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List of Abbreviations

ABA	Abscisic Acid
ADG	Assistant Director General
AF&E	Agroforestry and Extension Division
AFRI	Arid Forest Research Institute
AMF	Arbuscular Mycorrhizal Fungi
AM	Arbuscular Mycorrhiza
ANOVA	Analysis of Variance
ATMA	Agricultural Technology Management Authority
AICP	All India Co-ordinated Project
BAP	Benzyl-aminopurine
BOD	Biochemical Oxygen Demand
CAZRI	Central Arid Zone Research Institute
CBL	Clear Bole Length
CD	Critical Difference
CETP	Common Effluent Treatment Plant
COD	Chemical Oxygen Demand
CPTs	Candidate Plus Trees
CPP	Candidate Plus Plant
CSIR	Council of Scientific & Industrial Research
CSMCRI	Central Salt & Marine Chemical Research Institute
CSOs	Clonal Seed Orchards
DBH	Diameter at Breast Height
DBT	Department of Biotechnology
DEMO	Demonstration
DNH	Dadra & Nagar Haveli
EC	Electrical Conductivity
ENVIS	Environmental Information System
FAS	Financial Accounting System
FAO	Food & Agriculture Organization
FED	Forest Ecology Division
FGTB	Forest Genetics and Tree Breeding
FPD	Forest Protection Division
FRI	Forest Research Institute
FYM	Farmyard Manure
GBH	Girth at Breast Height
GCA	General Combining Ability
GCV	Genotypic Coefficient of Variation
GEER	Gujarat Ecological Education & Research

GFD	Gujarat Forest Department
GFRC	Gujarat Forest Rangers College
GIS	Geographic Information System
GPS	Global positioning system
GSFDC	Gujarat State Forest Development Corporation
HRD	Human Resource Development
ICFRE	Indian Council of Forestry Research & Education
IAA	Indole Acetic Acid
IBA	Indole butyric Acid
IFRIS	Indian Forestry Research Information System
IGNP	Indira Gandhi Nahar Pariyojana
IIRS	Indian Institute of Remote Sensing
IITJ	Indian Institute of Technology, Jodhpur
IT	Information Technology
IWST	Institute of Wood Science & Technology
IWMP	Integrated Watershed Management Project
IVI	Importance Value Index
JA	Jasmonic Acid
JFM	Joint Forest Management
LCM	Leaf Compost Manure
MD	Managing Director
Mg	Mega Gram(10^6 g)
MKU	Madurai Kamaraj University
MLA	Member of Legislative Assembly
mM	Millimol
MMS	Modified Murashige and Skoog
MOU	Memorandum of Understanding
MS	Murashige and Skoog
NABARD	National Bank for Agriculture and Rural Development
NBPGR	National Bureau of Plant Genetic Research
NBRI	National Botanical Research Institute
NFLIC	National Forest Library and Information Centre
NGO	Non Governmental Organization
NMPB	National Medicinal Plant Board
NPK	Nitrogen-Phosphorus-Potassium
MPTs	Multipurpose Tree Species
NS	Not significant
NTFP	Non Timber Forest Product
NWFP	Non Wood Forest Product
OBC	Other Backward Class

PAL	Phenylalanine lysase
PCV	Phenotypic Coefficient of Variation
PDA	Potato Dextrose Agar
PIMS	Personnel Information Management System
PMS	Payroll Management System
RADAR	Radio Detection and Ranging
RAPD	Random Amplified Polymorphic DNA
RT-PCR	Real Time Polymerate Chain Reaction
RBD	Randomized Block Design
RD	Relative Distance
RFD	Rajasthan Forest Department
RIMS	Research Management Information System
RSFD	Rajasthan State Forest Department
RSR	Root Shoot Ratio
RTI	Right To Information
SA	Salysilic Acid
SAUs	State Agriculture Universities
SC	Schedule Caste
SE	Somatic Embryo
SFD	State Forest Department
SHAN	Sequential Agglomerative, Hierachial and Nested
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SPAs	Seed Production Areas
SSP	Single Super Phosphate
SSOs	Seedling Seed Orchards
ST	Scheduled Tribe
SWC	Soil water Content
TANU	Tamilnadu Agriculture University
TDZ	Thidiazuron
TOF	Tree Outside Forest
TREE	Training, Research, Extension & Education
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
USDA	United States Department of Agriculture
UT	Union Territory
UV	Ultra Violet
VAM	Vesicular Arbuscular Mycorrhiza
VVK	Van Vigyan Kendra
WAS	Wild Ass Sanctuary
ZSI	Zoological Survey of India

ANNUAL REPORT 2014-15

Executive Summary

Since establishment in western dry region of India, Arid Forest Research Institute is addressing forestry research needs of Rajasthan, Gujarat, Dadara & Nagar Haveli and Daman & Diu (UT). Research project taken up cover different Thrust areas and themes. Thirty two projects executed during 2014-15 included 6 new projects initiated in the year. Out of this 10 projects have been completed, whereas 16 projects are ongoing. Forestry research findings were disseminated to the end users/stakeholders through three VVKs (Van Vigyan Kendra), established in Rajasthan, Gujarat and Dadara & Nagar Haveli, Demo village and demonstration trials, participating in Kisan Mela/Hastshilp Mela, organizing different trainings, workshops, meetings, publishing and distributing brochures, pamphlets, AFRI Darpan, publications of research papers and participating in seminar, conferences and workshops. Besides, a manual book based on existing literature is in completion for SFD, Rajasthan.

The research theme managing forest and forest products for livelihood support and economic growth is addressed by projects including agroforestry, where *Hardwickia binata* and *Colophospermum mopane* trees reduced yield of *Cymopsis tetragonoloba* crop and *Cenchrus ciliaris* grass, respectively as compared to the sole crop. But removal of tree branch and root barrier treatment favoured system productivity. Likewise, annual increment in height was more in control trees but those of crown and collar diameter were higher in *C. mopane* -*C. ciliaris* silvipastoral system as compared to control but crown and collar diameter was less. The Grass yield ranged between 225 to 800 g m⁻². Total dry yield of C-1017 observed better as compared to 1003 cultivar in *S. nudiflora*-*C. tetragonoloba* system. To enhance fruit yield, *Capparis decidua* trees were treated with leaf compost, goat FYM and VAM in combination of different phosphorus, potassium and micro-nutrients combinations along with moisture conservation measures. Overall 9.34 % shrubs fruited three times, 20.5 % two times, 45.8% one time and 24.3 % shrubs did not flower in one year. Combined result indicates that out of three organic manures, LCM is the best in combination to inorganic fertilizers. Fruits from marked trees of *Capparis decidua* and *Prosopis cineraria* were collected. Based on their morphological parameters, grading of these fruits was carried out. For standardization of non-destructive harvesting practices of *Commiphora wightii* gum Kumatia enclosure near Jodhpur and

Taranga hills near Kheralu in Mehsana have been selected and guggul plants of different age marked. Cuts of four different sizes and three different patterns were applied and gum production estimated.

Nutritional value of edible leaves/fruits/tubers of eight wild plants namely *Calligonum polygonoides*, *Cassia tora*, *Haloxylon salicornicum*, *Ceropegia bulbosa*, *Leptadenia pyrotechnica*, *Leptadenia reticulate*, *Cordia gharaf*, and *Grewia tenax* was evaluated. Anti-oxidant activity of flowers of *Calligonum polygonoides* was observed highest ranging from 81.10 - 93.08%. Quantification of NTFPs in tribal dominated area of Sirohi reveals that NTFP is a year round activity and on an average contributes to about 15% (10-30%) of the total income of the families. Neem products and their role in socio-economic upliftment have also been documented. In Mehsana, Gujarat, farmers are using Neem leaves as assured fodder costing Rs 3-4/kg for cattles (either alone or mixed with dry fodder or straw) and woody portion of lops as fuel wood. Information on forest dependency and socio-economic conditions of the selected forest fringe villages have been collected in 12 districts each in Rajasthan and Gujarat.

Growth and yield studies of *Tectona grandis* is being conducted in plantation in Gujarat, growth measured and 15 trees fell from three plots for validation of the data and modeling. Attempt has also been made to study post harvest technologies of *Azadirachta indica* and *Acacia senegal* wood as alternative timber species for handicraft industries. Soil physical and chemical parameters and site characteristics compiled, district maps delineated and geo-referenced data points have been overlapped on the maps using GIS for mapping of carbon stock and soil class. Under managing pathogens and insect pests, antifungal properties of various parts of *Balanites aegyptiaca*, *Tephrosia purpurea*, *Citrullus colocynthis*, *Tribulus terrestris*, *Datura stramonium* and *Argemone mexicana* were evaluated, where increased concentration of extract was inversely related to fungal growth. A checklist of 171 insect pests associated with eight important forest trees and grass species of Gujarat has been prepared. Population dynamics and life cycle of some insect pests studied and their control measures suggested.

Finding of the coordinated project on Khejri mortality management, reveals that trees are drying due to attack of root rotting fungus (*Ganoderma lucidum*) and subsequently by root borer (*Acanthophorus serraticornis*). Management trial is in process in nursery as well as laboratory against the root rot pathogen (*G. lucidum*) and root borer (*Acanthophorous serraticornis*) in which a combination of chemical pesticides/fungicides as well as botanicals and bioagents are being used. Data collected on pod parameters from 52 individual CPTs revealed highly significant differences and

heritability. Progeny trial of 52 families has been established. A total of 25 RAPD primers have been screened for DNA fingerprinting and for genetic variability. Correlations analysis between ground water table/ground water recharge data and mortality and biochemical tests of health and infested trees are in progress. 387 villages covering 3000 farmers of Jodhpur, Nagaur, Sikar, Churu and Jhunjhunu districts has been surveyed for socio-economic impact of khejri mortality. Brochures/pamphlets highlighting khejri mortality problems and its management strategy were distributed round the year to the farmers and other stakeholders to generate awareness.

Biodiversity conservation and ecological security is covered the projects, where an inventory of 123 sacred groves of Rajasthan shows dominance of 131 woody species belonging to 48 families and home of many faunal species indicated by at least 19 birds, 25 mammals and 10 reptiles including the Alexandrine parakeet. Threats identified and various steps in managing and rehabilitating the sacred groves suggested. Impact of *Prosopis juliflora* on biodiversity has been assessed where 25 plant species and 34 animal species have been found associated with it.

Modern nursery practices are under refinement for raising quality seedlings of forest tree species namely *Prosopis cineraria*, *Tecomella undulata* and *Azadirachta indica*. Different treatments were different sized polybags/ containers and composts like manure compost, vermicompost, Gobar manure, leaf compost and goat manure. An attempt has also been made for rapid decomposting, vermi-composting and production of biofertilizers (AM, *Rhizobium*, *Azospirillum* and *Azotobactor*) for its use in improving seedling growth of forestry species. Different combinations of *Rhizobium* sp., *Trichoderma viride*, *Bacillus thuringiensis*, AM, *Azospirillum* and PSB have also been tested and observed enhancing growth and vigour of seedlings of different tree species. Besides, fungus associated with Charcoal root rot disease, white root rots, damping off and wilting of Neem in plantation as well as in nursery have also been isolated and identified. Extent of wastewater disposal and its utilization is being studied through survey, sampling and planting with different tree species. *Azadirachta indica*, *Eucalyptus camaldulensis* and *Prosopis juliflora* exhibits better growth at ¾ of full irrigation. A new project has also been initiated to evaluate different tree and shrub species for their suitability in restoration of degraded hills using rainwater harvesting structures.

Forest and climate change is covered by a project identifying best practices for enhancing livelihood and climate change adaptations among the villagers and supporting mitigation (i.e., carbon sequestration) methods of field sampling and people interaction have been adopted and adaptation and mitigation strategies to climate change documented. Adaptation strategies include change in

occupation and migration to other places for livelihood; use of hybrid seeds, chemical fertilizers, pesticides to increase production; mix-cropping and vegetable farming; increased irrigation capacity; and rain water harvesting for enhanced drinking water security.

Forest Genetics Resource Management and Tree Improvement have been dealt with the projects including salt tolerance through gene expression pattern analysis has been studied using *Lepidium sativum*-a halophyte. Gene expression level is interpreted through extraction of RNA by growing plants at different salinity levels. RT-PCR was performed on transcripts of selected genes, amplified gene separated and values of bands on gel images captured. Micro propagation protocol of *Capparis decidua* and *Salavadora persica* were developed. MS medium supplemented with BAP, IAA and additives were found best for *in vitro* shoot multiplication of *C. decidua* and *S. persica*. *In vitro* rooting was obtained. Different success rates of hardening have been obtained in these species. Additionally, clonal propagation of genetically superior trees of Neem, Ardu and Bamboo have also been taken up and superior trees selected and marked. *In vitro* shoot multiplication optimized. Mature cuttings of Ardu and Neem were also treated with different concentrations of IBA and planted in vermiculite and soil + vermiculite rooting medium.

For assessment of variability and improvement of *Tecomella undulata*, progeny trial has been established and genetic diversity studies initiated. Progeny of CPT No-36 from Pali district gave the best growth attaining the height of 120 cm and collar diameter of 1.58 cm. Besides, genetic improvement of *Melia composita* is in way by laying three progeny trials consisting of 24 families and two progeny trials with 21 families. Respective values of height and color diameter are 2.80 m and 19.66 cm at Deesa, 2.42 m and 15.85 cm at Jodhpur and 0.84 m and 5.45 cm at Gandhinagar trials. The study on inheritance of teak and estimation of the genetic parameters in western Indian teak based on individual trees data from four progeny trials indicates very low to high family heritability values. Height, clear bole length, sap wood length, sap wood percent, heart wood percent, heart wood sap wood ratio and specific gravity exhibited significant variation amongst the 16 families.

Summary of projects

Projects	Completed Projects	Ongoing Projects	New Projects Initiated During the Year
Plan	6	11	-
Externally Aided	4	5	6
TOTAL	10	16	6

Significant findings

- Literature analysis indicates an exponential increase in human population and decrease in water availability in Rajasthan, whereas livestock population increases by a power model.
- Removal of branch and application of root barrier enhanced productivity of *Hardwickia binata* and *Colophospermum mopane* based agroforestry systems.
- Annual increment in tree height was more in control and those of crown and collar diameter increment were higher in silvipastoral system of *C. mopane* and *C. ciliaris* combination.
- Dry matter yield of C-1017 was observed better as compared to 1003 cultivar in *S. nudiflora*-*C. tetragonoloba*, system.
- Fruit yield of *Capparis decidua* trees was highest under leaf compost treatment as compared to other composts.
- Evaluation of nutritional value in different plant species indicated highest anti-oxidant activity in the flowers of *Calligonum polygonoides*.
- Non-timber forest products contribute to 15% (10-30%) of the total income of the families in tribal areas of Sirohi.
- Documentation of socio-economic importance of Neem products showed leaves as assured fodder costing Rs 3-4/kg and woody portion of lops as fuel wood.
- Small and marginal land holdings and poor irrigation facilities increases dependency of tribal peoples on forests.
- Continuous hacking, clearing of tree for cultivation, uncontrolled grazing and repeated fires affects regeneration of Teak, whereas regenerations of *Diospyros melanoxylon*, *Anogeissus latifolia*, *Butea monosperma* and *Lagerstroemia parviflora* are relatively better.
- 15 trees of *Tectona grandis* fell in plantation in Gujarat and data validated.
- Geo-referenced data points have been overlapped on the maps using GIS for mapping of carbon stock and forest soil class.
- Increased concentration of extract of *Balanites aegyptiaca*, *Tephrosia purpurea*, *Citrullus colocynthis*, *Tribulus terrestris*, *Datura stramonium* and *Argemone mexicana* affects fungal growth negatively.
- A checklist of 171 insect pests associated with eight important forest trees and grass species of Gujarat has been prepared.
- Causal organism of khejri mortality has been identified as root rotting fungus (*Ganoderma lucidum*) and subsequently the root borer (*Acanthophorus seraticornis*).
- A progeny trial of 52 families of *Prosopis cineraria* has been established.
- Twenty five RAPD primers have been screened for DNA fingerprinting and for genetic variability in *P. cineraria*.

- Maximum temperature, minimum relative humidity and increased ground water table showed beneficial effects, i.e. decreased khezri infestation percentage.
- Survey of 387 villages covering 3000 farmers of Jodhpur, Nagaur, Sikar, Churu and Jhunjhunu districts indicated a loss of 18.9 kg loong per tree during 2005 to 2010.
- An inventory developed for 123 sacred groves of Rajasthan shows occurrence of 131 woody species belonging to 48 families and observed dominated by 26 types of tree species.
- Sacred groves are home of many faunal species indicated by at least 19 birds, 25 mammals and 10 reptiles including the Alexandrine parakeet.
- Under impact assessment, 25 plant species and 34 animal species have been found associated with *Prosopis juliflora*.
- Performance of *Prosopis cineraria*, *Tecomella undulata* and *Azadirachta indica* seedlings varied with size of polybags/ containers and types of composts used.
- Application of a combination of *Rhizobium* sp., *Trichoderma viride*, *Bacillus thuringiensis*, AM, *Azospirillum* and PSB enhances growth and vigour of trees seedlings.
- Different fungus associated with Charcoal root rot disease, white root rots, damping off and wilting of Neem in plantation as well as in nursery have been isolated and identified.
- *Azadirachta indica*, *Eucalyptus camaldulensis* and *Prosopis juliflora* exhibits better growth at $\frac{3}{4}$ of full irrigation with treated wastewater of Jodhpur.
- Climate change adaptation among the people of western Rajasthan are change in occupation and migration to other places for livelihood; intensification of farming; mix-cropping and vegetable farming; increased irrigation capacity; and rain water harvesting for enhanced drinking water security.
- RT-PCR was performed on transcripts of selected genes in *Lepidium sativum*, amplified gene separated and values of bands on gel images captured.
- Micro propagation protocol of *Capparis decidua* and *Salavadora persica* were developed, where MS medium supplemented with BAP, IAA and additives were found best for *in vitro* shoot multiplication.
- Superior trees of Neem, Ardu and Bamboo selected and marked and *in vitro* shoot multiplication optimized.
- Progeny trial of *Tecomella undulata* established and genetic diversity studies initiated.
- Three progeny trials of *Melia composita* consisting 24 families and two progeny trials with 21 families established.
- Height, clear bole length, sap wood length, sap wood percent, heart wood percent, heart wood sap wood ratio and specific gravity exhibited significant variation amongst the 16 families of teak.

1. Introduction:

A. Structure:

Arid Forest Research Institute, Jodhpur (Rajasthan), is one of the nine institutes of the Indian Council of Forestry Research & Education (ICFRE), an autonomous organization of the Ministry of Environment, Forests & Climate Change, Govt. of India. The goals of the institute are to carry out scientific research in forestry & allied fields to enhance the productivity & vegetative cover, to conserve the biodiversity and to develop the technologies for the stakeholders working in forestry sector in Rajasthan, Gujarat, Dadra & Nagar Haveli and Daman & Diu (Fig. 1).

The major emphasis of research of the institute are on soil, water & nutrient management, technologies for afforestation of stress sites, management of plantations, growth and yield modeling, planting stock improvement and biotechnology, bio-fertilizers and bio-pesticides, Agroforestry, JFM & extension, phytochemistry & non-timber forest products, integrated pest & disease management, biodiversity and climate change and forestry education and extension. During 2014-15, 32 projects were executed including 11 externally funded projects from different funding agencies like Rajasthan Forest Department, Gujarat Forest Department, National Medicinal Plant Board, New Delhi, Department of Science and Technology, New Delhi and IIM, Udaipur, Rajasthan. During the year under report thirty new group C technical and non-technical staff, namely, one junior hindi translator, one library information assistant, one research assistant grade-I, thirteen technical assistant group C, six lower divisional clerks and 8 multy tasking staff were recruited in the Institute. Also, three scientists, three research officers, three research assistants grade I and one research assistants grade II were given promotion to next higher grade. One steno grade I was promoted to the grade of private secretary. Three officers from Indian Forest Service joined the Institute on deputation.

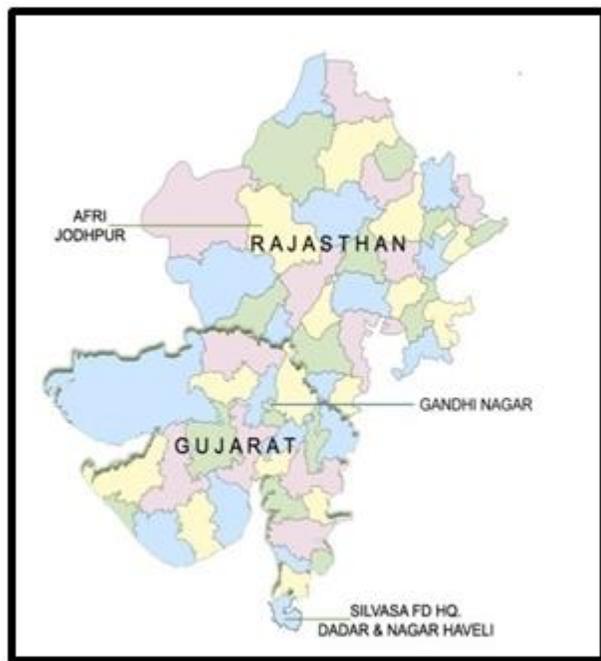


Fig 1. AFRI's mandated states & Union Territories

During the year eighteen new scientific equipment at total cost of 66 lakhs were procured under one time grant (OTGS) of ICFRE for different divisions.

2. Managing Forest and Forest Products for Livelihood Support and Economics Growth

Project 1: Enhancing fodder productivity through silvipastoral system on degraded land of India (AFRI-02/NWFP/Int(ICFRE)AICP/2012-2017).

Principal Investigator: Dr. Ranjana Arya, Scientist G

Silvipastoral systems are very important in arid and semi-arid areas to enhance productivity, livelihood support and mitigation of climate change and harnessing of environmental benefits. Different silvipastoral systems were assessed under above research project. Results achieved under this project are described in following paragraphs.

***Colophospermum mopane* - *Cenchrus ciliaris* Silvipastoral System**

Field trial was maintained including replacement and repairing of structures. Because of high soil pH (9.08 - 10.0) and poor grass establishment, soil replacement on those soil structure and resowing of *C. ciliaris* variety CC 358 grass obtained from CAZRI were carried out.

Germination was poor for the *C. ciliaris* variety CC 358, however, green grass yield for *C. ciliaris* CAZRI 75 (collected from the clumps sown in 2010 in the same field and sown last year) was estimated by laying quadrats of 1x1m randomly on the soil structures, and it was ranging from 225 to 350 g m⁻² which is slightly less as compared to last year (Fig 2 a-c). Grass yield for other *Cenchrus* spp was *C. setigerus* (400-780 g m⁻²), *Cenchrus* spp (500-800 g m⁻²) and *C. biflorus* (550 gm⁻²).

Annual growth data (height, crown diameter and collar diameter) was recorded for *C. mopane* plants. The mean incremental plant growth for height over last year was 13.6% in trees with grass as compared to 11.35% in control trees. The increment in crown diameter was 13.82% in control trees compared to 11.46% in trees with grass. Growth difference (21.2%) was highly significant for collar diameter with mean value of 18.03 mm for control trees to 14.88 mm for tree with grass.

Soil pH in June 2014 was 7.69 and 7.95 in 0-20 and 20-40 cm soil layer inside plant pit, however mean soil EC was 1.07 and 0.46 dSm⁻¹ for the same. Again in Feb 2015, pH was 7.9 to 8.22 and 7.95 to 8.29 inside plant pit for 0-20 cm and 20-40 cm soil layer. Similarly, EC values are also in

normal range of 0.44 to 0.5 and 0.17 to 0.67 d Sm⁻¹ for upper and lower soil layer, respectively indicating that plant growth helps in soil amelioration.

***Suaeda nudiflora*- *Cymopsis tetragonoloba* agroforestry system**

S. nudiflora seedlings were obtained from Harij nursery in Gujarat. Disc ploughing and soil leveling was done as preplanting preparations (Fig. 2 d-f). Layout was done and soil bunds of the size 1m x 18 m x 0.3 m were made at a spacing of 5 m. Seedling planting was done in August 2013 after good rain at a spacing of 4 m on each bund with goat FYM (1 kg) and SSP (15 g).

Trial was maintained and the casualty replacement was done (July 2014). The mean survival of 71.3% after 14 months (Oct 2014) did not register appreciable decrease from 75% in March 2013, while mean height (104.1cm) and crown diameter (81.2 cm) registered an increase by 1.5 times and 4 times, respectively over five months. Irrigation was done in Feb and March 2014 and double ridge mounds were created around the individual plants. In the next six months, there was 22.9 % increase in mean height (128 cm), but no change in crown diameter. The mean collar diameter was 20.3 mm registering 34.4% increase over the October values.

Crop (*C. tetragonoloba*) sowing:

Two varieties, BS RGC 1003 & TFL RGC 1017 of *C. tetragonoloba* obtained from Agriculture University, Mandore were sown in the inter row spaces of *S. nudiflora* plantation in the third week of August 2014. It has salinity gradient and the soil EC was ranging from 1.05 to 11.19 dSm⁻¹ for 0-20 cm and 0.92 to 7.59 dSm⁻¹ in 20-40 cm soil depth.

Initial germination after one week of sowing was 50-60% which increased to 80-85 % in first week of September 2014. Afterwards it rained and water logging took place in the crop area resulting in only 10-15% survival in Mid October. Crop yield was estimated in November 2014. Out of the two cultivars total dry yield of C-1017 were 170g/m² with 41.5g/m² seed yields in comparison to 1003 cultivar with 140g/m² including 34g/m² seed yield. Saline conditions of soils reduced the total dry yield as it was 164g/m² (35.1 g/m² seed yield) for C-1017 variety and 109.0 g/m² 23.1 g /m² seed yield) for C-1003. Seed size decreased, number of seed per gm was 35 and 36 for 1003 and 1017 respectively as compared to 27 and 29 originally.

After rain and due to leaching of salts many species appeared on the bunds. The number ranged between 5 and to 10 with decrease in salt concentration, totaling 15 number of species in the experimental area.



a. Establishment of *C. ciliaris* (C-75) on soil slope with *C. mopane*



b. Growth of *C. ciliaris* (C-75) between rows



c. Establishment of *C. ciliaris* (C-358) on bundslope with *C. mopane*



d. *S. nudiflora* on DRM



e. Growth of *C. tetragonoloba* on salty inter-row spaces



f. *C. tetragonoloba* on normal soil

Fig 2. Silvipastoral studies on degraded salty soil in Gangani, Jodhpur

Project 2: Tapping the potential of some selected indigenous lesser known wild edible plants for food and nutrition in arid and semi arid region (AFRI-110 /NWFPD/ICFRE/2011-2016).

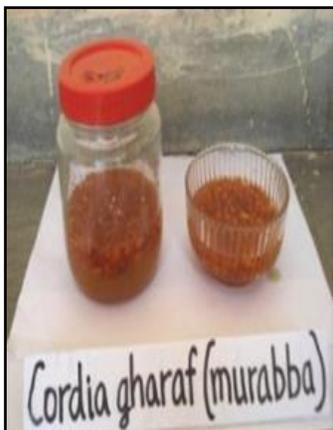
Principal Investigator: Dr. Mala Rathore, Scientist D

Because of useful food sources and traditional medicine, wild plants are important nutritional supplements too. Nutritional values of eight wild plants with their edible leaves/fruits/tubers were evaluated. Average nutritional contents of the proximate analysis for each species are described below.

- a. *Calligonum polygonoides* (Phog) flower buds were found rich source of dietary fibre (36.59%), protein (7.7- 9.3%) and minerals viz., Mn (224.25 mg/100gm), Mg (224.25 mg/100gm and K (1.157g/100gm).
- b. *Cassia tora* (Puad) leaves showed protein (11.1-16.9%), dietary fibre (17.31-24.09%) and minerals viz. Ca (1.4 - 3.75g/100 g), Mn (1.85-3.4%) and Fe (8.15-16.45%).

- c. *Haloxylon salicornicum* (Lana) seeds contained protein (11.5-14.5%) and dietary fibre (12.8-17.9%), whereas in it has 1.165 to 4.112 g/100gm calcium, 2.5 to 7.5 mg/100gm Zn, 406.5 - 462.5 mg/100gm Mg, 5 -7.25 mg/100gm Mn, 0.3-7.5 mg/100gm Cu and 1165 - 4112 mg/gm K.
- d. *Ceropegia bulbosa* (Khadula) tubers had protein (5.3-10.5%) and vitamin C (4.3-8.6 mg/100g). Concentration of minerals was: Mg (172.2 to 270 mg/100gm), Fe (11.85 to 42.33 mg/100gm) , Zn (1.5 - 5.33 mg/100gm) and Mn (1.15 - 5.5 mg/100gm).
- e. *Leptadenia pyrotechnica* (Khimp) pods contained protein content (13.3 to 19.6 %), sugar (3.47-7.35%), dietary fibre (22.25-29.72%), Vit C 0.64-1.07 mg/100gm) , minerals viz. Cu(1.2-3.0mg/100gm), Zn (3.3-5.3mg/100gm), Fe (12.1-35.8mg/100gm), K(1.583-1.885g/100gm).
- f. *Leptadenia reticulata* (Jivanti) pods was contained protein (7.85-13.38%), sugar (6.9-8.45 %) and minerals viz. Zn (1.55-2.5 mg/100gm), Fe (6.8 mg/100gm), K (1.612-2.777g/100gm) and Cu (0.55-1.7 mg/100gm).
- g. *Cordia gharaf* (Goondi) fruits had sugar (14.46-20.8%), protein (12.85-13.25%), Vit C (8.6-10.7 mg/100gm) and minerals viz. Fe (11.85 mg/100gm), K (1.123g/100gm) and Cu (1.60-4.6 mg/100gm).
- h. *Grewia tenax* (Gangeti) fruits were also rich in sugar (27.11-29.6%), protein (5.14-11.9%), Vitamin C (5.1-6.4mg/100gm). Also rich in minerals viz. Zn (1.55-1.60 mg/100gm), K (0.701-1.79g/100gm), Cu (0.30-0.95mg/100gm), Fe (6.1-9.45 mg/100gm) and P (0.77-1.305g/100gm).
- i. Analysis of antioxidant activity (DPPH scavenging) of alcohol extracts of the selected samples showed that flowers of *Calligonum polygonoides* and pods of *Leptadenia pyrotechnica* had maximum activity of 81.10 to 93.08% and 80.11 to 90.34%, respectively .

Analysis of samples collected during 2014-15 is in progress. Preservation in the form of various value added products viz. pickle, Murabba, squash, dehydrated juice of *Cordia gharaf* fruits, *Grewia tenax* fruits and *Leptadenia reticulata* pods has also been done (Fig. 3 a-f).



a. *C. gharaf*
(murabba)



b. *C. gharaf* (squash)



c. *L. reticulata*
(pickle)



d. *L. reticulata*
(mangodi)

e. *G. tenax*
(juice)

f. *G. tenax*
(pickle)

Fig. 3. Value added products from wild edible plants

Seedlings of *Cassia tora*, *Cordia gharaf*, *Leptadenia pyrotechnica*, *Calligonum polygonoides*, *Ceropegia bulbosa*, *Haloxylon salicornicum* have been planted in the nursery for their conservation. Establishment and growth of *Grewia tenax* and *Cordia gharaf* is found maximum among other species (Fig 4 a-b).



a. *Grewia tenax*



b. *Cordia gharaf*

Fig 4 (a-b). Conservation of nutritionally important wild edible plants in AFRI Model Nursery

Project 3: Quantification, value addition of NTFP and improved agricultural productivity to enhance livelihood opportunities in tribal belt of Sirohi District of Rajasthan (AFRI-03/ NWFP /Int (ICFRE)AICP/ 2012-2017).

Principal Investigator: Smt. Sangeeta Tripathi, RO

Quantification of NTFPs in tribal dominated area of Abu Road in Sirohi district of Rajasthan reveals that NTFP collection is round the year activity and contributes about 15% of the total income ranging from 10% to 30% for different families. The identified key NTFPs are playing significant role in tribal livelihood (Fig 5 a-b). Collection in kg/annum are: *Tamarindus indica* fruits (49.25 kg) at prevailing cost of Rs.30-40/kg, *Pithecolobium dulce* fruits (36.12 kg) at Rs.10-15/kg, *Momordica dioica* fruits (29.31 kg) at Rs.40-60/kg, *Annona squamosa* fruits (14.20 kg) at Rs.15-30/kg, *Diospyrose melanoxylon* fruits (14.08 kg) at Rs.15-30/kg, *Syzygium cummuni* fruits (13.48 kg) at Rs.30-40/kg, *Pongamia pinnata* seeds (13.18 kg) at Rs.7-10/kg *Phoenix* spp. fruits (12 .37 kg) at Rs.10-20/kg and *Jatropha curcus* seeds (10.14 kg) at Rs.10-15/kg.



Fig 5 (a-b): NTFPs and their selling in local markets

Tamarind and fennel are the two major spices of the study areas in Abu Road and their collection and cultivation are seasonal activity. Tamarind is collected from wild in six villages on average 49.25 kg per village per annum and accounts for 33% contribution of Key NTFPs to the total village economy. Cultivation of fennel is done in eight villages and contributes to about Rs.4800/- per annum with 0.98 % of the total income. This low contribution is due to primitive mode of agriculture practices and limited marketing linkages and information. Based on the information collected through structured questions for market study, different marketing channels for the identified keys NTFPs are:

(i) For NTFPs of local use (Palash flowers, sitaphal and other fruits etc)-

Primary collector → Village Agent → Local Market (Koteshwer and Ambaji)

or

Primary collector → Local Market (Koteshwer and Ambaji)

(ii) NTFPs of commercial importance (Except Honey, Gum and Tendu Patta)-

Primary collector → Village Agent → Agricultural Produce Marketing Co-operatives Agent → Unjha Mandi

or

Primary collector → Village Agent → Abu Road Adivasi Kya-Vikya Sahkari Samiti (Regional Office) → Adivasi Kya-Vikya Sahkari Samiti, Udaipur (Head Office) → Unjha Mandi or other processors.

Project 4: Managing resources to enhance productivity of agroforestry system in dry areas of Rajasthan (AFRI-01/AEFD/Int(ICFRE)AICP/2012-2017). AICP Project: Tree crop interaction study of exiting MPTs based silvi-agri system in arid and semi-arid region of India

Principal Investigator: Dr. Bilas Singh, RO

Hardwickia binata and *Colophospermum mopane* trees based agroforestry trials were established in 2012-13 at AFRI, Jodhpur. The four treatments comprises for each species were: Intact tree (T_1), Tree branch removal upto 70% of total tree height (T_2), root barrier treatment (T_3), and both tree branch removal and root barrier treatment (T_4). *Cymopsis tetragonoloba* crop was grown with *H. binata*, whereas integrated *C. ciliaris* grass with *C. mopane* trees was maintained. The grain production of *C. tetragonoloba* crop was significantly high in sole crop as compared to the treatments. The grain production of *C. tetragonoloba* was significantly ($P < 0.05$) higher in T_4 than other treatments. Grain yield of *C. tetragonoloba* crop was higher with the distances. Clump number and diameter and production of *C. ciliaris* grass were also higher in control as compared to the tree integrated plots.

Soil water content (SWC) did not differ among the treatments under *C. tetragonoloba* crop grown with *H. binata* but SWC increased significantly ($P < 0.05$) with increasing distances (i.e., as compared to 0.5 m distance). SWC was significantly ($P < 0.05$) higher in T_4 treatment as compared to T_1 treatment in *C. ciliaris* grass with *C. mopane* trees plots, SWC increased both due to soil depth as well as distance from tree trunk. Tree root density did not differ among the treatments in the both species. Physico-chemical properties of soil were analysed which did not differ among the treatments. Nitrogen content in *C. tetragonoloba* crop was observed low in T_4 and sole crop plots.

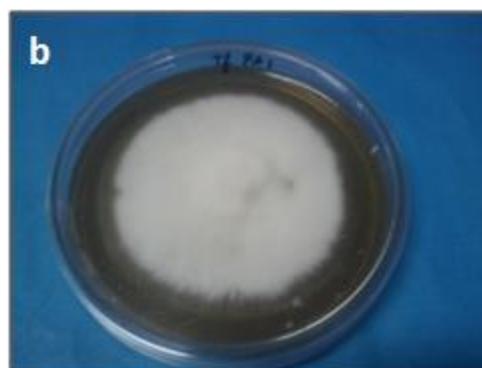
Project 5: Evaluation of antifungal potential and identification of broad spectrum antifungal compound from selected tree/shrubs/weeds of Indian arid region (AFRI-93/AFE/2009-15).

Principal Investigator: Smt. Bhawana Sharma, Scientist C

Antifungal properties of root, leaves, fruits and bark of *Balanites aegyptiaca*; roots, leaves seeds and flowers of *Tephrosia purpurea*; leaves, fruits and roots of *Citrullus colocynthis* and *Tribulus terrestris*; leaves, roots, seeds and flowers of *Datura stramonium*; and roots, flowers and fruits of *Argemone mexicana* were evaluated. Aqueous and ethanolic extract were prepared from each plant and evaluated against of selected fungi (*Rhizoctonia solani*, *R. bataticola*, *Fusarium moniliforme*, *Fusarium solani* and *Alternaria alternata*). Antifungal activities of extracts were determined by poison food technique. The antifungal activity of this extract was assessed in terms of percentage inhibition of fungus growth. Effect of different concentration (10, 20, 30, 40 and 50) of ethanol extract on growth of selected fungi showed an inverse relationship with fungus growth (Fig. 6 a-d).



Datura leaf alcoholic extract against *R. solani*



Tribulus terrestris fruit water extract against *F. solani*



Datura flower water extract against *F. solani*



B. aegyptiaca* leaves water extract against *F. moniliforme

Fig 6 (a-d): Effect of various plant extracts on pathogenic fungi through poison food technique

The ethanolic extract of *D. stramonium* leaf exhibited maximum inhibition against *Rhizoctonia solani* (88%) followed by *Fusarium solani* (76%). Qualitative analysis of this extract was done that showed presence of alkaloid and flavonoides in the ethanolic extract of *Datura* leaves.

Project 6: Carbon stock and soil classification mapping for Rajasthan forests (AFRI-115/FED/ICFRE/ 2011-16).

Principal Investigator: Sh. N. Bala, Scientist F

A GIS laboratory has already been established in the Division with work stations and facilities like plotter and printer. Integrated GIS software has been procured having the capabilities of spatial analysis, image processing, RADAR Analysis, hyper spectral analysis, photogrammetry, network analysis, GIS Modeling, surface analysis, watershed modeling and atlas creation, publishing geo-referenced image/map in printable

format and also in a format easily readable in the systems not having GIS software. Forest type maps of Rajasthan and Gujarat developed by the Forest Survey of India (FSI) have been procured for base map. Data of soil physical and chemical parameters and site characteristics have been compiled and entered for all the districts. District maps have been delineated for working on GIS. District-wise maps prepared in shape file. Geo-referenced data points have been overlapped on the maps (Fig. 7). Linking database is in progress.

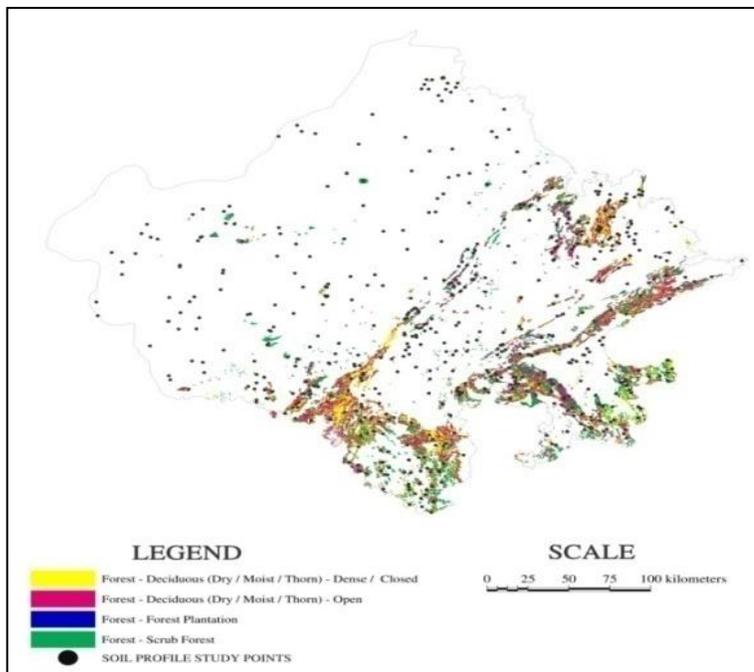


Fig 7: Forest Legend type map of Rajasthan

Externally Aided Projects:

Project 7: Productivity enhancement of Kair (*Capparis decidua*) fruit to generate livelihood in rural areas of Thar desert (AFRI-07/NWPF/Ext(SFD, Raj.)/2013-16).

Principal Investigator: Dr. Ranjana Arya, Scientist G

EXP 1 (Gogelao beed, Nagaur)

Field was selected in July 2013. All plants were divided into three blocks. Fertilizer treatments of leaf compost (LCM), goat FYM (GM) and VAM in combination to different fertilizers like SSP, SSP + K, K, Zn and SSP, K, + Zn and NPK were applied with irrigation in October 2013. Field trial was maintained, bowl repairing and termiticide application with irrigation was done in June. Trenches of

the size 1' deep 1' broad and minimum 6' in length, were prepared around individual or group of Kair plants for moisture conservation in the first week of July. Barbed wire fencing with cement posts was done in July. Standard rodent control procedures were applied in Feb 2015.

Three times flowering and fruiting was observed in the kair (*Capparis decidua*). Periodic phenological observations for April, July and October 2014 are summarized in. Table. Data analysis of April and May indicate maximum flowering (73.5%) in frost affected leaf compost treated kair plants followed by VAM treated plants (24.3%). Flowering was minimum (14.4%) in Goat FYM treated plants till second week of April 2014.

There was no flowering in untreated plants in any treatment. Treatment wise total mean fruit yield was 298.4 g in Block A, 25.0 g in Block B and 125.4 g in Block C (Table 1). In block A all treatments except control recorded fruiting shrubs varying from 33% in T₁ to 100% in T₄. Followed by C block where T₁ (33.3%), T₂ (28.5% and T₄ 14.2% shrubs recorded fruiting. In B block only two treatments, T₄ and T₇, recorded fruiting (Fig, 8 a-d).



a. Moisture conservation trench



b. T₄ treatment in LCM Block



c. Fruiting in Kair



d. Fruiting in Kair

Fig 8 (a-d). Fertilizer application to Kair plants and fruiting at Gogelao Beed, Nagaur

Second fruiting was observed in the third week of July where fruiting was in 48.3% shrubs in LCM block, 26.3% shrubs in GM Block and 26.8 % shrubs in VAM Block. Treatment wise mean fruit

yield was 179.3 g in Block A. 148.4 g in Block B and 141 .0 g in Block C. In Block A only T₃ (75%), T₄ (100%), T₅ (80%) and T₇ (20%) treatments recorded fruits shrubs, While in B Block it was in T₁ (75%), T₄ (80%), T₃& T₁ (20%).treatments and in C Block in T₁ (50%), T₃(42.9%) and T₁ (14.3%) treatments.

Table 1: Treatment wise total fruit yield in g (percent fruiting shrub/treatment) and per shrub fruit yield in g in different treatments in different seasons

A block (Leaf Compost)			
Treatments	April	July	Oct
T ₁ (LCM+ P + K)	58 (33%) 58	-	2167(100%) 722.3
T ₂ (LCM+ P)	477 (50%) 238.5	-	172 (50%) 86
T ₃ (LCM + K)	198(75%) 66	320 (75%) 106.7	75(50%) 37.5
T ₄ (LCM+P+K+Zn)	742(100%) 185.5	900(100%) 225	2707(100%) 676.8
T ₅ (LCM+ NPK)	725(80%) 181.3	199 (80%) 49.8	281(80%) 70.3
T ₆ (LCM+ Zn)	72 (60%) 24	-	111(60%) 37
T ₇ (LCM)	115(40%) 57.5	15(20%) 15	360(60%) 120
T ₈ (Control)	-	-	95(20%) 95
Mean total yield in g	298.4	179.3	746.0
B block(Goat manure)			
T ₁ GM + K	-	250(75%) 83.3	1810 (75%)603.3
T ₂ GM + P+ K + Zn	-	-	147(40%) 73.5
T ₃ GM + P1	-	45(20%) 45	220(40%) 110
T ₄ GM + P + K	160 (60%)53.3	882 (80%) 176.4	135(40%) 67.5
T ₅ GM + NPK	-	-	197(50%) 49.3
T ₆ GM + Zn	-	-	172 (75%) 57.3
T ₇ GM	40(40%) 20	-	100(40%) 50
T ₈ Control	-	10(20%) 10	98(40%) 49
	25.0	148.4	359.9
C block (VAM)			
T ₁ (VAM + NPK)	545(33.3%) 272.5	520(50%) 173.3	850(50%)283.3
T ₂ (VAM + P1)	12(28.5) 6	-	495 (57.1%) 123.8
T ₃ (VAM + P2)	-	165 (42.9) 55	357(57.1)89.3
T ₄ (VAM)	70(14.2) 70	-	392 (85%) 65.3
T ₅ (Control)	-	20(14.3) 20	600(85%) 100
Mean total yield in g	125.4	141.0	538.8

In the third week of October third fruiting was observed it was 62.9% in A block, 52.6% in B block and maximum 67.6% in C block which is significantly high as compared to April and July. Monsoon rain coupled with fertilizer application could be the reason for it.

Treatment wise T_1 & T_4 recorded fruiting in 100% shrubs followed by T_5 (80%), T_6 & T_7 (60%), T_2 (50%) and T_1 (20%) in block "A", while in "B" block T_5 recorded 80% fruiting shrubs followed by 75% T_1 & T_6 and 40% in T_2 T_3 T_4 T_7 and T_8 treatments. For C block maximum fruiting was observed in T_4 & T_5 treatments (75% shrubs) followed by 57.1% in T_2 & T_3 and 50% in T_1 treatment.

Total treatment wise maximum mean fruit yield was 746 g in A block (ranging from 75g to 2707 g in different treatments, followed by 538.8 g (392.0 g to 850 g) in C block and 360.0 g in B block (98 g to 1810 g). T_4 (LCM + P + K + Zn) was the best treatment for A block, T_1 (GM + K) for B block and T_1 (VAM + NPK) C block.

Overall 9.34 % shrubs fruited three times, 20.5% two times, 45.8% one time and 24.3 % shrubs did not flower in one year. Out of ten three times fruited shrubs 8 shrubs belongs to A (LCM block), four in T_4 , 3 in T_5 (LCM + NPK) and 1 in T_3 (LCM + K) treatment. One shrub each was in T_1 (VAM + NPK) and T_4 (GM + P + K).

Thus, out of three organic manures, LCM is the best in combination to inorganic fertilizers where T_4 and T_5 are the best treatments so far recording 100 & 80 % fruiting shrubs in all the three seasons overcoming frost effect. Further observations are underway.

EXP 2 (Khari Khurd, Jodhpur)

Area in Luni forest range was finalised July 2014. Enumerated the Kair population and prepared a detailed status map of the area & boundary marked. Prepared plants bowl and removed additional plants and grasses. All plants were divided into two blocks. Organic fertilizer and inorganic fertilizer with different combination LCM (1 Kg) + SSP 625g/ stem + K_2SO_4 (115 g/ stem) + $ZnSO_4$ (40 g/ stem) block -A and GM (1.5 kg/ stem) + SSP 625g/ stem + K_2SO_4 (115 g/ stem) + $ZnSO_4$ (40 g/ stem) in block- B were applied with irrigation in August 2014 (Fig. 9 a-c).

Soil sampling was done to analyze the initial soil status. pH values were ranging from 7.90 to 8.61, EC 0.07 to 0.12 dSm^{-1} and organic carbon (0.48 to 1.21%) in 0-20 cm soil layer. Temporary fencing with *P. juliflora* was done in October 2014. One weeding through tractor ploughing was undertaken in the experimental area in November 2014.

Growth data were recorded, the mean height and crown diameter ranged from 209 to 292 cm and 203 cm to 336 cm, respectively in A block, while in B block, it was ranged from 192.5 to 308 cm and 231.5 to 338 cm, respectively.

In November scanty flowering was observed ranging from 16.6 % trees to 50% trees with no effect of treatments. There was frost damage in last week of December to 1st week of January 2015, plants suffered 10 to 25% damage to upper branches. One irrigation was provided. No flowering or fruiting was recorded in January to March 2015.



a. General view of the site at Khari Khurd

b. Making of bowl after removal of other plants around Kair

c. APCCF (Research) at Experimental site Khari Khurd

Fig 9 (a-c). Fertilizer application to Kair plants at Khari Khurd, Luni Range, Jodhpur

Project 8: Optimization of processing methods for *Prosopis cineraria* and *Capparis decidua* fruits for their improved utilization in western Rajasthan (AFRI-15/NWFP/Ext(DST)/2014-17)

Principal Investigator: Dr. Mala Rathore, Scientist D

Forest Ecology Experimental Field, AFRI, Jodhpur, has been identified for collection of fruits of Ker and Khejri and healthy shrubs /trees have been marked. Fruit collection of Khejri was carried out in April-May 2014 and pod length and width, weight and moisture content were measured. Three fruiting seasons have been observed in Kair (*Capparis deciduas*) shrubs viz. April-May, July-August and November-December 2014 in the marked plants. Fruit collection was carried out during these periods and (fruit diameter, weight and moisture content) have been recorded. Based on the average size parameters of ker fruits, sieves of different sizes have been fabricated. Gradation of fruits using these sieves is under process. Purchase process for the sanctioned equipments has been initiated.

Deep freezer, solar driers (inclined and pre-heated) and laptop have been procured. Purchase order for Freeze Dryer has been placed.

Project 9: Documentation of Neem products and their role in socio-economic upliftment of rural livelihood in Rajasthan and Gujarat Rajasthan (AFRI-16/NWFP/Ext(DST)/2014-17)

Principal Investigator: Dr. Sangeeta Tripathi, RO

This project was initiated in May 2014 with an aim to address collection, utilization, marketing and processing of Neem products at village level, identification of constraints in the trade and marketing and to establish the direct linkage from collectors to the marketing channels. Literature updation and secondary data from different Govt. Agencies viz., District Statistical Department, Revenue Department, Forest Range offices of Pali and Mehsana districts, traders dealing with Neem products, were carried out. Prepared and updated semi-structured Questionnaire to assess the role of Neem products in rural livelihoods, in Pali and Mehsana districts. Socio-economic survey was carried out in 51 villages of Pali districts and 25 villages of Mehsana District (Fig. 10 a-b).



Fig 10 (A-B). Survey for documentation of Neem Products in Pali District

Farmers use Neem leaves as assured fodder (or as green leaf manure) and woody portion of lops as fuel wood. In Mehsana, farmers lop trees during (November and continues till first half of February) for stall feeding the cattle, whereas in Pali lopping is done in November to December. Normally, very few trees are seen without lopping in winter in both the districts. In most of the cases, farmers use lopped fodder at their home where cattle are kept. The lopped materials are normally carried as head-loads in the villages. Leaves are normally mixed with dry fodder or straw for feeding the cattle. The average prevailing prices of different kinds of green fodders in Mehsana district were Rs.3.00 to Rs. 4.00 per kg. Neem leaf as fodder is not traded commercially in Pali, but it normally costs Rs. 2.00 or more in Mehsana (Fig. 11 a-b).

Neem fruit collection and processing is a labour intensive and time consuming, therefore villagers in Pali district preferred to work in MNREGA programme because of ensured return instead of Neem fruit collection, processing and selling. Neem leaves are also mixed with Heena (Mehndi) in

herbal industries. Neem leaves collection is a seasonal activity and provides employment for about 4-5 months November-March. For rest of the year they use to switch over to other employment opportunities.



Fig 11 (A-B). Collection of Neem fodder in Mehsana District

Project 10: Studies on post-harvest technologies of *Azadirachta indica* and *Acacia senegal*—as alternative timber species for handicraft industries (AFRI-14/NWFP/Ext(DST)/2014-17).

Principal Investigator : Dr. Ranjana Arya, Scientist G

Literature updation has been done and a project associate selected. For *A. indica*, International Neem Provenance trial, AFRI, Jodhpur surveyed. Neem wood sample collected from Mehsana, Gujarat. For *Acacia Senegal*, Kumatia enclosure, Kailana, Jodhpur was visited. Attempt were made to obtained wood from saw mill in Bilara. Letters are written to CCF Jodhpur, Bikaner and Department operation circle Jaipur for providing the wood logs of *A. indica* and *A. senegal*. Some wood logs are obtained from the seized wood at Balotara Forest Range, Barmer. Process for purchase of Increment borer instrument has been completed and order placed. Letter for collaboration has been offered to Sun Art Export, Jodhpur.

Project 11: Identification of extent of forest land in forest fringe village (AFRI-14/FED/ NRAA/2011-14).

Principal Investigator: Sh. S.R. Baloch, Scientist B

The project 'Identification of extent of forest land in forest fringe villages' was started to gather information on forest dependency and socio-economic conditions of the surrounding inhabitants and the root causes of the destabilization and shrinkage of the forest land in selected forest fringe villages of Rajasthan and Gujarat. Socio-economic survey and vegetation studies done in Jamnagar, Junagarh, Panchmahal,

Surat, Vadodra, Valsad, Dahod ,Kauchh, Narmada, Sabarkantha Banaskantha and the Dangs districts in Gujarat and Jhalawar, Kota, Banswara, Udaipur and Dholpur districts of Rajasthan (Fig. 12). The information so collected were entered simultaneously through online web portal and further reports on floristic and socioeconomic status of forest fringe areas were prepared. Data collected from forest fringe villages of Banswara, Banaskantha and Sabarkantha districts indicates that the area is either Teak dominating or mixed type of community. Floristic diversity varies from undisturbed forest where *B. monosperma*, *A. catechu*, *P. juliflora*, *T. grandis*, *H. integrifolia*, *A. indica*, *D. melanoxylon*, *S. cumini*, *A. nilotica*, *M. parviflora*, *Terminalia tomentosa*, *Anogeissus latifolia*, *Lagerstroemia parviflora* etc. were found as common associate of teak. The IVI of Teak (25.62) is higher followed by *Madhuca indica* and *Diospyros melanoxylon* with diversity index of 1.6.1 and 1.32. Due to continuous hacking or clearing of tree for cultivation and uncontrolled grazing and repeated fires, the natural regeneration of Teak is low, whereas regenerations of Timru (*Diospyros melanoxylon*), *Anogeissus latifolia*, *Butea monosperma* and *Lagerstroemia parviflora* were relatively better. High frequency of 81.2% and 80.3% was observed for *Cassia tora* and *Lantana camara* respectively, in Junagadh district. As per socio-economic survey, majority of the population in Dang, Panchmahal, Banaskantah and Sabarkantha is tribal and have small and marginal land holdings. The irrigation facilities are poor therefore the farmers have to depend on kharif crops. Bheel, Rebari and Garasia are dominant OBC/tribal castes in the area. In forest fringe villages of Kauchh and Junagadh population wise OBC people dominate over the tribal people.



Fig. 12: People interactions and data recording in forest fringe villages of Rajasthan and Gujarat

Project 12: Studies on seed insect pests of indigenous and exotic forest tree species and to develop IPM package for major insect damages in Gujarat (AFRI-107/GCR/SFD-Guj./2011-15).

Principal Investigator: Dr. Meeta Sharma, RO

The checklist of one hundred and seventy one insect pests associated with eight important forest trees and grass species of Gujarat has been prepared. These insects have been found attack on seeds, pods, flowers, fruits as well as stem, root and leaves of different species. A wide range of insect species feeding on seeds belong to the groups- beetles, bugs, moths, butterflies and wasps. The larval stage of insects mostly feed on seeds, while adults feed on more easily digestible material such as flower or nectar. The infested seed samples were examined for pest incidence and the adult insects were identified. The life cycle of some major pest such as: *Atteva fabriciella*, *Eligma* spp., *Caryedon serratus*, *Hyblaea puera*, *Bruchus bilineatopygus*, *Helopeltis antonii* and *Hydreliia flammeolaria* have been studied (Fig. 13). The insect diversity was greatly influenced by season and monsoon to early winters (autumn) are the preferred seasons. The decline in population was observed in early summers and late winters. August, September and October were the months, when the population of *Caryedon serratus* and *Bruchus bilineatopygus* were at its peak. In the Integrated Pest Management component, all the possible strategies viz., silvicultural, mechanical, botanical, biological, microbial and chemical control measures were adopted. The hand-picking, fruit trap installation in fields, their spacing, dehusking of seeds for storage, fumigation, disinfection of used bags, and storage of seeds in air-tight containers are recommended. The tin and glass containers were found the most suitable for seed storage. *Balanites aegyptica* and *Psorolea corylifolia* plant extracts are recommended as antifeedents. Rockon was the most effective botanical insecticide in field trial in the plantations of *Ailanthus excelsa* and *Tectona grandis* and Weapon was found effective for stored seeds of *Acacia nilotica* and *Prosopis cineraria*. Crab spider, praying mantids, coccinellid beetles are the most effective bioagents or predators. They keep the insect pests population under threshold level. *Beauveria bassiana* and *Paecilomyces farinosus* were recommended as most promising entomopathogenic fungi. Quinalphos and Monocrotophos were found the most effective chemical insecticides to check the spread of the insect pests upto epidemic level.





Fig. 13. Insect pests of seeds of forestry trees: a. Leaf of *Tectona grandis* showing skeletonisation pattern by larva of insect, b. Mature larva of *Hyblaea puera*, c. Pupa formation by *Hyblaea puera* and d. Adult moth of *Hyblaea puera*.

Project 13: Productivity study and growth and yield in teak plantation in Gujarat state (AFRI-96/Silvi/JBIC/2009-15).

Principal Investigator: P.H. Chawahn, Scientist E

Estimation of stand volume with greater accuracy has always been a matter of interest for forest managers as it is directly related with the production estimation. The wood volume equations assume importance in projecting the total volume at different stages to final harvest as the plantations mature. Teak (*Tectona grandis*) is well known of its high grade timber value. The volume equations developed for *Tectona grandis* in this project is useful to the SFD, Gujarat. Field visit was conducted and annual observations of diameter, height etc, of *Tectona grandis* on were recorded for year 2014-15 from the sample plots located in various locations in Gujarat. Fifteen trees were felled from three plots of Dang Awhaa Division for validation of the data. The project is extended up to March 2016 for its for conclusive closer.

3. Biodiversity Conservation and Ecological Security

Project 14: Innovative approaches for augmentation of composting and biofertilizer production in hot arid regions (AFRI-111/FPD/2011-15).

Principal Investigator: Dr. K.K. Srivastav, Scientist F

The main objectives of the project were development of innovative rapid decomposing, vermi-composting and production of biofertilizers (AM, *Rhizobium*, *Azospirillum* and *Azotobactor*) and to improve seedling growth of forestry species. The nursery experiments were conducted by using alone as well as various combinations of AM fungi, *Rhizobium*, *Azospirillum* and *Azotobactor* (Fig. 14). Indigenous strain of *Trichoderma viride* was also selected as a bio agent for best growth and vigour of

seedlings of Khejri (*P.cineraria*), Sisaham (*Dalbergia sissoo*) and Ardu (*Ailanthus excelsa*). Consortium inoculum of AM fungi with dominancy of *Glomus fasciclatum* was used for the experimentation. The seedlings treated (*Rhizobium* + *Trichoderma viride* + *Bacillus thuringiensis* (BT) was found best enhancing growth and vigour of *P. cineraria* and *Dalbergia sissoo* seedlings. In case of *Ailanthus excelsa*, combination of AM + *Azospirillum* + PSB was found best as compared to other treatments. Vermi- compost samples were analysed for soil organic carbon (SOC), soil organic matter (SOM), Ammonium (NH₄-N) and nitrate(NO₃-N) with various pedding material viz., *Azadirachta indica*, *Alestronia* spp. *Cardia myxa* and mixed leaves of various species. The SOC ranged from 4.5 to 5.13mg/kg, SOM ranged between 7.75 and 8.79 mg/kg. NH₄-N) 13.49 to 21.46 mg/kg and (NO₃-N) ranged from 90.27 to 103.34 mg/kg in various treatments. Microbial population was determined by using dilution plate technique and observed higher in samples of vermicompost as compared to compost. The mycoflora were isolated and identified from vermicompost samples as *Acremonium* spp., *Cladosporium* spp., *Penicillium* spp. *Aspergillus niger*, *Aspergillus flavus*, *Alternaria* spp., *Trichoderma viride*, *Fusarium* spp. and *Actinomycetes* (identified as *Streptomyces*). Unidentified bacterial colonies were also observed. *Asperigillus* spp. and *Mucor* spp. were found abundantly.

Training on production of compost, vermicompost and biofertilizer multiplication and their application in forestry was imparted to different stakeholders.

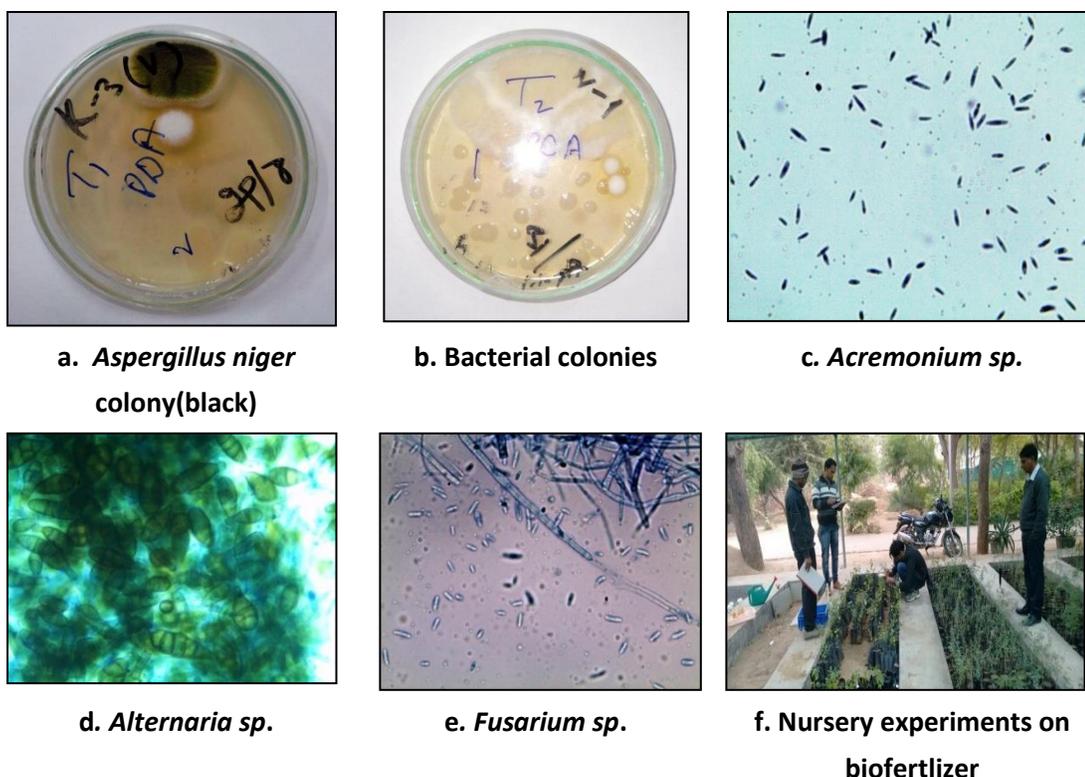


Fig 14(a-f). Nursery experiment and mycoflora associated with litter decomposing fungi

Project 15: A coordinated project on integrated management of khejri mortality for socio-economic upliftment in Rajasthan (AFRI-99 /FPD/ICFRE/2010- 2015).

Principal Investigator: Dr. K.K. Srivastava, Scientist F

Aims of this coordinated project are: to find out casual organism, bio-ecological studies of *Acanthorhynchus serraticornis*, field demonstration for mortality management, development of IPM package, genetic improvement and mapping genetic diversity, socio-economic impact of mortality and generation of awareness to manage it compared with findings are described below :

Component I - Forest Protection Studies

Co-PIs: Dr. Sangeeta Singh, Sci C and Dr. Shiwani Bhatnagar, Sci. B

Survey work in Naguar, Sikar, Jodhpur, Churu and Jhunjhunu districts has been done. Mortality ranged from 18 to 22% with an average mortality of 20.9%. Rearing of *Acanthorhynchus serraticornis* on standardised artificial diet for studying complete life cycle is in progress. Till date 14th instars of larvae has been recorded in laboratory condition. Inoculation of *G. lucidum* in control conditions was done using mycelium to prove pathogenicity through Koch's postulate. Data has been collected on the biotic stress from all the experimental sites viz., Jhareli, Raghunathpura, Fatehpur, Churu, Jhunjhunu and Surani. Infested Khejri trees were uprooted and examined for presence of *Acanthorhynchus serraticornis*/*Ganoderma lucidum*. Data indicates that all infested Khejri trees were found invariably infested with either root borer or root rot. The samples were collected and studied for confirmation. Khejri trees were lower in tractor ploughed land as compared to Gochar/ undulated land where the land is left untilled. Similar trend was also observed to Khejri seedlings. After third round of field management trials using AFRI, CAZRI, ARS treatments alongwith a control at different experimental sites in five districts, average loong production increased in the treated trees. Total average increase in loong production of severely infested Khejri trees of all four experimental sites was 1.64 kg in T₁ AFRI, 1.45 kg in CAZRI, 1.42 in ARS whereas, in control treatment, an average increase was 0.30 kg.

Management trial against the root rot pathogen was laid out in nursery. Approximately 400 seedlings were established and inoculated with the pathogen. The disease was established after two months as evident from the top drying symptoms. Integrated management trial against *Ganoderma* spp. using integration of biocontrol agent with chemical fungicides and botanicals (compatible to each other) are being used. The experiment is under progress with promising result of some botanical extracts.

Component II - Genetics

Genetics: Co-Principal Investigator: Sh. P.H.Chawaan, Scientist-F

Data collected from 52 individual CPTs on pod parameters viz. length, width and weight has subjected to the analysis of variance followed by estimation of genetic parameters (Fig 15 a-b). A difference in pod length and weight of 10 pods amongst all the selected trees was highly significant. Genotypic component of variance for these traits were also high for these traits. These traits also exhibited moderately high heritability (broad sense) estimates of 27 and 25 percent respectively coupled with genetic gain of 3.23 and 5.89 percent. Immature pods (*sangris*) were collected from 34 CPTs and data on biochemical parameters were recorded.

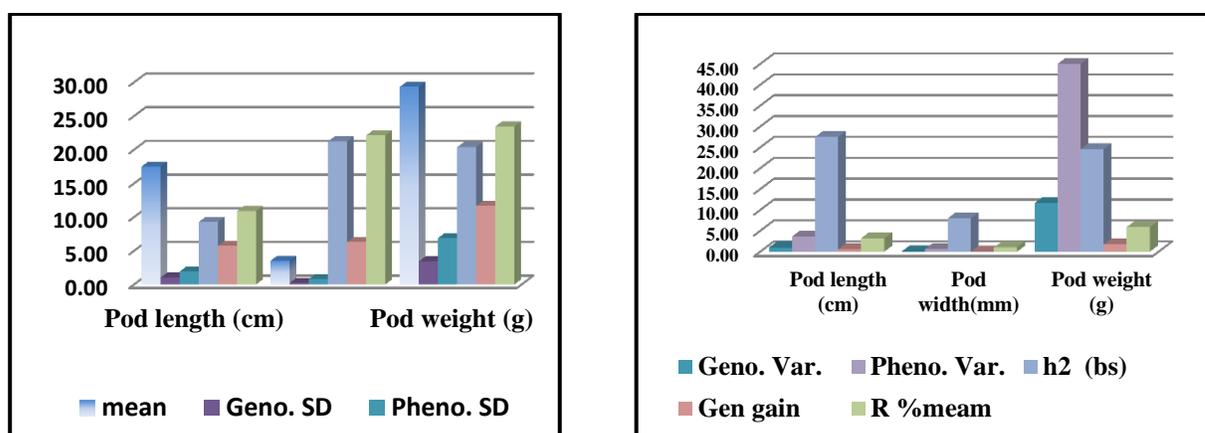


Fig 15 a. Descriptive parameters in Pod characters of *P. cineraria* (Left), b. Estimates of genetic parameters in Pod characters of *P. cineraria* (right).

Progeny trial established with 30 families at AFRI, Jodhpur was maintained. Weeding, watering and soil working have been done. Mortality replacement of seedlings has been done. Growth data on individual trees was collected and analyzed. Highly significant variation was observed for collar diameter as well as height. Twelve trees namely RT-11, RT-3, RT-7, K-1, L-2, LM-1, JRM4, S-9, T-1, B1, LJ2 and JP2 out performed others as indicated by their general combining ability values (Fig. 16) Another progeny trial established with 52 families employing Randomized Block Design with 4 replications and six individuals per family per replication at Samaspur, Junjhunu.

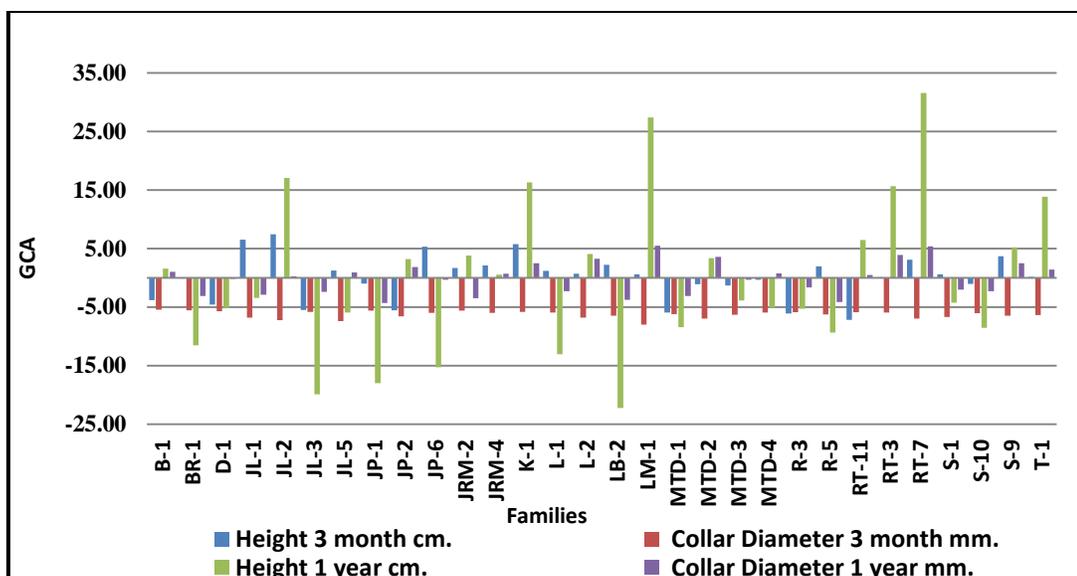


Fig 16. General combining ability of different families of *P. cineraria*

Component III - Biotechnology

Co- Investigator: Dr. Tarun Kant, Scientist-E

Stem nodal segments from mature tree were taken from tree directly without lopping. Newly emerging soft stem nodal segments after lopping (fresh flushes) were used to achieve axillary bud proliferation. Five to six fold multiplication of microshoots was achieved from fresh flush material than the rate of multiplication achieved from mature un-pollarded trees. Rooting has been achieved, but at low frequency. The nodal stem segments were cultured on MS medium supplemented with Auxin (IAA) and Cytokinins (Kn and BAP). Nodal segments obtained from new flushes on MS medium supplemented with various concentrations of BAP gave good response. Best response was on MS + 2.5 mg/L BAP. Upto 2 shoots/nodal segment has been seen in 50% explants. An experiment on effect of season by regular monthly explant inoculation on MS + BAP, (1, 2.5 and 5 mg/L) was also performed. Experiments on rooting continued, but only sporadic rooting was obtained so far. Materials from 28 trees (19 selected CPTs + 9 diseased trees) from different locations were collected and DNA was extracted, purified and quantified for further RAPD-PCR analysis.

Component IV - Ecological Component

Co- Investigator: Dr. Abha Rani Gupta, Scientist-E

For assessing effect of abiotic stresses on Khejri mortality, meteorological data of Churu, Jhunjhunu and Jodhpur and Ground water table data (pre-monsoon and post monsoon) of Churu,

Sikar, Jhunjhunu, Nagaur districts were collected. Soil samples were collected from the Khejri mortality areas and analysed for pH, EC, organic carbon, phosphorus, ammonium and nitrate nitrogen. Initial analysis indicated that maximum temperature and minimum relative humidity has the positive effect on infestation percentage. Jodhpur district, where average ground water recharge was positive (489.00 mcm) suffered less mortality and infestation. The districts namely Churu, Sikar and Nagaur where ground water recharge was negative were associated with maximum mortality.

Component V - Biochemical Studies

Co-Principal Investigator: Dr.Mala Rathore, Scientist-D and Dr. Sangeeta Singh, Scientist-D

Bark and root samples were collected from infected and healthy trees of *Prosopis cineraria* (Khejri) from different districts and their morphological parameters were recorded. Samples were analysed for studying the variations for protein, proline, potassium and ash contents. An overall decrease in average protein content from healthy (11.6%) to infected trees (5.84%) was observed. Average proline content was also less in healthy trees (1.98 $\mu\text{mol/gm}$) and it was higher in infected trees (4.75 $\mu\text{mol/gm}$). However, average ash content was high in healthy trees (14.2 %) and less in infected trees (16.1%). In case of roots an increase in the average proline content from 4.69 $\mu\text{mol/gm}$ (healthy trees) to 8.33 $\mu\text{mol/gm}$ (infected trees) was observed. However, a decrease in ash content from 8.89% in healthy trees to 3.28 % in infected trees was seen. Potassium content was also measured in root and bark samples. In stem bark samples, the overall potassium content decreased from 9.25 ppm in healthy to 8.28 ppm in infected trees whereas it increased with infection from 5.62 ppm to 8.42 ppm. Further analysis is in progress.

Component VI - Socio-Economic Component:

Co-Principal Investigator: Smt. Sangeeta Tripathi, RO

A detailed socio-economic survey of 377 villages was completed and 1500 farmers were interacted and questionnaire filled. The collected data from the five districts entered in computer and data analysis and writing of report is in progress.

In five districts viz. Jodhpur, Nagaur, Sikar, Churu and Jhunjhunu, a total 7745 khejri trees were recorded in 735.12 ha area during 2005 to 2010. Out of these, 1601 trees were died by 2010. Density of khejri tree was maximum in Sikar (2945 trees in 313.5 ha area) and minimum in Jhunjhunu district. The rate of mortality was maximum in Sikar and minimum in Jodhpur district. Average lopped fuelwood/tree was 37.71 kg/tree in 2005 which decreased to 15.71 kg/tree in 2010. From 2005-2010, the loss of lopped fuelwood in these districts was recorded to 25.19 kg/tree. Maximum lopped fuel

wood obtained in 2005 and 2010 was from Jodhpur (40.20 kg/tree) and Jhunjhunu (18.33 kg/tree), respectively. The minimum was in Churu (36.89 kg/tree) in 2005 and in Nagaur (14.50 kg/tree) in 2010. In 2005, the maximum loong production was 34.20 kg/tree which decreased to 15.29 kg/tree in 2010. It is concluded that in the last five years (2005-2010), the loss in loong production in these five districts was 22.06 kg/tree. Loong production was 35.15 kg/tree and 18.22 kg/tree in 2005 and 2010 respectively in Jhunjhunu district. Minimum of 33.52 kg/tree and 12.80 kg/tree was from Sikar in 2005 and Nagaur in 2010.

There is a lack of information on socio-economic aspect of Khejri mortality, which is very essential to understand its impact and effect on crop productivity and livelihood of the locals. The major impacts of Khejri mortality on the status of losses and reduction in the availability of fuel wood and fodder and on its potential of productivities. The data are being recorded to assess the overall impact on socio-economic status of beneficiaries.

Component VII - Extension Component:

Co-Principal Investigator: Mrs. Bhawana Shrama, Scientist-C

Problem of khejri mortality was displayed and demonstrated by participation in

- Hastshilp Mela organized at Jodhpur Rajasthan during 2-11 January 2015. Banad Kisan Mela organized by NABARD on 9-2-15; a Kisan Mela was organized by NABARD at Rohit and farmer fair organized by NABARD at Jaisalmer on 17-2-15. Pamphlets and brochure distributed to farmers to highlighting management strategies. This problem was also presented and demonstrated to
- 50 Members of Village Forest Protection Committee, Sikar, a team of 22 forest guard visited AFRI on 20-2-15; a group of 40 women farmer with agriculture Officer from Bhopalgarh, Jodhpur (under ATMA scheme) visited institute on 26-2-15; a group of 48 farmers with agriculture Officer from Bawadi, Jodhpur on 26-2-15 and a group of 55 farmers from from Krishi Sewa Institute, Parvatsar visited institute on 03-03-2015.

Project 16: Development of package for integrated management of insect pest and diseases (IPDM) and improvement of planting stock material of neem in (*Azadirachta indica*) through biofertilizers (AFRI- 12/FP/EXT(DST)/2014-17).

Principal Investigator: Dr. Sangeeta Singh, Scientist-D

Survey was conducted to identify and isolate infected samples of neem. Samples of Charcoal root rot disease, white root rots, Damping off and wilting were collected. Fungus associated with these diseases were isolated and identified as *Macrophomina phaseolina*, *Ganoderma* spp., *Phytophthora* spp., *Rhizoctonia solani* and *Fusarium solani*, respectively. Two different types of mollusks and one sap sucker were also recorded from AFRI nursery, Jodhpur. Myllocerus and molluscs were identified damaging Neem seedlings in nursery.

Soil samples were collected and biopesticides like *Trichoderma viride* and *Pseudomonas fluorescence* were isolated. Few bioagents were procured from IMTECH, Chgandigarh like *Azospirillum brasilense*, *Azotobacter beijerinckii*, *Bacillus thurengensis*, *Trichoderma harzianum*. Consortia of Arbuscular mycorrhiza like *Glomus*, *Gigaspora sclerocystis* and *G. scutellospora* were isolated and multiplied on maize in pots.

Azospirillum brasilense, *Azotobacter beijerinckii*, *Bacillus thurengensis*, *Trichoderma harzianum*, consortia of AMF (Arbuscular mycorrhizal fungi consisting of species of *Glomus*, *Gigaspora sclerocystis* and *G. scutellospora*) individually as well as in different combinations were used on Neem seedlings in greenhouse condition were to study their efficacy in promoting growth. Recorded data like shoot length, root length, collar diameter, fresh weight and dry weight after 90 days of treatment. The results showed that the consortia of biofertilizers were more effective as compared to the individual microorganisms. Overall maximum growth was observed in the treatment in which combination of *Azotobacter*+*Azospirillum*+*Trichoderma* was there. IT was followed by PSB+*Azotobacter*, *Azospirillum*+AMF and PSB+*Azotobacter*+*Azospirillum*.

Project 17: Impact of *Prosopis juliflora* on biodiversity, rehabilitation of degraded community lands and as a source of livelihood for people in Rajasthan State (AFRI-104/AFED/ICFRE/2010- 2015).

Principal Investigator: Dr. Seema Kumar, Scientist D

Parts of five agro-climatic zones of Rajasthan viz. Arid Western Plain (I A) Transitional Plain of Inland Drainage (II-A); Semi-arid Eastern Plain (III-A); Sub-humid southern plains and the Aravalli Hills (IV-A) and Humid south-eastern plains (V) of Barmer, Ajmer, Jaipur, Sikar, Kota and Bhilwara districts were surveyed. Data recorded and density of *P. juliflora* from the surveyed districts worked out. 25 plant and 34 animal species were found associated with it. Faunal diversity and spread of *P. juliflora* recorded in parts of six districts. Six species of insects belonging to Hymenoptera: Formicidae and one species of Coleoptera: Cerambycidae were recorded for first time in association with *P. juliflora*. One species of Formicidae recorded for the first time from Rajasthan and 2 species of Formicidae recorded for the first time from Barmer district. Two species of Parakeets were found feeding on the pods and

seeds of *P. juliflora* out of which one species is near threatened. One species of raptor found utilizing *P. juliflora* as a perching ground. Studies revealed that *P. juliflora* is utilized mainly as fuel wood and as a major source of energy in the brick manufacturing industry. It is largely utilized as biological fencing and dry thorny fencing in agriculture fields. The farmers were found utilizing *P. juliflora* trees in their agriculture fields as an agro-forestry tree that is the major observation recorded in the field studies under the project.

Project 18: Refinement of modern nursery practices for raising quality seedlings of selected important forest tree species and arid and semi arid areas (AFRI-109/Silvi/ICFRE/ 2011- 2016).

Principal Investigator: Dr. N.K. Bohra, RO

In the project *Prosopis cineraria*, *Tecomella undulata* and *Azadirachta indica* were raised in different sized polybags viz. long (24x19 cm), middle (19x18 cm) and small (20x13 cm) size polybags as well as in two sized root trainers 150cc and 250 cc. Manure compost (C), vermicompost (V), gobar manure (G), leaf compost (L) and goat manure (M) were used. These seedlings were filled with different potting mixture ratio of soil: sand: manure viz. $C_1/G_1/M_1/V_1/L_1$ (1:1:1), $C_2/G_2/M_2/V_2/L_2$ (1:1:2), $C_3/G_3/M_3/V_3/L_3$ (1:1:3), and $C_4/G_4/M_4/V_4/L_4$ (1:2:1) respectively. Growth parameters of all these species were recorded at 2 months intervals. On the basis of growth performance the treatments were treated with 5 types of biofertilizers viz., PSB, Azospirillum, Azotobactor, Trichoderma and VAM. Controls without biofertilizers were also kept for comparisons (Fig. 17).

Tecomella undulata

After 4 months, *Tecomella undulata* seedlings with compost manure in long polybags performed better in all treatments. The average girth and height were in the range of 3.18-3.91 mm and 39.0 -50.3 cm, respectively. Seedlings under gobar manure and long polybags perform better in all treatments with average girth and height of 2.6 -3.85 mm and 33.0-46.1 cm, respectively. In Goat manure also long polybags perform better in all treatments with average girth and height of 2.38-3.03 mm and 32.1-41.5 cm, respectively.

In leaf compost treatments L_1 and L_4 long polybags perform better with average girth and height of 2.16-2.52 mm and 23.5-37.2 respectively, whereas in L_2 average girth and height were 3.19 mm and 39.5cm, respectively. In L_3 average girth and height was recorded as 2.25 mm and 32.9 cm respectively. In vermicompost manure treatment in long polybags of V_1 , V_3 and V_4 performance was better with average girth and height of 2.9-3.29 mm and 38.8-47.4 cm respectively, whereas in V_2 , average girth and height was highest in small polybags as 3.69 mm and 42.3 cm respectively.

Azadirachta indica

After 4 months *Azadirachta indica* seedlings with Compost manure and long polybags performed better in C₂, C₃ and C₄ treatments. The average girth and height were in the range of 3.62 - 4.86 mm and 39.0 -50.33 cm, respectively. In C₁ treatment middle size polybags perform better (girth 6.05 and height 34.0 cm) Gobar manure with long polybags seedlings performed better in G₂, G₃ and G₄ treatments with average girth and height of 5.17-6.62 mm and 51.5-61.17 cm, respectively. In Goat manure G₁ treatment with small size polybags perform better with average girth and height of 5.29 mm and 51.89 cm, respectively.

In leaf compost, treatments L₁ to L₄ long polybags perform better with average girth and height of 2.89-4.78 mm and 19.7-42.5 cm, respectively. In vermicompost manure treatment in long polybags of V₁- V₄, performance was better with average girth and height of 3.65-4.79 mm and 26.0-35.1 cm, respectively. In Goat manure, long polybags perform better where average girth and height were 4.66 -6.14 mm and 49.6 -56.1 cm. respectively.



a. Khejri seedlings



b. Growth data recording of biofertilizer treated seedlings



c. Neem seedlings



d. Rohida seedlings

Fig 17 (a-d). Recording of growth parameters in Nursery

Prosopis cineraria

Prosopis cineraria seedlings with Compost manure and small polybags seedlings performed better in C₁, C₂ and C₃ treatments. The average girth and height were 1.89-2.46 mm and 39.33 -53.83 cm, respectively. In C₄, long polybags perform better with average girth and height of 1.97 mm and 46.67 cm, respectively

In leaf compost, in treatments L₃ and L₄ long polybags perform better with average girth and height of 2.59-3.97 mm and 61.3-66.2 cm, respectively whereas in treatments L₁, middle size polybags perform better (3.03 mm and 60.48 cm, respectively). In treatments L₂, small polybags perform better with average girth and height of 3.67 mm and 64.33 cm respectively.

In Goat manure with M₂ –M₄ treatment long size polybags perform better with average girth and height of 1.84-2.08 mm and 35.51-44.42 cm, respectively. In M₁ small polybags perform better with average girth and height of 1.73 mm and 36.34 cm, respectively.

In vermicompost manure treatment in long polybags of V₁- V₄ performance of seedlings was better with average girth and height of 1.47-2.16 mm and 34.08-50.37 cm, respectively. In Gobar manure long polybags small polybags seedlings performed better in G₁, G₂ and G₃ treatments (1.85-2.06 mm and 47.80-59.37 cm, respectively). In Goat manure with G₄ treatment long size polybags perform better with average girth and height of 1.95 mm and 48.42 cm, respectively.

Performance of individual biofertilizers varies in different treatments. Root shoot ratio and other parameters were recorded for further analysis for all species.

EXTERNALLY AIDED PROJECTS

Project 19: Phytoremediation of soil for productivity enhancement during land disposal of effluent (AFRI-113/FED/SFD-Raj/ 2011-16).

Principal Investigator: Dr. Abha Rani Gupta, Scientist E

Survey was conducted on effluent disposal along the river basin Jojari in Jodhpur and Bandi in Pali districts. Different locations were selected along the river and geographical coordinates were recorded and validated with the existing maps and GPS locations. Major points of effluent disposal along the river basin Jojari are Nandra Khurd, Banar, Kharda Randhir, Mahalo ki dhani, Basni Benda, Jhalamand, Kudi, Bakarsani, Bakaroda (Bhato Ki dhani), Tanawara, Salawas, Nandwan, Bhandu Kalan, Bhandu Khurd, Lunawas, Dhawa and Doli village. Along Bandi river these points are Bumadra, Utvan,

Punaita, Jawadia, Gadwara upto Nehda dam. Effluents, soil and plant samples were collected from effluent disposal area and analyzed for different physico-chemical parameters. Plantation in field (split plot design) and lysimeter experiment (CRD) have been maintained by applying different treatments. Growth data in field (yearly basis) and lysimeter experiment (monthly basis) was recorded. Preliminary observation indicates that *Azadirachta indica*, *Eucalyptus camaldulensis* and *Prosopis juliflora* perform better in terms of growth under application of effluent at ¾ level of full irrigation.

Project 20: Documentation of sacred groves of Rajasthan and assessment of biological diversity in some of them for improved management and people livelihoods (AFRI-09/FE.Ext (SFD-RAJ)/2013-214).

Principal Investigator: Dr. G. Singh, Scientist F

Sacred groves are distinct patches of vegetation ranging in size from a cluster, a few trees to a large forest stand spanning several hundred acres and are consecrated in the name of local deities or ancestral spirits. Removal of any living material from the sacred groves is a taboo. However, dead logs and leaves are sometimes collected from some of the sacred groves. Sacred groves are known as 'Oran', 'Devabani', 'Kakerbani' or 'Baag' in Rajasthan and are the best example of indigenous traditional resource use practices promoting conservation of biodiversity and a source of livelihood. Though described as remnants of pristine forests in climax formation, our survey of sacred groves in Rajasthan indicates occurrence of *Acacia tortilis*, *Eucalyptus camaldulensis*, *Prosopis juliflora*, *Lantana camara* etc species along with the indigenous flora. Our inventory of 123 sacred groves covering all districts of Rajasthan showed the presence of 131 woody species belonging to 48 families. These sacred groves were observed dominated by 26 types of tree species depending upon their adaptability to edaphic and climatic conditions. Dominant species with decreasing number of sacred groves are in order *A. pendula*>*P. juliflora*>*Salvadora oleoides*> *Capparis decidua*>*P. cineraria*>*Tectona grandis*>*Acacia leucophloea*>*Acacia nilotica*>*Butea monosperma*>*Zizyphus rotundifolia*. Sacred groves dominated by *P. roxburghii*, *W. tinctoria*, *E. officinalis*, *B. monosperma*, *M. parviflora*, *A. indica*, *A. catechu* and *Tectona grandis* indicated higher vitality in terms of diversity and regeneration status and can be promoted under restoration of the groves. In arid region, *P. cineraria* and *Salvadora* spp. found effective in maintaining diversity of the groves. Tree diversity in sacred groves increased with rainfall indicated by more diverse sacred groves in east of Aravalli as compared to west (Fig. 18). At least 19 birds, 25 mammals and 10 reptiles including the Alexandrine parakeet were observed or said to be visited these sacred groves. Since sacred groves are associated by a range of oral narratives and belief systems, which are unique social means to prevent intra-group conflicts and violation of the traditional ethos participatory involvement of all members of the user

community in protection of the sacred groves appeared more effective. Indeed, customary edicts to protect sacred groves are more acceptable to preindustrial communities than the externally imposed laws restricting traditional land use practices. Effective management strategies for protection and conservation of sacred groves would be **strengthening the existing conservation system of the villagers and restoring the degraded once following landscape level approach. Various steps in managing the sacred groves would be:** (i) People participation and awareness generation; (ii) Effective government policy and planning; (iii) Documentation and delineation of the sacred groves; (iv) People mobilization and management; (v) Restoration of sacred groves; (vi) Control of over grazing and over exploitation; and (vii) Control of invasive species like *P. juliflora* and *Lantana camara* through applying physical, chemical and biological approaches.

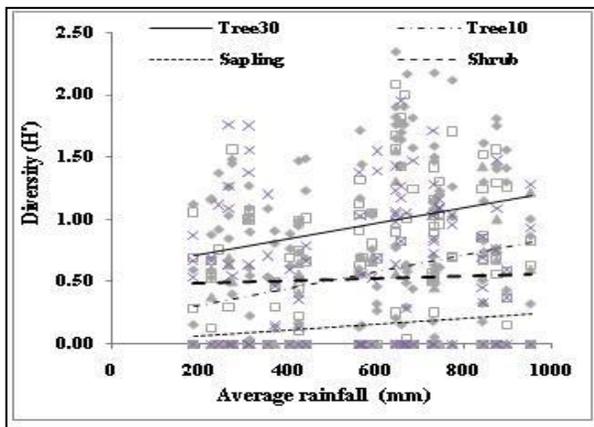


Fig 18. Trend of diversity index of trees with girth class >30 cm (tree30) and 10-30 cm (tree10), shrubs and tree saplings in the sacred groves with rainfall; and Performing rituals in a sacred grove

Project 21: Documentation of important research findings and technologies for applications to forestry in Rajasthan (AFRI-08/FE/Ext(SFD: Raj.)/2013-15).

Principal Investigator: Dr. G.Singh, Scientist F

This project is funded by State Forest Department, Government of Rajasthan with total outlay of Rs. 11.66 Lakhs to develop a book in the form of manual based on existing knowledge in the region and abroad. As per the action plan we have to develop a book encompassing a complete guideline to restore dry lands, to combat desertification and to improve people livelihoods by way of forestry applications. Book entitled 'A manual for Dry land Afforestation and Management' has been finalised. Literatures have been collected related to forestry, agroforestry, water harvesting and conservation, stress site management and afforestation from different institution working in dry areas. Out of the 13 chapters proposed, 10 chapters have been completed and three chapters are under preparation. Literature review indicates that high population, variable rainfall and increasing

temperature together with natural resource devastation are promoting the process of desertification in different sectors (Fig. 19). Increasing wind and water erosion, salinity development, reduction in standing forest biomass, carbon storage, biodiversity and village commons are the potential threats to drylands. There are different policies and programmes at international, national and regional levels to curb the problem of desertification, land degradation and drought, but the problem remain same. There needs to conserve the existing biological diversity and natural resources and biomass productivity to maintain functional behaviour of the drylands ecosystem and enhance people livelihood by reducing dependency of the poor on the rich ones.

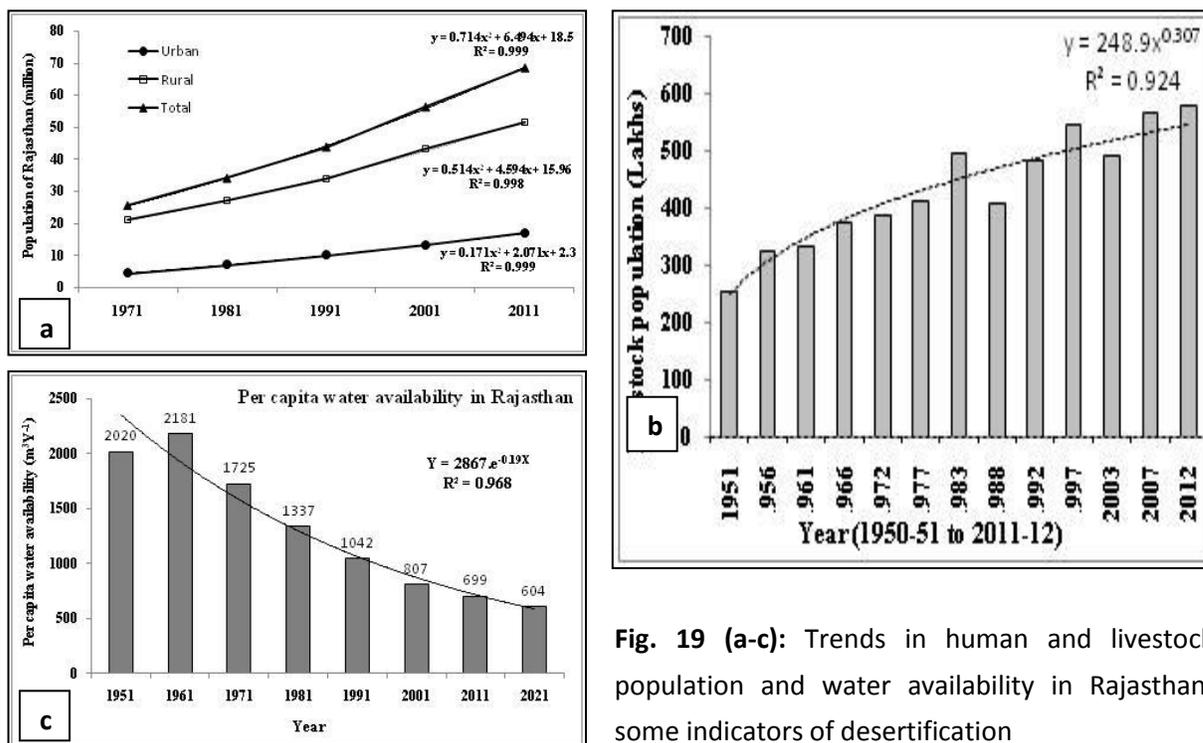


Fig. 19 (a-c): Trends in human and livestock population and water availability in Rajasthan: some indicators of desertification

Project 22: Species evaluation for landscaping and restoration of degraded Aravalli hills at IIM campus, Udaipur (AFRI-13/FE/Ext(IIM, Udaipur)/2014-2017).

Principal Investigator: N. Bala, Scientist F

The project has been initiated during August 2014 with the aim to evaluate different tree and shrub species for their suitability in restoration of degraded hills. Survey of the site has been done and experimental details finalized with layout of the experiment. One hundred thirty three plants of *Dendrocalamus strictus* and *Terminalia catappa* were planted in October 2014. Advance soil working has been initiated with the help of state forest department involving village forest protection and management committee (VFPMC) for detail plantation.

4. Forest and Climate Change

ICFRE PLAN PROJECTS - Nil

EXTERNALLY AIDED PROJECTS

Project 23: Studies on the effects of MPOWER programme on mitigation and adaptation towards Climate Change in western Rajasthan (FE/AFRI/MPOWER/2013-15).

Principal Investigator: Dr. G.Singh, Scientist F

This project is funded under Mitigating Poverty in Western Rajasthan (MPOWER) project, which has been implemented on pilot basis in six blocks one each in Jaisalmer, Barmer, Jodhpur, Pali, Jalore and Sirohi districts of western Rajasthan for mitigating poverty of the target groups households through strengthened capacity, improved livelihood, sustainable enterprises, natural resources management and increased access to credit and markets. One hundred two villages were selected for field survey and data collection. Three types of questionnaires were developed, i.e. related to village profile data collection; socio-economic and people perception about climate change and adaptation strategies; and interaction with project implementing agencies. Further, depending upon availability of land uses in the selected village, soil samples were collected in 0-30 cm soil layer and analysed for soil organic carbon, bulk density and gravel content estimation. Out of 28691 household, a total number of 2345 households were surveyed and interactions made with people (Fig. 20). Interactions with the local people indicate: (i) villagers experiences varying rainfall and warming of the day because of decreased rainfall and increased summer temperature; (ii) peoples are reducing livestock herd size because of decreased pastures; (iii) people use to collect fuelwood from forest area within few days and store it for use during summer and rainy seasons; (iv) people use to develop assets like jewelries, livestock, poultry farming etc as a coping mechanism against any future mishap. As an adaptation to climate change: (i) people of Baitu and Sankra block are changing their occupation and use to migrate to other places for livelihood; (ii) use of hybrid seeds, chemical fertilizers, pesticides to increase production; (iii) people of Aburoad block have adopted mix-cropping and vegetable farming by dividing agriculture land for crops and vegetables for generating immediate benefits by selling seasonal vegetables, which help them improve livelihood; (iv) irrigated area has been increased in many villages of Bali, Aburoad and Sanchore blocks, where villagers are irrigating their farmland as use of 'Saran' (irrigation channel) in Bali block; (v) people have also started rain water harvesting (through community water tank) to ensure drinking water supply.



Fig 20 (a-b). People interaction and construction of 'Tanka' for rainwater harvesting as adaptation to climatic abrasions

5. Forest Genetics Resource Management and Tree Improvement

ICFRE PLAN PROJECT

Project 24: Study of salt tolerance through gene expression pattern analysis (AFRI-102/FGTD/ICFRE/ 2010- 2015).

Principal Investigator: Dr. Tarun Kant, Scientist E

The project aims at analyzing the pattern of expression of four genes (NHX1, SOS1, HKT1 and CLC-c) that are known to function in maintaining ionic balance within the plant particularly in regulating the non-toxic levels of sodium chloride, which is the dominant salt in saline soils. High Na⁺ levels in a plant cells lead to detrimental effects reducing productivity and survival. In the project, a halophyte (salt tolerant plant) – *Lepidium sativum* was used and grown hydroponically at different levels of salinity ranging from 40 to 200 mM NaCl. The amplified gene products were separated electrophoretically. Using semi-quantitative approach, the intensity values of the bands on gel images was captured. *LsNHX-1*, *LsSOS-1* and *LsCLC-c* had a high baseline constitutive gene expression levels even under normal non-saline conditions indicating that genes are hyperactive even without salt stress. The expression levels of *LsHKT-1* gene do not undergo a remarkable change even at highest salinity levels of 200 mM NaCl treatment (Fig. 21). In leaf tissue of *L. sativum* grown at high salinity levels (160 and 200 mM NaCl), *LsNHX-1* gene attains a 4 fold up-regulation state by 6 hours, while in root tissue, the same level is achieved at 3 hours. *LsSOS-1* gene in root tissue is expressed at a higher level compared to that in the leaves, while in case of *LsCLC-c* gene, the expression level differences between the leaf and root tissue is not remarkable.

This is the first ever report of use of *Lepidium sativum* as a halophytic close relative of *Arabidopsis thaliana* in understanding the expression pattern of key genes involved in salt tolerance mechanism using a comparative genomics approach.

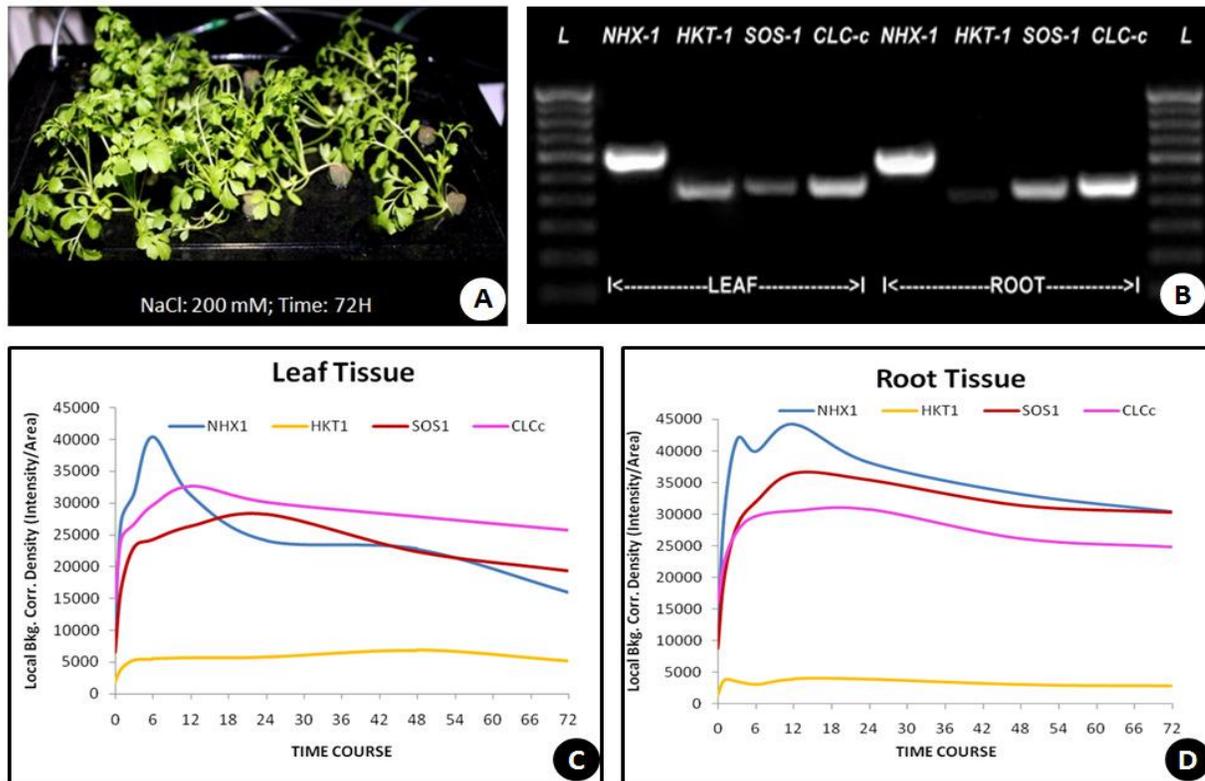


Fig. 21. Study of gene expression pattern: **A.** Effect of 200 mM of NaCl on *L. sativum* after 72 hours of salt exposure; **B.** Expression levels of four genes (*NHX-1*, *HKT-1*, *SOS-1* & *CLC-c*) in shoot tissue and root tissue at 160 mM of NaCl; **C & D.** The graph plotted from gel image band intensity values (B) in leaf and root tissue respectively.

Project 25: Development of technologies for multiplication of economically important desert plant – *Capparis decidua* (AFRI-105/FGTB/ICFRE/2010-2015).

Principal Investigator: Dr. Sarita Arya, Scientist F

Objective of the project was to develop micropropagation and macropropagation protocol of economically important desert plant *Capparis decidua*. Effect of BAP, Kn, Zeatin and TDZ were studied for *in vitro* shoot development. MS medium supplemented with 2.0 mg/l BAP+0.1mg/l IAA and additives were found best for *in vitro* shoot multiplication. Other medium tried (WPM,B5) not yield good shoot multiplication. pH of 5.5-6.5 range was needed for *in vitro* shoot multiplication. Sucrose at 3% concentration in the medium was the best. *In vitro* rooting experiments were performed with the

use of Auxins (IBA & IAA). The effect of various media and auxins were studied for *in vitro* rooting. 1/4 MS medium with 4.92µM IBA was the best for *in vitro* rooting of 94%. These tissue culture raised plants were hardened in mist chamber.

Project 26: Assessment of variability, improvement and refinement of cloning techniques of *Tecomella undulata* (sm.) Seem. (AFRI-04/FGTB /Int(ICFRE)Reg/2012-2017).

Principal Investigator: Km. Desha Meena, RO

Tecomella undulata (Sm.) Seem (Bignoniaceae) is an important timber yielding tree species of arid region. The tree is economically valuable due to quality wood production. Indiscriminate felling for timber and fuel, coupled with poor regeneration and sluggish growth however has severely depleted the natural population of this valuable tree, with an associated loss of valuable germplasm and considered threatened species. Exploitation of genetic variability in the available population is essential for success of any breeding programme. Therefore this project is planned to expand the area of CPT selection to entire Rajasthan and to study the level of variations existing among the populations using molecular markers.

Progeny trial was established during September, 2014 with 36 families in 4 replications at spacing of 3m x 4m in RBD at Dorasar Nursery, Jhunjhunu. About 92.5% of survival was recorded after six months of its establishment. Also maintained and recorded the growth parameters of the progeny trial established at AFRI experimental field, Jodhpur in 2013. After 1 year of its establishment, an average height of 75.1 cm and average collar diameter of 0.50 cm was recorded. The progeny of CPT No-36 from Pali district gave the best growth attaining the height of 120 cm and collar diameter of 1.58 cm. Initiated the genetic diversity studies and standardized the genomic DNA isolation and purification methods. Screening of fifteen ISSR primers has been completed.

Project 27: Development of macro and micropropagation technology for multiplication of economically important desert plant- *Salvadora persica* (AFRI-92 /FGTB/ICFRE/2009- 2015).

Principal Investigator: Dr. I.D. Arya, Scientist G

Objective of the project was to develop tissue culture technology for economically important desert plant *Salvadora persica*. Success was obtained in standardizing various stages of protocol development. Cultures were established from aseptic culture of nodal segments containing axillary buds. *In vitro* shoot proliferation was standardized on media formulated. *In vitro* shoots so developed were regularly multiplied every four week subculture duration. MS media tested for different concentrations of BAP showed that 2.0mg/l BAP + 0.1mg/l IAA gave best results for *in vitro*

shoot multiplications. On the whole, it was concluded that among different cytokines (BAP, Kn, TDZ, Zeatin alone) tested, BAP was found the best. Among the different auxins (IAA, IBA or NAA) used, for *in vitro* shoot multiplication, IAA was found to be the best. Thus combination of BAP + IAA in the medium was most suitable for *in vitro* shoot multiplication. It was found that MS medium supplemented with 1.0mg/l IBA along with additives successfully induce *in vitro* rooting in *in vitro* shoots. A gradual hardening and acclimatization procedure is must for the tissue culture raised plants before they can be transplanted into the field.

Project 28: Screening of high oil and Azadirachtin in Neem (AFRI-34/FGTB/ICFRE/2002-2015).

Principal Investigator: Dr. U.K.Tomar, Scientist F

Third objective "Identification of high oil and azadirachtin yielder" was to identify genetically superior genotypes for high Aza and oil contents through progeny trial and to study the heritability of these characters. However, we could not accomplish this objective completely due to poor flowering and fruit setting this year (2014-15) and previous years. Hence it was requested by PI in RAG 2014 to close this project and concluded in March 2015 with results achieved so far. Henceforth, data on flowering and fruiting may be recorded every annually with minimum plan budget in non-project mode. Once more than 50% plants in the trial started fruiting in sufficient quantity a follow-up project may be initiated for three years for estimation of Oil and Azadirachtin and achieving its last but important objective.

ADG (M & E) also recommended in Annual Review November 2014 that Project may be concluded this year (March 2015) as proposed by PI and this Neem Progeny trail may be maintained with bare minimum budget. It was also suggested to prepare a follow up project in due course of time to achieve its main objective.

Project 29: All India co-ordinated project on genetic improvement of *Melia composita*. (AFRI-10/Silva/Int(ICFRE)AICP/2013-2024).

Principal Investigator: Pravin H. Chawhaan, Scientist F

Melia composita Willd. (Syn. *Melia dubia* Cav.) is commonly known as Burma Neem is fairly large, deciduous and fast growing tree. It grows upto a height of ~20 m and straight cylindrical bole of ~ 9 m. The tree is commonly found in the Eastern Himalayas particularly in the states of Sikkim, North Bengal, Assam, Khasi Hills and Orissa. The tree is cultivated in the arid, semiarid and semi moist areas. Due to its fast growth and multiple uses, it is emerging as a favorite tree for growing under agro-forestry plantation in the North-Western states of India. If tested it may be a good

introduction in agro forestry in arid and semi arid tracts where irrigation is available. Keeping this in view this project is being implemented to test performance of this species at multilocation under the auspices of all India coordinated project. Open pollinated seed of 42 CPTs have been pretreated and germinated in nursery.

Three progeny trials consisting of 24 families established at Jodhpur, Gandhinagar and Deesa were maintained (Fig. 22). Growth data was collected from these trials and subjected to analysis of variance followed by computation of genetic parameters. In terms of growth, Deesa trial showed best performance with mean values of 2.80 m and 19.66 cm followed by Jodhpur (2.42 m & 15.85 cm) and Gandhinagar (0.84 m & 5.45 cm for height and collar diameter respectively). However, Deesa trial encounters severe damage due to termites and wilt infestation.



Fig 22. Progeny trial *Melia composita* at Jodhpur (left) and Progeny trial of *Melia composita* at Deesa: Soil drenching with fungicide & insecticides (right)

Analysis of variance reveals that both height and collar girth varied significantly amongst the tree tested except in the case of collar diameter at Gandhinagar. Replication X family variance of collar diameter was also significant and greater in case of Jodhpur and Gandhinagar trials; therefore further genetic analysis for these traits was not carried out.

Individual and family heritability in narrow sense for height was 9.7 and 25.7% in Jodhpur; 11.9 and 32% in Deesa, and 1.42 and 6 percent in Gandhinagar, whereas these estimates were 12.7 and 32 percent for collar diameter in Deesa trial. On the basis of general combining ability analysis Family Nos. 24 and 75 exhibited positive values for both the traits in all three locations (Fig. 23). In addition to this, two more trials at Bassi, Jaipur and Ghodiwada, Jhunjhunu with twenty one families and five replications each have been established.

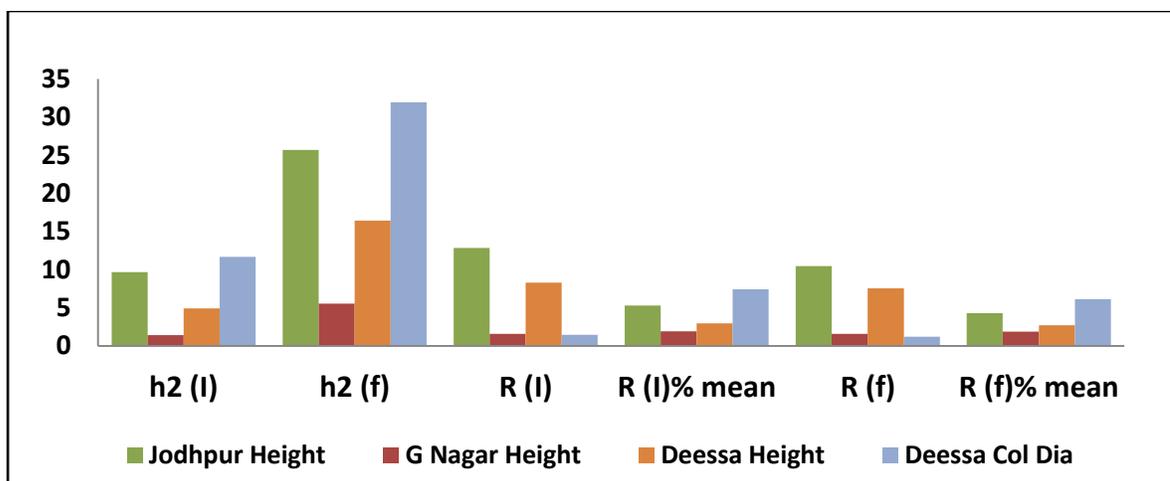


Fig. 23. Heritability and genetic gain estimates in *Melia composita*

Project 30: Investigations on genetic variation and inheritance of Western Indian teak (*Tectona grandis* L.f) (AFRI-94 /Silvi/ICFRE/2009-2015).

Principal Investigator: Sh. Pravin H. Chawhaan, Scientist F

The extent of teak (*Tectona grandis*) forest of Western Indian states is about 6, 192 sq. km. Amongst the states of the region Gujarat have the largest teak forest amounting to 5,637 km² followed by Rajasthan (426 km²) and Dadra and Nagar Haveli (129 km²). The extent of these forests, account for about 46, 3.2 and 63 percent of the total forest cover of these states and UT, respectively. At present information on the inheritance of teak and estimation of the genetic parameters in western Indian teak is lacking and the endeavours of genetic improvement have not been continued beyond the first cycle of improvement.

Individual tree data from four progeny trial established with 16, 16, 28 and 9 half-sib families of teak at Rajpipla, Shivrajpur, Sajjangarh and Jodhpur respectively was collected and analyzed. As teak is paragon amongst the timber species, investigation on genetic variation and inheritance of wood traits along with growth traits is of paramount importance. In this regard wood core samples were extracted from selected trees of all the families in Rajpipla progeny trial and data on bark thickness, sap wood percent, heart wood, specific gravity etc was generated (Fig. 24). Data was subjected to analysis of variance followed by computation of genetic parameters. Height, clear bole length, sap wood length, sap wood percent, heart wood percent, heart wood sap wood ratio and specific gravity exhibited significant variation amongst the 16 families.



Fig. 24. Variation in wood parameter (left) and extraction of wood core sample (right)

The detailed genetic analysis (to compute variance components and genetic parameters) was performed according to Zobel and Talbert (1984). Computation of genetic advance was done using selection intensity of 5 %. In the present materials, individual and family heritability values for different traits were very low to high (Fig. 25 and 26).

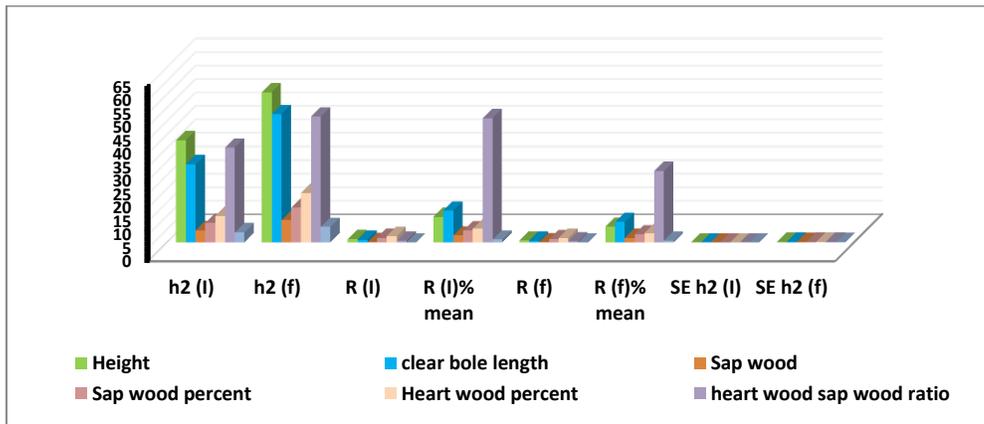


Fig. 25. Estimate of genetic parameters of growth and wood traits in Rajjipla Progeny trial

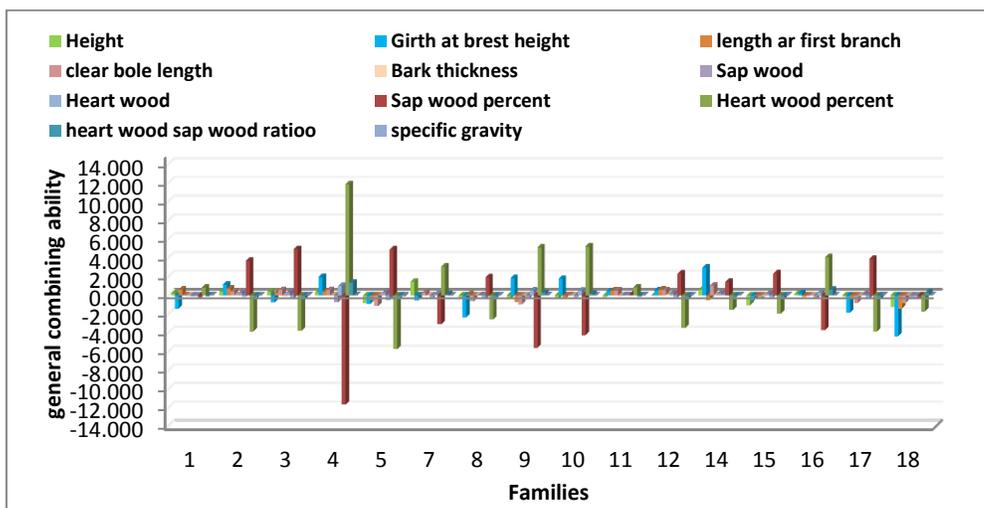


Fig. 26: Estimate of general combining ability of growth & wood traits in Rajjipla Progeny trial.

These values were as high as 38 for height and 35 for heart wood : sap wood ratio. Family heritability values were considerably higher for all the traits suggesting effectiveness for family selection. Genetic advance estimates for these traits also followed similar trend and ranged from 1.0 to 46 percent. It appears that growth and wood traits in teak of this region are controlled by both additive and non additive gene actions. From the general combining ability estimates, 9 parents were found to possess positive values of GCA for wood specific gravity, which is the single most important trait.

EXTERNALLY AIDED PROJECT

Project 31: Utilization of biotechnological tools for clonal propagation and supply of genetically superior trees of Neem, Ardu And Bamboo's (AFRI-06/FGTB/Ext(SFD-Guj) 2013-2016).

Principal Investigator: Dr. I.D. Arya, Scientist G

Already marked superior tree of SFD, Gujarat were used as source material for mass multiplication. Nodal segments were cultured aseptically for *in vitro* shoot proliferation. Media was formulated for the purpose. Conditions were standardized for *in vitro* shoot multiplication. For that different media and plant hormones were tested. *In vitro* shoot multiplication in neem was optimized in MS medium supplemented with BAP (1.0 mg/l) + Kn(1.0 mg/l) and additives (ascorbic acid, citric acid, adenine sulphate, ammonium sulphate and amino acids). In Bamboo *in vitro* shoot multiplication was optimized using MS medium supplemented with BAP (3-5.0 mg/l). *In vitro* shoots were elongated either on hormone free medium or on low dose of BAP in the medium (1.0 mg/l). In Ardu, *in vitro* shoot multiplication was achieved in MS medium supplemented with BAP (2.0 mg/l) + IAA (0.5 mg/l) and additives. Levofloxacin (10-50 mg/l) was used to check contamination in the cultures. In neem, *in vitro* rooting was achieved in MS medium supplemented with IBA (1.0mg/l) + additives. In case of bamboo, 3 mg/l NAA or 10.0 mg/l IBA was used for *in vitro* rooting. Mature cuttings of Ardu and neem were treated with different concentrations of IBA and planted in vermiculite and soil + vermiculite rooting medium.

Project 32: Standardization of non-destructive harvesting practices of *Commiphora wightii* gum Oleogum resin (AFRI-11/FGTB/Ext.NMPB (2014-17)

Principal Investigator: Dr. U.K. Tomar, Scientist F

Guggul growing areas were surveyed and Kumatia (*Acacia senegal*) enclosure in Kailana hills of Jodhpur in Rajasthan and in Mehsana Kheralu in Taranga hills have been marked. Guggul plants of different age groups were marked and properly labelled and the individual data of each plant was

recorded including girth sizes and GPS location. The traditional methods of guggul gum tapping was documented. The experiment was designed with four different sizes and three different patterns of cuts as the treatment. These designed treatments (cuts) were applied on the marked plants. A total of 234 treatments (cuts) of different sizes and patterns were applied on the plants of different girth sizes (Fig. 27). The extracted gum from each treatment was collected in zip lock bags and weighed for further statistical analysis.



Fig. 27 a: Guggul plant labelled with tag, b: Cut applied on the plant, c: Gum extracted from the applied cut

6. Forestry Education and Policy Research to Meet Emerging Challenges

6.1 Improving Formal Forestry Education

6.1.1 FRI University (Applicable for FRI, Dehradun only)

6.2 Accreditation of Universities

-NA-

6.3 Networking Forestry Education with research and extension

6.3.1 Participation in Seminar/Symposia/Workshop/Trainings

- Arya I.D. (2014). Introduction of edible bamboo *Dendrocalamus asper* in India. A case history of its mass multiplication through tissue culture and field establishment in the country. Presented in National seminar on Bamboo November 25-26, 2014 held at FRI, Dehradun.
- Arya I.D. (2015) *In vitro* and *ex vitro* clonal technology for plus trees of Neem and Kair.

Presented paper in National Symposium on Biotechnology & Molecular Biology, January 29-31, 2015 held at Mangalore.

- Arya Sarita (2014). Tissue culture technique for lab to land transfer of economically important Bamboo. Presented the paper in National Seminar on Developing Bamboo based livelihood and Enterprise Opportunities, November, 18, 2014 held at Gandhinagar, Gujarat.
- Baloch S. R, Singh G. and Bala N. (2014). An assessment of mining activity impact and suggested measures for restoration of mine overburden in Rajasthan. Presented in National Stakeholders Meet on Forestry and Mining: Forest Mining Interface in Service of Nation during 13th Silviculture Conference organized from 24th to 28th November, 2014 at FRI Dehradun.
- Baloch S.R (2015) "Commission for Scientific and Technical Terminology" two days national Seminar on organized by "तकनीकी शब्दावली आयोग" Human Resources and Development Ministry from 2nd to 3rd March 2014 at Mahila P.G. College Jodhpur (Rajasthan)
- Baloch S.R, Singh G. and Bala N. (2014). Ethnobotanical study in some forest fringe village of Dahod districts of Gujarat. Presented in National Seminar on Sustainable Management of Medicinal Plants and NTFPs during 13th Silviculture Conference organized from 24th to 28th November, 2014 at FRI Dehradun.
- Kant Tarun (2014). Attended the 84th Annual Session of National Academy of Sciences, India and Symposium on Desert Science – Opportunities and Challenges, December 4-6, 2014 held at Faculty of Science, Jai Narayan Vyas University, Jodhpur.
- Kumar Seema (2015). Attended & participated in one day workshop on Conservation of Great Indian Bustard organized by BNHS, Mumbai at DRC, ZSI, Jodhpur on 22 February, 2015.
- Kumar Seema (2015). Delivered Lecture on topic entitled "Biodiversity of AFRI" on International Biological Diversity Day held at AFRI, Jodhpur on 22.05.2014.
- Rathore T.S., Vasu N.K. and Singh G. (2014). Overview of forests, plant biodiversity & its conservation with main emphasis on Thar Desert. Presented in 84th Annual session of National Academy of Sciences, India & Symposium on Desert Science:

Opportunities and Challenges, organized by Jai Narayan Vyas University, Jodhpur, on 4th December 2014.

- Sharma, Meeta and Sharma Noopur (2014). “Ovi-larvicidal activity of Rockon, an extract of cinnamon oil against lepidopteron pests”. Poster presentation in International conference: changing scenario of pest problems in agri-horti ecosystem and their management held on 27-29 November, 2014 at Udaipur.
- Sharma, Meeta and Sharma Noopur (2014). “Seasonal polyphenism in butterflies of Gir forest, Gujarat” presented in National Conference on Biodiversity: harmonizing conservation with life and landscape of arid and semi-arid areas held on 29-30 October, 2014 organized by Dept. of Botany, The IIS University, Jaipur in collaboration with Rajasthan State Biodiversity Board Jaipur.
- Singh G. and Vasu N.K. (2015). Desertification with reference to forests in Rajasthan, research achievements and initiatives. Presented in regional workshop on 'Alignment of national Action Programme on Combating Desertification to 10 year strategy of UNCCD' held at AFRI, Jodhpur on 18th March 2015.
- Singh G., Singh B. and Mishra D. (2014). Biomass production and carbon accumulation in *Calligonum polygonoides* L. dominated region of Indian Desert. Submitted in National Stakeholder Meet on Forestry and Mining: Forest Mining Interface in Service of Nation during 13th Silviculture Conference organized from 24th to 28th November, 2014 at FRI Dehradun.
- सिंह, संगीता एवं निर्वाण, बिन्दु (2015). मानवीय हस्तक्षेपों का पादप रोगों के विकास और महामारी में भूमिका। राष्ट्रभाषा वैज्ञानिक संगोष्ठी, 23-24 फरवरी 2015, विषय :राष्ट्रीय विकास में नवीन उपलब्धियां एवं भावी अनुसंधान की संभावनाएं।
- Shri N.K. Vasu, Director AFRI, Dr I.D. Arya, Scientist F, Dr G. Singh, Scientist F, Sarita Arya, Scientist F and Dr U.K. Tomar, Scientist F attended the 84th Annual Session of National Academy of Sciences, India and Symposium on Desert Science – Opportunities and Challenges, December 4-6, 2014 held at Faculty of Science, Jai Narayan Vyas University, Jodhpur.

6.3.2 Visits Abroad

-NIL-

6.4 Capacity Building Scientific and Management Cadre (Training Organized)

- Organized five days refresher course training for IFS officers as course director on '**Integrated approach for sustainable development of fragile desert eco-system**' during 15-19th December 2014 at AFRI, Jodhpur.

7. Forestry Extension for Taking Research to people

7.1 Collection, Compilation and Publication of forestry reports/journals

7.1.1 Research Publications

National/International Journals

- Gehlot, A. Tripathi, A. Rathore, I.D. Arya and S. Arya (2014). Effect of sowing depth and media on seed germination of *Ailanthus excels* Roxb. *Indian Forester* 140(8):763-768.
- Gehlot, I.D. Arya, S. Arya, R. K. Gupta, A. Tripathi and S.K. Sharma (2014). Role of Tryptonphan on *in vitro* rooting in microshoots of *Azadirachta indica* A. Juss (neem). *Advances in Forestry Science Cuiabá*, 1(4): 101-106, Brazil.
- Gehlot, I.D. Arya, V. Kataria, R.K. Gupta and S. Arya (2014). Clonal multiplication of multipurpose desert tree *Azadirachta indica*-Neem. *Journal of Arid Land Studies*, 24(1):37-40. Japan.
- Gehlot, R.K. Gupta, Atul Tripathi, I.D. Arya and Sarita Arya (2014). Vegetative propagation of *Azadirachta indica*: effect of auxin and rooting media on adventitious root induction in mini-cuttings. *Advances in Forestry Science, Cuiabá*, 1(1): 1-9. Brazil.
- Ashok Kumar Parmar, Tarun Kant (2014). Efficient somatic embryogenesis and molecular marker based analysis as effective tools for conservation of the red-listed plant *Commiphora wightii*. *J. Biosci. Biotech.* 3(2): 169-182.
- G. Singh (2014). Effect of rainwater harvesting on distribution of water and nutrients in soil influencing growth of *Dendrocalamus strictus* in degraded hills in Rajasthan, India. *Bamboo Science and Culture: Journal of the American Bamboo Society*, 27(1): 11-26.
- G. Singh, M. Bhati, T.R. Rathod, and U. K. Tomar (2014). Physiological responses to nutrient accumulation in trees seedlings irrigated with municipal effluent in Indian Desert. *Physiology Journal*, Volume 2014, Article ID 545967, 15 pages. doi.org/10.1155/2014/545967.
- Garima Mandora, SK Sharma, Tarun Kant (2014). In vitro propagation and field establishment of *Hardwickia binata* Roxb. and assessment of polymorphism through molecular markers. *J Plant Develop.*, 21: 23-31.

- Gufran Usmani, Pravin H. Chawhaan, Yogeshwar Mishra and Asim Kumar Mandal (2015). Geographical variation of total alkaloid and reserpine content in *Rauwolfia serpentina* (L.) Benth. ex. Kurz. *Euphytica* , 202(3):427-434.
- K.K.Srivastava, Neelam Verma, Sangeeta Singh, Bhawana Shrama and K.C. Jedia (2013) AM-Diversity and spore population in mehndi (*Lawsonia inermis* L.) in Rajasthan. *My Forest* 49 (2) 41-52.
- Mahadeo Gorain, Naveen Sharma, Anchal Shrama, Anil Kumar Meena, Sangeeta Singh , Krishnakant Srivastava and Syed Irfan Ahmed (2014). Spatial prototype and phenotype of variations in populations of prichly acacia in semi-arid regions in India. *International Journal of Agriculture Science Research* 3 (4) pp xxx-xxx Available online.
- Meeta Sharma and Noopur Sharma (2014). Seed insect pests associated with important forest tree species in arid and semi-arid regions of Gujarat, India. *Ecology, Environment and Conservation*, 20 (1): 137-141.
- N. Bala, G. Singh, N.K. Bohra, N.K. Limba and S.R. Baloch (2014). Biodrainage for Restoration of Canal Command Waterlogged Area in Indian Desert. *Indian Forester*, 140(5): 60-61.
- S. R. Baloch, Lokho Puni, Priya Sati, B. P. Tamta and Attar Singh (2014). Germination Behavior of Fiber Species of Himalayan Nettle (*Girardinia Diversifolia*) in Different Altitude. *Indian Forester Volume*, 140(4): 374-37
- Sangeeta Singh, Vineeta Srivastava, Bindu Nirwan, Shiwani Bhatnagar and K.K. Srivastava (2015) Study of incidence of stem canker of Rohida and its causal agent. *Indian Forester* 141(2): 227-229.
- Shiwani Bhatnagar, Parveen Goran and Sangeeta Singh. (2014) Life cycle of small salmon arab *Colotis amata* (Lepidoptera: Pieridae). *The Bioscan*. 9(3): 1063-1066.
- Singhal, H., Gaur, A. & Tomar, U.K. 2014. Observations on flowering and fruiting in *Commiphora wightii* (Arnott) Bhandari. *Eur J Med Plant*, 4(9): 1087-1097.
- N. Tak, and Seema Kumar (2014). New records of ants (Insecta: Hymenoptera: Formicidae) from Haryana, India. *Rec. zool. Surv. India*: 114 (Part-4): 529-538.
- Vijay, N., Arya, S. and Arya, I.D. (2014). Rapid and mass propagation of the economically important desert plant *Capparis decidua* for its afforestation program. *Journal of Arid Land Studies*. 24-1:33-36. Japan.

Proceeding/Book Chapter

- Anuradha Rathore, Ramniwas Choyal, Ashok Gehlot, I.D Arya and T.S. Rathore (2014). Studies on *in vitro* micropropagation of *Ailanthus excelsa*. In National conference on Plant Bioresource Management, held on 29 - 31 January, 2014 at University of Rajasthan, Rajasthan, 135.

- G. Singh (2014). Effects of Rainwater Harvesting and Vegetation Cover in Reducing Water, Soil and Nutrient Losses during Restoration of Degraded Hills in Rajasthan, India. Proceeding of Asia Pacific Workshop on Forest Hydrology: Water and Forests: Beyond Traditional Forest Biology. APAFRI Secretariat c/o Forest Research Institute Malaysia (FRIM), Malaysia. pp. 154-159.
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7.1.2 National Forest Library and Information Centre (NFLIC) (Applicable for FRI, Dehradun only)

-NA –

7.1.3 Environmental Informatin System (ENVIS) (Applicable for FRI, Dehradun only)

7.2 Dissemination of developed technologies

7.2.1 Van Vigyan Kendras (VVKs) and Demo Villages (DVs)

Shri B.R. Bhadu, Group Coordinator (Research) and Shri Mahipal Bishnoi, RA-II visited Hi-Tech nursery Bicchawal, Bikaner from 2-3rd Feb 2015 and observed nursery activities.

Hi-Tech nursery: Hi-Tech nursery at Demo village, Salawas has been maintained. The developed cattle proof trenches, planted lives hedges, medicinal plants and agroshed net and compost chamber are being maintained for demonstration purpose. The planted medicinal plants viz; *Nyctanthus arbortrestus* (Harsingar), *Cybopogon citrates* (Leman grass), *Asparagus racemosus* (Satawari), *Crinumasi aticum* (Sudarsan), *Adhatoda beddomei* (Adusa) maintained at Demo village nursery, Salawas for knowledge sharing and use of local people.

Maintenance of raised seedlings and selling out: Raised seedlings (700 Nos.) of different tree species in last year was maintained and 255 seedlings were sold among farmers to promote agroforestry. The amount received Rs. 1275 after selling seedlings at Demo village.

Demonstration site: The demonstrated technologies on soil and water conservation and silvipastoral model of *Cenchrus ciliaris* grass along with *Cordia gharafa* and *Zyziphus nummularia* with intervention of *in-situ* water conservation were maintained.

7.2.2 Direct to Consumer Scheme

- A technical report 'Suitable Species for Biomass Energy Production' Submitted to Department of Forests, Government of Rajasthan & Banswara Biomass Energy Pvt. Ltd., Banswara (Rajasthan) jointly by MP University of Agriculture & Technology, Udaipur and AFRI, Jodhpur
- Presentation of project significant findings in meeting, conference/workshop/training and publication of articles for better outreach.

7.2.3 Technologies transferred

- NIL -

Technology developed

Developed regression equation for assessment of standing biomass of *Calligonum polygonoides* of the type:

SNo.	Equations for predicting dry biomass of <i>Calligonum polygonoides</i>
1	(i) Above-ground biomass (kg) = $0.018245686 * CD^{3.006409373}$
	(ii) Root biomass (kg) = $0.011522168 * CD^{3.064545624}$
	(iii) Total biomass (kg) = $0.029947869 * CD^{3.027203010}$
2	Established relationships between rock and soil types with plant species for their use in restoration of degraded areas.

CD: collar diameter in cm.

7.3 Evolving and coordinating comprehensive extension strategies in forestry research

7.3.1 SLEM/UNCCD

NIL

7.3.2 Seminars/Symposia/Workshops organized

- Organised one day workshop on 'Alignment of national Action Programme on Combating Desertification to 10 year strategy of UNCCD' organized at AFRI, Jodhpur on 18th March 2015 and field visit on 19th and 20th March 2015.

7.3.3 Special Activities (Such as Van Mahotsava, Forestry Day and Other Occasions)

I. International Biodiversity Day on 22nd May 2014

International Biodiversity Day was celebrated on 22 May 2014 (Fig. 28). Following activities conducted at AFRI:

- Ceremonial plantation- Plants of various species were planted in AFRI Arboretum by staff/guest and JRF/SRF/FA and photographs of event were published in “AFRI DARPAN” and local news paper.
- Lectures – Various lectures were arranged on this occasion. An interesting presentation was made by Chief guest Dr. G. S. Bharadwaj on wild life of hot and cold desert, Dr. U. K. Tomar also delivered lecture on Biotechnology and Biodiversity, Mrs. Seema Kumar delivered lecture on biodiversity.
- A debate was also organized for school children on the theme “Island Biodiversity”. Prize and certificates were distributed to winners/participants by Director T. S. Rathore and GCR, Sh. M. R. Baloch.



Fig 28. Ceremonial plantation (left) and Winner students of debate competition (right)

II. World Environment Day (5th June 2014)

Every year World Environment Day is celebrated on 5th June 2014 (Fig. 29). This year also a programme was organized at AFRI Arboratum. Following activities were carried out–

- Ceremonial Plantation –Plants of various arid and semiarid tree species were planted in the arboretum by AFRI officials.
- Lecture –Lecture session was started with welcome speech by Dr N. K. Bohra. After this Sh. M. R. Baloch GCR delivered a short speech on importance of World Environment Day, Dr. T. S. Rathore Director AFRI, presided over the function, also told that it is very necessary to protect environment by enhancing forest. Chief guests Dr. N. L. Harsh also requested people

not to use plastic bags in favor of environment safety. Sh. N. Bala Scientist E explained clean development mechanism on this occasion.

- Drawing Competition – A drawing competition was organized for primary, middle and senior level children for increase awareness towards environment. Prizes were distributed to winners by Chief guest Dr. N. L. Harsh and Dr. T. S. Rathore, Director AFRI.



Fig 29. Winner students of Drawing competition

III. Combating Desertification Day (17th June 2014)

Combat desertification was celebrated on 17th June (Fig. 30). Ceremonial plantation was done by Dr M. M. Roy, Director CAZRI, Jodhpur, who graced the occasion. All staff, scientist and officers of AFRI attended the celebration.. Following activities were carried out–

- Ceremonial Plantation - Plants of various tree species were planted by AFRI staff.
- In house Session - Dr. D. K. Mishra delivered a short speech on importance of this day. Dr. T. S. Rathore, Director AFRI emphasized the necessity of the day and suggested a combined efforts of general public, Forest department, universities and scientists to reduce desertification. Dr. G. Singh Scientist F delivered a lecturer on Sand dune stabilization through power point presentation. Chief guest Dr M. M. Roy, Director CAZRI, told about technique developed and transferred to farmers by this institute.
- Speech Competition - Speech competition was also conducted for school students. Students from various schools of Jodhpur participated. Prize were distributed to winners by Chief guest Dr M. M. Roy Director CAZRI.



Fig. 30. Chief guest speech on combating desertification day

IV. Van Mahotsav (19th July 2014)

Van Mahotsav 2014 was celebrated on 19th July, 2014 with involvement of Jai Naryan Vyas University Jodhpur. Sh. Gajendra Singh Shekhawat MP Jodhpur was invited as the chief guest of the function (Fig. 31). The programme started with the ceremonial planting of various tree species seedlings at JNVU campus by chief guest and Dr. T. S. Rathore Director AFRI. Other special guest invited on this occasion were syndicate members of JNVU, Dr. Akhil Ranjan Garg and Dr. Dungar Singh Khichi; ex- syndicate member Sh. Gulab Singh Chouhan, syndicate member of Maharaja Ganga Singh University, Bikaner, Sh. Kailash Daga. All the invited guests delivered their views about importance of trees in environment cleaning.



Fig. 31. Ceremonial Plantation

V. Other extension activities

During 2014-15 a total of 1506 visitors came to visit Interpretation and extension centre. These group of visitors included trainees of Indian Forest Services/State Forest services, SFD officials, Farmers, VFPMC members, Students from Universities, Colleges & schools, members from NGO and others persons from government/private organizations. All visitors learned about research activities and developed technologies of AFRI during their visit.

VI. Participation in Kisan Mela/Exhibition/Trade fair etc:

- Participated in Hastshilp Mela organized at Jodhpur Rajasthan during 2-11 January 2015. Demonstration of Institute research work was done through display board for public awareness at stall.
- Participation was done at Banad Kisan Mela organized by NABARD on 9-2-15. HoD AF&E Division & one RA represented AFRI and introduced farmers about research activities of institute through various display boards and pamphlets.
- Participation in a Kisan Mela organized by NABARD at Rohit, Pali on 11-2-15. HoD AF&E Division attended this and represented AFRI, Jodhpur. Farmer were introduced about research achievements and activities of AFRI through various display boards and pamphlets about management of Khejri mortality.
- Participation was also made in a farmer fair organized by NABARD at Jaisalmer on 17-2-15. Farmer were introduced about research achievements and activities of AFRI. Pamphlets about management of Khejri mortality problem were also distributed to Farmers.

VII. Awareness Week

As per the Direction of Govt. of India, AFRI celebrated Vigilance Awareness Week during 27th October 2014 to 1st November 2014. The programme started with oath ceremony for Vigilance awareness by Sh. N.K. Vasu, Director, AFRI. During this week essay & slogan competition on "अष्टाचार कारक एवं निवारण के उपाय" subject was also held. In the closing ceremony a Poster competition on "कितने जागरूक हैं हम अष्टाचार के प्रति" was held among the employees of the Institute. The chief guest was Sh. Vinit Kumar Mathur, Advocate, Rajasthan High Court, share his experience of vigilance related matters. Dr. G. Singh, Vigilance Officer, AFRI informed about the RTI Act on this occasion.

7.4 Consultancy Services

Systematic survey was done and soil profile at 56 locations studied under a consultancy project on 'Preparation of baseline database on soil and vegetation status at the new campus of IIM Udaipur at village Balicha, Tehsil Girwa. Vegetation study in the area has been conducted. Soil physical parameters, site characteristics, regeneration status, rock outcrop, litter accumulation etc. were recorded. Estimation of micronutrients in soils was also done and report submitted.

A survey has also been done for drying and dying of the trees in Bijoa Jod area of Pali District of Rajasthan. Report prepared and recommendation made accordingly.

7.5 Activities of Rajbhasha

राजभाषायी गतिविधियाँ 2014-2015

2014-15 के दौरान संस्थान का हिंदी पत्राचार 78.45 फीसदी रहा तथा फाईलों में लक्ष्य के अनुरूप टिप्पणियां हिंदी में लिखी गईं। हिंदी कार्यशाला सह वैज्ञानिक गोष्ठी संस्थान में आयोजित हुई। निर्धारित चार तिमाही बैठकें राजभाषा विभाग के निर्देशानुसार आयोजित हुईं। नराकास की नियमित बैठकों में भाग लिया गया तथा संस्थान की हिंदी प्रगति से उन्हें अवगत कराया गया। संस्थान की हिंदी पत्रिका "आफरी दर्पण" का प्रकाशन हुआ जिसमें विभिन्न विषयों के विशेषांक भी सम्मिलित हैं। दिनांक 12 से 26 सितम्बर 2014 को हिंदी पखवाड़ा आयोजित किया गया जिसमें सरकारी कामकाज में हिंदी के प्रयोग को बढ़ावा दिए जाने से विभिन्न प्रतियोगिताओं का आयोजन हुआ। हिंदी पखवाड़ा के दौरान वर्ष 2013-2014 के हिंदी कार्यों के लिए संस्थान कर्मियों को राजभाषा पुरस्कार प्रदान किए गए। तिमाही बैठकों में पत्राचार हिंदी में बढ़ाने हेतु जोर दिया गया।

कार्यालय प्रयोग की निर्धारित सामग्री का द्विभाषिक प्रयोग सुनिश्चित किया गया। संस्थान में कार्यरत प्रत्येक अधिकारी एवं कर्मचारी को हिंदी भाषा का ज्ञान है तथा अधिकांश लोग हिंदी में कार्य करते हैं। शीर्षस्थ प्रशासनिक बैठकों में वार्तालाप/कार्यवाहियां पूरी तरह हिंदी में की गईं। विस्तार गतिविधियों के अंतर्गत प्रचार-प्रसार में हिंदी का प्रयोग हुआ तथा शोध आधारित जानकारी मिली जुली भाषा में दी गईं। संस्थान की वेबसाइट को द्विभाषी करने हेतु कदम उठाए गए।

7.6 Awards and Honours

- Veer Durgadas Smriti Smarak Sthal, Jodhpur awarded Veer Durgadas Rathore award to Dr. Ranjana Arya, Scientist G for outstanding contribution in reclamation of salt affected soils in Rajasthan and Gujarat on 08.08.2014 for the year 2014.
- Dr. Ranjana Arya, Scientist G, awarded for her outstanding contribution by Indian Society of Salinity Research Scientists for the year 2014.

8. Administration and Information Technology

8.1 Information Technology

The existing IT infrastructure was maintained properly with the help of annual maintenance contract of network. The leased line provided by the National Knowledge Network (NKN) was maintained and 24 x 7 internet connectivity was provided to the users. Several video conferencing sessions were organized during the year. The Hindi and English website of the institute was shifted to the ICFRE web server and updated regularly throughout the year. The reports of the important events held at the institute were uploaded on the institutes as well as on the ICFRE websites. The PIMS and Payroll modules of IFRIS were run successfully throughout the year. The annual report, RPC presentations and other important documents of the institute were prepared. Other tasks related to the Information Technology were performed during the year.

8.2 Sevottam:

8.2.1 The charter has been prepared based on the seven steps mentioned in Sevottam. As ICFRE has already mandated its mission "To generate, preserve, disseminate advance knowledge, technologies and solutions for addressing issues related to forests and promote linkages arising out of interactions between people, forests and environment on a sustained basis through research, education and extension". Under the auspices, AFRI is enduring its forestry research for conservation of biodiversity and enhancement of bio-productivity in Rajasthan, Gujarat and Dadra & Nagar Haveli with special emphasis on arid and semi-arid regions. Keeping the National Forestry Research Plan (NFRP) in view, AFRI has identified its thrust areas based on the inputs and active participation of different stake holders. The institute is implementing its research endeavors after duly recognizing the users need. Main research focus of the institute includes:

1. Soil, water and nutrient management,
2. Development of technologies for afforestation of stress sites,
3. Seed handling, nursery, plantation techniques and management,
4. Planting stock improvement and biotechnology,

5. Biofertilizers and biopesticides,
6. Phytochemistry; non-wood forest products,
7. Biodiversity conservation and climate change,
8. Agroforestry and JFM,
9. Forestry education & extension.

Procedures have been formulated for identifying the research problems of the arid region; developing the projects based on the problems and dissemination of the research results and technologies to the users. In order to identify the research problem, stakeholders meeting are organized in the two states viz. Rajasthan and Gujarat falling under the jurisdiction area of the institute. Officials from SFD's, progressive farmers, scientists and NGO's participate in the stakeholders meeting and express the problems on which the research is required.

Based on the research problems given by the stakeholders, in house discussions are made amongst the scientists of the institute and the research projects are formulated by the scientists after the thorough review of scientific literature.

The projects are sent to the external experts for evaluation and their suggestions. After incorporating the suggestions/modifications, the projects are presented before the Research Advisory Group (RAG) Meeting. After including suggestion of RAG members if any, revised projects are prepared and progress of the ongoing projects presented in the Research Policy Committee (RPC) meeting for approval. After the approval of projects, the funds are allotted for the projects and the projects are executed by the scientists.

The technologies developed through the projects are extended/demonstrated to the end users with the help of demonstration trails, extension trainings, Van Vigyan Kendras, Demovillage, printed material, radio talk, workshops, conferences and publications upload to the website of the institute.

8.2.2 Action taken to implement the Charter:

To fulfill the charter, research projects have been prepared in consultation with the stakeholders in Rajasthan and Gujarat, vetted by outside experts, and RAG members and finally by RPC for internal funding and implementation. Projects have also been submitted for various donor agencies for implementing the Charter. Stakeholders meet of AFRI; Jodhpur was organized at Jaipur on 20th August 2014 and at Forest Training Research Center, Gandhinagar on 19th September, 2014. RAG Meeting of AFRI was held on 13-14th November, 2014. New project proposals of various divisions were presented by the PIs. RAG Meeting was chaired by Director, AFRI. Projects approved by RAG were sent to ICFRE for the RPC approval

Several extension trainings were held during the year for dissemination of research results of the various projects executed in the institute. Two issues of the AFRI darpan (quarterly magazine) of AFRI were published in order to apprise the public about the research findings of the institute. The research results of the projects, the technologies developed by the institute and the events held at the institute were continuously updated on the website of the institute.

In addition to these, environmental awareness programs were organized by the institute in the form of World Environment Day, Biodiversity Day, Combating Desertification Day and Van Mohotsava, the details of which have been mentioned above.

8.2.3 Details of Training Programmes, Workshops, etc. held for proper implementation of Charter: Mentioned above under point No. 6.4 & 7.3.2

8.2.4 Details of publicity efforts made and awareness campaigns organized on Charter for the Citizen/Clients:

8.2.5 Details if internal and external evaluation of implementation of Charter in the Organization and assessment of the level of satisfaction among Citizen/Clients:

All the new projects and progress of the ongoing research projects were presented to the internal and external experts of the Research Advisory Group, who gave their comments on the quality of the new projects and the progress of the ongoing projects. The experts prioritized the new projects and expressed their satisfaction on the progress of the ongoing projects.

8.3 Welfare measures for the SC/ST/Backward /Minority communities

To promote the general interest of SC/ST/OBC employees and to work for their collective betterment, development and upliftment, AFRI SC/ST/OBC Employees Welfare Association was formed on 20th September, 2012 by formulating the BYLAWS and electing the Executive Committee of twelve members. As per the DOPT's guidelines for various social groups, Liaison Officers had been nominated during 2012-13 as below:

- Sh. P.H. Chawhan, Scientist F, Chief Liason Officer
- Sh. N.Bala, Scientist E, Liaison Officer, SC
- Sh. S.L. Meena, RO, Gr-I, Liaison Officer, ST
- Sh. A.S. Chouhan, RA-II, Liaison Officer, OBC

For promotion/recruitment process, roaster has been maintained in AFRI, Jodhpur as per guidelines of the GOI. The roaster usually checked by the liaison officer at the time of considering promotion/recruitment for SC/ST/OBC. The roaster has been signed by the concerned liaison officers.

To spread the message of equality and harmony among the various sections of the society the SC/ST/OBC Employees Welfare Association of AFRI made their efforts to celebrate the Dr. Ambedkar Jayanti on 14th April 2014 to commemorate the birthday of Babasaheb Ambedkar. Dr. T. S. Rathore, Director, AFRI presided over the program to pay homage to Baba Saheb Ambedkar on his 123rd Birth anniversary. Shri M.R. Baloch, GCR, AFRI also addressed the gathering on the ideals of Baba Saheb Ambedkar and his teacher Jyotiba Fule. Shri P.H Chawaan, Scientist and Chief Liason Officer of the AFRI Cell and Shri K.C Gupta, Hindi officer addressed about the immense contributions of Dr. Bhim Rao Ambedkar for the down trodden people of India. Scientists/officers/staff of AFRI had assembled for the program

9 Balance Sheet:

Abstract of the Schedule to Monthly Receipt & Payment Accounts

Month & Year: March 2015

2014-15

(Amount in Rs.)

S. No.	Particulars	Budget Alloted (Lakh `)	Exp. Up to Last Month	During Month	Progressive Total	Bal. at the End of the Month
Plan (General Component) -- 'General'						
I(a)(i)	Establishment Expenditure -- Research	634.71	59733680	892253	60625933	2845067
I(a)(ii)	Establishment Expenditure -- Non-Research	198.11	16214459	39718	16254177	3556823
Total [I(a)(i) + I(a)(ii)]		832.82	75948139	931971	76880110	6401890
I(b) Administrative Expenses						
A	Infrastructure	49.60	3944401	554760	4499161	460839
B	Repairs & Maintenance of Infrastructure Assets	40.30	3324578	950905	4275483	-245483
C	Communication	3.80	300852	72678	373530	6470
D	Others	49.30	2663372	2129567	4792939	137061
Total [A + B + C + D]		143.00	10233203	3707910	13941113	358887
I(c)	Research Expenses	46.40	3848573	853004	4701577	-61577
I(d)	Education	0.80	63471	9210	72681	7319
I(e)	Extension	6.70	376364	181692	558056	111944
Total [I(b) to I(e)]		196.90	14521611	4751816	19273427	416573
Total Plan (GC) -- 'General' [I(a) to I(e)]		1029.72	90469750	5683787	96153537	6818463
Plan (General Component) -- 'Creation of Capital Assets'						
II	Expenditure on Fixed Assets & Capital Works-in-Progress	5.11	9489	470846	480335	30665
Grand Total of Plan (GC)		1034.83	90479239	6154633	96633872	6849128

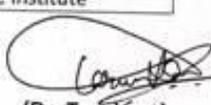
10 Annexure

Annexure 1 -RTI

Names and addresses of public information officers and appellate authorities under the right to information act 2005 in ICFRE and its institutes

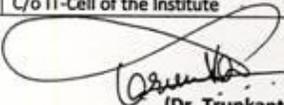
Headquarters / Institutes	Appellate Authorities	Public Information Officers	Subject matter(s) allocated
Arid Forest Research Institute	N.K. Vasu, Director, AFRI 0291-2722764 Email: dir_afri@icfre.org Phone : 0291-2742549 FAX : 0291-2722764	Dr. Tarun Kant, E, FGTB Division, AFRI Email: tkant@icfre.org Phone : 0291-2729143 FAX : 0291-2722764	All matters related to AFRI, Jodhpur

Annexure 1-A (April to June 2014) Quarterly Returns:

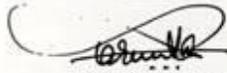
RTI Annual Return Information System Quarterly Return Form													
Public Authority : Ministry of Environment & Forests													
Quarter – I (April to June, 2014)													
Year: 2014-15													
Mode Insert :			Status : New Return										
Progress during the month													
	Opening Balance as on beginning of qtr.-III	No. of applications received as transfer from other PA's U/S 6 (3)	Received during the Quarter (including cases transferred to other Public Authority)	No. of cases transferred to other PA's U/S 6 (3)	Decision where requests/ appeals rejected.	Decision where requests/ appeals accepted							
Requests	Nil	01	16	Nil	Nil	16							
First Appeals	Nil	Nil	01	Nil	Nil	01							
No. of CPIOs designated		No. of CPIOs designated		No. of AA's designated									
01		01		01									
Block II (Details about fees collected, Penalty imposed and disciplinary action taken)													
Registration Fee collected (in Rs.) U/s 7(1)	Additional fees collected (in Rs.) U/s 7(3)	Penalties Amount recovered (in Rs.) as directed by CIC U/s 20(1)		No. of cases where disciplinary action taken against any officer U/s 20(2)									
150/-	562/-	Nil		Nil									
Block III (Details of various provisions & while rejecting the requested information) - NA													
No. of times various provisions were invoked while rejecting requests													
Relevant Section of RTI Act 2005													
Section 8(1) -													
a	b	c	d	e	f	g	h	i	j	9	11	24	other
Block IV (Details regarding compliance of direction/recommendation of the commission) - NA													
S. No.	Reference no. of cases wherein commission made specific recommendation as per sec.25(5)	Where action is initiated to comply with recommendation of Commission .			Details thereof (Max. 250 chars.)								
		-Select-											
		-Select-											
		-Select-											
		-Select-											
If the public authority made any changes in regard to its rules/regulations/procedure as a result of requested information by the citizens, please provide the summarized details of the changes (Max. 500 chars.)													
Block V (Details regarding compliance of direction/recommendation of the commission) - NA													
Last Date of Uploading the Pro-active Disclosures on the website of PA		Name of the person who is entering/Updating data		Designation of the person who is entering/Updating data									
General information uploaded		Smt. Kusum Parihar		Research Assistant –II C/o IT-Cell of the Institute									
 (Dr. Trunkant) Public Information Officer, AFRI, Jodhpur.													

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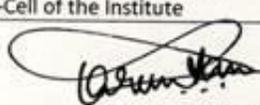
Annexure 1-B (July to September 2014) Quarterly Returns:

RTI Annual Return Information System													
Quarterly Return Form													
Public authority : Ministry of Environment & Forests													
Quarter – II (July to Sept.,2014)													
Year: 2014-15													
Mode Insert :			Status : New Return										
Progress during the month													
	Opening Balance as on beginning of qtr.-III	No.of applications received as transfer from other PA's U/S 6 (3)	Received during the Quarter (including cases transferred to other Public Authority)	No. of cases transferred to other PA's U/S 6 (3)	Decision where requests/ appeals rejected.	Decision where requests/ appeals accepted							
Requests	Nil	Nil	20	Nil	Nil	20							
First Appeals	Nil	Nil	Nil	Nil	Nil	Nil							
No. of CAPIOs designated		No. of CPIOs designated		No. of AA's designated									
01		01		01									
Block II (Details about fees collected, Penalty imposed and disciplinary action taken)													
Registration Fee collected (in Rs.) U/s 7(1)	Additional fees collected (in Rs.) U/s 7(3)	Penalties Amount recovered (in Rs.) as directed by CIC U/s 20(1)		No. of cases where disciplinary action taken against any officer U/s 20(2)									
210/-	536/-	Nil		Nil									
Block III (Details of various provisions & while rejecting the requested information) - NA													
No. of times various provisions were invoked while rejecting requests													
Relevant Section of RTI Act 2005													
Section 8(1) -													
a	b	c	d	e	f	g	h	i	j	9	11	24	Sections other
Block IV (Details regarding compliance of direction/recommendation of the commission) - NA													
S. No.	Reference no. of cases wherein commission made specific recommendation as per sec.25(5)	Where action is initiated to comply with recommendation of Commission .			Details thereof (Max. 250 chars.)								
		-Select-											
		-Select-											
		-Select-											
		-Select-											
If the public authority made any changes in regard to its rules/regulations/procedure as a result of requested information by the citizens, please provide the summarized details of the changes (Max. 500 chars.)													
Block V (Details regarding compliance of direction/recommendation of the commission) - NA													
Last Date of Uploading the Pro-active Disclosures on the website of PA		Name of the person who is entering/updating data		Designation of the person who is entering/updating data									
General information uploaded		Smt. Kusum Parihar		Research Assistant -II C/o IT-Cell of the Institute									
 (Dr. Trunkant) Public Information Officer, AFRI, Jodhpur.													
Dr. Tarun Kant Scientist E Forest Genetics & Tree Breeding Division Arid Forest Research Institute Jodhpur 342005 (India)													

Annexure 1-C (October to December 2014) Quarterly Returns:

RTI Annual Return Information System Quarterly Return Form													
Public Authority : Ministry of Environment & Forests													
Quarter – III (Oct to Dec.,2014)													
Year: 2014-15													
Mode Insert :			Status : New Return										
Progress during the month													
	Opening Balance as on beginning of qtr.-III	No. of applications received as transfer from other PA's U/S 6 (3)	Received during the Quarter (including cases transferred to other Public Authority)	No. of cases transferred to other PA's U/S 6 (3)	Decision where requests/ appeals rejected.	Decision where requests/ appeals accepted							
Requests	Nil	02	03	Nil	Nil	Nil							
First Appeals	Nil	Nil	Nil	Nil	Nil	Nil							
No. of CAPIOs designated		No. of CPIOs designated-		No. of AA's designated									
01		01		01									
Block II (Details about fees collected, Penalty imposed and disciplinary action taken)													
Registration Fee collected (in Rs.) U/s 7(1)	Additional fees collected (in Rs.) U/s 7(3)	Penalties Amount recovered (in Rs.) as directed by CIC U/s 20(1)		No. of cases where disciplinary action taken against any officer U/s 20(2)									
10/-	Nil	Nil		Nil									
Block III (Details of various provisions & while rejecting the requested information) - NA													
No. of times various provisions were invoked while rejecting requests													
Relevant Section of RTI Act 2005													
Section 8(1) -													
a	b	c	d	e	f	g	h	i	j	9	11	24	Sections other
Block IV (Details regarding compliance of direction/recommendation of the commission)- NA													
S. No.	Reference no. of cases wherein commission made specific recommendation as per sec.25(5)	Where action is initiated to comply with recommendation of Commission .			Details thereof (Max. 250 chars.)								
		-Select-											
		-Select-											
		-Select-											
		-Select-											
If the public authority made any changes in regard to its rules/regulations/procedure as a result of requested information by the citizens, please provide the summarized details of the changes (Max. 500 chars.)													
Block V (Details regarding compliance of direction/recommendation of the commission) - NA													
Last Date of Uploading the Pro-active Disclosures on the website of PA		Name of the person who is entering/updating data		Designation of the person who is entering/updating data									
General information uploaded		Smt. Kusum Parihar		Research Assistant –II C/o IT-Cell of the Institute									
 (Dr. Tarun Kant) Public Information Officer, AFRI, Jodhpur.													

Annexure 1-D (January to March 2015) Quarterly Returns:

RTI Annual Return Information System													
Quarterly Return Form													
Public authority : Ministry of Environment & Forests													
Quarter – IV (Jan to Mar.,2015)													
Year: 2014-15													
Mode Insert :				Status : New Return									
Progress during the month													
	Opening Balance as on beginning of qtr.-III	No.of applications received as transfer from other PA's U/S 6 (3)	Received during the Quarter (including cases transferred to other Public Authority)	No. of cases transferred to other PA's U/S 6 (3)	Decision where requests/ appeals rejected.	Decision where requests/ appeals accepted							
Requests	Nil	01	03	Nil	Nil	04							
First Appeals	Nil	Nil	Nil	Nil	Nil	Nil							
No. of CAPIOs designated		No. of CPIOs designated		No. of AA's designated									
01		01		01									
Block II (Details about fees collected, Penalty imposed and disciplinary action taken)													
Registration Fee collected (in Rs.) U/s 7(1)	Additional fees collected (in Rs.) U/s 7(3)	Penalties Amount recovered (in Rs.) as directed by CIC U/s 20(1)		No. of cases where disciplinary action taken against any officer U/s 20(2)									
30/-	Nil	Nil		Nil									
Block III (Details of various provisions & while rejecting the requested information) - NA													
No. of times various provisions were invoked while rejecting requests													
Relevant Section of RTI Act 2005													
Section 8(1) -													
a	b	c	d	e	f	g	h	i	j	9	11	24	other
Block IV (Details regarding compliance of direction/recommendation of the commission) - NA													
S. No.	Reference no. of cases wherein commission made specific recommendation as per sec.25(5)	Where action is initiated to comply with recommendation of Commission .				Details thereof (Max. 250 chars.)							
		-Select-											
		-Select-											
		-Select-											
		-Select-											
If the public authority made any changes in regard to its rules/regulations/procedure as a result of requested information by the citizens, please provide the summarized details of the changes (Max. 500 chars.)													
Block V (Details regarding compliance of direction/recommendation of the commission) - NA													
Last Date of Uploading the Pro-active Disclosures on the website of PA		Name of the person who is entering/updating data			Designation of the person who is entering/updating data								
General information uploaded		Smt. Kusum Parihar			Research Assistant –II C/o IT-Cell of the Institute								
 (Dr. Tarun kant) Public Information Officer, AFRI, Jodhpur.													

Annexure 2 Email and Postal Address

Arid Forest Research Institute,
P.O. Krishi Upaz Mandi,
New Pali Road, Jodhpur, 342005
Email : dir_afri@icfre.org
Phone : 0291-2742549
FAX : 0291-2722764

Annexure 3 Intellectual Property

3.1 Patent Property – NIL

3.2 Others – NIL