts, respectively were selected and invited to the Directorate for exposure visit cum training. An on-farm introductory training programme was organized at Zarva village in Jambughoda tehsil. Keeping an aim to
promote cultivation of MAPs, a field day was organized at Jadoli village of Dediapada Tehsil in Narmada District. During the training programme, improved farm implements, sickles, *Phavda* and seed materials of different MAPs were distributed to the beneficiaries for the promotion of cultivation of medicinal plants.

**Krishi mahotsav**

ICAR-DMAPR participated in *Krishi mahotsav* 2015 held during 29 April to 01 May, 2015 at Lunawada in Panchmahal district organized by the Gujarat state government. More than 2000 interested farmers visited the ICAR-DMAPR exhibition stall which comprised of live plants, planting material of MAPs, raw drug materials and posters exhibiting the Directorate's major research findings and technologies for the MAP growers. Our main objective was encouraging MAPs cultivation considering the demands of MAP sector.

**Launching of Mera Gaon Mera Gaurav programme**

In commemoration with the 24th Institute foundation day celebration, *Mera Gaon Mera Gaurav* (MGMG) programme at ICAR-DMAPR was officially launched. The function was chaired by Dr. Jitendra Kumar, Director, ICAR-DMAPR. The institute also made five core groups consisting of five scientists in each group and selected 25 nearby villages for implementing the programme. Baseline line surveys were also completed from these villages. Sarpanches and Village officers of the selected villages were invited for the official launching ceremony.

**Farmers' fair**

An exhibition was displayed in Gujarat State level farmers' fair at KVK Godhra on 1st March, 2016. Another exhibition was displayed in National *Kissan Unnthi Mela* during 19-21 March, 2016 at IARI New Delhi. During these exhibitions, live plants, planting material of MAPs, raw drug materials and posters exhibiting the Directorate's major research findings and technologies were displayed with a main objective of encouraging the MAP based agro-commercial sector, agro based industries, and export oriented market, scientists to produce their optimum potential products and to showcase the Directorate's research findings for farming and business community.
Demonstrations imparted

As per the annual plan of action 2015-16, five demonstrations were given on Lemongrass, Palmrosa and Tulsi in an area of 2.0, 2.0 and 1.0 ha, respectively, under centrally sponsored Mission for Integrated Development of Horticulture (MIDH) scheme at Petlad, Anand, Gujarat. Planting materials and fertilizers were also distributed to selected farmers under this programme.

Training on cultivation of aromatic plants in Gujarat

One-day training programme entitled “Cultivation of aromatic plants in Gujarat” was organized on 18.02.2016 at Pandoli, Petlad, Anand, Gujarat by the ICAR-DMAPR under the Central Sector Scheme (CSS). One hundred farmers were selected from different villages of Petlad tehsils of Anand for the training. In this training programme, different cultivation and marketing aspects of MAPs were covered through lectures. The various topics covered under this training programme included propagation techniques, good agricultural practices including planting material selection, agro-techniques, disease management, efficient marketing and importance of record keeping and contract farming.

Model training course on value addition and post harvest management

A model training course on value addition and post harvest management in Medicinal and Aromatic Crops was organised at ICAR-DMAPR during 3rd to 10th December, 2015. This Model training course was sponsored by the Directorate of Extension, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers’ Welfare, Government of India, New Delhi. The programme was formally inaugurated on
3rd December, 2015. On this occasion Dr. K.B. Kathiria, Director of Research & Dean, P.G. studies, AAU, Anand was the Chief Guest; Dr. K. P. Patel, Principal and Dean, AAU, Anand was the Guest of Honour. Dr. Jitendra Kumar, Director, ICAR-DMAPR & Course Director presided over the function. Dr. Satyanshu Kumar, Course Coordinator presented a brief report about the training programme. Dr. Kathiria in his speech stressed the importance pre and post harvest management as well as value addition in MAPs. Dr. Patel described Medicinal and Aromatic crops as natural medicine. He expressed concern over possible changes in concentration of bioactive compounds as a consequence of the environmental changes. Dr. Jitendra Kumar highlighted the need of conservation and adoption of good agricultural and collection practices so that sustainable supply of quality crude drugs could be ensured. At the end of the inaugural function, Dr. A.P.Trivedi, Course Co-Coordinator proposed vote of thanks. Twenty one people including Horticulture Officers, Forest Officers, Subject Matter Specialists from KVKs, Research Scientists from State Agricultural Universities and ICAR institutes participated in the training course. Resource persons for training course included faculty members from Anand Agriculture University; Sardar Patel University, V.V. Nagar; ICAR-IARI, New Delhi; ICAR-DMAPR and Horticulture Department, Government of Gujarat. The complete value chain of medicinal and aromatic plants including collection and conservation, taxonomic identification, pre and post harvest management, good agricultural practices including organic cultivation, phytochemical techniques, marketing issues and technology dissemination were covered in the lectures. Visits to herbal industry and processing centres were also organised during the training.

**Showcasing of Directorate's technology**

<table>
<thead>
<tr>
<th>Date</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>29th April-01st May, 2015</td>
<td><em>Krishi Mahotshav</em> 2015 at Lunawada, Gujarat</td>
</tr>
<tr>
<td>1st February, 2016</td>
<td><em>Kissan Sammelanat</em> KVK, Godhra, Gujarat</td>
</tr>
</tbody>
</table>
## Training imparted by the Directorate

<table>
<thead>
<tr>
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<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>14&lt;sup&gt;th&lt;/sup&gt; July to 3&lt;sup&gt;rd&lt;/sup&gt; August, 2015</td>
<td>ICAR sponsored Summer School on Advances in Medicinal and Aromatic Plants Research at ICAR-DMAPR</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; -10&lt;sup&gt;th&lt;/sup&gt; December, 2015</td>
<td>Model Training course on Value Addition and Post Harvest Management in Medicinal and Aromatic Crops at ICAR-DMAPR</td>
</tr>
<tr>
<td>20&lt;sup&gt;th&lt;/sup&gt; -22&lt;sup&gt;nd&lt;/sup&gt; January, 2016</td>
<td>Trainers’ Training programme on Conservation, Cultivation and Post Harvest Management of Medicinal and Aromatic Plants at ICAR-DMAPR</td>
</tr>
<tr>
<td>20&lt;sup&gt;th&lt;/sup&gt; -22&lt;sup&gt;nd&lt;/sup&gt; January, 2016</td>
<td>NMPB Sponsored Farmers’ Training programme on Conservation, Cultivation and Post Harvest Management of Medicinal and Aromatic Plants at ICAR-DMAPR</td>
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<tr>
<td>18&lt;sup&gt;th&lt;/sup&gt; February, 2016</td>
<td>One Day Training Programme on Scientific cultivation of Aromatic Plants in Gujarat for farmers at ICAR-DMAPR</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; March, 2016</td>
<td>One Day Training programme on Promotion of Medicinal Plants cultivation in Tribal Areas of Gujarat for Livelihood and Health Security at Petlad, Anand, Gujarat</td>
</tr>
<tr>
<td>15&lt;sup&gt;th&lt;/sup&gt; March, 2016</td>
<td>One Day Training Programme on Promotion of Medicinal Plants Cultivation in Tribal Areas of Gujarat for Livelihood and Health Security conducted at Zarva Village, Kambughoda, Panchmahal, Gujarat.</td>
</tr>
<tr>
<td>29&lt;sup&gt;th&lt;/sup&gt; March, 2016</td>
<td>Field Day on promotion of medicinal plants cultivation organized at Jadoli village of Dediapada Tehsil in Narmada district, Gujarat</td>
</tr>
</tbody>
</table>
**Other activities**

हिंदी चेतना सप्ताह

निदेशालय की राजभाषा कार्यान्वयन समिति के तत्वाधान में १५-२२ सितम्बर, २०१५ के दौरान हिंदी सपाह हरियाणा से मनाया गया, जिसके अन्तर्गत हिंदी के प्रयोग को बढ़ावा देने हेतु अनेक संगठन कार्यक्रमों का आयोजन किया गया। इस दौरान हिंदी निर्देश, पत्र लेखन, सामान्य हिंदी (हिंदी संबंधित ज्ञान हेतु), सामान्य ज्ञान, व्याख्यान व वाचार प्रतियोगिताओं आयोजित की गई।

कार्यक्रम के प्रारंभ में निदेशक व सत के समापति डॉ. जितेन्द्र कुमार ने मुख्य अतिथि को गुलवस्ता भेंट कर स्वागत किया, तत्पश्चात राजभाषा कार्यान्वयन समिति के सदस्य संचाले एवं हिंदी अधिकारी, डॉ. चंदना त्रिपाठी ने अपने स्वागतिक भाषण में मुख्य अतिथि महोदय का स्वागत करते हुए उनका लघु जीवन विचार समा के समक्ष प्रस्तुत किया। उन्होंने डॉ. एस. अरुणनाथ, साहित्य, कृषि अनुसंधान एवं शिक्षा विभाग तथा महानिदेशक, भारतीय कृषि अनुसंधान परिषद, नई दिल्ली की अर्पण भी समा के समक्ष प्रस्तुत की, जिसमें महानिदेशक महोदय ने सरकारी कामकाज में हिंदी का अधिक से अधिक प्रयोग करने का संक्षेप लेने का कहा। स्वागतिक भाषण में प्रश्न-उत्तर व द्वितीय से प्रतिभागियों को प्रश्न पत्र एवं प्रश्नावली पुस्तक मुख्य अतिथि महोदय के कर कमलों द्वारा प्रदान किये गए। पुस्तक प्रदान समारोह के उपाध्यक्ष मुख्य अतिथि महोदय ने हिंदी के प्रचार-प्रसार के संबंध में अपने विचार प्रकट किए। उन्होंने हिंदी के प्रति अपने रुझान के बारे में बताया व हिंदी के सरल शब्दों का प्रयोग को बढ़ावा देने के कहा, जिसमें सरकारी कामकाज करने में आसानी हो। निदेशालय के निदेशक तथा सत के समापति डॉ. जितेन्द्र कुमार ने हिंदी की महूर्त बनाने की बहस करते हुए निदेशालय के दैनिक कामकाज में हिंदी को अधिक बढ़ावा देने पर बल दिया।

हिंदी सहस्त्रता का समापन समाहरण २२ सितम्बर, २०१५ को मनाया गया। इस अवसर पर श्री आशोक कुमार श्रीवास्तव, उपमंडल अभियंता (माहेश्वर), भारत संघर्ष निगम लिमिटेड, आदि को मुख्य अतिथि के स्थल आयोजित किया गया। निदेशालय के निदेशक एवं राजभाषा कार्यान्वयन समिति के अध्यक्ष डॉ. जितेन्द्र कुमार ने समारोह समाहारण सत की आयोजण की।

समारोह का संचालन डॉ. जी. आर. रिमंत्रा द्वारा किया गया तथा समारोह का समापन डॉ. सतीश सिंह द्वारा ध्यानार्थ ज्ञापन से हुआ जिसमें उन्होंने आगामिक अतिथि, निदेशालय के निदेशक, हिंदी समिति सदस्यों, विभिन्न प्रतियोगिताओं के प्रतिभागी, कार्यक्रम में सहयोगीजों, सभी कर्मचारी जिन्हें प्रोक्ष व अप्रोक्ष रूप से अपने सहयोग दें कर इस कार्यक्रम को सफल बनाया, उन सबका आभार जताया किया।
हिन्दी कार्यांशाला

औद्योगिक एवं संगीतीय पालन अनुसंधान निदेशालय, आर्यनद में "सरकारी कामकाज में हिन्दी का आवश्यक प्रयोग" विषय पर 29 सितंबर, 2015 को हिन्दी कार्यांशाला का आयोजन किया गया। जिसमें हमारे निदेशालय सहित भारतीय कृषि अनुसंधान परिषद के गुरुमंत्र निष्ठा अय्य संस्थानों, श्रीरंजीव अनुसंधान केंद्र, कार्यालय के उद्घाटन सत्र में संस्थान की हिन्दी अधिकारी डॉ. बंदना जियानी ने सभी उपस्थित प्रतिभागियों का स्वागत किया। निदेशालय के निदेशक डॉ. जितेश कुमार ने मुख्य अधिकारी श्री दुर्गा सिंह, प्राथमिक पाठ्यक्रम, केंद्रीय विद्यालय, विद्यागार, आर्यनद के फूलों के गुलदस्ता द्वारा स्वागत किया। तत्पश्चात मुख्य अधिकारी महोदय ने अपने भाषण में कहा कि हिन्दी भाषा का लोकप्रियता देश में ही नहीं अपने विद्वेशन में भी कौन होने है। निदेशालय के निदेशक महोदय ने हिन्दी के प्रयोग पर चल देते हुए कहा कि हिन्दी कार्यांशाला या हिन्दी निदेश को केवल व्यवस्थापन की तरह नहीं लेना चाहिए। बल्कि संस्कृति कार्य में हिन्दी का प्रयोग बढाना चाहिए। हमें हिन्दी को वैभव का मायने में प्रयोग लाना चाहिए। जिससे कार्यालय के हिन्दी कामकाज में बढ़ुनाट पाएं। सभी अनुसंधान कार्य हिन्दी तथा स्थानीय मुद्दाओं के माध्यम से समाप्त किया जा सके। उद्घाटन सत्र के अंत में वैज्ञानिक, डॉ. रतना जी. आर. ने मुख्य अधिकारी महोदय को धन्यवाद सांपर्क किया।

केंद्रीय मुद्दा एवं जात संस्थान अनुसंधान एवं प्रशस्त संस्थान, वास्तव केंद्रीय बागवानी परीक्षण केंद्र, गोदाम केंद्रीय अनुसंधान केंद्र, केंद्रीय मौजूदा जीय पालन संस्थान, आर्यनद के लगभग 10 प्रतिभागियों ने भाषा लिखा। इस कार्यालय में डॉ. नवनीत चौहान, अध्यक्ष एवं प्रोफेसर (हिन्दी विभाग) सर्वर पटेल विश्वविद्यालय, विद्यागार, आर्यनद एवं डॉ. कनकलता, योजना समन्वय, केंद्रीय, वेंजलपुर, पंचमहल मुख्य वक्ता थे।

कार्यालय के प्रथम सत्र में मुख्य वक्ता डॉ. कनकलता ने हिन्दी के उपयोग में अवसाद होने के कारणों पर रैशनल दाती और उनके निवारण भी बताए। कार्यालय के दूसरे सत्र में मुख्य वक्ता डॉ. नवनीत चौहान, अध्यक्ष एवं प्रोफेसर (हिन्दी विभाग) सर्वर पटेल विश्वविद्यालय, विद्यागार, आर्यनद, गुजरात ने हिन्दी को भाषा को संपर्क खाता के रूप में परिभाषित करते हुए बताया कि भाषा हमेशा समाज के साथ जुड़कर चलती है। उन्होंने यह भी बताया कि भाषा जिन्हीं समय नहीं है उसकी लोकप्रियता उन्हीं ही बढ़ती है, इसलिए हमें हिन्दी को सहज और संस्कृत रूप में स्वीकार करना चाहिए। भोजन के पश्चात कार्यालय के तृतीय सत्र में बाद-प्रवाह प्रतिभागिता "स्वच्छता अभियान का प्रभाव" विषय पर अनेक प्रतिभागियों ने भाषा लिखा एवं पढ़- लिखा दोनों पर अपने विचार व्यक्त किए। समापन सत्र में निदेशक महोदय एवं दोनों मुख्य वक्ताओं द्वारा प्रतिभागिता में विजेता रहे प्रतिभागियों को पुरस्कृत किया गया। कार्यालय के अंत में निदेशालय के वैज्ञानिक, डॉ. तारिक सारा विद्या ने धन्यवाद जापन प्रस्तुत किया तथा राष्ट्रीय गान के साथ कार्यालय का समापन हुआ।
Brain storming meeting held

A brain storming meeting was held on April 07, 2015 at ICAR-DMAPR, Boriavi, Anand, Gujarat to discuss about the strategies to be taken for the progress of R&D in Medicinal and Aromatic Plants. Stalwarts participated in the meeting were Dr. A. Bandopadhyay, Formerly, National Coordinator, NFBSFARA, ICAR, New Delhi; Dr. M. Anandaraj, Director, ICAR- IISR, Calicut; Dr. Balraj Singh, Director, ICAR- NRCSS, Ajmer; Dr. Jitendra Kumar, Director, ICAR-DMAPR, Anand; Dr. Muraleedharan G. Nair, Senior Associate to the Dean, College of Agriculture and Natural Resources & Professor, Department of Horticulture, Michigan State University; Dr. Suresh Walia, Emeritus Scientist, Division of Agricultural Chemicals, IARI, New Delhi; Dr. Arun K Tripathi, Chief Scientist, CSIR- Central Institute of Medicinal and Aromatic Plants, Lucknow; Dr. Sharad Srivastava, Principal Scientist, Pharmacognosy & Ethno pharmacology Division, CSIR-National Botanical Research Institute, Lucknow; Dr. Vikram Trivedi, General Manager, Vasu Research Centre, Vadodara and Dr. M.S. Chandorkar, Zandu Foundation for Health Care, Valsad, Gujarat. Dr. Jitendra Kumar welcomed the dignitaries and presented an overview of the research activities and also the details of on-going research projects at ICAR-DMAPR. Thereafter, a presentation on “Predictions for nature to treat human diseases” was done by Dr. M. Nair. Dr. V. Trivedi highlighted the ongoing research and development activities at Vasu Research Centre. Importance of organic cultivation practices of medicinal plants for better quality was highlighted by both Dr. V. Trivedi and Dr. M.S. Chandorkar. Supply of quality planting materials and their finger printing was also emphasised by Dr. A. Bandopadhyay. Dr. S. Walia presented a detailed report on development of nutraceuticals from plants. An elaborated presentation on quality standards in Medicinal and Aromatic Crops was made by Dr. S. Srivastava. Dr. Anandaraj mentioned the importance of “omics” and traceability of products from source to supply and mentioned the utility of simulation studies in drug discovery. Dr. Balraj Singh, mentioned the importance of quality of medicinal and aromatic plants and showed his concern over cultivation on polluted soils and with contaminated water. In the post lunch session, an open interaction of experts with the ICAR-DMAPR scientists was held. The scientists of ICAR-DMAPR put forward their queries and discussed their future research plans with the experts. The meeting ended with a proposal of vote of thanks by the Director, ICAR-DMAPR to the dignitaries for
sparing their valuable time and suggesting the future path of research and development activities at the Directorate.

**Dr. S. Ayyappan, Secretary, DARE & Director General, ICAR visited ICAR-DMAPR**

Dr. S. Ayyappan, Secretary, DARE and Director General (DG), Indian Council of Agricultural Research, visited ICAR-Directorate of Medicinal and Aromatic Plants Research (ICAR-DMAPR), Anand, Gujarat on 8th July, 2015. Dr. S.B. Dandin, Formerly Vice Chancellor, University of Horticultural Sciences (UHS), Bagalkot and Chairman, Research Advisory Committee (RAC), ICAR-DMAPR, Anand accompanied the DG during his visit. Dr Jitendra Kumar, Director, ICAR-DMAPR welcomed the DG and other dignitaries and gave an overview of the Directorate. While interacting with the scientists, Dr. S. Ayyappan emphasized the role of secondary agriculture in the development of MAP sector in particular. He expressed the necessity of collaborative research for development activities in all aspects of MAP with the other stakeholders. He also advised to have databases on MAP and attract start-ups for the development and commercialization of high value compounds. The DG released Annual report of the Directorate and Extension bulletins on MAPs for the benefit of the farmers.

**Annual Group Meeting of AICRP-MAPB**

The XXIII annual group meeting of All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine (AICRP-MAPB) was held at the ICAR- DMAPR, Anand, Gujarat during 28th to 30th September, 2015. Dr. N. K. Krishna Kumar, Deputy Director General (Hort. Sci.), ICAR, New Delhi inaugurated the group meeting. Dr. N.C. Patel, Vice Chancellor, Anand Agricultural University, Anand was the Chief Guest and Dr. S.B. Dandin, Former Vice Chancellor, University of Horticultural Sciences, Bagalkot and Dr. M. Anandaraj, Director, ICAR-Indian Institute of Spices Research, Calicut were the Guests of honour. Other dignitaries present in the function were Dr. K.C.Dalal, former Director, NRCMAP; Dr. K.B. Kathiria, Director of Research, Anand Agricultural University, Anand and Dr. Jitendra Kumar, Director, ICAR-DMAPR and Project Co-Ordinator, AICRP on MAPB. Dr. P. Manivel, Principal Scientist, ICAR-DMAPR welcomed the guests. Dr. Jitendra Kumar, Project Co-ordinator, presented the project report and highlighted the actions taken for the implementation of the technical programme effectively. Dr. N.C. Patel, in his address emphasised that medicinal plants are directly related to human beings but the developments on this group of important crops were not given due care.
He suggested that exploration in the areas of Junagadh and Dang districts of Gujarat could be useful for identification of some high value medicinal shrubs. Dr. Krishna Kumar emphasised the need of understanding of chemistry behind blending of ingredients since the demand for cheaper medicine is increasing globally. He said that the focus of the AICRP-MAP&B should be “More factor of productivity in terms of active ingredients in medicinal and aromatic plants”. The formal function was concluded by the vote of thanks proposed by Dr. Satyanshu Kumar, Principal Scientist, ICAR-DMAPR.

During the 3-day discussions, research achievements and future technical programme of AICRP-MAP&B project were reviewed in different technical sessions such as Plant Genetic Resource Management, Crop Improvement, Crop production, Crop protection and Phytochemistry. An interaction meeting with the developmental agencies was also organized. The plenary session was held on 30th September, 2015 under the Chairmanship of Dr. T. Jankiram, Assistant Director General (Horticultural Science-I), ICAR, New Delhi and Dr. Jitendra Kumar, Project Coordinator, AICRP-MAP&B as the Co-Chairman. Salient research outcome, recommendations and future research programmes formulated through the three day deliberations were presented in the plenary session. At the end Dr. Satyanshu Kumar, Principal Scientist, ICAR-DMAPR proposed the vote of thanks.

**Panel discussion on Medicinal and Aromatic Plants Research: A way forward**

One-day panel discussion on “Medicinal and aromatic plants research: A way forward” was organized on 1st October, 2015 by the Medicinal and Aromatic Plants Association of India (MAPAI) in association with ICAR-DMAPR at Anand, Gujarat. Prof. Harish Padh, Vice Chancellor, Sardar Patel University, Vallabh Vidyanagar was the Chairman, Dr. S.B. Dandin, Liaison Officer, Bioversity International & Former Vice Chancellor, University of Horticultural Sciences (UHS), Bagalkot and Dr. Jitendra Kumar, President, MAPAI and Director, ICAR-DMAPR Co-chaired the sessions. Dr. Harish Padh, Chairman emphasized on need based research on conservation, cultivation, supply of quality raw material to the user industry, adulteration and substitution of MAPs and bio-fortification. Dr. S.B. Dandin highlighted the loss of biodiversity in MAPs and need for in situ and ex situ conservation through thematic gardens and large scale multiplication of genuine quality planting material. Dr. Jitendra Kumar in his speech emphasized on the isolation of bio-active compounds from various MAPs, their identification and product development to address today's life style diseases. Eight panellists who were experts from different fields of MAPs made their deliberations on different aspects of MAPs like biodiversity, conservation, plant genetic resources, crop diversification, breeding, good agricultural and collection practices, pest management, phyto-chemistry and medicinal plants in ayurveda system of medicine which was followed by interactive discussions from the delegates.
Workshop on Development of road map for agriculture in Gujarat plains and hills region

One-day workshop on “Development of Road map for Agriculture in Gujarat Plains and Hills region” was held at ICAR-DMAPR, Anand, Gujarat on 12th October, 2015. The workshop was inaugurated by Dr. A.K. Sikka, Deputy Director General (Natural Resources Management), ICAR, New Delhi in the presence of Dr. A.R. Pathak, Vice Chancellor, Junagadh Agricultural University, Junagadh; Dr. N.C. Patel, Vice Chancellor, Anand Agricultural University, Anand; Prof. M.C. Varshneya, Vice Chancellor, Kamadhenu University, Gandhinagar; Dr. Shiva Prasad Kimothi, Additional Director General (Coordination), ICAR; Dr. P.P. Rohilla, Director (Acting), ATARI Zone-VI and Dr. Jitendra Kumar, Director, ICAR-DMAPR, Anand. Dr. Jitendra Kumar, Director, in his welcome address emphasized need for integration of Medicinal and Aromatic plants (MAP) in farming systems especially in hilly/tribal areas of Gujarat. Dr. A.K. Sikka chaired the workshop and he emphasized the need for integration of solar and wind power generation system for efficient utilization of natural resources and convert city compost into effective organic manure. Nearly 30 farmers from various districts of the plains and hills region of Gujarat participated in the workshop and placed their specific problems and issues which need attention and solution. Directors and senior officials from ICAR Institutes in Gujarat; Director of Research and senior officials of Anand Agricultural University, Anand; Navsari Agricultural University, Navsari; Junagadh Agricultural University, Junagadh; Danthewada Agricultural University, Sardar Krushinagar; KVKs of Gujarat and Department of Agriculture, Gujarat participated in the workshop and provided their inputs for providing solutions to specific problems of the farmers in the region to develop road map. At the end Dr. R.S. Jat presented the vote of thanks.

Institute foundation day celebrated

ICAR-DMAPR celebrated its 24th foundation day on November 24, 2015. The inaugural session of this event was held at the Auditorium of ICAR-DMAPR. Dr. B. G. Patel, Provost (Vice Chancellor), Charotar University of Science and Technology (CHARUSAT), Changa, Anand was the Chief Guest. Ms. Anjali Pandya, Founder, Global Indian Business Council (GIBC), Ahmedabad was the Guest of Honor and Dr. Jitendra Kumar, Director, ICAR-DMAPR presided over the function. Important dignitaries, to name a few, Dr. K. B.
Katheria, Director of Research, Anand Agricultural University (AAU), Anand; Dr. K.P. Patel, Dean and Principal, BA college of Agriculture, AAU, Anand; Heads and professors of various departments from AAU, Anand and Sardar Patel University, Vallabh Vidyanagar; Heads of ICAR organizations located in Gujarat; scientists and staff of ICAR-DMAPR, Anand and the print and visual media were present on this occasion.

Stakeholders' meeting held

A stakeholders meeting was organized on November 24th, 2015 at the Directorate. In the meeting, discussion was held on identification of strategies for developing the MAP value chain through production, protection and processing technologies developed by the ICAR-DMAPR for the farmers through cooperation with the developmental agencies. The session was chaired by Dr. Jitendra Kumar. Dr. Satyanshu Kumar, Principal Scientist, ICAR-DMAPR briefed about the stakeholders meeting and opined that efforts are needed for sustainable and constant supply of medicinal plant from grower to industry. The multi-disciplinary team of scientists from ICAR-DMAPR, Anand actively participated in the stakeholders meeting. On this occasion near about 50 stakeholders in different section of Medicinal plants, from growers to end-users along with farmers from different adopted villages under MGMG scheme also participated.

Visit of Mr. C. Roul, Additional Secretary (DARE) & Secretary (ICAR)

Mr. Chhabilendra Roul, IAS, Additional Secretary, DARE, Ministry of Agriculture and Farmers' Welfare, Govt. of India & Secretary, ICAR, New Delhi visited ICAR-DMAPR, Anand on February 01, 2016. Mr. Roul visited the experimental fields of the Directorate and during his visit he keenly interacted with the scientists of the Directorate. An interaction meeting with the staff members was also organized after the field visit. Dr. Jitendra Kumar, Director, ICAR-DMAPR, presented an “An Overview of ICAR-DMAPR” during the interaction meeting. Shri Roul asked many detailed information about the activities those were presented by Dr. Kumar. Shri Roul specifically inquired about the implementation and progress of programmes such as ARYA, Tribal Sub Plan, Mera Gaon Mera Gaurav, etc. He categorically expressed the need of variety release of Medicinal and Aromatic plants for the benefit of stakeholders and formation of guidelines for minimum support price for MAP crops as well as marketing.

International Women's Day Celebration

ICAR-DMAPR celebrated International Women's Day (IWD) on 8th March, 2016. The function was organized by the Women's Committee, ICAR-DMAPR. The UN theme for the International Woman's Day for 2016 was "Planet 50-50 by 2030: Step It Up for Gender Equality". Another independent campaign, separate from the UN, put forward the theme for the year 2016 as “Pledge for Parity”. A formal function was organized in the auditorium of the directorate under the Chairmanship of Dr. Manivel, Director in
Charge, ICAR-DMAPR. The function started with welcome address by Dr. Smitha G.R., Scientist (Horticulture). Dr. Geetha K.A., Chairperson, in her lecture, reminded the audience about the empowerment of women for the well being of the society. Dr. P. Manivel in his presidential address appraised the audience about the role of women in different facets of life. The day was dedicated to the womanhood who are the strength behind a healthy society.

Memorandum of Understanding

A Memorandum of Understanding (MOU) was signed by the Directorate with an Ahmedabad based NGO, Global Indian Business Council on the foundation day of the Directorate. Under this MOU, an agreement was finalized for the promotion of cultivation of MAPs in Gujarat.

Transfer/promotion

- Dr. Vandana Tripathy was transferred on promotion as Senior Scientist (Pay band IV) to ICAR-IARI, New Delhi w.e.f. 03.12.2015
- Dr. R.S. Jat was transferred to ICAR-DRMR, Bharatpur w.e.f. 02.01.2016
- Dr. Thania Sara Varghese was transferred to JN-TBGRI, Palode consequent upon her selection as Scientist (C) w.e.f. 23.03.2016

New Joining

- Dr. Manish Kumar Mittal, Scientist (Economic Botany and Plant Genetic Resources) joined ICAR-DMAPR after NAARM training on 09.04.2015
- Dr. Prince Choyal, Scientist (Plant Physiology) joined ICAR-DMAPR after NAARM training on 09.04.2015
- Dr. P.L. Saran, Senior Scientist (Horticulture) joined ICAR-DMAPR on transfer from IARI RS, Pusa (Bihar) to ICAR-DMAPR on 21.04.2015
- Dr. K.A. Kalariya, Scientist (Plant Physiology) joined ICAR-DMAPR on transfer from ICAR-DGR, Junagadh on 27.04.2015

Distinguished Visitors during 2015-16

- Dr. V. A. Parthasarathy, Formerly Director, ICAR-IISR, Calicut on 25.5.2015
- Dr. M. Mahadevappa, Formerly Chairman, ASRB, New Delhi on 27.6.2015
- Dr. S. Ayyappan, Secretary (DARE) & DG (ICAR), New Delhi on 8.7.2015
- Dr. S. B. Dandin, Formerly Vice Chancellor, UHS, Bagalkot on 8.7.2015
- Dr. Alok K. Sikka, DDG (NRM), ICAR, New Delhi on 12.10.2015
- Dr. A.R. Pathak, Vice Chancellor, Junagadh Agricultural University, Junagadh on 12.10.2015
- Dr. N.C. Patel, Vice Chancellor, Anand Agricultural University, Anand on
12.10.2015

- Prof. M.C. Varshneya, Vice Chancellor, Kamadhenu University, Gandhinaga on 12.10.2015
- Dr. Shiva Prasad Kimothi, Assistant Director General (Coordination), ICAR, New Delhi on 12.10.2015
- Dr. P.P. Rohilla, Director (Acting), ATARI Zone-VI, Jodhpur on 12.10.2015
- Prof. A. K. Tripathi, Director, CSIR-CIMAP, Lucknow on 7.12.2015
- Sh. C. Roul, Addl. Secretary (DARE) & Secretary, ICAR, New Delhi on 1.2.2016
- Dr. Dhaval Patel, Collector, Anand on 13.4.2016

Deputations/meetings attended by the Director

- 11th National Symposium on Dynamics of Crop Protection: Challenges in Agri-horticultural Ecosystems Facing Climate Change at RCA, Udaipur during 23-25 April, 2015.
- To attend the meeting on Terminal Evaluation of GEF-Goi-UNDP project entitled 'Mainstreaming Conservation and Sustainable Use of Medicinal Plants Diversity in Three Indian States' at UNDP Office, New Delhi on 17th June, 2015.
- To evaluate GEE-Goi – UNDDP Project at Arunachal Pradesh and Assam during 18-23 June, 2015.
- Brainstorming Session on technology development in aromatic crops and aroma engineering on 3-4 July, 2015 at FFDC, Kannauj, UP to develop a well-focused network programme on technology development in aromatic crops and aroma engineering for possible financial support by DBT.
- To attend the Fourth meeting of the (First of the Reconstituted) Expert Committee on Medicinal Plants at National Biodiversity Authority (NBA) on 10th July, 2015 at Chennai.
- Brainstorming Session on Integration of medicinal and aromatic crop cultivation and Value-chain management for small farmers at NAAS, New Delhi on 18th August, 2015.
- Business meeting between the industry representatives and scientific community at ICAR – IISR, Calicut during 5-7 October, 2015
- Regional Consultation on “Agroforestry: The Way Forward” at NASC Complex during 8-10 October, 2015
- Attended a Meeting at Ministry of Environment & Forestry, New Delhi on 4th November, 2015
Mid-Term Review meeting of the ICAR Regional Committee at ICAR-CAZRI, Jodhpur on 07th November, 2015

Fifth meeting of the Expert committee on Medicinal Plants scheduled held on 26th November, 2015 at NBA, Chennai.

Fourth meeting of Ayurveda Selection Committee, FAD 26 at Manak Bhawan, New Delhi on 14th December, 2015.

Symposium on Spices, Medicinal and Aromatic Crops – SYMSAC-VIII at Tamil Nadu Agricultural University, Coimbatore during 16-18 December, 2015.

National Conference on Agrotechnology, Commerce and Sustainable Use of Medicinal and Aromatic Plants. NASC, New Delhi during 6-7 February, 2016.


National Seminar on “Dissemination of Agro-technology of important medicinal plants Developed through NMPB – Issues and Challenges” held at New Delhi on 28th February, 2016.

Brainstorming Session-cum-Stakeholders Meeting on Aroma Crops and Technologies for North East Region on 10-11 March, 2016 at Institute of Advanced Study in Science and Technology (IASST), Vigyan Path, Paschim Boragaon, Guwahati, Assam 781035.


TRAFFIC's consultative workshop on Medicinal and Aromatic Plants in India held at New Delhi on 29th March, 2016.

Awards and Recognitions

Dr. Jitendra Kumar was selected as NAAS Fellow, 2015

Dr. Jitendra Kumar was awarded Shree P. P. Singhal Memorial Award, 2015

Basak, B.B. was selected for Post Doctoral Research under Endeavour Research Fellowship programme sponsored by Dept. of Education, Govt of Australia at University of Newcastle, Callaghan, NSW 2308, Australia during 1st July to 31st December 2015
## Training and Capacity Building

### Training and Seminar/Symposium attended

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<tr>
<th>Name</th>
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<td><strong>Trainings</strong></td>
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<td>Dr. Vandana Tripathi</td>
<td>Training on ‘Advances in medicinal and aromatic plants research’ at ICAR-DMAPR, Anand</td>
<td>July 14-August 03, 2015</td>
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<td>Dr. Ajoy Saha</td>
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<td>July 14-August 03, 2015</td>
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<td>Dr. Hemlata Bharti</td>
<td>Training on ‘Plant Omics-emerging tools and techniques for crop improvement’ at ICAR-IARI, New Delhi</td>
<td>November 18-December 08, 2015</td>
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<td>Mr. Manish Mittal</td>
<td>DST training on ‘Role of scientist in natural resources and environment management’ at Indian Institute of Forest Management, Bhopal</td>
<td>February 08-12, 2016</td>
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<td>Dr. Satyanshu Kumar</td>
<td>Workshop on ‘Competency development for HRD Nodal Officers of ICAR’ at HRM Unit ICAR and ICAR-NAARM</td>
<td>February 10-12, 2016</td>
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<td>Dr. V. Thondaiman</td>
<td>Short course on ‘Exploitation of underutilized horticulture crops for sustainable production’ at ICAR-CHES, Godhra</td>
<td>February 11-02, 2016</td>
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<td><strong>Technical staff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. A.P. Trivedi</td>
<td>Training on ‘Advances in medicinal and aromatic plants research’ at ICAR-DMAPR, Anand</td>
<td>July 14-August 03, 2015</td>
</tr>
<tr>
<td>Mrs. Parul Purohit</td>
<td>Training on ‘Conservation cultivation and Post harvest management of Medicinal and aromatic plants’ at ICAR-DMAPR, Anand</td>
<td>January 20-22, 2016</td>
</tr>
<tr>
<td>Mr. R.B. Koli</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. B.K. Mishra</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. S.R. Patel</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. M.B. Vaghari</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. J.M. Padhiyar</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. K.R. Patel</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td><strong>Administrative Staff</strong></td>
<td></td>
<td></td>
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<tr>
<td>Mr. M.A. Hayat</td>
<td>Training on ‘MIS (FMS)’ at ICAR-IASRI, New Delhi</td>
<td>April 15-18, 2015</td>
</tr>
<tr>
<td>Mr. Vijay Kumar</td>
<td>MDP on ‘Public procurement’ at NIFM, Faridabad</td>
<td>February 01-06, 2016</td>
</tr>
<tr>
<td><strong>Skilled /Support Staff</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr. M.A. Saiyed</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Name</td>
<td>Details</td>
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<tr>
<td>Mr. J. S. Vasava</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. C. K. Vankar</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. D. M. Parmar</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. R. B. Bhoi</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. A. C. Bhoi</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. L. F. Talpada</td>
<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td>Mr. C. A. Vankar</td>
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</tr>
<tr>
<td>Mr. R. N. Parmar</td>
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<tr>
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<td>Training Programme for Technical and Skilled Supporting Staff at ICAR-DMAPR, Anand</td>
<td>March 17, 2016</td>
</tr>
<tr>
<td><strong>Seminar/Symposium</strong></td>
<td><strong>XXIV National Conference of Indian Virological Society on “Trans-boundary Viral Diseases Under One Health: Prospective and Challenges at Shillong</strong></td>
<td>October 08-10, 2015</td>
</tr>
<tr>
<td>Name</td>
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<tr>
<td>Mr. R. P. Meena</td>
<td>Workshop on ‘Application of technical terminology in higher education’ at JNVV, Jodhpur</td>
<td>March 27-28, 2016</td>
</tr>
<tr>
<td>Dr. Satyanshu Kumar</td>
<td>International Symposium on Medicinal Plants and Herbal Drugs in Human and Livestock Wealth A Global Prospective at P.G. &amp; Research Department of Botany, Pachaiyappa’s College, Chennai</td>
<td>January 29-31, 2016.</td>
</tr>
<tr>
<td>Dr. Raghuraj Singh</td>
<td>Making Engineering Scientists’ Contribution more Meaningful to Stake Holders and the Nation at NASC, New Delhi</td>
<td>April 13-14, 2015</td>
</tr>
</tbody>
</table>

**Scientists' attachment training provided to ICAR-ARS scientists at ICAR-DMAPR**

<table>
<thead>
<tr>
<th>Name of the Scientists</th>
<th>Institute</th>
<th>Area of research</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. Sivaranjani. R</td>
<td>ICAR-IISR, Kozhikode, Kerala</td>
<td>Plant Biochemistry</td>
<td>75 days</td>
</tr>
<tr>
<td>Dr. Azeze Seyie</td>
<td>ICAR-RC for NEH region, Umiam, Meghalaya</td>
<td>Spices, Plantation, Medicinal and Aromatic Plants</td>
<td>90 days</td>
</tr>
</tbody>
</table>
PUBLICATIONS

Research papers:

ICAR-DMAPR, Anand


**Book Chapter**

Basak, B. B., Sharmistha Pal and Debarati Bhadhuri. 2015. Soil microbial diversity and nutrient transformation as influenced by Introduction of transgenic plants. In: Advances in Plant Physiology Vol. 16 (Ed. A. Hementaranjan), pp 217-238. Scientific Publisher (India)

**Popular article/News, etc**


**Abstracts published/Paper presented in Seminar/Symposia, etc**

Basak, B. B. and Jat, R. S. 2016. Sustainable Collection and Cultivation of Medicinal


Dhanani, T., Sharma, R., Singh, R., Kumar, J. and Kumar, S. 2016. Supercritical fluid extraction technology for three medicinal plants, Kalmegh (Andrographis paniculata), Senna (Cassia angustifolia) and Ashwagandha (Withania somnifera). International Symposium on Medicinal Plants and Herbal Drugs in Human and Livestock Wealth A Global Prospective at P.G. & Research Department of Botany, Pachaiyappa's College, Chennai during January 29-31, 2016.


Jat, R.S. and Kumar, J. 2015. Good agricultural and collection practices of medicinal and aromatic plants for better quality and returns. In: Souvenir on Panel discussion on Medicinal and Aromatic Plants Research: A way Forward at DMAPR, Anand October 01,


Kumar, J. and Jat, R.S. 2015. Medicinal and aromatic plants for health and wellness. In: Souvenir of II World Noni Congress held at SRM University, Chennai, Tamil Nadu during 5-7 December 2015.


Makasana, J., Dholakiya, B. and Gajbhiye, N. A. 2016. LC-MS/MS analysis of bio-active compounds from Clitoria ternatea L. –used as a brain tonic. In: Souvenir and


Extension bulletin

Hindi Anuvad Sampadan:

- एलो प्रक्रियाएं कृषि बेहतर की (धृतकृमारी)
- ईसबगोल की बेहतर कृषि प्रक्रियाएं
- सनाब की बेहतर कृषि प्रक्रियाएं

AICRP MAP&B Centres

BCKV, Kalyani

Paper presented in seminar/ conferences

Mondal, G. 2015. The diseases of Kalmegh (Andrographis paniculata) recorded from West Bengal, India. Presented in the National Seminar on Sustainable Agriculture for Food Security and Better Environment organized by Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya held during 17-18th December, 2015 at Farmers Academy and Convention Centre (FACC), BCKV, Kalyani, Nadia.

Mondal, G. 2016. Occurrence of Synchytrium inducing gall on Kalmegh (Andrographis paniculata) from West Bengal, India. Presented in 6th International Conference on Plant, Pathogens and People with the mission Challenges in Plant Pathology to benefit humankind at NASC Complex, New Delhi organized by Indian Phytopathological Society, Division of Plant Pathology, IARI, New Delhi 110012, India during February 23-27, 2016. p.236
Mondal, G. 2016. Occurrence of Synchytrium inducing gall on punarnava (Boerhavia diffusa) from West Bengal, India. Presented in 6th International Conference on Plant, Pathogens and People with the mission Challenges in Plant Pathology to benefit humankind held at NASC Complex, New Delhi, organized by Indian Phytopathological Society, Division of Plant Pathology, IARI, New Delhi 110012, India during February 23-27, 2016. p.236.

NDUAT, Faizabad


KAU, Thrissur

Research papers:


**Paper presented in seminar/ conferences**


**BAU, Islampur**

**Book chapter**


**IGKV, Raipur**


JNKVV, Jabalpur


Vibha. 2015. Effect of Trichoderma enriched organic amendments and chemical fungicide on Cercospora leaf spot of Sarpagandha (Rouvollia serpentina). In: Proceedings of National Symposium on Recent Advances in Research and Development in Medicinal and Aromatic Plants-A country Scenario held at SFRI, Jabalpur (M.P) during from 27th -28th November, 2015. pp.75-76.


Technical Bulletin


UUHF, Bharsar


PERSONNEL

ICAR-DMAPR

Director
Dr. Jitendra Kumar

Scientific
Dr. P. Manivel, Principal Scientist (Plant Breeding)
Dr. Satyanshu Kumar, Principal Scientist (Organic Chemistry)
Dr. K. A. Geetha, Principal Scientist (Plant Breeding)
Dr. N. A. Gajbhiye, Senior Scientist (Organic Chemistry)
Dr. R. S. Jat, Senior Scientist (Agronomy) (up to 02.01.2016)
Dr. P. L. Saran, Senior Scientist (Horticulture)
Dr. Vandana Tripathy, Senior Scientist (Agricultural Chemicals) (up to 03.12.2015)
Dr. Smitha G.R., Scientist (Horticulture)
Dr. R. Nagaraja Reddy, Scientist (Plant Breeding)
Dr. Raghuraj Singh, Scientist (Farm Machinery and Power)
Dr. Biraj Bandhu Basak, Scientist (Soil Science)
Dr. K.A. Kalariya, Scientist (Plant Physiology) (from 27.04.2015)
Mr. R. P. Meena, Scientist (Plant Pathology)
Dr. Thania Sara Varghese, Scientist (Agricultural Entomology) (up to 23.03.2016)
Dr. Ajoy Saha, Scientist (Agril. Chemistry)
Dr. Thondaiman V. Scientist (Spice, Plantation & MAP)
Dr. Hemlata Bharti, Scientist (Spice, Plantation & MAP)
Smt. Rohini M.R., Scientist (Economic Botany & Plant Genetic Resources)
Mr. Akula Chinapolaiah, Scientist (Spices, Plantation & MAP)
Mr. Manish Mittal, Scientist (Economic Botany & Plant Genetic Resources) (from 09.04.2015)
Mr. Prince Choyal, Scientist (Plant Physiology) (from 09.04.2015)

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

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Mr. Vijay Kumar, Administrative Officer
Mr. Mangal Singh, Assistant Finance & Account Officer
Mr. Raghunadhan K., Assistant Administrative Officer
Mr. Suresh S. Patelia, Private Secretary to the Director
Mr. N. J. Ganatra, Assistant
Mrs. R. J. Vasava, Assistant
Mr. S. U. Vayas, UDC
Mr. V. P. Rohit, UDC
Mr. Raghuveer Prasad, LDC
Mr. Hayat Ashhar Mohammad, LDC

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Mr. J. S. Vasava, Skilled Supporting Staff
Mr. C. K. Vankar, Skilled Supporting Staff
Mr. D. M. Parmar, Skilled Supporting Staff
Mr. R. B. Bhoi, Skilled Supporting Staff
Mr. A. C. Bhoi, Skilled Supporting Staff
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Mr. R. N. Parmar, Skilled Supporting Staff
Mr. A. S. Bhoi, Skilled Supporting Staff
Mr. S. B. Bhoi, Skilled Supporting Staff

**AICRP on Medicinal & Aromatic Plants and Betelvine**

**Project Coordinating Cell Headquarter**
Dr. Jitendra Kumar, Project Coordinator

**AAU, Anand**
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Mr. B. V. Hirpara, Assistant Research Scientist (Agronomy)

**AAU, Jorhat**
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Dr. S.N. Das, Junior Scientist (Agronomy)

BAU, Ranchi
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Dr. Arun Kumar Tiwari, Assistant Professor (Horticulture)

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Dr. G. Mondal, Associate Professor (Plant Pathology)

CCSHAU, Hisar
Dr. V. K. Madan, Professor (Phytochemistry)
Dr. G. S. Dahiya, Associate Professor (Plant Breeder)

IGKV, Raipur
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Dr. Alice Tirkey, Assistant Professor (Plant Breeding)

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Dr. (Mrs.) Hima Bindu, Principal Scientist (Plant Breeding)

JNKVV, Jabalpur
Dr. Vibha, Associate Professor (Plant Pathology)
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Dr. B. Y. Pawar , Assistant Professor (Entomology)

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

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Dr. Sandeep Kumar, Assistant Professor (Plant Pathology)

PDKV, Akola
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Dr. Udit Kumar, Assistant Professor (Horticulture)

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Dr. H. Patidar, Professor (Plant Breeding)
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Dr. S. N. Mishra, Professor (Phytochemistry)
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TNAU, Coimbatore
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Dr. L. Nalina, Assistant Professor (Horticulture)

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a Human touch