2.6 Non-Wood Forest Products

2.6.1 Overview

Role of Non-Wood Forests Products (NWFPs) as a source of income and livelihood for the large population of our country, depending on forests resources is indispensible. People in rural areas get self employment through the collection of NWFPs. More than half of the employment generated in the forestry sector till date in our country, is through NWFPs.

Although NWFPs are a renewable resource, their continuous harvest may deplete these natural resources thereby affecting biodiversity as well as threatening the livelihood of forests depended communities. Sustainable forest management practices only can ensure effective conservation of NWFP resources and address the need of forest dependent communities vis-a-vis augmenting their livelihood. Accordingly, ICFRE institutes have undertaken extensive researches on various aspects that include resource development of medicinal plants and NWFPs, conservation technologies, sustainable harvesting regimes, value addition, natural gums, bio-prospecting, cultivation technologies, plantation techniques, and documenting the traditional knowledge of indigenous people besides exploring the bamboo, bio-fuel and bio-energy prospects of Indian forests.

Project under the Theme			
Projects	**Completed Projects**	**Ongoing Projects**	**New Projects Initiated During the Year**
Plan	13	24	16
Externally Aided	07	12	03
Total	**20**	**36**	**19**

2.6.2. Resource Development of NWFPs

Development of Nursery Technique of Fibre Yielding Himalayan Nettle

The nursery technique of fibre yielding Himalayan Nettle *(Gerardina heterophylla)* was developed by conducting different trials of seed germination and vegetative propagation in natural habitat area Chakrata (6000ft above m.s.l.) and at FRI, Dehradun. The extension activities on nursery and cultivation of nettle was also carried out with Uttarakhand State Forest department.

Nettle Seedlings in Chakrata NWFP Nursery

Nettle Seedlings in FRI- NWFP Nursery

Standardization of Drying and Storage Protocol and Quality Assessment of Selected Commercially Cultivated Medicinal Plants of Uttarakhand

Farmers are cultivating a number of medicinal plant species without much concern for the quality of planting material, leading to perhaps an inferior produce that makes them vulnerable to market forces. Besides, this approach also significantly affects the quality and therapeutic efficacy of the resultants products. In view of the emergence of global marketing system, it is of utmost importance that the raw material produced under cultivation systems must adhere to global standards. Most of the cultivation packages available to the farmers, however, lack post-harvesting processing like optimal drying and storage conditions. Further, there is need to assess the shelf life of the raw material, in order to achieve the quality standards desirable by the herbal industry and exporters. There are very limited studies that have been undertaken in fragmented form that deals with the determination of quality of raw material. In order to achieve the objectives of GMP, it is therefore, necessary to investigate and develop protocols for optimum drying and storage conditions of medicinal plants and assessing the effect of these processes on the quality of the produce.

Keeping in view the above slated reasons, the present project proposed envisaged to undertake detailed scientific investigations on the effect of different drying and storage conditions for some selected medicinal plants, being cultivated in Uttarakhand with the major aim of developing package of drying and storage regimes/protocols.

Development of standard optimum drying and storage conditions have been achieved for five commercially cultivated medicinal plants namely *Asparagus racemosus, Withania somnifera, Rauvolfia serpentina, Aconitum heterophyllum* and *Picrorrhiza kurroa*.

Data Compilation of R & D in Medicinal and Aromatic Plants by ICFRE Institute and Other Institutional Projects funded by ICFRE

Project completion reports (164 nos.) from FRI, Dehradun, HFRI Shimla, TFRI, Jabalpur, AFRI, Jodhpur, IFGTB Coimbatore and IWST Bangalore, IFP Ranchi were analyzed and compiled. Research papers (303 nos.) from Indian Forester and individual scientists were collected. Compilation and updating of R&D information on 57 medicinal plants is in progress.

Field Trials for Increasing NWFP Productivity Using *Piper pedicellatum*

Piper pedicellatum plant grows in moist subtropical and sub-tropical forest areas. The germ plasm was collected and Nursery technique developed in FRI, nurseries. Site development carried out in FRI central nursery under *Prunus cerasoides* and Lachhiwala RF under *Dalbergia sissoo* plantation. The seedlings were planted in both developed sites. The initial result indicated from the collected data, that Lachhiwala RF

Piper Fruits

Field Trial of *Piper pedicellatum* FRI Central Nursery

was not suitable for *Piper pedicellatum* growth hence high mortality rate was found, whereas, in FRI central nursery area, it showed success of plantation with 92% (approx) survival rate. Field trials were maintained.

National Study on Commercial Production of Non Timber Forest Products for Ensuring Fair Economic Returns to Primary Collectors

In order to estimate the production of Non Nationalized Commercial NTFPs, a national level study has been sanctioned by the MoEF. Under this programme, Data Collection Manuals and Formats have been developed for field data collection. Extensive household based surveys have been undertaken in Six (PESA) states and field data collection on production of various NTFPs has been undertaken.

Development of Sustainable Model for Enrichment of Selected Medicinal Plant Conservation Areas (MPCAs) of Uttarakhand Himalayas

Survey for identification of habitats of target species at Khuliya and Kandara MPCA were undertaken. Collection of seeds of Atish and Kutki 50 gm each done and Atish (400 nos.) and Kutki (200 nos.) plants procured. Seed sowing of Atish and Kutki done in identified sites at

Habitat of **(a)** *Nardostachys jatamansi*, and **(b)***Picrrohiza kurroa* at Khuliya and **(c)** *Aconitum heterophyllum* at Kandara MPCA

Kandara and Khuliya MPCAs. Maintenance of nursery/ planting stock also done. Data recorded on habitat types, their geo coordinates and frequency and density of target species collected from Kandara MPCA area.

Diversification of Hill Agriculture through Integration of Medicinal/Aromatic Plants for Livelihood

Willing farmers (02) identified at Gawar village Khirsu for undertaking on-farm trials. *Thymus serpyllum*

Field Planting of *Thymus serpyllum*

Growth in Stone Walls in Farmer's Field

nursery (6000 no.) raised. On farm trial on stone walls of terraced agriculture fields (approx. 0.05 ha) area were established at the identified farmers fields in northern, western, eastern and southern aspects.

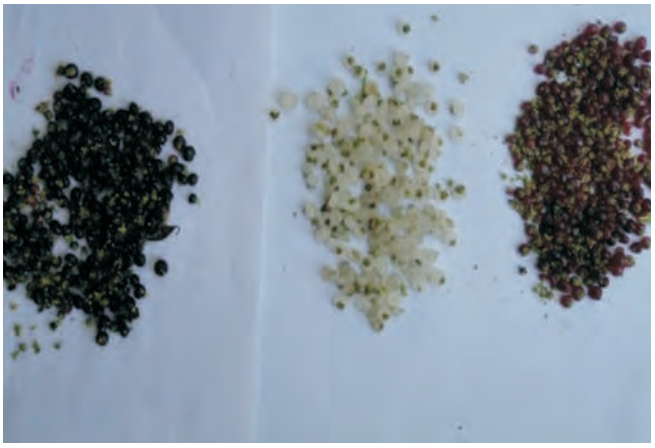
Effect of Fertilizer Application on Growth and Yield of 10 years old *Salvadora persica* and *Acacia ampliceps* plantations under Silvipastoral System on Arid Salt Affected Soil

Salvadora persica Trials

In the above average monsoon (562 mm) year, the fruit yield ranges from 1.24 kg (T12- FYM + K2SO4 + SSP) to nil in control treatment in *Salvadora persica* in 2010. Treatments significantly influenced the fruit yield as there was no fruit setting in control. T12 was the best treatment recording maximum overall fruit yield of 1.25 kg (207 g/tree), closely followed by T13- 1.20 kg (240 g/tree) and T8-1.10 kg (353g/tree), respectively indicating the positive influence of Potassium on fruit yield in a salty soil. Fruit yield in other treatments ranged from 64 g to 1.04 kg. During 2009 with deficient monsoon (212 mm) use of ZnSO4 promoted fruit yield.

The flowering was initiated in the month of Nov., 2011 and small seedless fruits were formed in 100% trees. However, they were aborted. Second fresh flowering was initiated in January, 2012. A total of 85.5% tree flowered and fruit setting took place in March, 2012 which was late as compared to that in 2011. While, multicolored fruits were observed in most of the plants, only white fruits were observed in six plants. Annual growth data for the year 2011 showed that the incremental growth of height and crown ranged from 5.2 to 13.2 cm and 6.4 to 13.0 cm, respectively in different treatments.

Seedless Fruits of *S. persica*



Fruits of Different Colour of *S. persica*

Normal Fruits of *S. persica*

Fruits in Different colour of *S. persica*

Acacia ampliceps Trials

In the year 2010, very good monsoon facilitated a high pod yield, 1.32 Kg (control) to 14.66 Kg (FYM + Urea) treatment in *A. ampliceps* trial, while there was no pod setting in the year 2009 due to failed monsoon. In this trial, maximum seed yield recorded was 2.13 kg in T4 (SSP) treatment and minimum 0.05kg in control. Treatments influenced pod/seed yield. Maximum 14.2kg pod yield was recorded in T_7 treatment where pod setting was observed in 90% trees, followed by T4 treatment (9.36kg pod yield in 88% trees) and T5 (6.0 kg pod yield in 50% trees). Zn influenced seed size and no of seed/g were 45 in T5 treatment as compared to 54 & 56 in T7 and T4 treatment, respectively while overall seed yield per tree was same 31-32 in all the three treatments.

Grass trials

Field trial was laid with two grass species *Cenchrus ciliaris* and *Sporobolus diander* on three soil structures, i) raised platform, ii) raised bund and iii) control in 2009. In the year 2011, soil structures influenced the dry grass yield; it was 313.1 and 285.9 g/m^2 for the platform and slope soil structures, respectively as compared to control 234g/m^2 for *S. diander*. Grass height ranged from 85- 107cm, no of clumps/m2 were 17-30, mean no of tillers /clumps were 48.5 – 71 in different treatments. In case of *C. ciliaris,* slope was the best structure which favoured 130.3 g/m^2 yield, followed by plat-form

Cenchrus ciliaris on Raised Platform

Cenchrus ciliaris on Raised Slope

Cenchrus ciliaris- Control

130.3 g/m^2 and minimum in control 61.7 g/m^2. Grass height ranged from 36- 110 cm, no of 5.7-13 clump/m^2, mean no of tillers /clumps 15.5 – 21 in different treatments. Thus, it is concluded that soil structures showed positive effect on leaching and helped in establishment of non salt tolerant grass on saline soil.

Identification of Superior Chemotypes and Ex-*situ* Conservation of *Podophyllum hexandrum* Royle from Himachal Pradesh and Jammu & Kashmir (Ladakh Valley)

Identified the superior genetic stock of *Podophyllum hexandrum* Royle after carrying out extensive survey in 28 sites in different geographical locations of HP and J&K. (Ladakh Valley). Each site was geo- referenced along with characterization of micro habitat. By using the germplasm collected from 34 sites, FGB (Field Gene Bank) has been established at Field Research Station,

Podophyllum hexandrum with Fruiting at Leh (J&K)

Brundhar, Jagatsukh (H.P.). Seed and vegetative propagation trials have been established to develop user friendly propagation trials of *P. hexandrum*

Population Assessment and Identification of Superior Genetic Stock of *Picrorhiza kurroa* Royle ex Benth and *Valeriana jatamansi* Jones by Screening Different Populations from North Western Himalayas (Himachal Pradesh and Uttarakhand)

Identified Superior Genetic Stock of *P. kurroa* and *V. jatamansi* from different geographical locations of Himachal Pradesh and Uttarakhand. In case of *P. kurroa*, out of total 34 sources studied throughout Himachal Pradesh and Uttarakhand, about 10 sources have been found to contain more than 10% total Picroside (P1 & PII). Highest total picroside content (14.70%) has been observed with HFRI/PK/04/KD while the minimum (4.30%) with P

Field Gene Bank of *P. kurroa* at FRS, Brundhar, Kullu H.P.

(2). As far as *V. jatamansi* is concerned out of 39 sources studied throughout from Himachal Pradesh and Uttrakhand, 10 sources have been found to possess Valepotriate content 3.5% and above. Highest valeopotriates content (4.50%) has been observed with HFRI/VJ/03/NCH, while minimum (1.37%) with V-6. DNA fingerprint profiling of superior genetic stock of *P. kurroa* has been carried out.

Conservation of Medicinal Plants through Commercial Cultivation and Value Addition by Joint Forest Management Committees / Panchayats and Farmers in Eastern Himalaya and its Socio-economic Impact

Total 320483nos of QPM has been created. 77200 nos. of QPM was distributed for cultivation to the JFMC members through State Forest Department and to the farmers for commercial cultivation on free of cost for motivation. 43800 nos. of QPM were supplied to the farmers for commercial cultivation at minimum rate of Rs. 1/- and utilizes 30950 nos. of QPM for seed garden at USJ Research Plot and IFP, Ranchi and trail plot during the year 2009-2010. Study and survey was done in Bijanbari, Distt. Darjeeling, Lingsey Village, Kalimpong, Distt. Darjeeling, Mangrakata Village, Distt. Jalpaiguri to evaluate socio-economic impact of commercial cultivation of medicinal plants on the cultivator. Preparation & maintenance of trail plantation of different medicinal plant viz. *Rauvolfia serpentina, Withania somnifera, Stevia rebaudiana, Asparagus racemosus, Gymnema sylvestre, Abelmoschus moschatus* for providing practical knowledge on cultivation technique of medicinal plant and study of yield for assessment of income on cultivation of medicinal plant.

Standardization and Dissemination of Complete Package of Cultivation and marketing in Relation to Principal Active Ingredient of ten Selected Medicinal Plants of Jharkhand, Bihar, West Bengal and Odisha

Six medicinal plants have been cultivated using RBD design in Jharkhand and West Bengal. 30 companies have been selected and appropriate data collected from them, growth data have been collected & complete

package will be standardized after harvesting of plants. Demonstration plots in farmer's field have been established. One awareness training on selected medicinal plants was organized in ERS, Sukna & also practical demonstration of cultivation of selected medicinal plants was given to the farmers, NGOs etc.

Standardization of Nursery Techniques for Cultivation of *Celastrus paniculatus and Vitex peduncularis* – Medicinal Plants Highly Exploited in Jharkhand

Seven sites of the natural occurrence of *V. peduncularis* in Gumla, Simdega, Ramgarh and Lohardaga have been identified. Five sites of the natural occurrence of *C. paniculatus* have been identified in Ramgarh and Lohardaga. Propagation from root suckers and shoot cuttings have been very successful in *V. peduncularis*. A nursery has been raised out of the shoot cuttings of *C. paniculatus*.

Multilocational Trial of *Jatropha curcas* in Different Agro-climatic Zones and Study of Agronomic Practices

Four replications of agronomy trial have been established. Each replication has 10 treatment blocks including control. In each treatment block, 20 accessions of Jatropha have been planted at a rate of 9 plants per accessions. Irrigation and fertilizer treatment was given as per the recommended experimental treatment plan. Data including plant height, collar diameter, no. of branches per plant, no. of inflorescence per plant, no. of fruit bunches per plant and other remarkable feature like disease susceptibility etc. were recorded. Four replications of Silviculture trial has been established. Each replication has 10 treatment blocks of 2 accessions planted randomly. Each block of either accession has 9 plants. Irrigation, fertilizer and pruning treatment were given as per the recommended treatment plan. Data including plant height, collar diameter, no. of branches no. of inflorescence per plant, no. of fruit bunches per plant and other remarkable feature including disease susceptibility etc were recorded. Four replications of multilocation trial, each having 100 accessions of Jatropha have been planted with 9 plants in each replication. Data for plants height, collar diameter, no. of branches, no. of inflorescence per plant, no. of fruit bunches per plant and other remarkable feature including disease susceptibility etc were recorded.

2.6.3. Sustainable Harvesting and Management

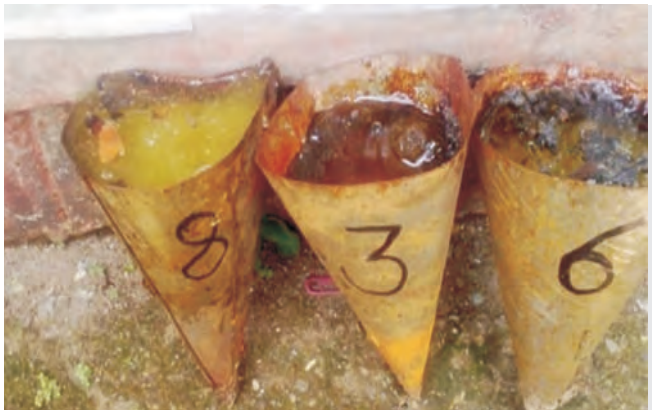
Creation of Seed Production Areas and Commercial Cultivation Trials of *Uraria picta*

Collected germplasm from Uttarakhand and planted in seed bank at FRI campus. Seed Bank area has been developed and is being maintained. Seed Bank has been established with 1000 mother plants in NWFP nursery at FRI campus and is being maintained. The seed production of 5.6 kg has been achieved and seeds produced in the seed bank have been sown in the mother beds for commercial cultivation trials. Field plantation in 2 bighas of land around Dehradun has been undertaken for commercial cultivation trials. The field plantation was maintained using irrigation as per requirement and manuring was undertaken. The crop has been maintained by undertaking weeding and requisite soil working. Observations on plant growth have been recorded on periodic intervals.

Field Trial of Borehole Method of Resin Tapping for *Chir pine* of Uttrakhand for Better Oleoresin Yield

Pinus roxburghii trees were selected for developing effective and non-harmful resin tapping technique in Mussoorie Forest Division (Magra Compartment) .The site was divided in three portions on the basis of altitude in the selected compartment. One site selected at FRI in Champion and Seth Block for demonstration purpose. Total 195 trees were marked for resin tapping work using Borehole method and the yield compared with rill method. Field trial sets were maintained in Magra Mussoorie and FRI Champion Block. Determination of tree age was done by using increment borer. Closing of bore holes and removal of resin pots was done. Oleoresin data from both sites were collected and analyzed. Recorded variation in the yield of resin in different sites using the two methods. Oleoresin sample was kept for analysis.

Collection by Bore Hole Method



Collection by Rill Method

Propagation of *Microstylis wallichii in the Experimental Site Field*

Testing of Vegetative Multiplication Technique of *Microstylis wallichii* in its Natural Habitat

Vegetative propagation techniques of *Microstylis wallichii* were carried out in its natural habitat at Chakrata, Mussoorie and Dhanolti. The survival and growth data were recorded under different trials at selected sites. Germplasm collected from Pauri, Mussoorie and Chakrata Dehradun. Surveys conducted for occurrence of species in Badrinath and Uttarkashi Forest Division. Growth data recorded and trial plots were maintained at three sites.

Population Dynamics of Selected Threatened Medicinal Plant Species and Conservation Management through Community Participation In Buffer And Transition Zone of Achanakmar-Amarkantak Biosphere Reserve, Madhya Pradesh

The project activity includes mapping the populations of threatened selected medicinal species, namely *Celastrus paniculata* (Malkangani), *Embelia tsjeriam-cottam* (Baibidang), *Rubia cordifolia* (Pilia), *Thalictrum foliolosum* (Mamira) and *Peucedanum nagpurens* (Tejraj) in Amarkantak Range, Anuppur Forest Division, Anuppur (M.P.) and Karanjia Range, Dindori Forest Division, Dindori (M.P.) of Achanakmar-Amarkantak Biosphere Reserve. Marking of plots with tagged plants has been done for recording of demographic observations in the next season. The awareness generation amongst forest villagers for sustainable harvesting of medicinal plants targetted under the project has been initiated. The physico-chemical properties of soil from population sites were analysed for comparison among varied habitat.

Studies on Developing Alternative Methods of Sustainable Harvesting of Medicinal Plants

Sustainable harvesting practices of *Bauhinia*

veriegata (Kachnar), *Holarrhena antidysenterica* (Kutaj), *Oroxylum indicum* (Sheonak), *Saraca asoka* (Ashoka) and *Terminalia arjuna* (Arjuna) have been standardized. The experiments were laid out in the forest areas of Jabalpur, Balaghat, Rewa, (M.P.); Chandrapur, Tadgaon, Allapally, Tadoba, Nasik (Maharashtra); Keonchi, Marvahi, Bilaspur, Kavardha, Raigarh, Gariyaband (Chhattisgarh); Harishankar, Champagarh, Khurd (Odisha). Various harvesting methods such as ⅓, ¼ blaze size and longitudinal strip (alternate and opposite strips) harvesting were experimented. Different plant parts i.e. trunk bark, branch bark, twig bark, root bark, leaves, flowers etc. were collected and analyzed for their phytochemical constituents (tannins, total alkaloids, flavonoids, total phenols, phenolic acids, arjunic acid, baicalein). Regenerated bark was also collected and evaluated for major active ingredients. Regular observations were recorded on bark regeneration. Results revealed that longitudinal strip harvesting method is superior to other harvesting methods in all designated species. In Kutaj and Sheonak bark recovery was faster in trees having GBH $<$40cm and completely recovered in 12 months; Arjuna bark recovery was faster in trees having GBH $<$90cm and completely recovered in 18 months, Kachnar and Ashoka bark recovery was faster in trees having GBH $<$35cm and completely recovered in 24 months. Minimum harvestable girth varies from species to species. There was significant variation in bark recovery among different girth classes of targeted species. Among all selected species Kutaj and Sheonak have faster; Arjuna has medium; Kachnar and Ashok have slower bark recovery. Bark can be harvested from the previously harvested trees after two years from opposite side of previously harvested part. Phytochemical analysis of various plant parts revealed that the trunk bark contained maximum amount of active ingredients but branch bark and leaves can also be used in place of trunk bark. Original bark contains higher amount of phytochemical constituents than regenerated bark. In case of Sheonak, maximum amount (327.8 $\pm$ 1.26%) of baicalein was observed in root bark which is at par with stem bark (307.29 $\pm$ 1.67). In Arjuna, arjunic acid content was varied from 10.120 to 49.087 mg/100g and also increased with increase in GBH. Arjunic acid varied significantly in original and regenerated bark. *T. arjuna* was found to possess maximum antioxidant activity among all the studied species. The adoption of above harvesting practices will be helpful in sustainable management of above studied species and also provide quality raw material to pharmaceutical industries on sustainable basis.

Terminalia arjuna Tree Showing a Blaze on the Trunk

Terminalia arjuna Tree Showing Regeneration of Bark

Standardization of sustainable harvesting practices of Arjuna (*Terminalia arjuna*) bark

Sustainable harvesting practices of *Terminalia arjuna* (Arjuna) bark have been standardized. The study was carried out in the forest areas of Keonchi, Pendra, Bhairosang, Khodri, Marvahi, Gariyaband and Raigarh in Chhattisgarh. Three harvesting methods such as ⅓, ¼

blaze size and longitudinal strip harvesting were experimented. Different growth regulators and plant extracts e.g., IAA, IBA, bordeaux mixture, leaf extracts of Neem, Aak, Karanja etc. were applied on harvested surface of tree trunk in order to study their influence on bark regeneration. Different plant parts i.e. trunk bark, branch bark, twig bark, leaves etc. were collected and analyzed for their phytochemical constituents (tannins, flavonoids, phenols, phenolic acids and arjunic acid). Plant samples were also evaluated for their antioxidant activity. Regenerated bark was also collected and evaluated for their major active ingredients- arjunic acid. Bark re-growth results revealed that longitudinal strip harvesting method is superior to other harvesting methods. The bark re-growth was faster in younger trees having GBH <90 cm and bark recovered completely in 18 months. Minimum harvestable girth should be >60 cm. The trees having GBH more that 120 cm, the bark may be harvested from ¼ of tree girth by removing outer and middle bark (longitudinal blaze) leaving inner bark for regeneration. Bark can be harvested from the previously harvested trees after two years from opposite side of the previously harvested part. Results on different growth regulator treatment did not show any significant variation in bark recovery. Phytochemical analysis of original and regenerated bark revealed that original bark contains higher amount of active ingredients than regenerated bark. Stem bark possess maximum amount of active ingredients than other plant parts. Trunk bark exhibited maximum antioxidant activity. Arjunic acid content varied from 10.120 to 49.087 mg/100g and also increased with increase in GBH. Arjunic acid content showed significant variation in original and regenerated barks. There were no adverse effects on the overall growth of the tree. The adoption of above harvesting practices will be helpful in sustainable management of *T. arjuna* and also provide quality raw material to pharmaceutical industries on sustainable basis.

Standardization of Sustainable Harvesting Practices of Bhumi-aonla (*Phyllanthus amarus*), Sal-parni (*Desmodium gangeticum*) and Baichandi (*Dioscorea hispida*)

Sustainable harvesting practices for Bhumi aonla (*Phyllanthus amarus*), Sal Parni (*Desmodium gangeticum*) and Baichandi (*Dioscorea hispida*) have been standardized for tropical climate of Chhattisgarh. Experiments were laid out in six different sites of three forest divisions of Chhattisgarh *viz*. Marwahi, Gariyaband and Dhamtari. Periodical regeneration surveys were conducted to evaluate the regeneration status in the experimental areas. Regeneration index of the studied species was determined. Plant samples were collected at different maturity stages for assessment of quality of produce. *P. amarus* should be harvested in the month of October at the time of initiation of fruiting. 80% plants can be harvested to maintain sustainability. Maximum phyllanthin content (0.384%) was found at fruiting stage (October) on dry weight basis. For sustainable harvest plants should be cut from the collar part and not uprooted. In *Desmodium gangeticum* only 40% plants should be harvested (uprooted) in the month of December. Maximum (0.113%) total alkaloids content was found in the roots harvested in the month of December. In *Dioscorea hispida* 10% tuber should be left for regeneration while harvesting. If more bulbs are present one bulb should be left for maintaining sustainability. Maximum diosgenin (0.7748 %) and starch (17.56%) content were found in the tubers harvested in the month of January

Standardization of Sustainable Harvesting Practices of Mahul Patta (*Bauhinia vahlii*)

A study has been initiated to standardize sustainable harvesting practices of Mahul leaves (*Bauhinia vahlii*). Experiments pertaining to harvesting intensities and time were also laid out in the forest areas of Keochi, Pendra Road (Marvahi);

Saplawa Pahadi, Pali (Katghora) and Futka Pahad, Balco (Korba) in Chhattisgarh. In each study site 10x10m quadrates (0.1h) were laid out in randomized design with five replications. Each quadrate was sampled initially for Mahul populations before harvesting. To standardize sustainable harvesting limits, leaves were harvested as per different treatments [T_0 (No harvest/control), T_1 (50% harvest), T_2 (60% harvest), T_3 (70% harvest) and T_4 (80% harvest)] in each site. Mahul leaves were also harvested in different months of the year to evaluate effect of harvesting time on quality of leaves. Quarterly observations were recorded. Maximum plant population was found in Futka Pahad, Korba followed by Keochi, Pendra. It was observed that the time of harvesting affects the quality of leaves. Data revealed that best quality Mahul leaves with respect to leaf length, width and area, were found in Korba. Moisture content was found higher (68%) in the small sized leaves harvested from Korba. Further quality analysis on leaf strength is under progress.

Quality Standardization of Some Important Medicinal Plants of Madhya Pradesh

The project started in January 2012. Surveys are being conducted in different agroclimatic zones of Madhya Pradesh for collection of plant samples. Giloe and Gudmar samples were collected from Rewa and Chhindwara districts. The samples were dried and processed for further analysis. Phytochemical screening of the plant samples of Giloe showed the presence of different constituents *viz*. carbohydrate, proteins, phenols, flavonoids, terpenoids, saponins, cardiac glycoside and steroids. Qualitative analysis for various constituents is under progress. Giloe satva (starch) has also been extracted from the samples.

Harvesting Time of Some Selected Medicinal Plants for their Natural Antioxidants Constituents

Survey was conducted in Tamia and Delakhari natural forest and Medicinal Plants Conservation Area, Delakhari for the availability of the selected species under study. *Gymnema sylvestre* species was available in Rainikheda beat, compartment no. P-36, Jhirpa range. *W. somnifera* and *Stevia rebaudiana* experimental beds were established in CFRHRD nursery and are being maintained. *M. oleifera, G. sylvestre, W. somnifera* and *S. rebaudiana* leaves samples were collected from existing plantations of the centre and natural forest at monthly time intervals. Method was standardized and estimated antioxidant constituents viz. ascorbic acid, total phenols, phenolic acids, elements and flavonoids. Phenol content was highest in *S. rebaudiana* and *M. oleifera* leaves which can serve as a potential source of nutraceuticals. Vanillic acid and caffeic acid were the two dominant phenolic acids found in *G. sylvestre* leaves. Results were disseminated through various training programmes of the centre.

Standardization of Inoculation Technique for Agarwood formation in *Aquilaria malaccensis* L

Artificial inoculations of fungi were carried out at Tezpur for inducement of agarwood in agar trees. Fifteen trees were inoculated as per the technical programme. Inoculated trees were observed after 3 months for external symptoms of agar wood formation if any. Spread of formation of agarwood at the point of inoculation was measured. Samples were collected from the inoculated site and brought to the laboratory for laboratory studies. Isolation from the infected samples revealed the presence of the inoculated fungi. Technology is standardized and multilocational trial is being carried out at Rauta (Udalguri District). Edaphic and climatic factors in relation to the agar wood formation are also being studied

Assessment of Optimum Harvest Limits of *Picrorhiza kurroa* and *Valeriana jatamansi* in Himachal Pradesh

Population data of medicinal plants were collected following quadrat study in all the selected experimental sites. Experimental harvesting trials (control 25, 50, 75 and 100 per cent harvest of selected medicinal plants) were established in all the five selected sites to determine

optimum harvest limits of selected plants. Training was organised on identification, conservation and sustainable utilization of medicinal plants of Himachal Pradesh on 25 February 2011 at Forest Training Institute, Chail for field staff of State Forest Department.

Population status, growth, regeneration and the ability of the population to withstand the extraction is being monitored for *Picrorhiza kurrooa* and *Valeriana jatamansi* in all the five experimental sites. The above data have been collected both from the field and nursery trials established already. The preliminary results revealed that both the species have the ability to regenerate after experimental harvest. To create awareness on medicinal plants among the field staff of state forest department, training was imparted on "Sustainable utilization, conservation and cultivation of important medicinal plants" on 27 July 2011 at the DFO office, Keylong, Lahaul Forest Division for about 50 field staff of State Forest Department, Himachal Pradesh and farmers.

Participants of the Workshop

Identification of Extent of Forest lands in Forest Fringe Villages

Study has been initiated for identification of extent of forest lands in forest fringe villages of Madhya Pradesh. Socioeconomic survey in 34 forest fringe villages of Jabalpur district has been completed. Ecological survey has also been initiated.

2.6.4. Chemistry of NWFPs, Value Addition and Utilization

Phytochemical Examination of *Acacia albida*

Five pure compounds were isolated from the *Acacia albida* leaves. Crude extracts of leaves and bark (Petroleum ether, Chloroform, Methanol, and ethyl acetate and butanol fractionated part of methnol extract of leaves and methanol extract of Bark) were tested on *Cylendrocladium quinqueseptatum, Aspergillus niger* and *Rhizoctonia solanii*. Extracts were found active at 0.5 % concentration.

To Study the Marketing Mechanism of Commercially Important Medicinal Plants in Selected Districts of Eastern Uttar Pradesh

Based on discussion with relevant resource persons, selected two districts of Gangetic plains i.e. Allahabad, Varanasi and two districts of Vindhyan Plateau i.e. Mirzapur, Renukoot and two districts of Tarai region of Eastern Uttar Pradesh i.e. Baharaich and Basti. Questionnaire on market survey has been tested for Farmers, Market and Industry and modified accordingly as per statistician. Survey of Allahabad district has been completed and the Varanasi district is under progress. Data collected from Allahabad district were compiled.

Non-edible Oils Derived from Tree Borne Oil Seeds as Potential Pesticides

TBO seeds were processed and extracted the oil fractions for bioassays and chemical analysis. Nucleus culture of defoliator and fungal cultures were maintained under laboratory condition till the bioassay study was completed. Oils fractions were tested against *Atteva fabricella* and *Eligma narcissus* larvae in *Ailanthus excelsa* field plantation at Kurumbapatti, Salem and restrained the larval activity. The bioactivity of the extracts and fractions of the oils were further confirmed through bioassay methods. Extracts were sprayed against some of the microbials infected seedlings viz. *Tectona grandis*, *Swietenia mahogani*, *Terminalia bellirica, Syzygium cumini, Pterocarpus*

marsupium and *Gmelina arborea* raised by Tamil Nadu Forest Department at Thirumurthi Hills Udumalpet. Tree borne seed oils were analysed and identified the major bioactive compounds like fatty acid methyl esters (FAME). Bioefficacy of the identified individual compounds against pests and diseases is in progress.

Essential oil of *Lantana camara* a Noxious Alien Weed as Biopesticide

Essential oil was steam distilled from the leaves of *Lantana camara* differing in flower colour collected from different agro climatic zones. The bioefficacy of the extracts tested against the teak defoliator *Hyblaea puera* showed 60% larval mortality at higher concentration, and antagonistic activity against five fungal pathogens. The bioactive compounds of the essential oil and fractions have been analysed through different chromatographic techniques. Experiments on antifeedant/insecticidal/antifungal properties of the individual compounds (β-Caryophyllene and Aromadendrene II oxide) against pests and diseases are in progress.

Biotransformation of Secondary Metabolites of *Frankia* Strains for Nodulation Enhancement in *Casuarina*

Lyophilized Frankia culture of 15, 25 and 30th day were sequentially extracted with ethyl acetate and methanol/chloroform for lipid extraction. The extracts of the lyophilized cultures were resolved in TLC using different solvents. The eluates were further fractionated in HPLC for mass spectral characterization in GC. The GC-MS-MS analysis and the spectral comparison revealed a total of 13, 23 and 14 components in 15, 25 & 30th day cultures respectively. Presence of some of the hopanoids and fatty acid derivatives and their variations were estimated in different day Frankia cultures. It was observed that some of them are very specific to nodulation/nitrogen fixation and to different day cultures. Better growth performance was observed at the mixtures of Frankia in combination with bioactive compounds inoculated to casuarina seedlings under nursery condition. Experiments are to be repeated for further confirmation.

Screening of Plant products (TBO's, Lantana, Ethnobotanicals) for their Bioefficacy in Lab, Nursery and Field Conditions

Fatty Oil Composition and Utilization of Lesser Known Tree Borne Oilseeds- *Givotia rottleriformis* Griff., *Madhuca insignis* (Radlk.) H.J.Lam, *Shorea tumbuggaia* Roxb, *Poeciloneuron indicum* Bedd, *Hopea parviflora* Bedd, *Mesua ferrea* L *and Balanites roxburghii* Planch

Survey was conducted to various parts of Karnataka and Andhra Pradesh, identified and collected seeds of seven tree species namely *Givotia rottleriformis* Griff., *Madhuca insignis* (Radlk.) H.J.Lam, *Shorea tumbuggaia* Roxb, *Poeciloneuron indicum* Bedd, *Hopea parviflora* Bedd, *Mesua ferrea* L *and Balanites roxburghii* Planch. The seeds were processed and the fatty oil extracted. The physico chemical properties of the oils like Acid value, Saponification value, Iodine value, Unsaponifiable matter and Refractive index were determined. Estimated Fatty acid constituents of *Madhuca insignis, Mesua ferrea, Givotia rottleriformis and Balanites roxburghii* seed oils by converting into their corresponding methyl esters. Evaluated the anti-fungal activity of two oils namely *Givotia rottleriformis, Balanites roxburghii*. Fatty oils of *Madhuca insignis, Mesua ferrea* and *Givotia rottleriformis* were converted into biodiesel by transesterification.

Madhuca insignis (Radlk.) H.J.Lam (Sapotaceae) -Edible Oil Yielding Tree Borne Oilseeds

Lesser known TBOs- *Poeciloneuron indicum* Bedd

Tree Borne Oilseed-*Mesua ferrea* L

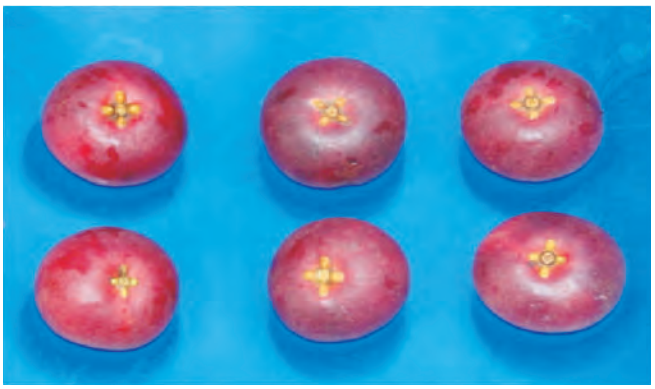

Unexploited High Oil Yielding tree of tropical forests- *Givotia rottleriformis* Griff


Balanites roxburghii Planch –High Oil Yielding Used for Biodiesel

Garcinia indica Choicy: Pharmacological Evaluation of the Extract/ Active Principle for Anti Diabetic Property

Garcinia indica fruits were collected from two places in Karnataka viz. Subramanya and Puttur. The fruits were processed and rind was dried in shade. The rind was, then, loaded in a soxhlet and extracted sequentially for active ingredients with solvents of varied polarities. The methanol extract yielded about 40% wt/wt of the rind loaded and on phytochemical investigation gave positive results for coumarins.

The methanol extract was, then, further separated with benzene-alcohol combinations and two distinct fractions were separated. These extracts (methanol and benzene alcohol extract) were tested in mice model using streptozotocin-nicotinamide to induce diabetes and Glibenclamide as the standard drug. The dosages of 200 mg and 400 mg/kg body wt of mice were administered. The methanol extract and benzene alcohol extract have shown comparable anti-diabetic activity with the standard drug.

Garcinia indica Tree and Fruits

Testing of extracts for acute and Chronic effects of Garcinia fruit rind extracts (methanol and benzene-alcohol extracts) completed. The results indicate reduction of 60 % blood sugar after sub- acute observation (14 days blood sample analysis). In chronic studies, the blood sugar level was reduced to about 49% (i.e. after 21 days blood analysis after administration of extracts). Results will be analyzed, compiled and reported. Project is completed.

Evaluation of the Performance of Steam Volatile Creosote (SVC) as a Wood Preservative

Procured creosote and Steam Volatile Creosote was obtained by steam distillation. Applied SVC to wood surface of eight selected tree species and kept for standardization to know its effectiveness. Applied SVC with natural dye (*Dalbergia latifolia*) and synthetic dye in various concentrations and combinations as wood coating. Worked out the coating schedule for the treated four tree species. Worked out the coating schedule for the treated tree species. SVC treated wood were put for effectiveness as wood preservative under terrestrial conditions (Grave yard test). SVC treated wood were also put for effectiveness under marine conditions at Vizhakapatnam.

Screening and Evaluation of Selected Members for Rutaceae from Southern India for Anti-malarial Activity

Plant materials of *Toddalia asiatica* and *Ruta graveolens* were collected from Devarayanadurga and Savanadurga areas of Karnataka. The plant parts were washed, processed and shade dried. Then, pulverized and stored for extraction of phytochemicals. The powdered plant material were loaded in soxhlet and extracted sequentially with solvents of varied polarities. Extractives were quantified and phytochemcial analysis was carried out. Then the extractives were tested from larvicidal activity of mosquito (WHO guidelines). Preliminary tests for larvicidal effect with extract of *Toddalia asiatica* root (Chloroform extract) have given good results (LC50 value at 155ppm). Experiments on ovi-position deterrent activity is in progress.

The extracts of root, stem and leaves (*Toddalia asiatica* and *Ruta graveolens*) are used to evaluate larvicidal effect and ovi-position activity and experiments completed. Mosquito Repellent property by hand exposure method completed at NIMR. Ovi-position activity and larvicidal activity for extracts of *Ruta graveolens* is in progress and standardization of cell lines (RBC and liver cells) primary screening completed and testing of extracts on these cell lines is in progress.

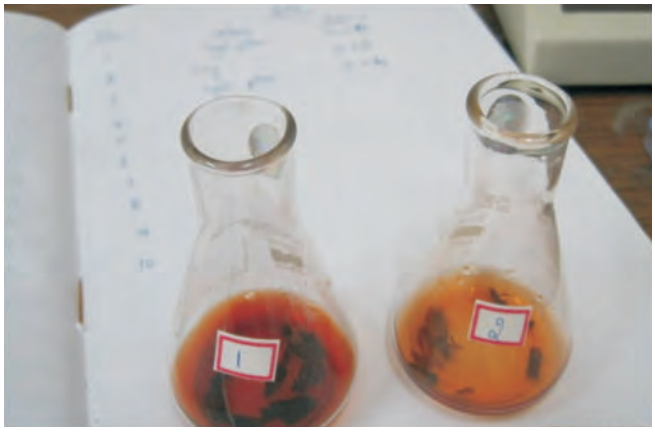
Toddalia asiatica and *Ruta graveolens*

Quantitative Estimation of Sandal Oil from Different Locations by Colour Reaction

A survey has been carried out in sandal bearing areas of Karnataka, Tamil Nadu and Kerala states, identified sandal trees of above 40 cm girth to validate the colour reaction based on enzyme activity in living bark tissue, of the 12 substrates identified for colour

reaction, only 2 substrates – Benzidine and Guiaicol were found to be effective for distinguishing sandal plants in too low and high oil yielders. Of these two reagents, Guiacol is found to be cost effective, environment and user friendly and sharp colour to distinguish and high and low yielders of oil in the standing tree. Core samples were taken using increment borer from the experimental plants and oil content in each plant was estimated using UV- spectroscopic method. These results are then compared with developed colour reaction in each plant for verification. Further refinement has been made to estimate oil content in standing tree by measuring colour intensity using portable colorimeter. Recorded growth and climatic factors of the location to correlate with quality and yield of heartwood and oil content. Results of the colour reaction in the selected plants were reviewed periodically to check the results and same results as earlier have been obtained.

Santalum album, L. Collection of Core Samples



Colour Reaction Low and High Yielder of Sandal

Determination of Polysaccharides for the Development of Bioproducts:

Polysaccharides from different species viz.,*Curcuma angustifolia*, *C. pseudomantana*, *Dioscorea bulbifera*, *D. hispida and Hyptis suaveolens* were isolated and modified by acetylation, hydroxyl-propylation and carboxy methylation. Physical and chemical properties of polysaccharides–starch and mucilage i.e. morphology, size, solubility, viscosity, extraction temperature, amylose, cellulose, oil per cent were determined. Degree of substitution of modified starches were found to be varying from 0.040 to 1.30. The introduction of different chemical groups and their charecterization were performed by FTIR spectra.

Compatibility of starches with mucilage, polyvinyl alcohol, chitosan and bentonite and their effect on properties of polyfilms were evaluated. The value of tensile strength of unmodified polyfilms was found to be 9.1 MPa, while significant variation i.e. 12.5 to 45 MPa were observed in modified polyfilm with different additives.

Bio-chemicals like alkaloids, triterpenes, phenols, tannins, flavanoids, and saponins were detected and quantified in mucilage.

Starch-based bioadhesive has been prepared through chemical modification. The changes in physical and chemical properties of adhesives were assessed. Binding ability of adhesives with different substrate were evaluated. Properties of adhesives i.e. setting time, water resistivity, solubility in water and organic solvents were assessed. Comparative efficiency of bio adhesives and synthetic adhesives were also screened.

Processing Techniques of *Aegle marmelos* (Bel) Fruits

Experiments were laid out for standardization of processing techniques (extraction of pulp and drying) *Aegle marmelos* (bel). Traditional as well as indirect heating methods were applied for pulp extraction. It was observed that traditional methods of pulp extraction were found to be severely affecting quantity as well as quality of pulp.

The different drying modes were applied for drying of pulp. The effect of drying on physico-chemical properties of bael pulp samples i.e. colour, moisture, carbohydrate, protein, minerals, fat, fiber, carotenoids, phenolic acids and riboflavin were assessed.

Mini portable solar drier for direct and indirect drying were designed for efficient drying of pulp samples utilizing solar energy which was found to be less time consuming in comparison to traditional methods of drying and retain quality of the pulp.

Drying method had significant effect on carbohydrates percentage with different drying methods, quantity ranged 15.7 -26.7%. Riboflavin concentration i.e. 20.04 μg/g was recorded in sun-dried samples. Solar drying in solar cooker, direct and indirect solar drier resulted in 0.01 μg/g,22.03 μg/g and 92.02 μg/g, respectively. The samples dried in shade gave 21.03 μg/g riboflavin value. Tannin concentration varied from 0.05-1.40%. Lower tannin percentage was recorded in sun drying and direct solar drying samples. The HPLC analysis of phenolics isolated from pulp samples, processed by different methods, revealed the presence of phenolic acids i.e. chlorogenic acid, vanillic acid, caeffic acid, elagic acid and gallic acid. Chlorogenic acid was identified as major component varied 0.001- 0.006%. Maximum percentage was detected in shade dried Bael pulp samples. Gallic acid was ranged from 0.002-0.004%.

Bel samples were also collected from Kawardha and Pendra of Chhattisgarh, processed by the villagers and quality of pulp samples were evaluated. Samples were found to be damaged by fungal attack due to destructive processing practices.

Evaluation of Non-edible Oil Seeds for Development of Surfactants and their Utilization in Pest Management

Seeds of *Jatropha curcas*, *Sapindus mukrossi* and *Pongamia pinnata* were collected, processed and seed chemicals were extracted. Physico-chemical properties of oil i.e. specific gravity, saponification value and free fatty acids were evaluated. Seed oil and protein concentrates of *Jatropha curcas, Sapindus mukrossi* were modified by sulphation, saponification and dietanolamine reactions. The properties of developed products viz., solubility, surface tension, viscosity, wetting time and foaming power were assessed. The viscosity, wetting time and foaming power of different dilutions varied from 0.58-1.60mPa.s, 9-60sec and 2.9-7cm, respectively. Pesticidal activities were assessed against forest pest i.e. insects (*Triboleum castaneum*), fungi (*Fusarium oxysporum*, *Penicillium crysogenum*, *Alternaria alternate,Flavodon flavus, Ganoderma lucidum, Tramatis cingulated, Stachylidia* spp.) and weed (*Echinocloa colanum*) at different dilutions (0.5-15%) under laboratory conditions.

Chemo-profiling of Some Dashmoola Species (*Solanum indicum, Solanum xanthocarpum* and *Uraria picta*) in Madhya Pradesh

A study has been initiated to quantify the active ingredients of three Dashmoola species (*Solanum indicum, Solanum xanthocarpum* and *Uraria picta*) collected from different agroclimatic regions of Madhya Pradesh to locate the best areas/ populations for getting the quality raw material. Under the above said study, forest area was surveyed and the different plant parts of *Solanum xanthocarpum* were collected from four agroclimatic regions i.e. Kymore Plateau and Satpura Hills, Satpura Plateau, Chhattisgarh plains and Central Narmada Valley. The plant material of *Solanum indicum* were collected from two agroclimatic regions i.e. Kymore Plateau and Satpura Hills and Chhattisgarh plains. The plant material of *Uraria picta* was collected from Satpura Plateau agroclimatic region. The collected plant materials were shade dried and processed. The preliminary phytochemical screening (alkaloids, terpenoids, flavonoids, carbohydrates, phenols, saponins, cardiac glycosides, steroids & tannins) of different plant parts of *Solanum indicum, Solanum xanthocarpum and Uraria picta* were carried out.

Standardization of HPLC method for quantification of active ingredients (Alpha – Solanine in case of *Solanum indicum* and *Solanum xanthocarpum* and Rhoifoilin in case of *Uraria picta*) is under progress.

Development of Food Products from *Madhuca indica* Flowers for the Upliftment of the Tribal/Rural Communities of Central India

Collection of *Madhuca indica* flowers from available source was done. Method standardization for extraction and quantitative estimation of *M. indica* flowers for their nutritional constituents was done. Quantitative estimation of mahua flowers for their nutritional constituents was done. Three value added food products viz. mahua jam, squash and chutneys were developed using dried mahua flowers in collaboration with Department of Food Technology, Rashtra Sant Tukdoji Maharaj Nagpur University, Nagpur. Consumer acceptability tests were conducted. All the three products were accepted by the consumers and were consistent with the Food Products Order (FPO) specifications. Results were disseminated by conducting two training –cum-workshops of two days duration. Target groups were Women Van Samiti members of various forest ranges of Chhindwara District. Practical demonstrations were given for preparation of three value added food products and feedbacks were obtained. Raw material could be effectively utilized for development of cottage scale mahua based food products industry in tribal/rural areas.

Products of Mahua

Comparative Studies on Optimum Treatment Time and Durability Test of Commercially Important Bamboo Species of North Eastern Region

Bambusa pallida and *Dendrocalamus hamiltonii* treated with 8%, 10% and 12% CCB under 1 and 1.5 kg pressure using Boucherie Apparatus (Jagriti) revealed the result that optimum treatment time of bamboo *Bambusa pallida* needed lesser time for chemical preservative treatment in comparison to *D. hamiltonii*. Age of bamboo and its moisture content was found to play an important role in predicting the optimum

Some Boidegrading Agents of Bamboo

Damage to Bamboo due to Undetermined Termite

treatment time required. The average preservative treatment time required was from 25 to 90 minutes. These bamboo samples were established in test yards at Jorhat, Assam and Aizawl, Mizoram for biodegrading agents to act upon them. The test yards were observed every six month for any development of bio-degradation.

Studies on Phyto-proteins from Selected Plants of Northeast Region for the Production of Protein Concentrates with Greater Food Value

Increasing prices for animal feed has compelled researchers for research on unconventional feed with special emphasis on protein substitutes. Use of leaves and other parts of plants as possible source of protein can be a viable option in meeting the nutrient need and maintaining the productivity of ruminant and non-ruminant population. However, there is paucity of information on the potential of plant species, as nutritious feed source for animals and adequate research is still needed in the field. Therefore, with an aim to develop new Leaf Protein Concentrates three leaves (*Diplazium esculantum, Alocasia macrorhiza and Samanea saman*) have been explored. Leaf Protein Concentrates from these three species have been prepared in our lab. Best physical and chemical conditions were optimized for yield enhancement of leaf protein concentrate from these species. Functional properties of leaf protein concentrates were also examined to judge the potential of these leaf proteins concentrates for industrial applications. This is the first study on the leaf protein concentrate from these species. Three samples of Leaf Protein Concentrate, prepared from *Diplazium esculantum, Alocasia macrorhiza and Samanea saman,* examined for Anti-oxidant activity for its best end use. The antioxidant activities of these three LPCs were encouraging in comparison to commonly used antioxidants. This property of prepared LPCs may lead to their use in the development of new nutraceutical products with high protein contents and food value.

Molecular Characterization of *Mimosa diplotricha* Seed Polysaccharide

Mimosa diplotricha, a noxious weed is a serious threat to the ecosystems and demands concerted efforts for its management. Though a number of approaches have been adopted for effective management of *Mimosa diplotricha,* however, each approach has inbuilt limitation and satisfactory approach is yet to be seen. Chemical and medicinal screening of *Mimosa diplotricha* plant, which is not undertaken so far, would be open the door for the utilization of this plant. Utilization of abundantly available biomass derived from *Mimosa* could be a practical proposition for the management of the weed to prepare value added derivatives for applications in Herbal Medicare, Cosmetics and other industries. Recent studies based on traditional knowledge have also led to novel and, hitherto, unexplored chemotherapeutic plant polysaccharides to cure various dreaded diseases viz. typhoid, leishmaniasis, meningitis, cholera, cancer, hepatitis, etc. Therefore, the structure determination of polysaccharides is always a matter of interest. In our laboratory, the work of thorough and complete structure elucidation of *Mimosa diplotricha seed* polysaccharide is in progress. Fresh seeds of *Mimosa diplotricha* were collected from RFRI campus in the month of November-December, 2011. Proximate analysis of seed samples was performed in triplicate. Shade dried seeds, in semi-powdered form, have been used for polysaccharide isolation. Polysaccharide from seeds has been isolated by alcoholic precipitation method. The precipitated polysaccharide samples were purified by dialysis and re-precipitation methods. Homogeneity of pure polysaccharide was also determined. The polysaccharide of *Mimosa* seed was hydrolyzed completely by using strong acidic conditions for 18-20 hrs. duration. The hydrolyzed mass was concentrated after neutralization on vacuum rotary evaporator. Qualitative estimation of monosaccharides present in hydrolyzed mass has been

done by Thin Layer Chromatographic technique by using different solvent systems and monosaccharide standards.

Tapping the Potential of Some Selected Indigenous Lesser Known Wild Edible Plants for Food and Nutrition in Arid and Semi Arid Regions

To determine the nutritional content of some selected important wild food plants and to explore the possibility of developing value added products from lesser known species, field survey was carried out for availability of various samples in Jodhpur, Pali, Udaipur, Phalodi, Dungarpur, Barmer and Bikaner districts. BSI, JNV University, local people and forest officials were also contacted. *Cordia gharaf* fruits were collected from Jodhpur area and fruit pulp and seeds were separated. Moisture content, seed dimensions (seed index = 26.45) and seed: pulp ratios (1:4) were determined. Samples of *Cassia tora* were collected from Pali from three areas; Phalna, Bali and Kheda. Samples were shade dried and physical parameters of leaf and pods viz; length x width (4.08 x2.28cm – leaves and 19.54 x 2.76 cm-pods, Pali), weight, moisture content were recorded. Bhopalgarh area of Jodhpur was surveyed for *Ceropegia bulbosa*. Few samples of *C. bulbosa* were obtained from Kheda (Pali). The weight, length x width (2.82 x 2.32 cm - small; 4.6 x1.4 long) of leaves and tubers (2.8 x1.6 cm of Udaipur region) were recorded. Few tubers were sown in polybags for germination. *Haloxylon salicornicum* seeds were collected from Phalodi area. Samples were dried in shade and moisture content was determined. *Grewia tenax* fruits were collected from Kailana, Jodhpur. Nutrient analysis work has been initiated.

Assessment of Nutritional Status of Most Preferred Wild Edible Plants of Kinnaur District, Himachal Pradesh

A total 110 wild edible plant species were documented from different areas of Kinnaur district. Among the edible plants, fruits (33%) and leaves (27%) are the most widely used plant parts while herbs (58%) and shrubs (22%) are the most widely used growth forms. Total pH, Ascorbic acid, mineral nutrients, carbohydrate, total sugar and antioxidant activity of *Elaegnus umbellata, Malus baccata, Rosa webbiana, Hippophae salicifolia* and *Berberis aristata* were estimated. To disseminate the research findings to stakeholders, two interactive workshops on wild edible plants were organised and a pamphlet on wild edible plants prepared.

Information on wild edible plants was documented by interviewing 16 people from Dunii, Thapa and Kamru villages and alpine areas near Pangi. Samples of wild edible species such as *Berberis aristata, Elaegnus umbellata, Malus baccata, Pyrus persica, Prunus cornuta, Pyrus pashia, Ramaria sp* and *Viburnum cotonifolium* were collected for nutritional analysis. Moisture content, pH, Total soluble solids, Ascorbic acid, crude fiber, reducing sugar, non-reducing sugar of the collected samples were estimated at the institute. The samples are also analyzed at the Institute of Himalayan Bioresource & Technology, Palampur for protein, reducing sugar, phenolics, sugars and anti-oxidant activity to cross-check the results while the mineral composition of the wild edible plant samples were analyzed at CSK Agricultural University, Palampur.

Wild Edible Plant Samples for Analysis

Helvella sp- A wild Edible Fungi

Installation of Chemical Reactor

Residual Lignin

Hydrolysate

Study of Various Factors Effecting the Quantity of Active Principles in Some Commercially Important Medicinal Plants Under Cultivation

Two sites have been identified for collection of propagules of *G. sylvestre* from natural sources at NBPGR, Palandu. The dried leaves of *G. sylvestre* have been defatted with petroleum ether; Benzene and chloroform extracts have been prepared from the leaves of three year old plants. *G. sylvestre* plants have been raised under the shade of Teak, Sal and Sissoo.

2.6.5. Biofuels and Bioenergy

Effect of Improved Operational Parameters on Hydrolysis of Lignocellulosic Biomass to Enhance Total Reducing Sugar Yield for Bioethanol Production

Conditions for the pretreatment of *Lantana camara and Pine needle* was optimized by varying alkali and acid charge (1%, 2%, 4% and 6%) in bath ratio (solid: liquid) 1:6, 1:10 and 1:20 at 120^{0}C temperature for 90 minute reaction time. The alkali treatment (6% NaOH) of lignocellulosic biomass (*Lantana camara* and Pine needle) in bath ratio 1:20 (solid: liquid) extracted maximum 12.92 g/l (25.84 %) total reducing sugars and 10.69 g/l (21.38 %) xylose in case of *Lantana camara* while in case of Pine needle, total reducing sugars extracted was 10.83 g/l (21.66 %) and xylose 8.54 g/l (17.08 %). The acid treatment (4% H_2SO_4) of lignocellulosic biomass (*Lantana camara* and Pine needle) in bath ratio 1:20 (solid: liquid) extracted maximum 21.36 g/l (42.72 %) total reducing sugars and 16.30 g/l (32.60 %) xylose in case of *Lantana camara* while in case of Pine needle, total reducing sugars extracted was 19.72g/l (39.44 %) and xylose 14.33 g/l (28.66 %). Installed a new Chemical reactor and the working efficiency of reactor has been checked out by several trials with water and sulphuric acid at elevated temperature (Maximum 250^{0}C). A more amorphous residual lignin after treatment with sulphuric acid was extracted.

Hydrolysis of lignocellulosic biomass (*Lantana camara* and Pine needle) was carried out by varying the acid concentration (0.1 – 0.5 N H_2SO_4) and different ageing period (0-5 days) at elevated temperature (180^{0}C) in bath ratio (solid: liquid) 1:15 for 90 minute reaction time with mechanical agitation in a chemical reactor to extract total reducing sugars. A study to improve the fermentation efficiency was undertaken with combination of yeasts i.e. *Saccharomyces cerevisiae*

and *Pichia stiptis*. Fermentation of glucose sample with co-culture of micro-organism i.e. *Saccharomyces cerevisiae* and *Pichia stiptis* was carried out in different inocula size. It was observed that the co-culture of micro-organism enhanced the fermentation efficiency up to 89.97 % against the previous studies i.e. 82.79% fermentation efficiency.

Chemoenzymatic Saccharification of Cellulosic Biomass

Cellulosic biomass was hydrolysed using Chemoenzymatic route. Different chemical pre-treatment studies were carried out in isolation and in combination of - periodate urea and sodium hydroxide. Variables of pre-treatment reaction studied were viz., reaction time, temperature, solid liquid ratio. The enzymatic treatment was optimized for time, pH, temperature and concentration of the cellulose enzyme. Cellulosic biomass was subjected to treatment with variable solid liquid bath ratio from 1:20 to 1:60 (w:v) of the buffer with cellulase enzyme varying from 1-5% for variable time period from minimum 3 hrs to 120 hrs . The temperature of the reaction was varied from 20 to 70^{O}C and the conditions were optimized for maximum TRS. The chemically treated biomass with urea was also depolymerised using the optimized parameter.

National Network Programme on Integrated Development of *Jatropha curcas* (Externally funded)

Networking trial I: In field trials, genotypes Akola (PKVJ-MKU-1) and PJ Sel-2 performed well for seed yield attribute over others in multi-locational trial with oil content of 33.56 % and 30.66 % on degraded silica mining site of Allahabad in Vindhya region. It was found that in zonal trial, CSFER-1 showed best performance followed by Jhansi (NRCJ-42).

Networking trial II: CPTs CALD-13 and CALD-14 from Allahabad has performed well for growth as well as seed yield. In seed yield, two CPTs of Allahabad, one CPT of Deoria and three CPTs of Gorakhpur performed well with an average seed yield in the range of 323 – 385 kg /ha with good oil content. The canopy dia and collar dia was highest in the CPTs of Allahabad over other progenies with a value of 211.13 and 45.46 cm.

Networking trial III: Promising genotypes having more than 33% oil content were contributed by the participating institutes and centers. CSFER, Allahabad has received a total of 16 provenances from different Institutes/centers. CSFER, Allahabad also contributed samples of CALD- 14 to member institutes. Seedlings were raised and field trial was carried out at Padilla. Weeding hoeing and maintenance of networking trials are in progress. Pruning was carried out at the height of one feet. Growth ,branching and fruiting data were recorded.

Maintenance and Management of Field Trials are being done as per the requirement. Recording of growth data and fruit yield going on and rate of decomposition and carbon sequestration are being studied.

Study on Microwave Assisted Extraction and Transesterification of *Pongamia pinnata* (L.) seed oil

The effect of microwave irradiation on oil extraction from *Pongamia pinnata* seed was studied. It was observed that microwave irradiation reduces the time of oil extraction from the seeds significantly. The effect of microwave irradiation on the transesterification was also investigated and compared with conventional heating. The result of the study suggested that 0.5% sodium hydroxide and 1.0% potassium hydroxide catalyst concentration were optimum for biodiesel production from *P. pinnata* oil under microwave irradiated conditions. The result also shows a reduction in reaction time for microwave induced transesterification as compared to conventional heating. The fuel properties of biodiesel (viscosity, flash point, cloud point, neutralization value, sulphur content, water content etc.) were determined as per biodiesel ASTM standards. The quality of biodiesel was found suitable as per biodiesel standard.

Production Synthetic Biodiesel from Wood Wastes

Visited the Coal to Liquid Lab of CFRI, Dhanbad and IICT Hyderabad to get input and advice from

them for the work. Necessary chemicals and glassware were procured. The Instruments like FT Reactor, GC accessories, Biomass pellet press and air compressor were procured. Biomass wastes were collected from the AWTC workshop and its Physical properties were measured. The calorific value and proximate analysis of collected biomass were also determined. TGA analysis was done for Bamboo and wood wastes.

Study the Effect of Microwave Assisted Heating and Seed Storage Conditions on Quality of *Pongamia pinnata* (L.) Seed Oil for Cost Effective Production of Biodiesel

The fresh seeds of *P. pinnata* were procured and damaged and infected seeds were shorted out. After initial cleaning, the seeds were irradiated to microwave for different time (1.0, 1.30 and 2.0 min) and then, stored at different storage temperatures (5, 25 and 35 ^{0}C). The oil from the seed (treated and untreated) was extracted using hexane. The initial physical and chemical properties of the treated and control oil samples were recorded.

National Network on Integrated Development of Jatropha and Karanj

Jatropha: 175 CPTs of Jatropha were selected from Jabalpur, Chhindwara, Seoni, Balaghat, Dindori, Mandla, Betul, Katni, Shahdol, Satna, Rewa, Panna, Gwalior, Shivpuri, Sagar, Damoh and Sheopur-Kala district of Madhya Pradesh. The selected CPTs were used for establishment of progeny trials at Chhindwara and Baraha comprising of 20 progenies each. Kherwani; Chhindwara, Timarikala; Chindwara, Rakala; Panna, Chapara; Seoni, Bizoli Janarpura; Gwalior-4, Gesani Shivpuri-2, Gesani Shivpuri-3, Bilara Pahori Road Shivpuri-2 and Bizoli Janarpura Gwalior -3 was found performing better than other progenies. Multilocational trials in the form of national and zonal trials comprising of 36 accessions in national trials and of 14 accessions in zonal trial of Jatropha were established at the Institute's campus, Jabalpur. Data on growth performance, fruit yield and seed characters were recorded at regular intervals and oil yield estimation of fruits was done. TNMC–22, TFRI–I, TFRI–2, IGAU–2, PDKV-1, PDKV-2, TNMC–7 Palmpur–I, Palmpur-II, CSFER, RJ-92, TR-4, JCP-2, NRCJ-17 and TNJC-19 accessions performed better than the other on the basis of growth, seed yield and oil content. Seed yield was observed maximum in IGAU-1 (157.06 kg/ha) followed by TFRI-2 (155.22kg/ha). The oil content ranged from 32.17 to 39.43%. In zonal trial TFRI-1, TFRI–2, PDKV-1 and PDKV–2 performed better among all accessions. Seed yield was observed maximum in TFRI-1 (101.25 kg/ha) followed by RRL-1 (85.52kg/ha) accessions. Oil percentage varied from 31.80 to 39.50%.

Karanj: 81 CPTs of Karanj were selected from Jabalpur, Satna, Panna, Katni, Seoni, Chhindwara, Balaghat, Mandla, Dindori, Shivpuri, Gwalior, Muraina and Damoh districts of Madhya Pradesh. The selected CPTs were used for establishment of Progeny trial. 20 progenies were used for establishing the progeny trial at Balaghat in 2005. Kusmeli; Chhindwara, Sikharpur; Chhindwara and Lalpur; Satna were found most promising progenies among all other progenies. National trial of Karanj comprising of 5 accessions, zonal trial comprising of 17 accessions were established at the Institute's campus. In national trial TNMP-14 and RAK-5 accessions performed better, in zonal trial IGAU-1, CCSHAU–1, IGAU–5, NRCAF–2, JNKVV-29 and JNKVV-15 performed better. Fruit bearing progenies are Kusmeli; Chhindwara (90 fruits), Sikharpur; Chhindwara (80 fruits), Lalpur; Satna (63 fruits) and Chandangoan; Chhindwara (55 fruits). In zonal trial accessions CCSHAU, Bawal–1 (82 fruits); NRCAF–2, Jhans (81 fruits); IGAU-1, Raipur (55 fruits); TFRI-2, Jabalpur (52 fruits) and TFRI-3, Jabalpur (51 fruits) showed fruiting. However, the amount of fruits were less. The trials are maintained with regular weeding and hoeing practices and irrigation as and when required.

Establishment of Multilocational Trials of Superior Accessions of *Jatropha curcas* under the network Program of DBT

Multilocational trial comprising of nine superior accessions of *Jatropha curcas* and half sib progeny trial comprising of nineteen accessions were established in October 2008 and July 2009 respectively at Institute's campus. The trials are performing well and survival is more than 82%. Regular observations on growth attributes like height, collar diameter, number of branches, flowering, incidence of pests and diseases are being recorded on quarterly basis and data sent to Biotech Park, Lucknow for compilation. Minimal irrigation and maintenance were provided to the trials as and when required. In multilocational trial, two accessions HAP 41 and HAP 44 (HNB, Garhwal) have produced higher number of branches. Fruiting was observed in all accessions: JA-9, NBRI, Lucknow, JA-126, NBRI, Lucknow, JA-139, NBRI, Lucknow, BTP-U, BTP, Lucknow, HAP 41, HNB, Garhwal, HAP 42, HNB Garhwal and HAP 44, HNB Garhwal (74 fruits).Oil percentage in different accessions varied from 25% to 38%. In half-sib progeny trial, flowering has been observed in September-October 2011 in following accessions: JA-9, JA-18 (NBRI, Lucknow), MSSRF-10, MSSRF- 16, MSSRF- 51(MSSRF, Chennai), HAP- 41 and HAP-44 (HNB, Garhwal). However, less fruiting was observed. The experimental trials are being maintained.

Establishment of Multilocational Trials of 100 Superior Accessions of *Jatropha curcas* under the Network Programme of DBT

Multilocational trial comprising of 100 superior accessions of *Jatropha curcas* received from network partners was established in July-August 2010 at GRC farm house, Sita Pahad, Jabalpur. The experiment was established following Randomized Block design (RBD) with four replications. The experimental field was divided in 400 equal sized plots and 9 plants were

NBDA Type Brick Kiln

Half Burnt Bamboo Charcoal

On Opening the Brick Kiln

Calorific Value Estimation Using Bomb Calorimeter

Traditional Type Pit Kiln

Charcoal Trade in Manipur

planted per plot at a spacing of 3m x 3m. The trial is performing well and the survival is more than 78%. Regular observations on growth attributes like height, collar diameter, number of branches, flowering, incidence of pests and diseases has been recorded on quarterly basis and data sent to Biotech Park, Lucknow for compilation. Best performing accession are JA-128 (IC- 471346), HP-16 (IC -569356), TJS-18 (IC-561291), TJS-07 (IC-569342), TJS-07 (IC-566612), RU-1 (IC-566601), RU-101 (IC-565667), RU-18 (IC-564020), RU-5 (IC-564013) and DBT-20 (569131) on the basis of statistical analysis. The trial is being maintained properly.

Development of Viable Technique for Efficient Charcoal Production from Different Bamboo Species of North Eastern India

Surveys were carried out in charcoal production areas of North East India and bamboo samples were collected. Fabrication of drum kiln and brick kiln (NMBA type) and carbonization of bamboo samples were carried out. Studies on average calorific value of different charcoals (*B. balcooa* 3623 Kcal/kg, *B. bambos* 4636 Kcal/kg and *B. tulda* 2810 K cal/kg) were found out by using Bomb Calorimeter.

Establishment of Multilocational Clonal Trial and Seedling Seed Orchard of *Jatropha curcas*

Two multilocational clonal field trials have been established at Haldighati, Udaipur. The first trial was established in the month of November, 2007 with 12 accessions and the second clonal trial was established with 8 accessions in the month of September, 2008 in RBD with four replications. Seedling seed orchards in Randomized Block Design (RBD) with 5 replications were established at Arid Forest Research Institute, Jodhpur and 15 replications at Haldighati, Udaipur. Percent survival in trial 1 varied from 08 to 42 percent. Highest value of mean plant height, number of branches and collar diameter was observed 124.24 cm in TERI/DBT/Jat/04-05, 4.33 and 5.30 cm in SDHQ4N4.

While, lowest value of mean plant height, number of branches and collar diameter was observed in accession BTP-K (96.92 cm), 1.50 and 2.67 cm in TERI/DBT-Jat/06/16, respectively after 52 months of growth period. Data were non- significant for plant number of branches height and collar diameter.

In clonal trial 2, percent age survival varied from 0 to 13.89. Maximum value of mean plant height and collar diameter was 103.75cm and 4.32cm in NBRI-JA-9, whereas, maximum numbers of branches were 4.50 in J-2. However, minimum value of plant height was 41.67cm in HS-44, number of branches were 2.00 in both accessions i.e. HS-44 and NBRI-JA-139 and collar diameter 2.14cm in HS-44. Data were non-significant for all the three parameters.

At AFRI, Jodhpur site, percent survival varied from 0 to 100 percent in SSO. The accession TERI/DBT-JATROPHA/07/05-06/14 showed maximum plant height 340.00cm and collar diameter 11.39cm, whereas number of branches was 7.50 in accession J-110. Minimum plant height 142.50cm and collar diameter 3.45cm was observed in accession TERI/DBT-JATROPHA/05/85 whereas, minimum number of branches was 4.00 in five accessions (TERI/DBT-JATROPHA/04/03,TERI/DBT-JATROPHA/04/05-06/04,TERI/DBT-JATROPHA/04/19, TERI /DBT/ JATROPHA/01/05-06/02, and TERI/DBT-JATROPHA/05/26).

At Haldighati, Udaipur site, percent survival varied from 13 to 73 percent. Maximum plant height, number of branches and collar diameter were observed as 211.67cm, 5.20 and 6.61 cm in accession TERI/DBT-JATROPHA/04/16, TERI/DBT/ JATROPHA/ 01/05-06/24, and TERI/ DBT-JATROPHA/ 07/05-06/38, respectively. Minimum plant height was shown by accession TERI/DBT-JATROPHA/05/26 (81.25cm). While, minimum number of branches were 1.50 in accession TERI/DBT-JATROPHA/07/05-06/30 and collar diameter 2.78cm in accession TERI/DBT-JATROPHA/04/31. Plantation at AFRI, Jodhpur site performed better than at Haldighati, Udaipur in term of growth parameter, however, accessions planted at Udaipur site showed better survival than at Jodhpur site. Data were non-significant. In half-sib trial, survival after 33 months of plantation varied from 0 to 46.67 percent. Maximum average plant height, number of branches and collar diameter observed were 226.25cm, 7.75and 4.55cm in accession MSSRF-62, respectively. Accession HAB-GARHWAL showed lowest value of plant height (99.44cm), number of branches and collar diameter (1.94cm). The data were non-significant for all parameters.

Genetic improvement of *Jatropha curcas* for Adaptability and Oil Yield

Performance of 18 selected elite accessions under arid conditions after 72 months of growth period indicated that survival varied from 6.25 to 75.00 percent. Overall, mean plant height, number of branches and collar diameter varied from 165.00 to 250.00cm, 3.00 to 5.50 and 4.68 to 9.48 cm, respectively. Seed yield ranged from no seed to 660.00g per plant. Percent survival in accessions of CRIDA varied from 31.25-75.00 percent. In accessions of CRIDA mean plant height, number of branches and collar diameter varied from 182.69-218.33cm, 4.00-4.75 and 6.38-7.30cm, respectively. Maximum plant height and collar diameter was observed in CRIDA-MP-Jhabua-02-03-JJ-06, while number of branches in CRIDA-AP-Adila-0904-JL-06. In CRIDA sources, only one accession CRIDA-MP-Jhabua-02-03-JJ-06 produced fruits and seed was 740.0g per plant. Performance of 63 native accessions after 65 months of growth period under arid conditions ranged from 33.33 to 100 percent, whereas, average plant height, number of branches and collar diameter from 165.0 to 305.00 cm, 2.00 to 5.00 and 3.77 to 12.68cm, respectively. Seed production varied from nil to 340.00 g per plant.

On the basis of across site performance, 14 accessions have been selected. The percent survival varied from 12.50 to 50.00 percent in elite accessions and 33 to 66 percent in native accessions. Mean plant height, number of branches and collar diameter

ranged from 150.00 cm to 230.00 cm, 32.0 to 86.00 and 5.25 cm to 7.60 cm, respectively in elite accessions. In native accessions, mean plant height, number of branches and collar diameter ranged from 177.50cm to 290.0cm, 37.50 to 165.00 and 6.96 cm to 10.63cm, respectively. No fruiting was observed in elite and native accessions.

In spacing trial, after 56-months of planting, percent survival varied from 13.75percent in (2x2) to 38.75 percent in (3x3). Maximum mean plant height was observed 218.79cm in 2.5x2.5 spacing treatment, while number of branches and collar diameter was maximum 51.58 in 2.5x2.5 and 6.99cm in 3x3 spacing. Minimum plant height, number of branches and collar diameter was observed 192.00cm, 27.60 in 2x2 and 6.75cm in 2.5x2.5 spacing. Only one treatment seeded this year 86.4g per plant in 3x3 spacing.

From the result of main plot analysis (irrigation effect), average plant height was 230.00cm in treatment I_0 and varied up to 245.52cm in I_1. Maximum number of branches and collar diameter was observed 85.02 and 10.19cm in I_3, respectively, while these were noticed minimum 50.54 and 8.09cm in control. Three irrigation treatments were seeded this year except control and I_1, which was ranged from 40.10g per plant in I_2 to74.2g per plant in I_3 treatment. Plant growth performance was not significantly affected by irrigation.

From sub-plot analysis (effect of fertilizer) result revealed that mean plant height ranged from 227.01cm in F_1 to 246.56cm in F_2. The mean number of branches and collar diameter was observed maximum 80.83 & 10.12cm in F_2 and minimum 57.47 & 8.25cm in $F_1$and control, respectively. Three fertilizer treatments were seeded this year except control, which ranged from 3.2g in F_1 to 32.10g in F_2 treatment. Plant growth performance was not significantly affected by fertilizer. Interaction of irrigation and fertilizer does not show any significant effect on growth performance of *Jatropha* after 61-months of planting.

In pollarding trial, performance of all the treatments was recorded after 49 months of imposing treatment. Percent survival varied from 24 percent (except control) to 32 percent in (T_0). The mean plant height and collar diameter ranged 171.75cm (T_2) to 216.13cm (T_3) and 6.71cm (T_0) to 7.97cm (T_2), respectively whereas, the mean number of branches ranged from 16.34 in control (T_3) to. 30.70 in (T_0). In pollarding trial, fruiting was observed in control and T_2 treatments during 2011-12. Analysis of variance suggested that effect of pruning is non -significant on all parameters of plant growth after 56 months months of planting.

Network Research Project on Guggal *Commiphora wightii* Arn. Bhandari

The clonal performance trial was established in RBD design with 4 replications with each replication has 8 plants per accession in September, 2007. The trial is 53-months old and survival varied from 44% of Jalore to 100% of Jaipur, followed by 94% of Barmer, Bikaner and Dausa. Mean Plant height varied from 120.14cm of Bharatpur to 205.22cm of Tonk, mean crown diameter varied from 114.64cm in Jalore to 203.9cm in Sikar source, nearly followed by 193.5cm of Tonk source and mean number of branches ranged from 4.1in Bhratpur to 7.6 in Jhunjhunu source. The data were significant for all the growth parameters at <0.01 probability level.

The main effects of various irrigation (I_1, I_2, I_3; 30, 45, 60 days) and fertilizer treatments (F_0 = No organic manure (FYM), F_1 = 2kg/pit, F_2 = 5kg/pit, F_3 = Urea 50g pit (46% Nitrogen), F_4 = SSP 50 g pit (20% Phosphorus), F_5 = 5kg FYM+ Urea 50g/plant, F_6 = 5kgFYM+ SSP 50g/plant, and F_7 = Urea + SSP (50g each) applied. In agri-trial of *Commiphora,* after 52 months of planting in the field on mean plant height (cm), number of branches and crown diameter (cm) ranged from 192.69cm in I_3 to 208.69cm in I_1, 4.46 in I_1 to 5.05 in I_3 and 168.96cm in I_1 to 174.08cm in I_3, respectively. The analysis of variance showed that irrigation intervals had high significant effect on

mean plant height and number of branches, whereas, crown diameter was not affected by irrigation.

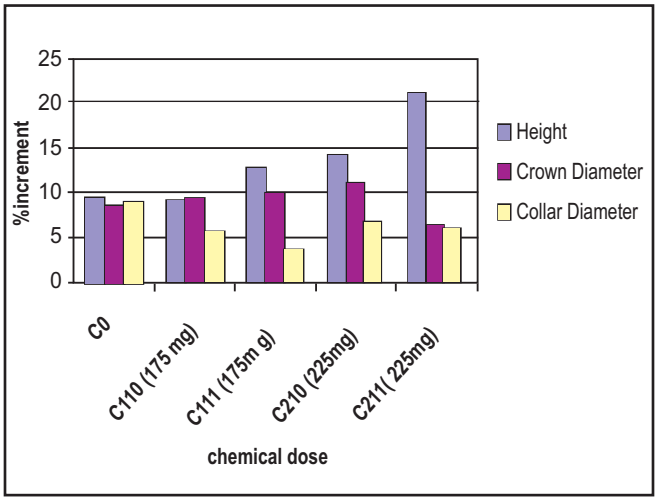
Fertilizer showed significant effect on *Commiphora wightii* plants. The mean height, number of branches and crown diameter varied from 192.2cm in F_7 to 215.8cm in F_2, 4.2 cm in F_1 to 6.6 cm in F_7 and 169.9 cm in F_5, nearly followed by F_1 (167.6cm) to 188.2cm in F_2, respectively. Analysis of variance revealed that effect of fertilizer on plant growth with respect to number of branches was highly-significant, whereas, plant height and crown diameter were significantly affected by fertilizer response.

To Develop Methodology for Enhanced/Non-destructive Gum Production

Tapping experiments were initiated in last week of March, 2011 in all the plants including those which were tapped twice earlier (in the year 2008 and 2009) with varying ethephon doses (C_0, C_1-175 and C_2-225 mg) and irrigation I (I_0 no irrigation, I_1-60 lit./plant; two days before tapping in both the ethephone doses). The first collection of gum was done after 7-15 days. Subsequent gum was collected after ten days to thirty days till May, 2011. Irrigation adversely influenced the gum yield in both the ethephone doses. Control recorded the least (25.13g) and C_2Io treatment yielded the highest (153.82 g) gum.

The total gum yield in different treatments was as C_0 - 25.13 g (range 4.62-12.59g), C_1Io (175mg) - 59.54g (range 11.36-27.98g), C_1I_1 (175 mg)- 36.53g (range 5.96-16.35 g), C_2Io (225mg)- 153.82g (33.63-65.19g) and C_2I_1 (225 mg)- 50.73g (12.77-22.65g). Though the trees were tapped third time so far (12 months after third tapping) there was no casualty in any treatment.

All the three experimental trials were maintained in Kumatia enclosure, Kailana Forest Area, Jodhpur. Protection measures (application of termiticide and fungicide) were applied in August, September and December, 2011. Growth data (Height, crown and collar diameter) were recorded in Oct- Nov, 2011.



Per cent Increment of Growth Parameters (year 2011)

While the control plants have minimum mean height 215.0 cm, crown diameter, 265.0 cm and collar diameter 13.5 cm C_2I_0(225mg ethaphone) treatment recorded maximum height 323.3 crown diameter 356.66 cm and collar diameter 18.06 cm, having 3-10 number of branches/plant. The incremental height, crown and collar diameter range from 8.91 to 21.11%, 6.31 to 11.17% and 3.72 to 8.96%, respectively, in different treatments.

Data showed that on the same dose of ethephon, irrigated plants have higher height increment as compared to un-irrigated plants. In case of collar diameter, the trend is reverse in which un-irrigated plants showed higher increment on the same dose. In crown increment, the effect of irrigation is not visible.

Soil analysis of plant pit samples collected in summer 2011 after cessation of gum exudation has been carried out. The ranges of per cent moisture were (0.25 to 1.22%), pH (7.31 to 8.32), EC (0.254 to 0.722 dSm^{-1}), % SOC (0.119 to 0.973 %) and phosphorus (0.22 to 2.26 ppm).

Thin branches were collected to analyze secondary metabolites in the month of November, 2011. Percent moisture in thinner branches (post ethephone treated plants) was ranging from 62.55 in treated plants to 68.66 % in control. In experiment-2, Pre-ethephon

solvent extractions with petroleum ether, ethyl acetate and acetone extracts were 1.52 to 1.86%, 1.02 to 1.38% and 0.71 to 0.94%, respectively. The thinner branches (post ethephon -2010) were collected after second consecutive gum extraction and pulverized. The powdered material was extracted with petroleum ether (60-80°), ethyl acetate and acetone, successively. The mean values showed that maximum per cent extractives were obtained with petroleum ether. It was maximum in control (2.89 %), followed by 2.36 to 2.76 % for different doses of ethephon. In case of ethyl acetate, the pattern was reverse, minimum per cent extractives obtained in control (1.56%) while, maximum 1.62 to 2.12% in different doses of ethephon. Similarly, in acetone, 1.35 per cent in control, followed by 1.38 to 1.51% in different doses of ethephon. Indicating that extractives yield is increasing in treated plants as compared to control. It is also reported that Guggulsterone comes in ethyl acetate fraction.

Phenological observations were recorded on monthly basis for all the plants in experiment viz; 1, 2 and 3. Plants were lush green after rains in monsoon with occassional fruiting. Leaves started yellowing in early October and all the plants were completely leafless in late October, 2011 with flowering and sporadic fruiting. Fruits were collected in Dec, 2011 and it was found that untreated plants recorded 130 fruits/20 g as compared to 144 fruits/20 g in treated plants.

Development of a Database on Tree Borne Oilseeds (TBO) in India

In order to estimate the statewise acreage of cultivation of seven Tree Borne oilseed species from Gujarat and Rajasthan, government Institutions viz; State Forest Department, Horticulture, Agriculture Departments, NGO etc. were contacted and data collected. Under this study, information regarding seven mandatory Tree Borne Oilseed Species viz; Jatropha (*Jatropha curcas*), Karanja (*Pongamia pinnata*), Neem (*Azadirachta indica*), Mahua (*Madhuca indica*), Mango kernel as feed, Jojoba (*Simmondsia chinesis*), Piloo (*Salvadora spp.*) falling in the jurisdiction of AFRI viz. Gujarat and Rajsthan were collected and summerized. Bio-fuel authority of Rajasthan plantation data; targets and achievement for *Jatropha curcas* raising, seedling raising and district-wise progress of nursery raising from 2006-07 to 2010-11 were collected.

Survey, Selection Performance Trial and Estimation of Yield Potential of *Jatropha curcas* in Rajasthan and Gujarat

Two progeny trials one with 5 replications at AFRI, Jodhpur and another with 15 replications at Haldighati, Udaipur having single plant per replicate in RBD with 30 CPTs were established in July, 2008. At AFRI, Jodhpur site, the survival varied from 40 to 100 percent. Maximum mean height, number of branches and collar diameter were observed as 268.33cm (in BK-499), 6.80 (in 86 AFRI-3) and 10.95cm (in CSMCRI-1), while, these were minimum 126.00cm, 3.60 and 4.66cm, respectively in EL-19 AFRI-17. At Haldighati, Udaipur site, percent survival varied from 20 to 67 percent. Plant height, number of branches and collar diameter were maximum 151.67cm, 5.33 and 6.36cm, respectively in 76 AFRI-2. Minimum plant height and collar diameter were 46.67cm and 1.83cm in (86 AFRI-3), respectively and number of branches was 1.75 in CSMCRI-3. The CPTs at AFRI, Jodhpur site only yielded fruit and seeds, whereas, at Haldighati, Udaipur no flowering/fruiting was observed. Analysis of variance showed that the number of branches was significant at 0.01 probability level in AFRI, Jodhpur trial, whereas remaining growth parameter were non-significant at both the sites.

Development of seed yield equations

Carried out measurement in the two sample plots of *J. curcas* laid out at Motiya Research Farm, Rajpipla (Gujarat) during 2011-12. Total mean height, mean collar diameter and mean crown width varied from 2.65m to 3.06m, 14.61-15.78cm and 2.23 to 2.33m, respectively. Observation on the seed yield was also

taken, which varied from 300.0g to 360.95g/plant. Regression could produce relationship between seed yield and height, and SY vs. CD. Two different relationships: one LN (SY) vs. 1/HT or 1/CD, other SY vs. HT or CD. Calculated estimated seed yield based on these equations. The equation which gives more close value to observed data was considered. It was clear that CSMCRI clones were better as compared to SRT and BCR. They are having more height and seed yield as compared to SRT and BCR, though their age as only 5 years, while ART and BCR are of 7 years of age. Based on data recorded from two plots (5-7 years) at Motiya research farm during 2011-12, the yield equation developed is as follows:

LN(SY(1) = 6.614686-2.24806*1/HT
LNSY(2) = 4.33385 + 22.36682*1/CD
SY(1) = 94.50689 + 69.33952*HT
SY(2) = 821.4786-32.1123*CD

Suitability of *Jatropha curcas L.* Seed Sources in Lower and Mid Himalayan Regions of Himachal Pradesh (Externally Aided Project)

Under this project, seeds were collected from 29 seed sources and 19 individual trees in Himachal Pradesh and sent to The Energy Research Institute, (TERI), New Delhi for estimation of oil per cent. Passport data of all the collections recorded as per standard format provided by National Bureau of Plant Genetic Reource (NBPGR), New Delhi. After the result of oil contents, the plants were raised from the seeds of superior accessions i.e. >30% oil contents. Identified 21 nos. seed sources having seed oil contents >30% from various parts of Himachal Pradesh out of which 9 nos. seed sources have oil content >35%. Established demonstration plantations with approximately 57,000 plants planted at various places of Himachal Pradesh on 23 ha. area namely Thakurdwara (Nalagarh), Joharji (Solan), Majhouli (Solan), Brahmpukher (Bilaspur), Bhojnagar (Solan), Samloe (Sunni), Devidhar (Sunni), Dharja (Solan), Samati (Solan), Narag (Sirmour), Sarahan (Sirmour), Nalagarh (Solan). At the end of the project, demonstration plantations on 16 ha. were surviving. The various growth parameters were recorded regularly in those demonstration-cum-experimental plantations. Subsequently seeds were also collected from the various demonstration plantations and seed yield recorded. The seeds from some progenies were also sent to TERI, New Delhi for oil estimation. Nursery studies, for raising *Jatropha curcas* in lower and mid-Himalayan regions of Himachal Pradesh was conducted. Seeds from various seed sources were also submitted to NBPGR, New Delhi for getting IC#No of the seed sources. Cuttings of different accessions were provided to network partners at different stages of the project. Frost seems to be an important factor in fruit setting in *Jatropha curcas* as frost prone areas produced very less seed per plant. Seed maturity was also reported as a serious problem owing to early winters in some areas of Himachal Pradesh. Altitude and aspect found to considerably affect growth and survival in *Jatropha curcas* plantations in lower and mid Himalayan regions. Establishment of *Jatropha* in Lantana infested areas was proved to be a very difficult task. However, the project has been completed successfully during March 2011 and, now, the demonstration plantations will serve as source of experimental material for future research activities as well as for training purposes.

Field Evaluation of Superior Accessions of *Jatropha curcas* Under Micro-mission Programme in Himachal Pradesh (Externally Aided Project)

Multilocational experimental trial of rooted cuttings of 10 superior accessions of *Jatropha curcas* repeated at Jawalaji area of Kangra district of Himachal Pradesh during September 2010 was maintained. The trial also covered 0.5ha area and recorded very good initial survival. The growth and survival data are being recorded regularly. Similarly, half-sib trial of *Jatropha curcas,* representing 20 superior accessions obtained from NBPGR, New Delhi as per the instructions of the funding agency was also carried out at Jawalaji of Kangra district of Himachal Pradesh in 1ha. area. The

Jatropha plants were growing vigorously in the trial and flowering was recorded in the second year of plantation. Pruning of plants has been done in the month of February 2011 as per the guideline provided by Jatropha National Coordinator of DBT, New Delhi.

Growth and survival data of experimental plantations was recorded regularly. Maintained Jatropha experimental plantations intensively, during 2011 for better growth, survival and branching. In Multi-location experiment, beating up of casualities carried out during 2011 rains. After pruning, vigorous branching has been recorded in the half-sib progeny trial, however, that also resulted into less fruit yield during 2011. Fruits/ seeds collected from different accessions during October- November 2011 from half-sib progeny trial and Various fruit and seed parameters were recorded.

Enhancement of Branching after Pruning in Jatropha plant at Half-sib trial

Half-sib Trial of *Jatropha*