About NRCMAP

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National Research Centre for Medicinal and Aromatic Plants
Boriavi, Anand – 387 310, Gujarat, India

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Published by : Dr. Satyabrata Maiti,
Project Coordinator
AICRP on Medicinal and Aromatic Plants &
Director, National Research Centre for
Medicinal and Aromatic Plants,
Boriavi, Anand 387310, Gujarat, India

Phone : 0091-268-78602
Fax : 0091-268-78601
E-mail : nrcmap@wilnetonline.net
Visit us : www.nrcmap.org

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Introduction

India with its varied agro-climatic conditions and topography has been considered as the botanical garden of the world. Our herbal wealth constitutes about 5000 species of known medicinal and aromatic plants. The increase in population, rapid expansion of the area under food and commercial crops, deforestation, extension of urban area, etc. are the cause for fast depletion of our herbal wealth. In the recent past plant based industries such as pharmaceutical, herbal medicines, perfumery, cosmetics and food flavour industries also expanded their production causing further pressure to this sector. Consequently many of the medicinal plants are on the verge of extinction because of over exploitation. In spite of the spectacular advancement in modern medicines, the present trend of "Back to the nature" and "Health for all in 21st century" has called for more and more natural and herbal products. This situation demands a systematic cultivation of these plants and collaboration with non-agricultural institutes at a much higher level than what has been envisaged till now.

Genesis

The Indian Council of Agricultural Research established National Research Centre for Medicinal & Aromatic Plants (NRCMAP) on November 24, 1992 in a 20.2 hectare irrigated land at Boriavi in Anand district of Gujarat. A sum of Rupees 2.5 crores was sanctioned for VIII Plan period. A total of 15 scientific personnel in addition to the Director were allotted to take up the research programme on medicinal and aromatic plants.

Location

NRCMAP, Boriavi, Anand is located in Ahmedabad-Bombay rail route. The centre is 7 km away from Anand Railway station on Anand-Ahmedabad state highway towards Nadiad. Anand is well connected to all parts of the country by road, rail and air. The nearby airports are at Vadodara (45 km) and Ahmedabad (65 km).

Research Mandates

- Develop appropriate production, protection and processing technologies for important medicinal and aromatic plants through basic, strategic and applied research.
- Germplasm enhancement of various medicinal and aromatic plants.
- Production of parental lines and breeder's stock.
- Act as a National Repository for the genetic resources of some important medicinal and aromatic plants.
- Coordinate research under the All India Coordinated Research Project on Medicinal & Aromatic Plants and Betelvine.
- Act as an Information Data Bank on medicinal and aromatic plants.
- Transfer of technologies developed by the NRCMAP to the farmers through cooperation with the developmental agencies.

Mandate Crops

1. Isabgol (*Plantago ovata*)
2. Senna (*Cassia angustifolia*)
3. Ashwagandha (*Withania somnifera*)
4. Liquorice (*Glycyrrhiza glabra*)
5. Guggal (*Commiphora wightii*)
6. Aloe (*Aloe barbadensis*)
7. Safed musli (*Chlorophytum borivilianum*)
8. Lemongrass (*Cymbopogon flexuosus*)
9. Palmarosa (*Cymbopogon martinii* var. Motia)

Objectives

- To identify plants which need attention of agricultural scientists and collect, maintain and evaluate the identified plants.
- To carry out those basic researches on the chosen crops, which are useful to develop their agro-technology.
- To coordinate the activities of the centres of the All India Co-ordinated Research Project on Medicinal & Aromatic Plants (AICRPMAP) located in various agro-climatic zones of India.
- To provide planting material and technical know-how generated for further testing and refinement by the centres of the co-ordinated project and NRCMAP.
- To develop partnership between this research centre and private sector, NGOs and Farmers' Associations/Progressive farmers interested in promoting the use of herbal medicines.

Outreach Programmes

The head quarters of the two All India Co-ordinated Research Projects such as All India Co-ordinated Research Project on Medicinal and Aromatic Plants (AICRPMAP) and All India Co-ordinated Research Project on Betelvine (AICRPB) are housed in the NRCMAP. The Director is also responsible for coordination and monitoring of research work in these two projects as Project Co-orinator in addition to his duties. There are nine centres in State Agricultural Universities (SAU) and two centres in ICAR institutes under AICRPMAP. Similarly eight centres in SAUs and one centre in Council of Scientific and Industrial Research (CSIR) set up are also participating under AICRPB.

Services Available

- Consultancy for cultivation of medicinal and aromatic plants
- Contract research on any aspects of medicinal and aromatic crops
- Contract services such as testing of chemicals/products, soil test, plant analysis, etc.

Facilities Available

NRCMAP is having good modern sophisticated instrumentation facilities as given below :

1. Gas Liquid Chromatograph (GLC)
2. High Performance Liquid Chromatograph (HPLC)
3. Leaf Area Meter
4. Photosynthesis System
5. Research Microscope with DIC & Photomicrographic Attachments
6. Spectrophotometer
7. High Speed Refrigerated Centrifuge
8. Plant Growth Chamber
9. Electrophoresis Apparatus
10. Seed Germinator
11. UV–Vis Spectrophotometer
12. Polarimeter
13. Freeze Microtome
14. Gel Documentation System
15. Deep Freezer
16. Dissection Microscope with Photomicrographic Attachment

Cadre Strength

NRCMAP

Sl. No.	Category	IX Plan Sanctioned		
		Plan	Non-Plan	Total
1	Scientific	11	3	14
2	Technical	6	7	13
3	Administrative	3	4	7
4	Supporting	9	1	10
	TOTAL	**29**	**15**	**44**

AICRP on Medicinal & Aromatic Plants

Sl. No.	Category	Sanctioned		
		Plan	Non-Plan	Total
1	Scientific	—	2	2
2	Technical	—	3	3
3	Administrative	—	1	1
4	Supporting	—	—	—
	TOTAL	**—**	**6**	**6**

AICRP on Betelvine

Sl. No.	Category	Sanctioned		
		Plan	Non-Plan	Total
1	Scientific	—	2	2
2	Technical	—	2	2
3	Administrative	—	2	2
4	Supporting	—	1	1
	TOTAL	**—**	**7**	**7**

Research Achievements

CROP IMPROVEMENT

Plant Genetic Resource (PGR) Management

Importance of PGR activities was recognised in the project and was taken up on priority at all the AICRP centres for exhaustive collection, evaluation, conservation and documentation of germplasm of medicinal and aromatic plants. This activity has also been included in the mandate of the on going National Agricultural Technology Project of Plant Biodiversity. Valuable genetic stocks of Aswagandha (48), Geranium (6), Isabgol (47), Khasi kateri (7), Long pepper (64), Liquorice (5), Periwinkle (8), Valeriana (40), Vetiver (37), Guggal (50), Henbane (14), Kacholam (12), Mucuna (44), Safed

musli (52), Aloe (72), Asparagus (9), Gentiana (12), Tinospora (12), Heracleum (10), Jasmine (109), Patchouli (7), Sylibum (10), Opium poppy (90) and Coleus (13) are maintained at various AICRP centres and NRCMAP. The evaluation and characterisation of these accessions are in continuous process.

Varietal Development

Multi-location evaluation trials conducted under the AICRPMAP have resulted in the identification and release of twenty five new improved varieties of medicinal plants of fourteen species and seven varieties of aromatic plants of six species.

List of Improved Varieties of Medicinal and Aromatic Plants

Medicinal Plants

CROP	VARIETY	DEVELOPED AT	YEAR OF RELEASE
Cassia angustifolia (Senna)	Anand Late Selection	Anand	1989
Dioscoria floribunda	FB(C)-1	Bangalore	1974
Dioscoria floribunda	Arka Upakar	Bangalore	1980
Digitalis lanata (Foxglove)	D.76	Solan	1991
Glaucium flavum (Yellow Horned Poppy)	H47-3	Solan	1991
Glycyrrhiza glabra (Liquorice)	Haryana Mulhatti-1	Hisar	1989
Hyoscyamus muticus (Egyptian Henbane)	HMI-80-1	Indore	—
Lepidium sativum (Cress)	GA-1	Anand	1998
Rauvolfia serpentina (Sarpagandha)	RI-1	Indore	—
Papaver somniferum (Opium Poppy)	Jawahar Aphim 16	Mandsaur	1984
Papaver somniferum (Opium Poppy)	Kirtiman	Faizabad	1990
Papaver somniferum (Opium Poppy)	Jawahar Opium 539	Mandsaur	1997
Papaver somniferum (Opium Poppy)	Jawahar Opium 540	Mandsaur	1998

CROP	VARIETY	DEVELOPED AT	YEAR OF RELEASE
Papaver somniferum (Opium Poppy)	Chetak Aphim	Udaipur	1994
Papaver somniferum (Opium Poppy)	Trisna	Delhi	—
Piper longum (Long Pepper)	Viswam	Trichur	1996
Plantago ovata (Isabgol)	Gujarat Isabgol- 1	Anand	1976
Plantago ovata (Isabgol)	Gujarat Isabgol-2	Anand	1983
Plantago ovata (Isabgol)	Haryana Isabgol-5	Hisar	1989
Plantago ovata (Isabgol)	Jawahar Isabgol-4	Mandsaur	1996
Solanum laciniatum	NH 88-12	Solan	1991
Solanum viarum (Khasi Kateri)	Arka Sanjeevani	Bangalore	1989
Solanum viarum (Khasi Kateri)	Arka Mahima	Bangalore	1992
Withania somnifera (Aswagandha)	Jawahar Asgand-20	Mandsaur	1989
Withania somnifera (Aswagandha)	Jawahar Asgand-134	Mandsaur	1998

Aromatic Plants

CROP	VARIETY	DEVELOPED AT	YEAR OF RELEASE
Cymbopogon flexuosus (Lemon Grass)	NLG-84	Faizabad	1994
C. martinii Var. Motia (Palmarosa)	Rosha Grass-49	Hisar	1989
C. martinii Var. Motia (Palmarosa)	CI-80-68	Indore	—
Jasminum grandiflorum (Jasmine)	Arka Surabhi	Bangalore	1993
Mentha spicata (Spearmint)	Punjab Spearmint-1	Solan	1991
Valeriana jatamansi (Mushakbala)	Dalhousi Clone	Solan	1994
Vetiveria zizanioides (Vetiver)	Hyb-8	Delhi	—

CROP PRODUCTION

Isabgol (*Plantago ovata* Forsk.): The crop requires cool and dry climate during the growing season. Sowing of seeds at 4 kg/ha in 0.25-0.50 cm depth during November 20 to December 20 was recommended. In medium black cotton soil of Malwa region, second week of November was reported to be optimum time for sowing. Broadcasting of seeds followed by light sweeping with broom found to give uniform germination. A spacing of 30x45 cm found to be most ideal to get higher seed yield in Isabgol under Madhya Pradesh situation. Response to chemical fertilizers was found low. However, a fertilizer dose of 25 kg/ha each of N and P_2O_5 as basal dose and 25 kg/ha N as top dressing at 30-42 DAS was recommended for commercial cultivation in Gujarat while 50 kg/ ha N reported to increase the seed yield in Mandsaur areas of Madhya Pradesh. At Anand, three irrigations viz. first at the time of sowing and subsequently at 30-40 and 70-80 days after sowing (DAS) proved to be beneficial. However, four irrigations at sowing, 10, 25 and 50 DAS at Mandsaur are recommended. Chemical weed control was found to be economical and a pre-sowing or pre-emergence application of Isoproturon (0.5 kg ai/ha) was recommended for weed control. One spray of Metalaxyl + two sprays of Mancozeb were found significantly superior in controlling downy mildew. In Gujarat, Pearl millet in Kharif and Isabgol in Rabi season are advocated as a suitable crop rotation. Groundnut-Isabgol rotation gave higher economic return followed by Soybean-Isabgol and Pigeon pea-Isabgol rotations in Maharashtra.

Senna (*Cassia angustifolia* Vahl): The crop prefers sandy loam to laterite soils. However, it is grown in marginal and sub marginal lands also with 7.0-8.5 pH range. The crop is sensitive to water-logging condition, therefore, requires well drained soil. Sowing time recommended for rainfed crop in Western India is June-July. Line sowing at 45 x 30 cm gives higher yield under irrigated condition. About 70-75 thousand/ha plant population is recommended for

optimum yield. Application of FYM at 10 t/ha as basal and 60 kg/ha N in 3 split doses are recommended for better yield. Two hand weedings followed by hoeings at 25-30 and 50 DAS are essential. Harvesting is recommended in dry season to avoid spoilage of leaves due to fungal infection during storage. A well managed irrigated Senna crop yielded about 15-20 q/ha dry leaves and 7-10 q/ha dry pods. Whereas, a rainfed crop recorded on an average about 10 q/ha of dry leaves and 4-5 q /ha dry pods. Sun drying of leaves and pods is advisable. Crop rotations such as Senna-Mustard and Senna-Coriander were found profitable.

Periwinkle (*Catharanthus roseus* (Linn.) G. Don.): Tropical and subtropical climates are found most suitable for its cultivation. However, water logged or highly alkaline soils may be avoided. A plant population of 75,000/ha is recommended to get higher yield. Nutrient dose of 15 t/ha FYM + 80 kg N/ha under irrigated and 15t/ha FYM + 40 kg N/ha under rainfed conditions were recommended. Detopping of plants by 2 cm at 50% flowering improves the root yield and alkaloid content. Pre-emergence application of Fluchoralin 0.75 kg ai/ha was found to be very effective as weed control. The crop requires 4-5 irrigations. Inter-

High perfomance liquid chromatograph for analytical work

Mandate Crops

A . Senna
B . Isabgol
C . Aloe
D . Safed musli
E . Ashwagandha
F . Liquorice
G . Guggal
H . Palmarosa
I . Lemon grass

Sophisticated research microscope

cropping with groundnut in 1:1 ratio was found to give highest monetary benefit. This crop is not suitable as inter-crop under shade condition because plant growth, root yield and alkaloid contents were observed to reduce under such condition. On an average, 1.8 t/ha dried leaves and 0.8 t/ha dried roots are harvested.

Safed musli (*Chlorophytum* spp. Ker.): The crop is grown in Kharif season in places having warm and humid climatic conditions and adequate soil moisture throughout the crop growth. Optimum time for its planting is middle of June under irrigated condition and onset of monsoon for rainfed condition. Fleshy roots at 2.5 - 3.0 q/ha are planted in ridges at 30 cm row to row and 15 cm plant to plant distance. High density planting of 3.33 lakh/ha to 4.4 lakh/ha plant population was found the best in increasing root yield. Application of 20-45 t/ha FYM showed significant yield increase. Fresh root yield 10 q/ha was recorded in experimental field. Removal of inflorescence (detopping) improved the bulking of fleshy roots and increased root yield significantly. Separation of Safed musli fleshy roots in the month of April reduced the fleshy root damage as compared to March and February. Sprouting percentage and storability were also increased when separated with a major portion

of stem disc. Paired fleshy roots used for planting recorded high degree of sprouting and survival in comparison to single root planting.

Liquorice (*Glycyrrhiza glabra* Linn.): The performance of liquorice was tested at Hisar condition. It grows well in rich fertile sandy loam soil ranging between acidic and slight alkaline soils having pH 5.5-8.2. Best time for planting is in middle of November with a spacing of 90x45 cm. Underground stem cuttings of 15-25 cm having 2-3 buds are most suitable for planting. However, treatment of root cuttings with seradix-B enhances sprouting. At the time of soil preparation, 10 t/ha FYM and 40 kg/ha each of N and P_2O_5 are added as basal dose. Thereafter, 20 kg/ha N as top dressing per year is recommended. The crop is harvested after 2 to 3 years. Root yield of 70-80 q/ha was recorded at Hisar.

Opium poppy (*Papaver somniferum* Linn.): The optimum time for sowing is first fortnight of November. Delay in sowing causes poor growth. A seed rate of 6-7 kg /ha is recommended in case of broadcasting and 5-6 kg /ha for line sowing. Line sown crop yielded more latex/ha than broadcasting. Seed inoculation with *Azotobacter*

Measurement of photosynthesis rate using Phtosynthesis System

ARIS Cell

culture (M-4/W-5) reduces the nitrogen requirement up to 40 kg/ha. A fertilizers dose of 90 kg/ha N, 50 kg /ha P_2O_5 and 40 kg /ha K_2O was reported to maximise the latex and seed yield. However, N, P and K at 150:75:45 kg/ha was recommended for higher seed, husk and latex yield and morphine content of opium poppy at Mandsaur. For weed control, an integrated approach with Isoproturon (0.37 kg a.i./ha + hand weeding at 30 DAS) showed very good control without any phyto-toxic effects. Ten to fourteen light irrigations are required in sandy soils at an interval of 10 days. Lancing is usually started on developing capsules about 15 days of flowering. Maximum latex yield is harvested in first lancing which decreases at subsequent lancings. Early morning is the best time for collection of latex. Latex yield ranges between 35 and 55 kg/ha and seed yield 8 and 12 kg/ha. Crop rotations: Maize-Opium poppy; Urd- Opium poppy and Groundnut-Opium poppy are profitable. Inter cropping with Garlic gave higher profit compared to sole crop without affecting the latex yield.

Rauvolfia (*Rauvolfia serpentina* Beth. ex Kurz): Frost free tropical to subtropical humid climate with irrigation facilities are found to be the most suitable for its cultivation. Root and stem cuttings

have been recommended for vegetative propagation. For transplanting, nursery is raised in the end of April. A fertilizer dose of 30 kg/ha N and 60 kg/ha P_2O_5 was found to increase the total alkaloid yield. Water requirement is very high in this crop, about 15-16 irrigations are required to get good crop. Inter cropping of Soybean (1:1) in *kharif* and Garlic (1:3) in *rabi* were reported to be the most suitable crop combinations.

Foxglove (*Digitalis purpurea* Linn. *and D. lanta* Ehrh): The crop requires 20-30°C temperature for seed germination and subsequent plant growth. Well drained loam to clay loam soils rich in organic matter are suitable for the crop. However, requirement of soil pH for higher yield of glycoside differs from species to species. It was reported that *Digitalis purpurea* thrives well in acid soil whereas *D. lanata* in neutral soil. Most suitable time for transplanting of seedlings is in April. Transplanting of seedlings at 45x30 cm proved to be better. Nitrogen requirement of foxglove is high. A fertilizers dose of 100 kg/ha N, 50 kg/ha P_2O_5 and 25 kg/ha K_2O along with 30-40 t/ha FYM was found to be optimum for good crop. Five to six weedings followed by hoeings increased the foliage yield. Three to four irrigations are needed during April to June. One harvesting in first year at rosette stage and three harvestings in second year starting from August were recommended. However, harvest comes in the month of February-March contains almost double the glycoside than in August cutting. About 28 q/ha dry leaf yield is harvested. Sun drying of leaves at 30-40°C is recommended to maintain quality.

Aswagandha (*Withania somnifera* Dunal): It prefers well drained sandy-loam to red soil having pH 7.5-8.0. The crop is sown in late *kharif* in 2nd or 3rd week of August. On an average, 60 to 75 cm rainfall is best suited for rainfed crop. Broadcasting is practised by the farmers with high seed rate of 20-25 kg/ha. However, line sowing at 25 cm in rows facilitates better inter-culture practices. One weeding and thinning at 25-30 days after sowing

found to be sufficient in sub-marginal lands. Multi-location trials showed that Isoproturon at 0.5 kg/ha, Glyphosate at 1.50 kg ai/ha and Trifluralin (48% EC) @ 4 l ai/ha were found effective in controlling weeds and increasing root yield. Raised bed condition has been reported to yield higher quantity of root. Root size, root and shoot biomass and alkaloid content were found maximum in 180 DAS which should be considered as harvesting time. The whole plant is uprooted and roots are separated. About 3-4 q/ha dry root and 50-75 kg /ha seeds are harvested .

Khasi Kateri (*Solanum viarum* Dunal): The crop is grown in various agroclimatic and soil types in India. However, commercial cultivation is confined to the Peninsular India and Diphu hills of Assam. Seeds are sown in nursery bed for raising seedlings for transplanting. Forty five days old seedlings having 4-6 leaves give high success after transplanting. Although higher yield of dry berries and solasodine per hectare were obtained in close spacing (45x60 cm), a spacing of 90x150 cm is recommended to avoid difficulties in inter-culture and harvesting operations due to spiny stems. However, a less spiny variety, Arka Sanjeevini recorded higher berry yield per hectare under high density planting (10,989 - 13,889/ha). The variety showed about three fold increase in dry berry and solasodine yield. Top dressing of N delayed flowering whereas combination of N and CCC initiated early flowering. Application of 250 ppm GA_3 increases solasodine content in diploid and 250 and 1000 ppm in tetraploid. Further, foliar spraying with CCC at 1600 ppm was reported to increase solasodine content significantly. Turning yellow stage was found to be the most ideal for berry harvesting. Berry yield varies from 3.0-14.0 t/ha depending upon variety and soil status.

Long pepper (*Piper longum* Linn.): Hot humid climate with 20-25% partial shade is ideal for its cultivation. The performance of Long pepper was superior under partial shade of Cassava under Kerala condition. Well drained and nutrient rich soil is recommended. Three to five-node rooted vine cuttings give cent percent field

establishment. The best time for raising nursery is during March to April. Long pepper responded to summer irrigation. Integrated water management strategy involving the application of irrigation water through the sprinkler system at IW/CPE ratio of one in combination with incorporation of coir pith for soil moisture conservation was found to enhance the annual spike yield in long pepper. High density planting at 30 x 30 cm combined with the organic farming technique, mulching and application of vermicompost resulted in higher spike yield under irrigated condition. Harvesting is done eight months after planting and 3-4 pickings are usually done in a year. About 400 kg/ha dried spikes in first year and 1000 kg/ha in second and third years are harvested. Harvested spikes are dried in sun for 4-5 days. Dried spikes are stored in moist proof containers. Besides spike, thicker stem and roots are cut and dried and used in Ayurvedic drug preparations. About 500 kg/ha roots are harvested.

Henbane (*Hyoscyamus niger* Linn.): North western hilly tracts are most suitable for this crop. About 2-3 kg/ha seeds are recommended. Seeds are sown in first week of October and 4-5 weeks old seedlings are transplanted in a spacing of 35 x 15 cm. A fertilizer dose of 80 kg/ha N, 40 kg/ha K_2O and 15-20 t/ha FYM was recommended for optimum crop yield. Two-three weedings and 5-7 irrigations are needed. Crop rotations such as Senna - Henbane and Basil - Henbane were reported to be most profitable. The crop is harvested at 125 to 145 DAS. The older leaves at the base of the plant touching the ground are picked up first which is followed by picking of leaves from the upper portion of twigs and branches at 50% flowering. The bio-mass is thereafter thoroughly sun dried. This procedure of harvesting is quite economical and fetches higher market rate.

Palmarosa (*Cymbopogon martinii* Stapf. var. Motia): It is a crop of warm tropical climate. Sowing time for raising nursery is end of April to mid of May. Transplanting is done in the last week of June to mid August at 45x30 or 60x60 cm spacing, depending upon soil fertility and climatic condition. Optimum dose of fertilizer was 75 kg/ha N and

40 kg/ha each of P_2O_5 and K_2O to get higher herbage and oil yield. Recently an integrated nutrient management trial was conducted in Palmarosa. It was found that FYM @ 10 t/ha, N&P @ 20 kg/ha each and *Azospirillum* or *Azotobacter* favoured higher productivity and oil yield. Frequent light irrigations are required during rain free period. Inflorescence is ready to harvest at 7-10 days after opening of flowers. Crop is harvested 10-15 cm above the ground level. First year 2-3 harvests and in subsequent years 3-4 harvests are taken. On an average 80 kg/ha oil yield from rainfed crop and upto 220 -250 kg/ha oil yield from irrigated crop were achieved from the second year.

Vetiver (*Vetiveria zizanioides* (Linn.) Nash): As a commercial crop, vetiver flourishes over rich sandy-loam soils having 6-8 pH under warm and humid weather conditions. Earthing up operation increases the root yield. Irrigation at 0.4 IW/CPE ratio showed maximum root yield (14.2 q/ha). However, 8 irrigations are required within 15 months. A fertilizers dose of 80 kg N and 30 kg each of P_2O_5 and K_2O per ha increases the root yield without affecting the oil quality. Combined application of farm yard manure @10 t/ha, N,P @37.5 & 20 kg/ha, respectively and *Azospirillum* or *Azotobacter* enhanced oil yield. Cowpea, Clusterbean and Black gram as intercrops added the income of the cropping system. Best time for harvesting of roots is 15 months after planting.

Mints (*Mentha* spp Linn.): The crop prefers well drained soil rich in organic matter and 6.0-7.5 pH. This group of plants need very high amount of nutrients particularly nitrogen. Application of FYM at 25-30 t/ha at land preparation, 30 kg/ha N and 40-60 kg/ha each of P_2O_5 and K_2O as basal dose followed by 75 kg/ha N at 40 days after sprouting and 75 kg/ha N after first harvest is recommended. Application of 120 kg N/ha and harvesting of spearmint shoots in June showed maximum herbage and oil yield. Zinc deficiency is common in Indo-gangetic plains. The crop response was maximum at 20 kg/ha of Zn application at planting. Iron and Boron deficiencies were also reported. Two to three weedings and hoeings are essential in mint

farming. Pre-emergence Terbacil (2.0 kg a.i./ha) application found to be effective in controlling of weeds. Six to nine irrigations are required during dry seasons. First crop is harvested at 105-110 DAS and subsequent harvest takes about 90 days thereafter. On an average 30 t/ha of herbage yield in Japanese mint and 20-25 t/ha of Bergamot mint are harvested which yield about 150 and 100 kg/ha oil, respectively.

Babchi (*Psoralea corylifolia* Linn.): Maximum seed yield was obtained when 40 kg N, 20 kg P_2O_5 per ha were applied at 30x30 cm spacing. Psoraline content was also found high in this treatment. Application of 500-750 ppm Maleic Hydrazide increased seed yield significantly when applied either at 30 DAS or 30 and 45 DAS.

Kalmegh (*Andrographis paniculata* Nees): Optimum transplanting and harvesting time for high herbage yield was obtained in 16th July transplanting and 16th November harvesting at Anand and Indore; 1st July transplanting and 16th November harvesting at Akola and Udaipur and 1st July transplanting and 1st November harvesting at Faizabad.

Lavender (*Lavendula officinalis* Chaix.): Sowing of lavender seeds during February and harvesting of the flowers for oil extraction at 50% flower initiation stage proved beneficial to get higher oil yield (32.41 kg/ha). The optimum spacing in lavender was found to be 45x60 cm for higher foliage yield.

Melisa (*Melissa officinalis* Linn.): Fresh herbage yield (141.4 q/ha) and oil recovery (29.60 kg/ha) were found to be maximum with GA_3 application at 200 ppm concentration.

Salvia (*Salvia Sclarea* Linn.): Transplanting of Salvia in February and application of 90 + 30 + 30 kg/ha NPK recorded highest oil yield of 35.24 kg/ha.

CROP PROTECTION

Limited work on disease and insect pest management was taken up in the project. However, recommendations for management of important diseases and insect pests are as follows:

Medicinal Crops

Crop	Disease	Etiology	Findings & Recommendations
Opium poppy (*Papaver somniferum*)	Downy mildew	*Peronospora arborescens*	Seed treatment with metalaxyl and four sprays of metalaxyl @ 0.2 % at 35, 55, 75 and 95 days after sowing found most effective in reducing primary and secondary disease incidence. It also increased latex yield (26.7%) and seed yield (24.7%) over control. Jawahar Opium poppy–540 having some resistance against the disease has been recommended for M.P.
Senna (*Cassia angustifolia*)	Leaf spot	*Alternaria alternata*	Spraying of Bordeaux mixture, benomyl, captafol and copper oxy-chloride is recommended.
Isabgol (*Plantago ovata*)	Downy mildew	*Peronospora alta P. plantaginis Pseudoperonosp-ora plantaginis*	Seed treatment with metalaxyl at 4g/kg seed and 3 sprays of metalaxyl (0.2%) at 15 days interval starting from first appearance is best for disease control. December sown crops are mostly disease free.
Sarpagandha (*Rauvolfia serpentina*)	Leaf blight Bud rot	*Alternaria tenuis*	Spraying of maneb (0.3%) or rovaral (0.2%). Seed treatment with contact fungicides.
Liquorice (*Glycyrrhiza glabra*)	Leaf spot	*Cercospora cavarae*	Maneb or zineb spray at 0.2%
Long pepper (*Piper longum*)	Leaf spot & rotting	*Colletotrichum & Cercospora* spp.	Spraying of Bordeaux mixture, one during May and 2-3 sprays during rainy season.
Khasi kateri (*Solanum vianum*)	Wilt	*Fusarium oxysporum*	Direct sowing of seeds instead of transplanting of seedlings can reduce the disease incidence.

Aromatic Crops

Palmarosa & Lemongrass (*Cymbopogon* spp.)	Red leaf spot	*Colletotrichum graminicola*	Two sprays of carbendazim (0.1%) or 3 sprays of maneb (0.3%) starting from first appearance of disease at 20 days or 10-12 days intervals, respectively.
Rosa (*Rosa damascena*)	Die back	*Diplodia rosarum*	Pruned ends of the shoots should be treated with copper fungicides.
Ambrette seeds (*Abelmoschus moschatus*)	Anthracnose	*Colletotrichum hibiscicum*	Seed treatment with contact fungicides and spray of Bordeaux mixture are recommended.

Future Research Thrust

Crop Improvement

- ❑ Enhancement of germplasm
- ❑ Breeding for high yield
- ❑ Breeding for quality
- ❑ Breeding for disease-pest resistance

Crop Production

- ❑ Development of package of practices for organic farming
- ❑ Water and nutrient management
- ❑ Multi-tier cropping system
- ❑ Cropping sequence

Crop Protection

- ❑ Development of IPM technology
- ❑ Disease-pest forecasting

Quality Assessment

- ❑ Development of new and fast techniques for quality assessment
- ❑ Monitoring of quality of raw material
- ❑ Fixing standards for raw material

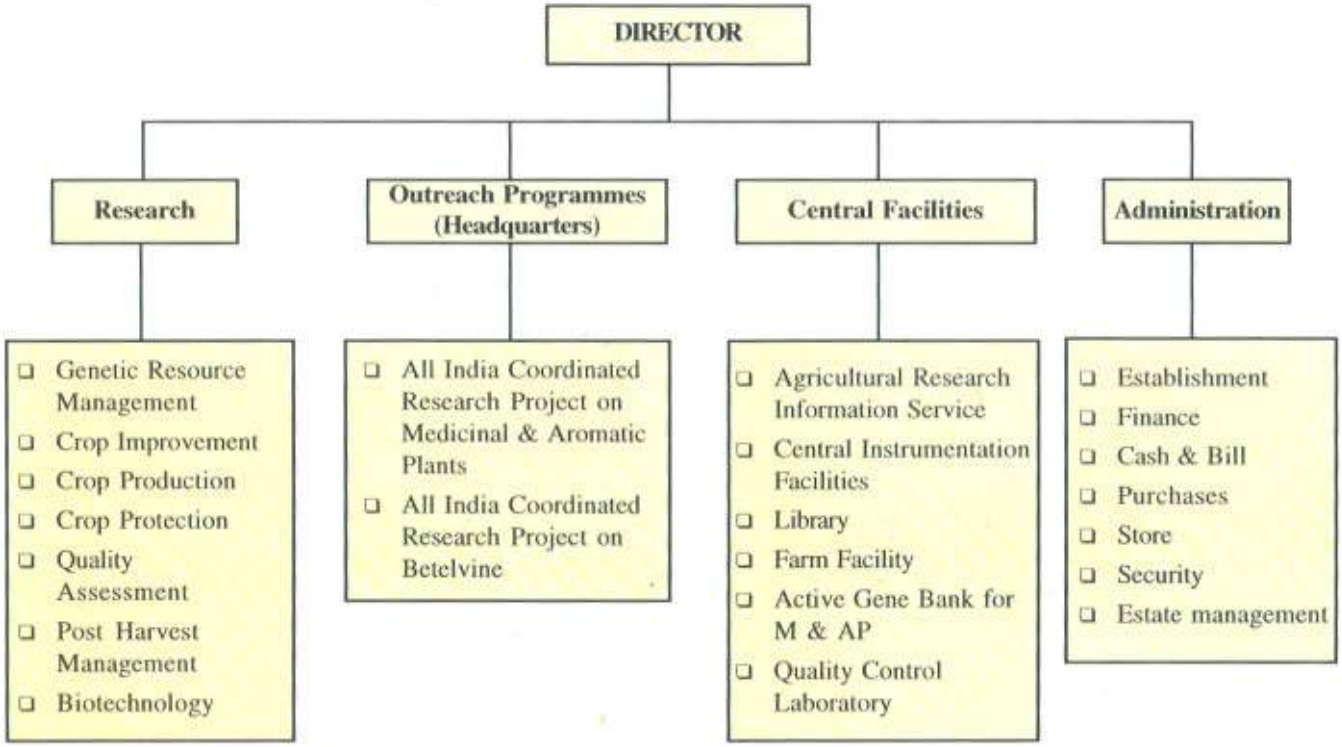
Post Harvest Management

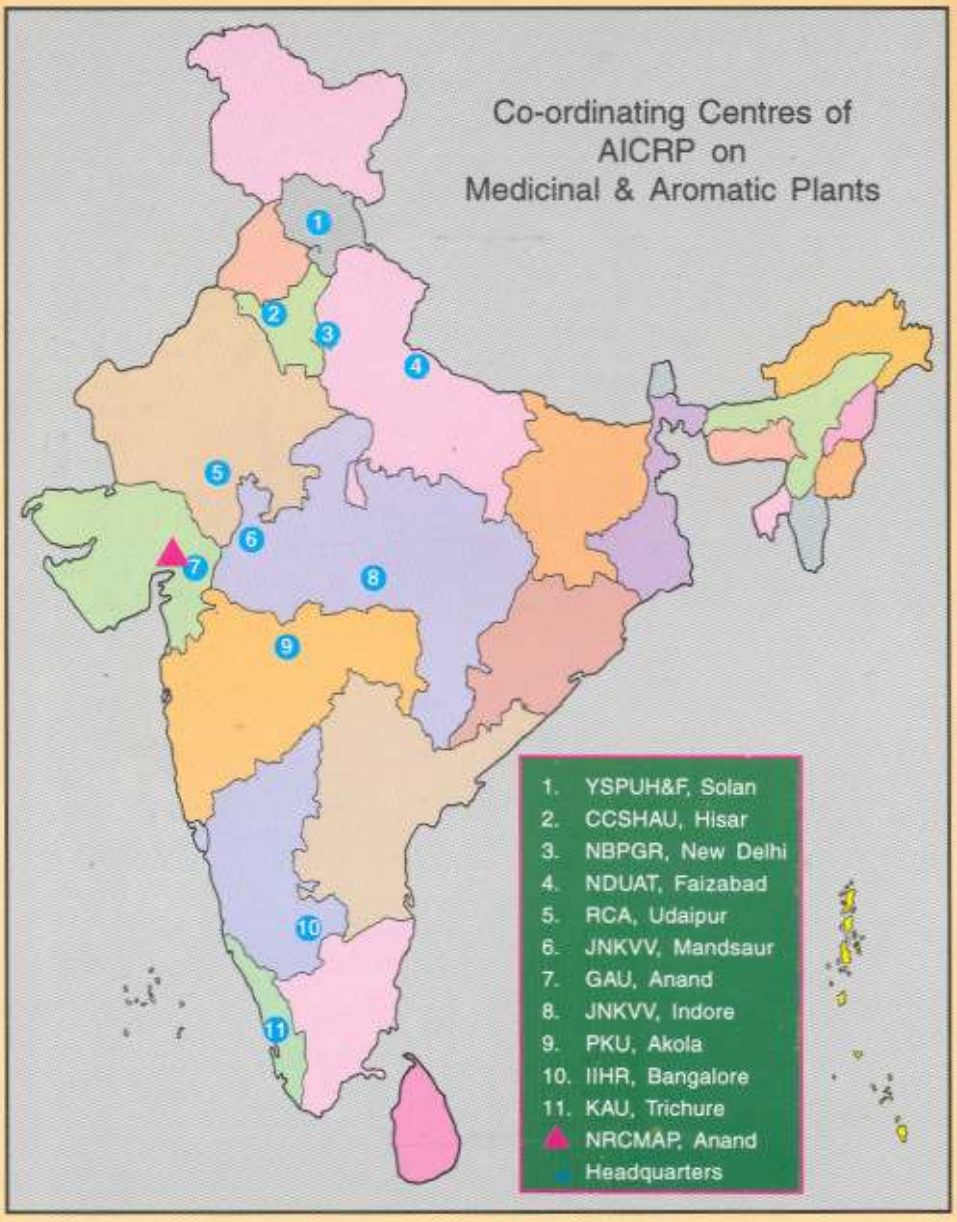
- ❑ Development of efficient drying system
- ❑ Development of storage technology for reducing post harvest losses

Biotechnology

- ❑ Application of Molecular techniques in medicinal and aromatic plants.

Organisational Structure





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