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Agroforestry

वार्षिक प्रतिवेदन
ANNUAL REPORT
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CAFRI

ICAR-Central Agroforestry Research Institute, Jhansi
भा.कृ.अनु.प.–केन्द्रीय कृषिवानिकी अनुसंधान संस्थान, झांसी

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COVER PHOTOGRAPHS

(i) Ber based agri-horti. system under rainfed condition, (ii) *Albizia procera* based silvipastoral system under wasteland condition, (iii) Lac Cultivation

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PREFACE

To conduct basic, strategic and applied research on agroforestry National Research Centre for Agroforestry (NRCAF) was established in the year 1988 at Jhansi. As approved in the XIIth Plan now NRCAF has been upgraded as Central Agroforestry Research Institute (CAFRI) w.e.f. 1st December, 2014. Agroforestry has the potential to achieve sustainability in agriculture, while optimizing its productivity and mitigating climate change impact. The Institute has strengthened its research activities and significant achievements of agroforestry research undertaken through the in house and external funded projects, network and inter-institutional collaboration, technology demonstrations and capacity building has paved the way for its recognition and upgradation.

In the current year Bundelkhand region experienced severe drought conditions and recorded the overall deficit 32%. However, the agroforestry based watershed interventions ensured drought mitigation in the two watersheds *viz.*Garhkundar- Dabar and Parasai-Sindh being implemented by CAFRI in Bundelkhand region. The institute continued its research activities by strengthening and updating the information on the basis of data collection, analysis, interpretation and reporting the results for all the projects. During the year, 14 trainings on agroforestry and NRM were organized for farmers and other stakeholders from Uttar Pradesh, Madhya Pradesh and Bihar including Kisan Study Tours, thereby helping in capacity building of more than four hundred participants. These trainings were organized in response to request from Land Development and Water Resources and Department of Agriculture (PIAs of IWMP) from UP and MP and State Forest Department of Bihar. CAFRI also organized two simultaneous five days International training programmes under ICAR-ICRAF Collaborative Work Plan at CAFRI, Jhansi and World Agroforestry Centre, ICRAF, Nairobi, Kenya during 1st - 5th December, 2014.

I express my gratitude to Dr. S Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi and Dr. A K Sikka, Deputy Director General (NRM), ICAR, New Delhi for their constant guidance, encouragement and support. My appreciation is also due to Dr. B Mohan Kumar, ADG (AAF/CC), ICAR, New Delhi and to other staff members of NRM division for cooperation and support. The help of the PME Cell and Editorial Committee in compiling and timely publication of the report is highly appreciated. I am thankful to Director, IGFRI, Jhansi for sharing the infrastructure from time to time.

(S K Dhyani)
Director

Executive Summary

After 26 years of successful research and development activities in Agroforestry, NRCAF has been elevated to Central Agroforestry Research Institute (CAFRI), by ICAR during 2014. The executive summary of the research and development activities carried during 2014 is presented development here under:

- Effect of irrigation in tree basin on performance of aonla under agroforestry system in red soil was studied in 19 year old plantation. Growth parameters and fruit yield data indicated that plants receiving year round watering in basin (at monthly interval in summer and bimonthly interval in winters) recorded maximum growth and fruit yield. Crop yield in interspaced was reduced by 23% (grain) and 16% (straw). Cropping in interspaces accompanied with summer irrigation in tree basin is recommended for aonla based agroforestry system.
- In nutrient management in ber based agri-horti system and observations recorded on different characters (plant growth, pruned material and fruit) of ber were found non-significant except number of fruits and fruit yield plant^{-1}and found significantly higher in treatment T_8 (Ber +75% RDF) and T_1 (Ber + 100% RDF), respectively. Sesame grown in *kharif* revealed that the treatments T_{10} (pure crop) and T_6 (Ber- 75% RDF + VAM + sesame + lentil) recorded highest seed yield of 1192 and 1018 kg ha^{-1} and was significantly higher with respect to other treatments. Lentil grown in *rabi,* 2013-2014 revealed that treatments T_{10} (pure crop) and T_6 (Ber- 75% RDF + VAM + sesame + lentil) recorded highest seed yield of 1184 and 1101 kg ha^{-1} and was significantly higher with respect to other treatments.
- In *Albizia procera* based silvipastoral system the pruning of tree component was done at 25, 50 and 75% intensity (during 2nd, 3rd, 4th, 5th and 6th year pruning initiation treatments) during December. Growth parameters of tree and pasture components were not affected significantly due to age of pruning initiation and its intensity. *A. procera* gained height in the range of 11.85 to 13.94 m, dbh (14.98 to 16.78 cm), canopy spread (1.95 to 3.94 m). The growth parameters of *C. fulvus* varied in the range of 1.27 to 1.42 m (height), 27.45 to 30.14 cm (tussock dia), 49.75 to 53.44 tillers tussock^{-1}, whereas *S. seabrana* gained 1.14 to 1.25 m (height) and 49.75 to 53.44 branches plant^{-1}. Total biomass production from the silvipastoral system varied in the range of 6.93 to 7.94 D.W. t ha^{-1} and was significantly affected by the levels of pruning intensity.
- Growth and biomass potential of eight year's old *Ailanthus excelsa* and *Grewia optiva* on alfisol recorded average height of 5.62 m (*A. excelsa*) and 5.34 m (*G. optiva*); dbh of 11.83 cm (*A. excelsa*) and 7.03 cm (*G. optiva*). Biomass production from understorey *Stylosanthes seabrana* was recorded as 2.18 D.W. t ha^{-1} (*A. excelsa*) and 2.34 D.W. t ha^{-1} (*G. optiva*).
- In bamboo based agroforestry system average height was recorded 7.74 m (*Bambusa vulgaris*), 5.78 m (*Dendrocalamus strictus*) and 3.27 m (*B. tulda*). *B. vulgaris*, *D. strictus* and *B. tulda* recorded 4.13, 3.28 and 2.63 cm dbh, respectively. New culms emergence was less in *B. tulda* (1.8 culms clump^{-1}) and *B. vulgaris* (6.36 culms clump^{-1}) as compared to *D. strictus* (7.48 culms clump^{-1}). Average number of internodes (old culms) was found 12.83 (*B. vulgaris*), 14.58 (*D. strictus*) and 7.93 (*B. tulda*). The average internodal length recorded in new culms was 22.37 cm (*B. vulgaris*), 19.86 cm (*D. strictus*) and 15.12 cm (*B. tulda*), respectively. *Bambusa vulgaris* planted at village Hastinapur as boundary plantation was also evaluated for various growth parameters. It was revealed by the farmers that he is earning about ₹ 25,000 to 30,000 per annum by selling the bamboo obtained from selective thinning.

- Experiments conducted to evaluate shade tolerance of crop species for agroforestry importance by growing lentil (*Lens esculenta*) and pigeon pea (*Cajanus cajan*) under different regimes of shade and without shade (in open field) revealed detrimental impacts of deep shade (50% shade and above) on the phenological, photosynthetic and biochemical traits. Impacts of varying shade on functional processes namely CO_2 assimilation, photochemical efficiency and some other related indices were conspicuous. Reduction in the activity of the physiological traits was reflected in the crop productivity as well.
- Factorial experiments were conducted on integration of DAP with bio-fertilizers in chickpea, lentil and pea, under field conditions. All bio-fertilizers based treatment combinations significantly increased yield plant^{-1} in chickpea, lentil and pea. Plant yields were significantly higher at 100 than 50% of recommended dose of DAP. Interactions between DAP and treatments were non-significant.
- From the functional scores of each observed indicator values, a unified value of Soil Quality Index was calculated. The increase in tree density of *H. binata* showed favorable effect on values of the most of the studied indicators. In comparison to baseline, the improvement in SQI was minimum (29.5%) in control and maximum (46.2%) in agroforestry plot having density of 800 tree ha^{-1}. All the tree density treatments showed higher value of soil quality index as compared with control. The improvement in soil quality over control ranged from 8.5% in tree density of 200 ha^{-1} to 22.9% in density of 800 tree ha^{-1} with mean value of 17.8%.
- Soil health indicator values and their respective functional scores from 21 year old *H. binata* based AF System (red soil) showed that the increasing levels of pruning from 25 to 75% also influenced indicator values positively. The improvement in soil quality over baseline ranged from 33.6% in control to 39.6 in 75% pruning plot. On an average, more SQI value (0.49) has been observed in pruning plots than control (0.45). The SQI value increased with increase in pruning levels and the improvement in SQI brought by pruning treatments ranged from 5.3 to 8.9% with a mean value of 7.4% over control.
- A total of 16 equations on timber volume of poplar species were found in the literature out of which 8 equations were for Punjab state, 6 for Haryana state and 2 for Uttarakhand. Dataset on diameter at breast height and volume were generated from these equations for developing generalized volume equations. The fitted models $V = 0.00257\ D^{1.65236}$ ($R^2 = 0.819$) and $V = 0.0002\ D^{2.1102}$ ($R^2 = 0.910$) were developed for states of Punjab and Haryana, respectively and may be used for estimating timber volume of poplar trees at state level. For country level generalized volume equation, the simulated data for states was pooled and analyzed. The model $V = 2.8443\ [1 + e^{(3.1012-0.0689\ D)}]$ was proposed to be used for predicting or estimating the timber volume of poplar tree for the dbh range of 14.0 to 41.0 cm.
- The Agroforestry based Conservation Agriculture for sustainable landuse and improved productivity project was laid out during 2014. Bael (CISH B-2) was transplanted during July, 2014 in bael based conservation agriculture system. The survival of the bael at six months of transplanting was 84.92%. Grain yield of greengram (PDM-139) varied in the range of 0.879 to 0.952 t ha^{-1} and grain yield of blackgram varied in the range of 0.635 to 0.719 t ha^{-1}. Teak (MHEM-R-2) was transplanted during August, 2014 in teak (*Tectona grandis*) based conservation agriculture system. The survival of the teak at six months of transplanting was 97.22%. Grain yield of greengram varied in the range of 0.737 to 0.811 t ha^{-1}, while grain

yield of blackgram varied in the range of 0.631 to 0.689 t ha^{-1}.

- Bael and teak were transplanted during July and August, 2014 in Bael + Teak based conservation agriculture system, respectively. The survival of the bael and teak at six months of transplanting was 96.03 and 96.83%, respectively. Grain yield greengram and blackgram varied in the range of 0.834 to 0.954 t ha^{-1} and 0.638 to 0.681 t ha^{-1}, respectively. Residue management had significant effect on grain yield in all the three experiments.
- Selected districts from Rajasthan, Madhya Pradesh and Karnataka were surveyed and data on existing agroforestry systems were collected. Land use and land cover analysis for the selected districts in three agro-climatic regions *viz.* lower gangetic plains, middle gangetic plains and central plateau & hill region was done using RS2/ LISS-3 data. Area under agroforestry in these regions was estimated to be 0.47, 0.85 and 1.13 million ha, respectively. The major tree species existing on farmer's field in three districts of Rajasthan (Bikaner, Dausa and Pali) were *Prosopis cineraria, Acacia tortilis, Prosopis juliflora, Azadirachta indica, Dalbergia sissoo* and *Ziziphus mauritiana.* The contribution of *Prosopis cineraria* in Bikaner and Pali districts was about 45 to 54% in total tree species, but the contribution of *Azadirachta indica* was 31% in Dausa district. It clearly indicated that tree species varied from one district to other district. Tree density also varied from 1.4 to 14.9 trees ha^{-1} in these districts. The Bikaner districts having 1.40 trees ha^{-1} on farmer's field but in Pali district, it was 14.9 trees ha^{-1}. Similarly in four districts (Guna, Panna, Hoshangabad and Jabalpur) of Madhya Pradesh, the major trees existing on farmer's field were *Eucalyptus tereticornis, Acacia nilotica, Leucaena leucocephala, Azadirachta indica* and *Tectona grandis.* The tree density in these districts also varied 4.37 to 29.49 trees ha^{-1}. In Dharwad district of Karnataka, the dominant tree species existing on farmer's field were *Glyricidia sepium, Tectona grandis, Acrus sapota, Mangifera indica, Moringa oleifera, Tamirindus indica* and *Leucaena leucocephala* with the tree density of 5.83 trees ha^{-1}.
- The biomass, biomass carbon, total carbon and net carbon sequestered in existing agroforestry system at district level in Karnataka, Rajasthan, and Madhya Pradesh was estimated by using CO_2FIX model and extrapolated for next 30-years. The tree biomass, soil carbon and total carbon in baseline was 1.85 t DM ha^{-1}, 9.89 t C ha^{-1} and 14.97 t C ha^{-1}, respectively in Dharwad district of Karnataka. It was expected that corresponding value of these parameters would increase up to 4.95 t DM ha^{-1}, 10.88 t C ha^{-1} and 17.64 t C ha^{-1}, respectively over the simulated period of 30-years. Net carbon sequestered in agroforestry systems over the simulated period of 30-years would be 2.67 t C ha^{-1} in the Dharwad district. In case of Pali, Dausa and Bikaner districts of Rajasthan, the total carbon stock available in baseline varied from 9.0 to 24.45 t C ha^{-1} and it is expected that over 30-years period the total carbon stock in agroforestry in these districts would be 13.32 to 35.39 t C ha^{-1}. Net carbon sequestered over the simulated period of 30-years would be 4.32 to 10.94 t C ha^{-1}**.** The tree biomass, soil carbon and total carbon available in existing agroforestry system in different districts of Madhya Pradesh (Guna, Hoshangabad, Panna and Jabalpur) is 3.57 to 7.39 DM ha^{-1}, 12.04 to 23.38 t C ha^{-1} and 16.10 to 27.61 t C ha^{-1}, respectively and its corresponding values over the simulated period of 30-years would be 7.75 to 11.99 t DM ha^{-1}, 12.74 to 24.80 t C ha^{-1} and 20.83 to 32.39 t C ha^{-1}, respectively.
- Physio-biochemical indices as emerged from the ongoing experiments with MPTs of agroforestry importance were utilized to assess the growth, carbon assimilation and its association with thermotolerance with

respect to temporal variation in the tree seedlings. Differential trend in leaf temperature with respect to ambient air temperature were recorded through infrared thermometer in the MPTs and the Canopy Temperature Depression (CTD) was estimated. Various physiological indices like PPFD saturated rate of CO_2 assimilation (A_{max}), CCM index, CTD, index of cellular lipid peroxidation including some spectral indices like NDVI and their association with thermotolerance were studied. Higher CTD of *Albizia procera* indicated its relatively better thermotolerance capacity than *Butea monosperma*.

- Total 26 WSHGs has been formed in Nayakheda, Dhikoli and Domagor villages of Domagor Pahuj model watershed area comprising 269 members. All WSHGs was linked with bank. Total saving of WSHGs was about ₹ 6.00 lakh. They were mainly involved in goat rearing and vegetable cultivation. These WSHGs were linked with Federation of SHGs for better livelihood options. Out of 26 SHGs, 20 SHGs were helped through revolving fund to start their activities. On an average each member of 10 SHGs involved in goatary is earning more than ₹ 8000.00 per annum.
- Open shallow dug wells are the only means of irrigation to the crops in Domagor Pahuj model watershed. The average water column during April, August and December was recorded 5.72, 5.60 and 5.42 m, respectively. Water column buildup improved the water yield of the open wells.
- To improve the productivity, 105 trials on different crops were conducted during this year. Due to delayed monsoon, groundnut was sown in limited area and its productivity was 236 kg ha^{-1}. To assess the general productivity of different crops during *rabi,* 2013-14, 72, 24, 24, 24 samples of wheat, chickpea, lentil and pea, respectively were taken and processed. Productivity of wheat, chickpea, lentil and pea was 2125, 536, 60 and 958 kg ha^{-1}, respectively. Productivity of wheat was lower than previous years due to lodging of crop.
- To develop agroforestry interventions in the Parasai-Sindh Watershed, 2928 seedlings of different species were planted on 92 farmers' fields during 2013-14. Survival of different species varied from 66 to 95 % by the end of November 2014. Apart from this, total 45 desi ber were budded with improved varieties and survival was about 39 % by November 2014. A total number of 76 participatory demonstrations (14-Parasai; 44-Chhatpur; 18-Bachhauni) during 2013-14 (*rabi* season) were laid out at farmers' fields with improved varieties. About 28% increase was observed in barley (RD-2552), while 17% increase was observed in mustard (Maya) over local varieties. During 2014-15 (*kharif* and *rabi*) a total of 65 participatory demonstrations 28-Parasai; 33-Chhatpur; 04-Bachhauni) were laid out at farmer's fields. About 18% higher yield was observed in case of greengram as compared to local varieties.
- *Chenopodium album*, *Digitaria sanguinalis* and *Physalis minima* among many other were some of the most dominant weeds prevalent in different agroforestry systems during *rabi* season. During *kharif* season *Commelina benghalensis* and *Echinochloa crusgalli* were some of the most dominant weeds observed in different agroforestry systems. Under wasteland conditions *Chenopodium album, Cirsium arvensis, Euphorbia hirta* and *Fumaria parviflora* (*rabi* season); *Ageratum conyzoides, Borreria hispida, Cyperus rotundus, Cynodon dactylon* and *Parthenium hysterophorus* (*kharif* season) were some of the wasteland weeds observed.
- Comparative studies of clonal and seedling plants of P*ongamia pinnata* under rainfed dry agroclimate were conducted with various physio-biochemical parameters including some spectral indices. Clonal

plants have shown better adaptability in dry hot summer conditions. As leaf level spectral studies were initiated and from the primary observations some important spectral indices like Normalized Difference Vegetation Index (NDVI) and Photochemical Refelectance Index (PRI) are being analysed. Physiological functioning as in rate of CO_2 assimilation and thylakoid electron transport rate were low in seedling plants in comparision to clonal plants in peak hot summer conditions. Total number of flowering bunches and number of pods plant^{-1} were higher in clonal plants due to its better adaptibility.

- In *Acacia nilotica* one provenance progeny trial (20) and two candidate plus tree trial (22 + 11 CPTs) were evaluated. The 20 provenance selections fall into four different clusters based on the Principal Component Analysis using the mean data. The 33 candidate plus trees which were evaluated at uniform age for morphological traits, fall into four clusters at an average distance of 1.0. These reflect the diversity present in germplasm collections at both intra and inter geographical regions of collection.
- In Jatropha breeding program, the mean performance of the hybrids showed better performance over the parents in terms of secondary and productive branches. This trend was observed after pruning to a height of 50% during February month. This indicates that the hybrids response to the management practices was better than parents and hence for effective selection in hybrids, management of Jatropha crop is essential.
- Molecular characterization of *Jatropha curcas* with RAPD primers resulted in one or more polymorphic bands in 20 primers out of 40 primers used in fifteen germplasm accessions.
- In the candidate gene based analysis of the *Pongamia* genotypes, for the current year the phenotypic analysis was carried out for all the morphological traits, seed and oil related traits and significant range of variation was found for most of the traits. These data will be used after generating the molecular data and analysis will be done for identifying allelic variation in the germplasm.
- Growth of established gum yielding tree based AF models was monitored. Besides, a gum garden of *Acacia senegal* was planted and depth of knotching or incision for tapping gum-butea standardized. The growth of existing plantation of *A. pendula* and *A. latifolia* was also monitored. The observations were recorded on survival of lac insect on butea trees in summer in relation to temperature and relative humidity.
- The field trial on naturally occurring 15-20 years old trees of *Butea monosperma* consisted of three depths of cuts *viz*. 0.5 cm, 1.0 cm and 1.5 cm each replicated on three trees. Maximum gum-butea was obtained when knotching was done up to 1.0 cm depth on stem bark of the trees. The knotching done up to depth of 0.5 cm yielded minimum gum-butea.

1. Introduction

Agroforestry played a dynamic role in the Indian economy by way of tangible and intangible benefits. In the current scenario, agroforestry is being looked upon as a solution to various problems related to low agricultural productivity, nutritional, energy and environmental security. To achieve full potential of agroforestry and to remove hurdles in the large scale adoption of the land use by the farmers across the country, the Government of India approved National Agroforestry Policy, which was launched on 10th February, 2014 by the Hon'ble President of India Shi Pranab Mukherjee, while inaugurating the 3rd World Agroforestry Congress in Delhi.

Since the inception of organized agroforestry research at global level, India has remained on the forefront, promoting this land management system. This Institute has developed a number of farm-friendly agroforestry technologies and contributed to natural resource conservation. In the past few years, the Institute has focused on mitigating climate change and its carbon sequestration potential, development of soil quality index and use of remote sensing and GIS technology in demarcating agroforestry areas at national level. Besides research activities the Institute made a significant contribution in the capacity building of farmers, researchers, policy maker and organizing an International Training Programme.

After 26 years of successful research and development activities on agroforestry, ICAR elevated the status of the NRCAF to as Central Agroforestry Research Institute (CAFRI).The institute will expand its activities in some of the upcoming researches like estimation of environment and ecosystem services, mapping of agroforestry through geoinformatics techniques, developing tree-signatures of important agroforestry species, increasing water use efficiency of agroforestry systems, agroforestry biofuel and bioenergy and livelihood options through agroforestry.

Vision

Integration of woody perennials in the farming systems to improve land productivity through conservation of soils, nutrients and biodiversity to augment natural resource conservation, restoration of ecological balance, alleviation of poverty and to mitigate risks of weather vagaries.

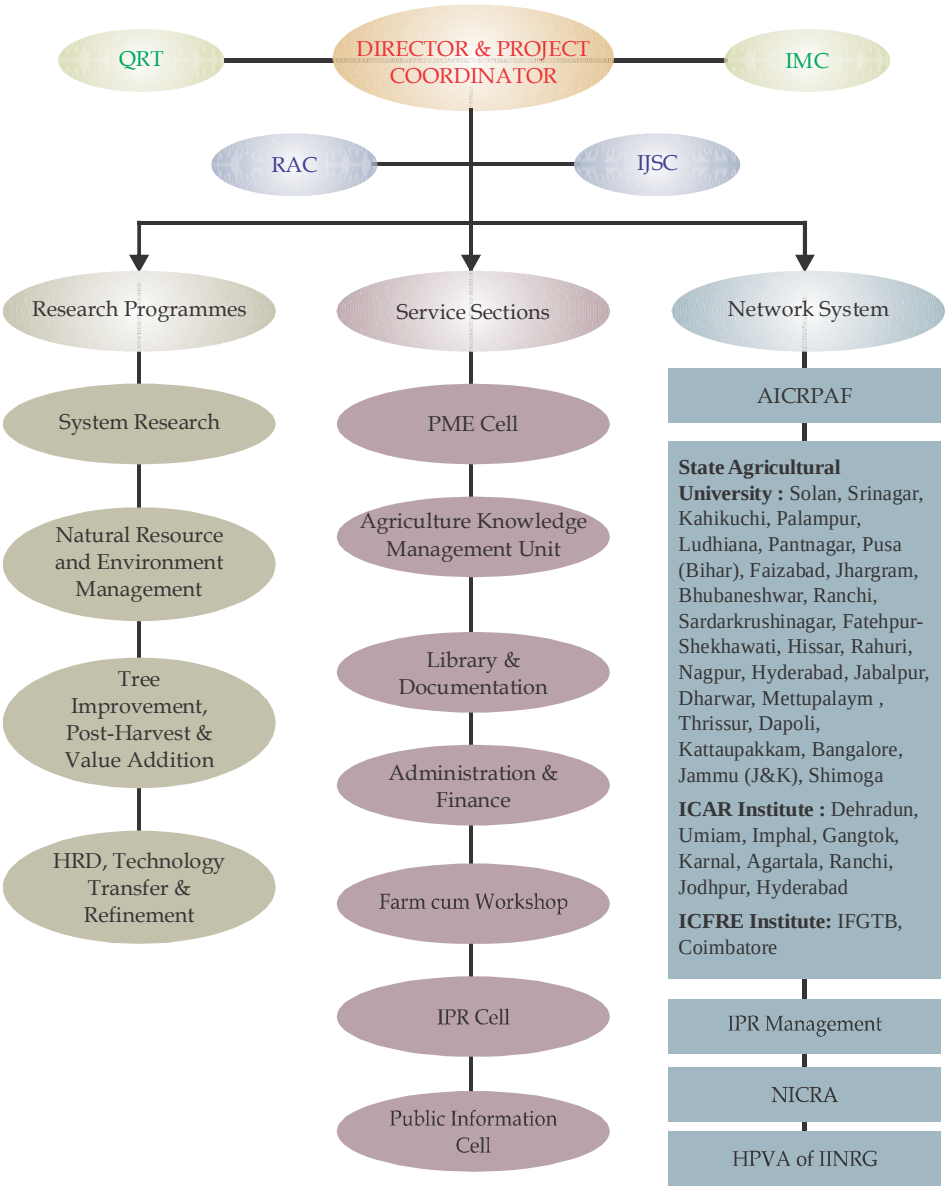
Mission

To improve quality of life of rural people through integration of perennials on agriculture landscape for economic, environmental and social benefits.

Mandate

- To undertake basic and applied research for developing and delivering technologies based on sustainable agroforestry practices for farms, marginal land and wastelands in different agroclimatic zones in India.
- To coordinate network research with the State Agricultural Universities/ICAR Institutes/other related research Institutes for identifying technologies which can be transferred from one region to another.
- To provide training in (a) research methodologies and (b) use and application of technologies developed, at various levels.
- To develop technological packages of different agroforestry practices for various agroclimatic zones for transfer to farm, field and wastelands.
- To act as repository of information on the subject.
- To collaborate with relevant national and international agencies for achieving the mandate.
- To provide consultancy.

Organizational Setup



NOTIFICATION

Consequent upon the decision of the Competent Authority of ICAR, The National Research Centre for Agroforestry, Jhansi under NRM Division has been upgraded as Central Agroforestry Research Institute (CAFRI), Jhansi w.e.f. 1st December, 2014 as approved in the XIIth Plan EFC (vide ICAR Communication F. No. 1-25/2014.PIM Dt.10/09/2014).

INFRASTRUCTURE

Academic and Laboratories

CAFRI has a main office-cum laboratory building with conference hall, computer laboratory, library, 40-seat-capacity air-conditioned committee room with video-conferencing facility and one air-conditioned conference room of 100 sitting-capacity. Institute has been recognized by the Bundelkhand University as a study Institute to conduct Ph. D. programme. The Institute conducts M. Sc. dissertation and Ph. D. courses in Agroforestry, Horticulture, Environmental Sciences, Plant Protection, Soil Science, Biotechnology and Soil &Water Conservation from different recognized Universities. The Institute has six well-equipped laboratories.

Agriculture Knowledge Management Unit

The Institute has its own web server and regularly updated website (www.nrcaf.res.in). The entire network administration of computers, internet and website management is looked after by the Agriculture Knowledge Management Unit (AKMU), which also accommodates a fully developed GIS laboratory. New domain "nrcaf.res.in" has been registered with ERNET India, New Delhi for Institute website. 10 Mbps leased line internet connection has been obtained from BSNL, Jhansi and E. mail/ Web servers have been configured.

Library

The Institute's library has more than 4428 books (including Hindi books), bounded back volumes of research journals and subscribes 16 Indian journals. It also maintains a CD-ROM server with a bibliographic database from the CERA (Consortium for E- Resources in Agriculture). These databases are accessible to an individual scientist through LAN.

Photography, Meetings and Training

A well-equipped photography unit meets the day-to-day photographic and reprographic needs of the scientists. Provision also exists for the preparation of charts and posters. Conference hall /committee/training room with modern facilities are available for scientific meetings and group discussions.

Research Farm and facilities

The Central Research farm possess about 86 ha land. Major area is rocky and degraded land, which was gradually developed. About 15% area occupied for office infrastructures, residential complex, roads etc. and rest 85% arable land have been utilized after phase development for various agroforestry experiments, cropping and block plantations. Research farm possess seven shallow dug wells, but their recharge is very poor due to hard pan (3-5 m below ground). Cultivation is totally dependent on rainfall. During *kharif* monsoon was delayed and draught like situation prevailed in the region. Blackgram, greengram, pigeonpea and sesame were sown in experimental and non-experimental area as per contingent plan. *Kharif* crops were badly affected and production almost failed. During *rabi* season crops were sown in maximum available fields on account of availability of irrigation water from Pahuj canal as well as from shallow wells. Crop wise area and production during *rabi,* 2013-14 and *kharif,* 2014-15 are given below:

Season / Crop & Variety	Area (ha)	Grain Yield (Kg)
***Rabi* 2013-14**		
Wheat-WH147/PBW550/HI-1168	9.65	12095.00
Barley - Jagrati/RD2552	4.45	5332.00
Chickpea - Samrat/KGD1168	3.45	605.00
Pea - Sapana	0.55	229.00
Mustard – T-59(varuna)	2.45	865.00
Lentil –K-75	1.11	125.00
Taramira -Karan	3.00	11.00
Straw yield	-	24850.00
***Kharif* 2014-15**		
Blackgram T-9/Azad-2	10.90	350.00
Greengram -PDM-139/SML668	2.45	410.00
Arhar-UPAS-120	2.52	67.00
Sesame - Shekhar	5.40	244.00

During *rabi,*2014-15 about 27.55 ha area have been sown which include 7.25 ha experimental and 20.30 ha general cropped area. Crop wise area sown in *rabi* season is given below:

Crop	Sown area		Total area (ha)
***Rabi* 2014-15**	**Experimental**	**General**	
Wheat-WH147/ HUW-235/Lok-1/ HI-1168	1.73	5.70	7.43
Chickpea - Samrat/ Abrodhi	0.50	1.80	2.30
Mustard - Varuna/RH749	1.70	1.20	2.90
Lentil -DPL62	0.90	1.20	2.10
Taramira- Karan	0.20	5.45	5.65
Barley- Jagrati/ RD2552	1.76	4.50	6.26
Pea- Sapana	0.06	0.25	0.31
Total	**7.25**	**20.30**	**27.55**

During the year a revenue to the tune of ₹ 5.24 lakhs have been generated from CR Farm and details thereof is as on next page:

S No	Farm Produce	Sum ₹
1.	Grains	263578
2.	Fruits (aonla/bael/ber/lemon)	14317
3.	Tree/Fuel wood	1,71,770
4.	Straw	74550
	Grand Total	**5,24,215**

The Research farm is equipped with most improved farm machineries and implements for mechanized farm operations. A mini workshop cum implement shed has been created maintenance of farm machineries.

Budget (2014-15)

(₹ in Lakhs)

S.N.	Head of Account	NON- PLAN		PLAN	
		Allocation	Expenditure	Allocation	Expenditure
A.	**Main Institute**				
1.	Establishment charges including LSP & PF	482.00	481.97	0.00	0.00
2.	Wages	3.54	3.53	0.00	0.00
3	Overtime allowance	0.04	0.04	0.00	0.00
4.	Traveling expenses	2.50	2.50	3.80	3.75
5.	A. Other charges including HRD	100.45	96.67	96.70	95.50
	B. Capital	5.00	3.67	0.00	0.00
6.	Works	0.00	0.00	0.00	0.00
	Major(Original)	0.00	0.00	30.00	29.99
	Miner incl. R & M	10.02	10.00	24.50	24.50
	Total	**603.55**	**598.38**	**155.00**	**153.74**
1	Pension	21.50	21.48	0.00	0.00
2	P-Loans & Advances	2.00	2.00	0.00	0.00
B.	**Plan Scheme**				
1.	AICRP on Agroforestry, Coordinating Unit: CAFRI, Jhansi				981.01
2.	Harvest and post-harvest processing and value addition of natural resins, gums and gum resins(ICAR, New Delhi)				7.06
3.	IPR Management in agroforestry (ICAR, New Delhi)				4.02
4.	National Initiative on Climate Resilient Agriculture (NICRA; ICAR, New Delhi)				28.35
C.	**Externally Funded Projects**				
1.	National network on integrated development of Jatropha and Karanj (NOVOD Board Project)				7.69
2.	Integrated Nutrient Management in Blackgram and Bengal gram in Central Indian Conditions (Science and Engineering Research Board, DST, India)				5.51
3	Development of insecticide resistant strain of Trichogramma for the management of lepidopterous pest in semi-arid Central India (DST Project)				3.73
D	**Revenue Receipt**		**Target**		**Achievement**
			58.90		18.25

2. Research Achievements

2.1. System Research Programme

AF 02.12: Effect of Irrigation on Performance of Aonla under Agroforestry Systems

(R K Tewari & Ramesh Singh)

The study continued in red soil. Plants in terms of height, collar girth and canopy spread was recorded where plants received year round water in basin. The effect of irrigation was pronounced on fruit yield. Plants receiving year round watering in tree basin (T_3) produced maximum 52.7 kg tree^{-1} fruit yield, while those under rainfed (T_1) yielded only 37.8 kg tree^{-1} fruits. Summer irrigation in plant basin yielded 44.4 kg tree^{-1} indicating effectiveness of basin irrigation during critical summer months. However, cropping in interspaces during *rabi* favored fruit production of aonla as fruit plants were benefited by irrigation to crop during late winters and early summer, which is eventually flowering and fruit set period of aonla. As compared to previous year's growth, the increase in plant growth was marginal as trees are old. The growth and fruit yield of aonla under different treatments is given below (Table 1).

Table 1: Plant growth and fruit yield of aonla as influenced by treatments

Treatments	Height (m)	Collar girth (cm)	Canopy spread (m)	Fruit yield (kg tree^{-1})
T_1 Aonla rainfed	5.79	59.8	5.85	37.8
T_2Aonla summer irrigated	5.38	64.4	5.98	44.4
T_3 Aonla irrigated	6.24	80.0	6.51	52.7
T_4 (T_1 + Crop)	5.20	60.4	6.15	46.7
T_5 (T_2 + Crop)	6.22	80.2	7.26	49.6

Wheat var. WH 147 was sown during *rabi*, 2013-14 on 12th December, 2013 in T_4 and T_5 besides sole crop (T_6). Data on crop yield is presented in Table 2. It is obvious from the data that crop yield reduced in interspaces. Sole crop recorded 318 kg ha^{-1} grain and 393 kg ha^{-1} straw yield. There was sizeable reduction in grain and straw yield to the tune of 23% in grain yield and 16% in straw yield. Yield reduction under aonla based system was low due to deciduous nature of aonla and sparse canopy, which permits adequate solar radiation to the companion crop.

Table 2: Crop yield (kg ha^{-1}) under aonla based agri-horticulture system

Distance from tree basin (m)	T_4		T_5		Control	
	Grain	Straw	Grain	Straw	Grain	Straw
1.0	143.0	177.0	183.0	203.0	--	--
2.0	230.0	285.0	265.0	325.0	--	--
3.0	301.0	426.0	336.0	436.0	--	--
4.0	307.0	468.0	380.0	507.0	--	--
Mean	**245.0**	**339.0**	**291.0**	**367.0**	**318.0**	**393.0**

AF 02.14: Nutrient Management in Ber based Agri-horti System

(Sudhir Kumar, Anil Kumar, Rajendra Prasad & Inder Dev)

The experiment was laid out during August, 2010 with ten treatments, *viz.* T_1- Ber (100% RDF), T_2- Ber (100% RDF) + Sesame- Lentil, T_3- Ber (75% RDF), T_4- Ber (75% RDF) + Sesame- Lentil, T_5- Ber (75% RDF) + VAM, T_6- Ber (75% RDF) + VAM + Sesame- Lentil, T_7- Ber (75% RDF) + *Trichoderma*, T_8- Ber (75% RDF) + *Trichoderma* + Sesame- Lentil, T_9- Ber (75% RDF) + VAM + *Trichoderma* + Sesame- Lentil and T_{10}- Sesame- Lentil, were imposed before onset of monsoon by adapting RBD with three replications at a spacing of 6m x 8m distance and each treatment is having six plants. The main objective of the experiment is to find out suitable nutrient management schedule for enhanced system productivity, profitability and sustainability under semi- arid conditions and also to observe whether by incorporating the bio-inoculants one can save fertilizer without compromising the production and quality of produce.

The observation recorded on fruits character and yield during 2013-2014 (plant age 3½ years) is presented in Table 3. It is evident from the table that all the fruit characters were found non-significant except number of fruits and fruit yield

Table 3: Effect of treatments on fruit characters and yield of ber (cv Seo) fruits

Treatment	Weight (g)	Size (cm)		Volume (cm^3)	Pulp wt. (g)	Stone wt. (g)	Pulp/ stone ratio	TSS ^0B	No. of fruits $plant^{-1}$	Yield (kg $plant^{-1}$)
		L	W							
T_1	26.27	3.57	3.62	27.05	24.92	1.35	18.41	12.82	**1392.89**	**36.56**
T_2	26.34	3.61	3.59	27.30	24.89	1.45	17.16	12.27	**1310.20**	**34.45**
T_3	25.21	3.58	3.58	26.20	23.91	1.29	18.48	11.54	1083.64	27.36
T_4	20.66	3.34	3.32	21.76	19.78	1.14	17.31	13.32	950.61	19.44
T_5	25.10	3.51	3.55	26.04	23.78	1.32	18.02	12.53	1035.75	26.11
T_6	24.60	3.55	3.50	25.52	23.34	1.26	18.43	12.38	992.11	24.31
T_7	22.20	3.38	3.40	22.64	20.95	1.25	16.70	12.24	1087.25	24.09
T_8	24.05	3.51	3.51	24.77	22.74	1.31	17.39	12.46	**1441.47**	**34.53**
T_9	23.27	3.38	3.46	23.83	21.87	1.40	15.74	12.30	1172.39	27.21
CD 0.05	NS	NS	NS	NS	NS	NS	NS	NS	172.36	5.57

$plant^{-1}$. However, maximum average fruit weight (26.34 g) was obtained in treatment T_2 where as it was minimum (20.66 g) in treatment T_4. Average bigger size fruits were harvested in treatment T_2 (3.61x3.59 cm) followed by T_1 (3.57 x 3.62 cm) and T_3 (3.58 x 3.58 cm). Fruit volume ranged from 21.76 in T_4 to 27.30 cm^3 in T_2. Likewise pulp weight was more in treatment T_1 (24.92 g), stone weight in T_2 (1.45 g) and pulp/stone ratio in T_3 (18.48), whereas it was recorded low in T_4 (19.78 g), T_4 (1.14 g) and T_9 (15.74), respectively. Maximum total soluble solids (TSS) were available in the juice of treatment T_4 (13.32^{0}B), however, they were less in treatment T_3 (11.54^{0}B). Number of fruits $plant^{-1}$ were found significantly more in treatment T_8 (1441) but at par with treatments T_1 (1393) and T_2 (1310) whereas fruit yield was statistically significant in treatment T_1 (36.56 kg $plant^{-1}$) but found at par with treatments T_2 (34.45 kg $plant^{-1}$) and T_8 (34.53 kg $plant^{-1}$).

The plants were pruned in the month of May, 2014 (in IVth year after planting) and obtained pruned material ranged from 2.26 kg to 6.04 kg $plant^{-1}$ being a minimum in T_4 and maximum in T_8 on fresh weight basis, however on dry weight basis it ranged from 1.12 to 2.93 kg $plant^{-1}$ in the same treatments, respectively. After pruning cent percent survival was observed in the field. The observations were recorded and analyzed on growth parameters such as collar diameter and canopy spread at quarterly intervals. The data recorded in the month of December, 2014 is being presented in Table 4. The Table reveals maximum collar diameter in treatment T_5 (8.47 cm) and minimum in treatment T_3 (6.77 cm) while canopy spread (East-West and North-South) was more in treatment T_1 (325.55 x 331.66 cm).

Ber based agrihorti system (Sesame-Lentil)

Lentil (var. Malika masoor K-75) sown in the 1st week of October, 2013 during *rabi* season was harvested in the month of March, 2014. Seed yield

Table 4: Effect of treatments on pruned material and plant growth characters of ber fruits (cv. Seo)

Treatment	Pruned material (kg $plant^{-1}$)		Collar diameter (cm)	Canopy spread (cm)	
	Fresh	Dry		EW	NS
T_1	4.71	2.38	**7.88**	**325.55**	**331.66**
T_2	3.19	1.57	**7.87**	295.97	299.44
T_3	5.14	2.65	6.77	284.56	269.11
T_4	2.26	1.12	7.34	290.56	297.50
T_5	5.18	2.55	**8.47**	304.17	288.34
T_6	3.30	1.52	7.63	**312.83**	**306.22**
T_7	3.79	1.96	7.65	**318.31**	**305.19**
T_8	6.04	2.93	7.22	311.78	294.61
T_9	3.55	1.74	7.80	311.89	293.78
CD 0.05	NS	NS	NS	NS	NS

Table 5: Lentil yield (*rabi*, 2013) and growth parameters (*rabi*, 2014) 60 DAS

Treatment	Yield (kg ha^{-1}): *Rabi*, 2013-14		Growth parameters 60 DAS: *Rabi*, 2014			
	Seed	Straw	Plant population (m^{-2})	Plant height (cm)	Root length (cm)	Root+ shoot (DW g plant^{-1})
T_2	925.00	1221.00	20.18	17.62	6.12	0.47
T_4	968.00	1277.00	21.52	16.94	7.03	0.43
T_6	1101.00	1420.00	19.75	17.33	6.75	0.48
T_8	902.00	1172.00	17.46	16.98	6.07	0.44
T_9	898.00	1158.00	18.55	15.29	6.42	0.42
T_{10}	1184.00	1527.00	17.95	16.75	8.23	0.53
CV (%)	17.98	19.14	18.14	18.47	12.89	19.31
CD 0.05	208.00	247.00	NS	NS	NS	NS

was recorded in the range of 898 to 1184 kg ha^{-1} and straw yield of 1158 to 1527 kg ha^{-1} under different treatments. The treatments T_{10} (pure crop) and T_6 (Ber- 75% RDF + VAM + Sesame + Lentil) recorded highest seed yield of 1184 and 1101 kg ha^{-1} and was significantly higher with respect to other treatments. Similar trend was observed for straw yield (Table 3). During *rabi*, 2014-15, lentil variety (DPL-62) was sown on 12th November, 2014 using seed rate 40 kg ha^{-1} on residual fertility under rainfed condition. During reporting period the data recorded on growth parameters are also presented in Table 5. Plant population varied in the range of 17.46 to 21.52 plants m^{-2} at 60 DAS (days after sowing). Plant height, root length and root + shoot dry matter accumulation varied in the range of 15.29 to 17.62 cm, 6.12 to 8.23 cm and 0.48 to 0.53 g plant^{-1}, respectively.

During *kharif*, 2014 sesame variety G-1 was sown on July 28, 2014 using 4.5 kg ha^{-1} seed rate was applied with recommended dose of nutrients (30 Kg N, 15 Kg P ha^{-1}). The crop was taken as rainfed. Data presented in Table 6 indicated that by and large the growth parameters were observed to be non-significant. The seed yield varied in the range of 878-1192 kg ha^{-1}. The treatments T_{10} (pure crop) and T_6 (Ber- 75% RDF + VAM + Sesame + Lentil) recorded highest seed yield of 1192 and 1018 kg ha^{-1} and was significantly higher with respect to other treatments. Similar trend was observed for straw yield (Table 6).

Table 6: Yield and yield contributing characters of sesame during *kharif*

Treatment	Plant population (m^{-2})	Plant height (cm)	Biomass (DW g plant^{-1})	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_2	16.54	68.93	190.33	19.21	2.63	16.47	878.00	1124.00
T_4	18.22	65.33	193.67	21.73	2.53	16.47	897.00	1139.00
T_6	17.53	66.87	198.48	19.47	2.59	16.53	1018.00	1364.00
T_8	19.21	67.68	192.67	22.23	2.53	16.07	943.00	1207.00
T_9	16.49	67.73	203.33	21.07	2.43	17.00	987.00	1293.00
T_{10}	18.17	63.47	235.00	25.80	2.36	16.13	1192.00	1549.00
CV (%)	15.13	18.92	17.48	16.45	18.34	17.19	16.84	17.57
CD 0.05	NS	NS	NS	NS	NS	NS	154	181.00

AF03.9: Initiation of Pruning and Its Intensity on Productivity of *Albizia procera*

(Inder Dev & K B Sridhar)

Initiation of pruning and its intensity on productivity of *Albizia procera* based silvipastoral system was started during August, 2006 with the plantation of *A. procera* saplings. The pasture component (*Chrysopogon fulvus* and *Stylosanthes seabrana*) was established during subsequent year (July-August, 2007). The pruning of *A. procera* was done at 25, 50 and 75% intensity (during 2nd, 3rd, 4th, 5th and 6th year pruning initiation treatments) during the month of December, 2014. The data on survival (%), growth and biomass production are presented in Table 7, 8 and 9. It was observed that most of the growth parameters of tree and pasture components were not affected significantly due to age of pruning initiation and its intensity. *A. procera* gained height in the range of 11.85 to 13.94 m, dbh (14.98 to 16.78 cm), canopy spread (1.95 to 3.94 m). The growth parameters of *C. fulvus* varied in the range of 1.27 to 1.42 m (height), 27.45 to 30.14 cm (tussock dia), 49.75 to 53.44 tillers tussock^{-1}, whereas *S. seabrana* gained 1.14 to 1.25 m (height) and 49.75 to 53.44 branches plant^{-1} (Table 8). Leaf fodder production was significantly affected by different levels of pruning. Total biomass production from the silvipastoral system varied in the range of 6.93 to 7.94 D.W. t ha^{-1} and was significantly affected by the levels of pruning intensity (Table 9).

Table 7: Survival and growth of *A. procera* influenced by age and intensity of pruning

Treatments	Survival (%)	Height (m)	dbh (cm)	Canopy spread (m)
Initiation of pruning				
2nd year	64.75	13.94	16.78	1.95
3rd year	52.51	13.42	16.49	2.36
4th year	48.45	13.25	15.97	2.64
5th year	46.75	12.72	15.04	2.92
6th year	32.40	11.85	14.98	3.94
CD 0.05	NS	NS	NS	0.95
Intensity of pruning				
25%	52.84	12.43	16.45	2.64
50%	54.46	12.98	15.98	2.82
75%	43.07	13.75	16.46	2.94
CD 0.05	NS	NS	NS	NS

Table 8: Growth of pasture component influenced by age and intensity of pruning in *A. procera* based silvipastoral system

Treatment	*Chrysopogon fulvus*			*Stylosanthes seabrana*	
	Height (m)	Tussock dia. (cm)	Tillers tussock^{-1}	Height (m)	Branches plant^{-1}
Initiation of pruning					
2nd year	1.24	28.18	55.72	1.14	49.75
3rd year	1.31	29.32	57.45	1.18	52.34
4th year	1.42	30.12	54.18	1.20	51.22
5th year	1.28	27.45	51.33	1.22	53.44
6th year	1.37	28.68	56.44	1.24	50.31
CD 0.05	NS	NS	NS	NS	NS
Intensity of pruning					
25%	1.32	30.14	54.37	1.18	52.72
50%	1.27	28.25	49.75	1.24	53.25
75%	1.24	27.76	53.28	1.25	51.46
CD 0.05	NS	NS	NS	NS	NS

Table 9: Fuelwood and forage production (D.W. t ha^{-1}) influenced by age and intensity of pruning in *A. procera* based silvipastoral system

Treat-ments	Tree		Pasture			Total fodder	Total bio-mass
	1	2	3	4	5 (3+4)	6 (2+3+4)	7 (1+6)
	Fuel wood	Leaf fodder	Grass fodder	Legume fodder	Total pasture		
Initiation of pruning							
2nd year	1.16	0.67	2.34	2.76	5.10	5.77	6.93
3rd year	1.27	0.65	2.72	2.68	5.40	6.05	7.32
4th year	1.32	0.68	2.64	2.52	5.16	5.84	7.16
5th year	1.37	0.71	2.81	2.64	5.45	6.16	7.53
6th year	1.58	0.75	2.68	2.93	5.61	6.36	7.94
CD 0.05	0.13	NS	NS	NS	NS	NS	NS
Intensity of pruning							
25%	1.32	0.54	2.46	2.74	5.2	5.74	7.06
50%	1.30	0.65	2.52	2.65	5.17	5.82	7.12
75%	1.47	0.82	2.41	2.82	5.23	6.05	7.52
CD 0.05	0.04	0.02	NS	NS	NS	NS	0.48

Albizia procera based silvipastoral system under wasteland conditions

AF 3.9 B: Evaluation of *Ailanthus excelsa* and *Grewia optiva* in Alfisols (*Rakar* soil)

(Inder Dev & K B Sridhar)

Growth and biomass potential of *Ailanthus excelsa* and *Grewia optiva* (planted during 2006 alfisol *i.e., Rakar* soil) were recorded during November, 2014. It was observed that average height gained was 5.62 m (*A. excelsa*) and 5.34 m (*G. optiva*) and dbh was 11.83 cm (*A. excelsa*) and 7.03 cm (*G. optiva*). Biomass production from understorey *S. seabrana* was recorded as 2.18 D.W. t ha^{-1} (*A. excelsa*) and 2.34 D.W. t ha^{-1} (*G. optiva*) (Table 10).

Table 10: Performance of *Ailanthus excelsa* and *Grewia optiva* in Rakar soils

Parameters	*A. excelsa*	*G. optiva*
Survival (%)	72.30	79.40
Height (m)	5.62	5.34
dbh (cm)	11.83	7.03
Canopy spread (m)	3.75	3.06
Leaf fodder (kg ha^{-1})	98.70	130.70
Fuel wood (kg ha^{-1})	-	547.30
Stylosanthes (branches plant^{-1})	48.34	46.48
Stylosanthes biomass (DW t ha^{-1})	2.18	2.34
Total No. of surviving plants	38.00	47.00

A. excelsa based silvipastoral system under wasteland conditions

Development of Bamboo based Agroforestry Systems

(Inder Dev & K B Sridhar)

The observational trial on Development of bamboo based agroforestry systems was a part of the National Bamboo Mission project till 2012. The plantation of *Dendrocalmus strictus*, *Bambusa vulgaris* and *B. tulda* was done during 2007 (rainy season). Average number of retained culms were 21.1 (*B. vulgaris*) and 24.2 (*D. strictus*) after harvesting during 2012.

Average height was recorded 7.74 m (*B. vulgaris*), 5.78 m (*D strictus*) and 3.27 m (*B. tulda*). *B. vulgaris*, *D. strictus* and *B. tulda* recorded 4.13, 3.28 and 2.63 cm dbh, respectively. New culms emergence was less in *B. tulda* (1.8 culms clump^{-1}) and *B. vulgaris* (6.36 culms clump^{-1}) as compared to *D. strictus* (7.48 culms clump^{-1}). Average number of internodes (old culms) was found 12.83 (*B. vulgaris*), 14.58 (*D. strictus*) and 7.93 (*B. tulda*). The average internodal length recorded in new culms was 22.37 cm (*B vulgaris*), 19.86 cm (*D. strictus*) and 15.12 cm (*B. tulda*), respectively (Table 11). *Bambusa vulgaris* planted at village Hastinapur as boundary plantation was also monitored. Visits of nearby farmers to this field were arranged during the year. The farmer informed that he is earning about ₹ 25,000 to 30,000 per annum by selling the bamboo obtained from selective thinning of 95 clumps.

Table 11: Growth parameters and yield in bamboo based agroforestry systems

Parameters	*B. vulgaris*	*D. strictus*	*B. tulda*
Average Height	7.74	5.78	3.27
Average dbh	4.13	3.28	2.63
Average number of new culms	6.36	7.48	1.80
Average number of old culms	23.53	26.84	11.62
Average number of internodes per culm			
New	12.83	14.58	7.93
Old	30.19	27.09	18.47
Internodal length (cm)			
New	22.37	19.86	15.12
Old	26.41	18.33	17.25

Bambusa vulgaris at Hastinapur village

Boundary plantation of *B. vulgaris* at village Hastinapur

Selective thinning of *Bambusa vulgaris*

Bamboo based agroforestry system

2. Research Achievements

2.2. Natural Resource & Environment Management Programme

AF01.16: Evaluation of Shade Tolerance of Crop Species for Agroforestry Systems

(Badre Alam & Ram Newaj)

Shade adaptive traits were comprehensively studied under varying regimes of shade namely 33, 50 and 75% shade of incident solar radiation or without shade (open) as control. Various physio-biochemical responses and photosynthetic traits of lentil (local name- masoor) (*Lens esculenta* variety- Mallika) crop were studied. Some remarkable differences of crop phenology, physiological and biochemical properties were noted. Major impacts were observed in germination pattern, plant growth, pigment profile, PSII mechanism, cellular biochemistry as well as photosynthetic efficiency under varying shade. Differential growth responses including germination and biomass index were noted depending upon the intensity of shade (Fig. 1 and Fig. 2).

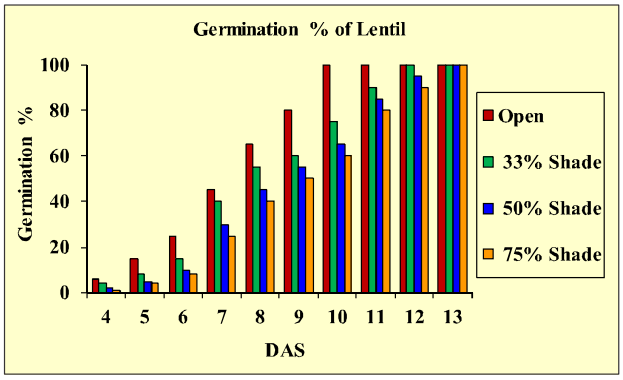


Fig.1: Impact of varying shade on germination pattern of lentil

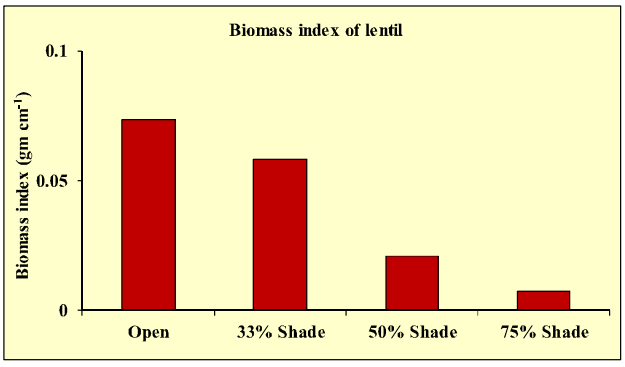


Fig. 2: Biomass index of lentil grown under varying shades

There was an increasing trend in Chlorophyll a, chlorophyll b and total chlorophyll with increase in shade intensity (Fig. 3). Percentage reduction over control (open) in yield was highest in 75% shade grown plants (Fig. 4). Some important antioxidant enzymes like Catalase and Ascorbate oxidase were studied to understand detrimental effects of shade. With increase in shade intensity Ascorbate oxidase activity increased and Catalase enzyme activity decreased (Fig. 5 and 6).

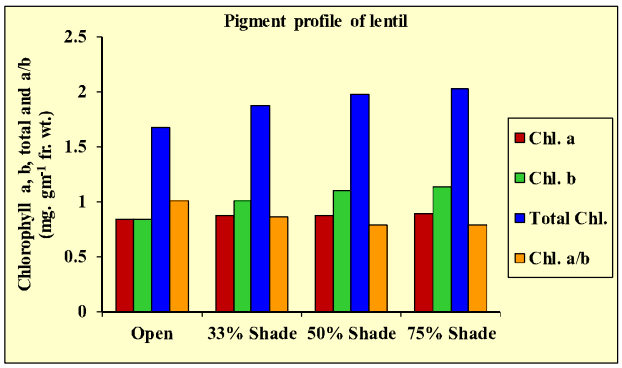


Fig. 3: Impact of various levels of shade on pigment profile in lentil leaves

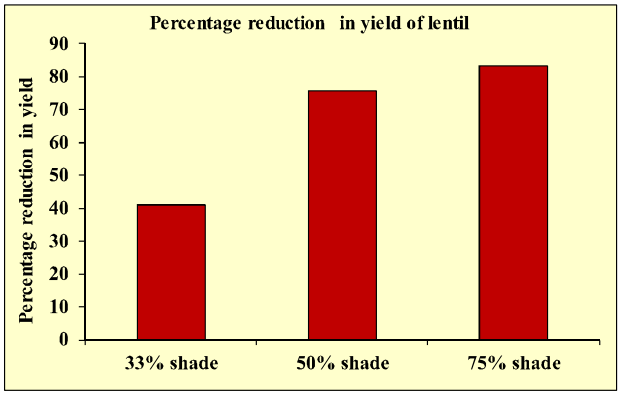


Fig. 4: Percentage reduction in yield of lentil grown under varying level of shade in comparison to open

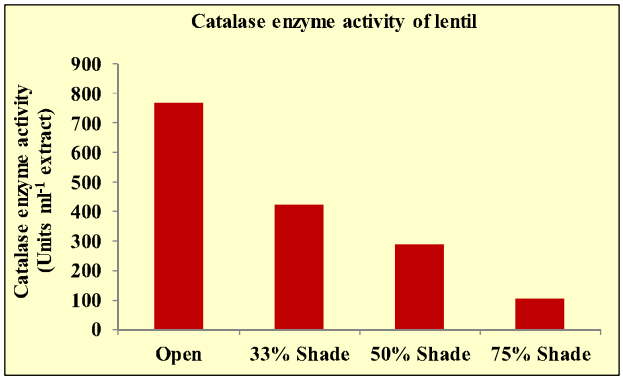


Fig. 5: Catalase enzyme activity of lentil as influenced under varying level of shade

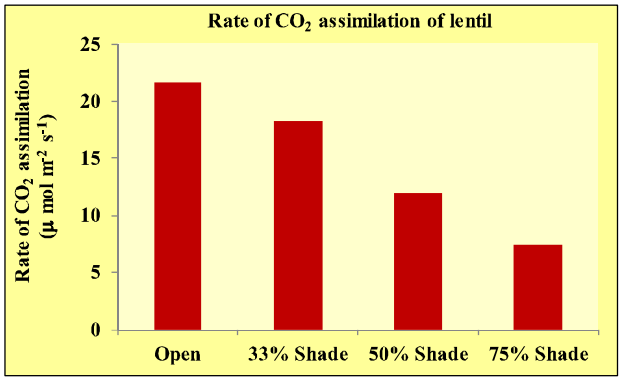


Fig. 7: Effect of varying regimes of shade on maximum rate of CO_2 assimilation of lentil

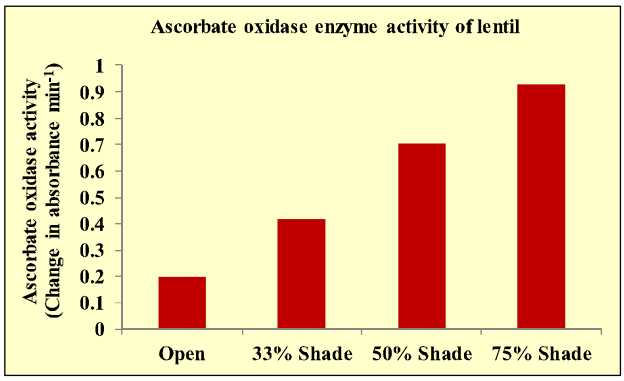


Fig. 6: Ascorbate oxidase activity of lentil under varying level of shade

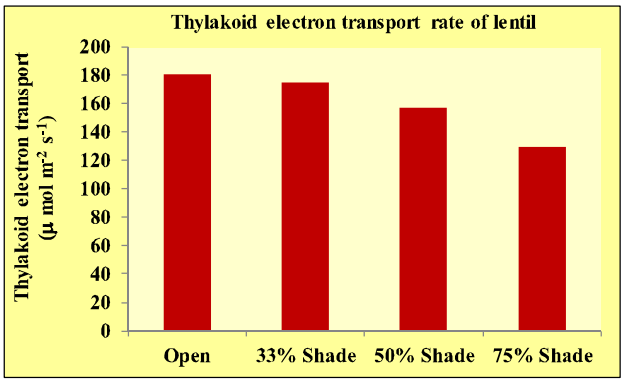


Fig. 8: Effect of varying regimes of shade on thylakoid electron transport rate of lentil

Comparative analysis of CO_2 assimilation ($A_{max\ PPFD}$), thylakoid electron transport rate (ETR) and other related photosynthetic traits of lentil crop under varying regimes of shade and in open were also conducted. There was reduction in $A_{max\ PPFD}$ in deep or extreme shade conditions (Fig.7). Electron transport rate (ETR) of open grown lentil crop was higher than shade grown crop and gradually decreased with increase in shade intensity (Fig. 8). Down regulation in physiological functioning of the plants namely in CO_2 assimilation and supply of ETR across photosystem-2 (PSII), reflected in the reduction of crop yield under shade. Effect of varying regimes of shade was clearly noticed in leaf protein profile of lentil through SDS-PAGE (Plate-1) as well.

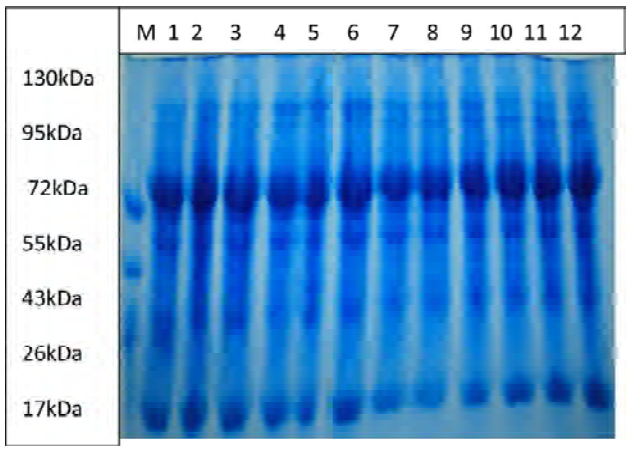


Plate-1: Impact of varying regimes of shade on proteins of lentil leaves studied through SDS-PAGE (M= molecular marker, lane 1-3= Open grown plants, lane 4-6= 33% Shade grown plants, lane 7-9= 50% Shade grown plants and lane 10-13= 75% Shade grown plants)

In *kharif* season, experiments on pigeonpea (*Cajanus cajan;* variety- UPAS) under varying shade were also conducted. Comprehensive studies were made on various physiological and biochemical aspects to analyse the impact of varying shade on the crop. Impact of varying regimes of shade was clearly observed through germination and biomass index (Fig. 9 and 10). Biomass index was highest in open grown plants and decreased as the shade intensity increased. Leaf area of pigeonpea was increased with increase in shade intensity (Fig. 11). Leaf pigments like chlorophyll a, chlorophyll b and total chlorophyll was higher in deep or deeper shade (Fig. 12). Various other experiments related to photosynthetic traits and cellular biochemistry have also been conducted. Activity of Catalase enzyme decreased with increase in shade intensity (Fig. 13). Rate of CO_2 assimilation versus photosynthetic photon flux density curve clearly indicated the detrimental effect of deep shade on photosynthetic mechanism (Fig. 14). Similar pattern were followed by thylakoid electron transport rate, which decreased under deep shade and moderately affected under 33% shade (Fig. 15). Various phenological changes throughout the life cycle were monitored as shown in plate-2. Studies on spectral indices on the select crops are in progress.

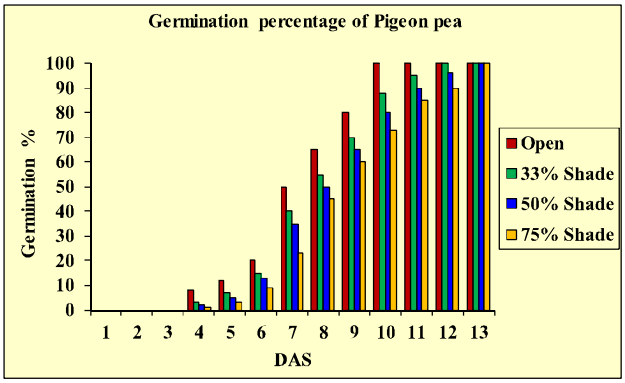


Fig. 9: Impact of varying shade on germination phenology

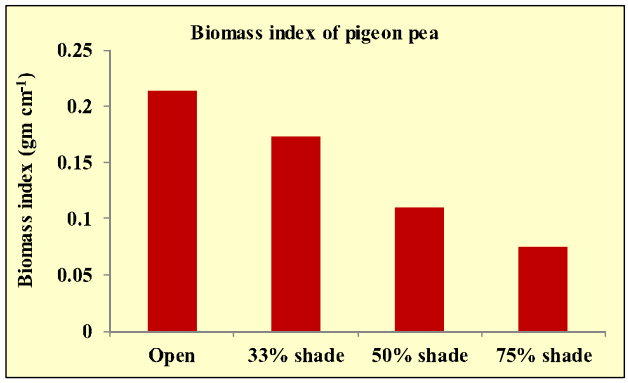


Fig. 10: Impact of varying shade on 60 DAS biomass index

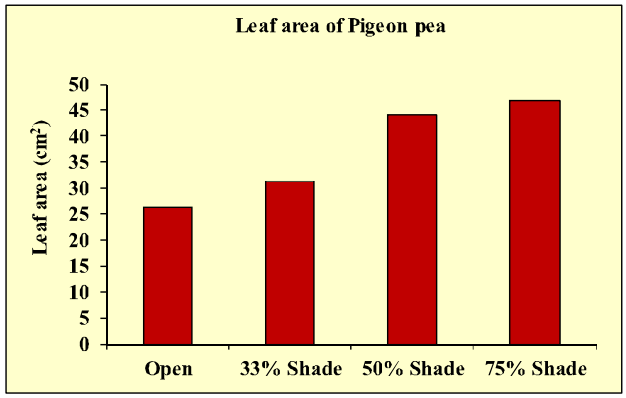


Fig. 11: Impact of varying shade on leaf area

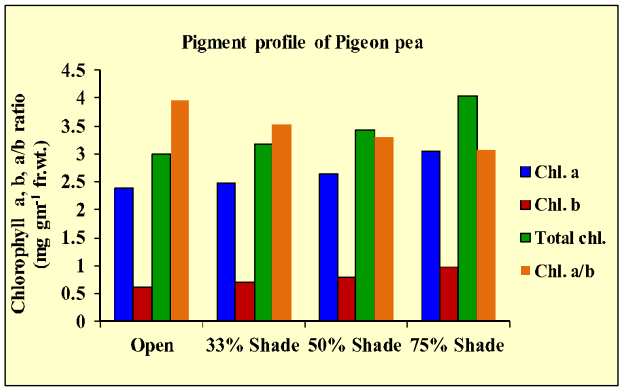


Fig. 12: Impact of varying shade on pigment profile of pigeonpea

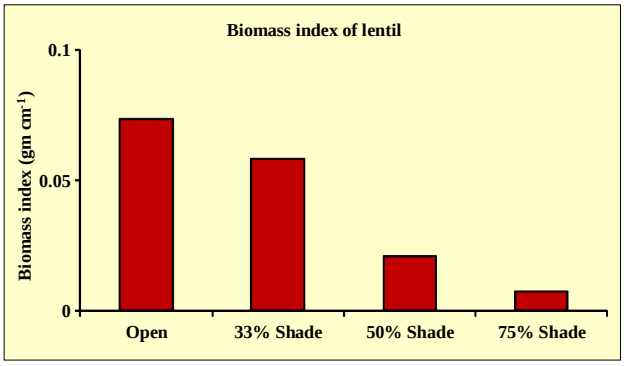


Fig. 13: Impact of varying intensity of shade on catalase enzyme activity

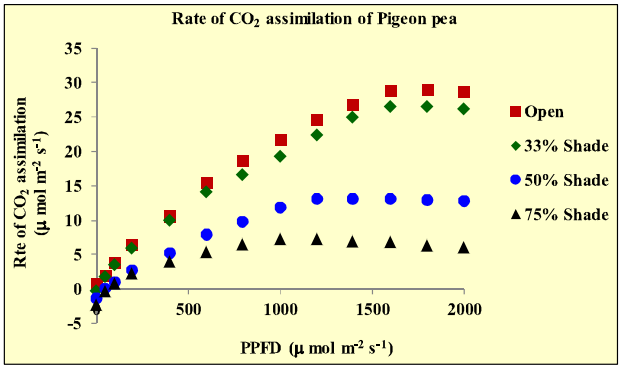


Fig. 14: Rate of CO_2 assimilation versus Photosynthetic photon flux density curve

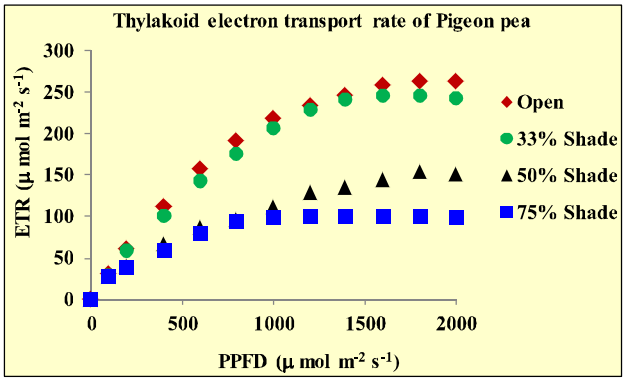
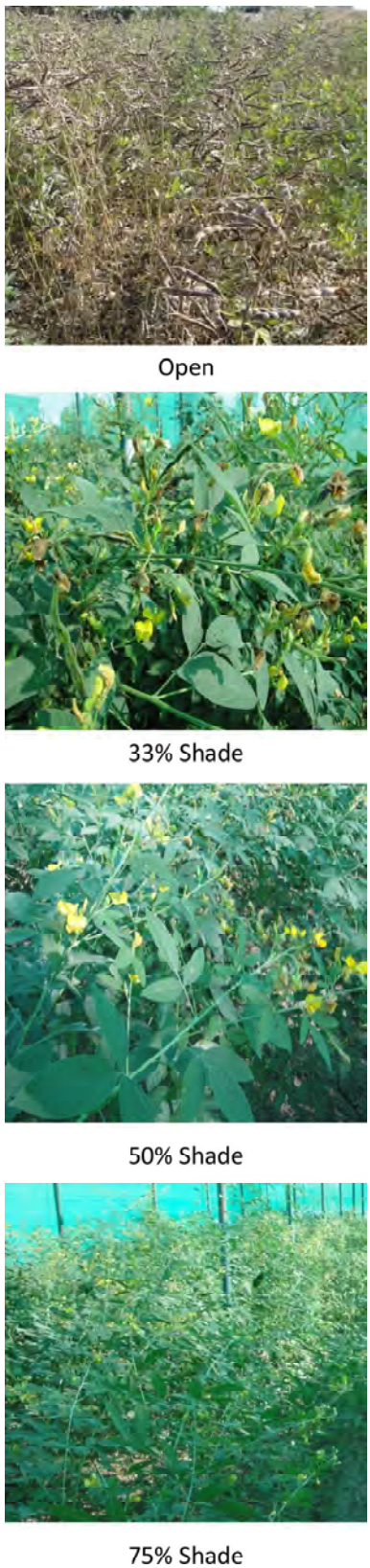


Fig. 15: Thylakoid electron transport rate versus Photosynthetic photon flux density curve



Phenological differences in pigeonpea crop grown under varying regimes of shade

AF 01.24: Studies on Arbuscular Mycorrhizal Fungi of Important MPT's

(Anil Kumar & Rajendra Prasad)

The present study was initiated during 2007-08 to develop suitable technology for inoculation of arbuscular mycorrhizal fungi (AMF) for important agroforestry tree species and intercrops. To achieve this, experiments on integration of chemical fertilizers with bio-fertilizers, DAP saving on account of inoculations with bio-fertilizers and effect of date of sowing on efficacy of bio-fertilizers were conducted in important pulses, during last year. The results obtained so far are being summarized below:

Integration of bio-fertilizers with chemical fertilizer: Factorial experiments (2^4) were conducted on integration of DAP with bio-fertilizers in chickpea, lentil and pea, under field conditions. The treatment combinations consisted of four factors at two levels each *viz*. DAP application at half and full of recommended dose, AMF, *Acaulospora scrobiculata* + *Rhizophagus intraradices* (level 1: applied: level 2: not applied), PSB (level 1: applied: level 2: not applied) and rhizobium (level 1: applied: level 2: not applied). The results indicated that:

- All bio-fertilizers based treatment combinations significantly increased yield plant^{-1} in chickpea, lentil and pea.
- Plant yields were significantly higher at 100 than 50% of recommended dose of DAP.
- Interactions between DAP and treatments were non-significant. So individual treatment combinations could not be compared.

Separate experiments on blackgram and greengram were conducted during last year on integration of bio-fertilizers with chemical fertilizers in bigger plots under field conditions. It consisted of six treatments *viz*., DAP, DAP + AMF, DAP + Rhi, DAP + PSB, DAP + Rhi + PSB and DAP + AMF + Rhi + PSB. The data were recorded on yield and other plant growth parameters. Plot yield was significantly increased by all bio-fertilizer based treatments (Table 12).

Table 12: Integration of bio-fertilizers with chemical fertilizers in blackgram and greengram, under field conditions

Treatments	Blackgram		Greengram	
	Yield (g plant^{-1})	Yield (g plot^{-1})	Yield (g plant^{-1})	Yield (g plot^{-1})
DAP alone	10.29	315.77	12.66	425.44
DAP + AMF	17.99 (74.8)*	585.94 (85.6)	20.11 (58.8)	685.91 (61.2)
DAP + Rhi	19.66 (91.1)	607.26 (92.3)	19.72 (55.8)	688.16 (61.8)
DAP + PSB	16.55 (60.8)	548.40 (73.7)	19.43 (53.5)	601.90 (41.5)
DAP + Rhi + PSB	17.42 (69.3)	617.45 (95.5)	18.65 (47.3)	603.11 (41.8)
DAP + AMF + Rhi + PSB	16.48 (60.2)	588.68 (86.4)	19.41 (53.3)	623.11 (46.5)
C D 0.05	4.39	128.1	2.76	109.6

*Values in the parenthesis indicate % increase over control

Saving of DAP in lentil on account of inoculations with bio-fertilizers: An experiment was conducted on saving of DAP in lentil on account of inoculations with bio-fertilizers. It consisted of two factors *viz*., application of bio-fertilizers (AMF + Rhi +PSB; level 1: applied and level 2: not applied) and DAP doses (50, 75, 90 and 100% of recommended dose). The data were recorded on yield and other plant growth parameters. Increase in yield was recorded by inoculation with bio-fertilizers at all tested DAP doses. There was significant increase in yield with increase in DAP doses (Table 13).

Table 13: Saving of DAP in lentil on account of inoculations with bio-fertilizers under field conditions at different doses

DAP dose	Yield (g plant^{-1})		Mean	Plot yield (g)		Mean
	Without bio-fertilizers	With bio-fertilizers		Without bio-fertilizers	With bio-fertilizers	
50%	2.91	4.12 (41.6)*	3.52	99.21	128.83 (29.9)	114.02
75%	3.78	4.53 (19.8)	4.15	123.51	173.26 (40.3)	148.40
90%	3.99	5.27 (32.1)	4.63	151.53	203.87 (34.5)	177.70
100%	4.65	5.89 (26.7)	5.27	191.59	207.46 (37.2)	231.02
Mean	3.83	4.95 (29.2)		141.46	194.10	
		Yield (plant^{-1} g)			Plot yield (g)	
DAP		0.550			17.764	
Inoculations		0.389			12.561	
DAP × inoculations		NS			NS	

*Values in the parenthesis indicate % increase over control

Effect of date of sowing on efficacy of bio-fertilizers in lentil: Results showed that the percentage increase in plot yield was 41.2 and 44.1% in normal and later sowing, respectively (Table 14). This indicated that the inoculations were equally effective in both types of sowing.

Table 14: Effect of date of sowing on efficiency of bio-fertilizers in lentil, under field conditions

Date of sowing	Yield (g plant^{-1})		Mean	Plot yield (g)		Mean
	Without bio-fertilizers	With bio-fertilizers		Without bio-fertilizers	With bio-fertilizers	
Normal	14.81	16.90 (14.1)	15.85	191.59	270.46 (41.2)	231.02
Late	16.11	18.82 (16.8)	1747	165.89	238.99 (44.1)	202.44
Mean	15.46	17.86 (15.5)		178.74	254.72 (42.5)	
		Yield (g plant^{-1})			Plot yield (g)	
Date of sowing		0.726			25.349	
Inoculations		0.726			25.349	
Date of sowing × inoculations		NS			NS	

*Values in the parenthesis indicate per cent increase over control

AF 01.25: Development of Soil Quality Index for Assessing Soil Health of Different Agroforestry Systems

(Rajendra Prasad, Ram Newaj & Ramesh Singh)

During the year, soil health indicator values generated from *Hardwickia binata* based agroforestry (AF) system were assigned functional scores and soil quality index was calculated. Also, the soil quality index was calculated for the data received from AICRPAF centre, Ludhiana on poplar based agroforestry system. Besides, soil quality indexing procedure used in assessing SQI was evaluated by the correlation coefficient between the SQI and biomass productivity in *Albizia procera* based agroforestry system.

Effect of tree density on soil quality of *H. binata* based AF System (Black soil)

The 20 year *H. binata* based AF system comprises of four treatment of tree densities *viz.* 200, 400 and 800 trees ha^{-1}. Data on soil health indicator values were assigned functional scores based on regional thresholds values for soil quality indicators. Linear scoring function (LSF) *viz.* more is better, less is better and optimum were used to assign scores to indicator values:

$$LSF\ (Y) = (x-s)/(t-s) \quad \text{---------- (1)}$$

$$LSF\ (Y) = 1-[(x-s)/(t-s)] \quad \text{---------- (2)}$$

Where, 'Y' is the linear score, 'x' the soil property value,'s' the lower threshold values and 't' the upper threshold values. Equation 1 is for 'more is better' scoring function, equation 2 for 'less is better' and a combination of both for 'optimum' scoring function. From the functional scores of each observed indicator values, a unified value of SQI was calculated. (Table 15). The increase in tree density of *H. binata* has shown favorable effect on values of the most of the studied indicators. In comparison to baseline, the improvement in SQI was minimum (29.5%) in control and maximum (46.2%) in agroforestry plot having density of 800 tree ha^{-1}. All the tree density treatments have shown higher value of soil quality index when compared with control. The improvement in soil quality over control ranged from 8.5% in tree density of 200 ha^{-1} to 22.9% in density of 800 tree ha^{-1} with mean value of 17.8%.

Effect of pruning levels on soil quality indicators in *H. binata* based AF System (red soil)

Data on soil health indicator values and their respective functional scores from 21 year old *H. binata* based Agroforestry System (red soil) has been presented in Table 17. For assigning linear functional scores, the regional threshold values and linear equation as explained for *H. binata* based Agroforestry System (Black soil) were used. On an average the pruning plots have shown higher values of soil indicators than control plot. The increasing levels of pruning from 25 to 75% also influenced indicator values positively. The improvement brought by pruning treatments in indicator values was reflected in soil quality index. In comparison to baseline all the agroforestry plots have shown higher value of soil quality index. The Improvement in soil quality over baseline ranged from 33.6% in control to 39.6 in 75% pruning plot. On an average, more SQI value (0.49) has been

Table 15: Effect of tree density on soil quality indicators in *H. binata* based AF System (Black soil)

Indicator	Threshold/ Reference value			Function	Indicator Values				Functional Score				
	lower	Upper	Baseline		Control (crop field)	Trees ha^{-1}			Baseline	Control (crop field)	Trees ha^{-1}		
						200	400	800			200	400	800
Rooting depth(cm)	50.00	250	60	more is better	90	90.00	90.00	90.00	0.05	0.20	0.20	0.20	0.20
Field capacity (%)	10.00	25	12	more is better	20.115	19.60	23.23	23.70	0.13	0.67	0.64	0.88	0.91
SOC (%)	0.20	1	0.4	more is better	0.26	0.52	0.59	0.57	0.25	0.08	0.40	0.48	0.47
CEC (Cmol /kg soil)	5.00	25	10	more is better	19.425	19.90	23.63	23.70	0.25	0.72	0.75	0.93	0.94
Available N (kg/ha)	80.00	250	140	more is better	214.00	219.52	238.33	219.50	0.35	0.79	0.82	0.93	0.82
Available P (kg/ha)	8.00	25	10	more is better	13.7	16.70	19.14	18.10	0.12	0.34	0.51	0.66	0.59
Available K (kg/ha)	100.00	300	140	more is better	119.855	135.30	145.30	139.60	0.20	0.10	0.18	0.23	0.20
Microbial biomass (ug/g)	50.00	400	75	more is better	93.71	125.25	155.35	164.14	0.07	0.12	0.22	0.30	0.33
Dehydrogenase activity (ug TPF/g/day)	25.00	275	50	more is better	34.40	83.74	96.20	150.82	0.10	0.04	0.23	0.28	0.50
Porosity (%)	20.00	80	31	optimum	29.67	35.84	36.86	38.41	0.18	0.19	0.26	0.28	0.31
Infiltration rate (cm/hr)	1.00	8	1.5	optimum	1.7	1.80	1.8	1.8	0.07	0.11	0.11	0.11	0.11
pH	5.50	8.5	6.5	optimum	7.44	7.98	7.52	7.24	0.33	0.35	0.17	0.33	0.42
EC (dS/M)	0.20	4	0.5	Less is better	0.07	0.16	0.12	0.06	0.92	1.03	1.01	1.02	1.04
Bulk density (g/cm3)	1.30	2.1	1.66	Less is better	1.52	1.43	1.45	1.44	0.55	0.73	0.84	0.81	0.83
Pot N mineralization kg/ha/wk	25.00	250	50	more is better	44.70	89.97	101.82	90.65	0.89	0.91	0.71	0.66	0.71
SQI									0.30	0.43	0.47	0.54	0.56

Table 16: Effect of tree density on soil quality index in *H. binata* based AF System (Black soil)

Treatments	Soil Quality Index	% Over Baseline	% Over Control (Crop Field)
Baseline	0.30	---	---
% Over control (crop field)	0.43	29.51	---
200 trees ha^{-1}	0.47	36.17	8.51
400 trees ha^{-1}	0.54	44.44	20.37
800 trees ha^{-1}	0.56	46.24	22.94
Mean	0.52	42.64	17.78

Table 17: Effect of pruning levels on Soil Quality indicators in *H. binata* based Agroforestry System (red soil)

Indicator	Indicator Values				Functional Scores				
	Control	Pruning (%)			Baseline	Control	Pruning (%)		
		25	50	75			25	50	75
Rooting depth(cm)	90.00	90.00	90.00	90.00	0.05	0.20	0.20	0.20	0.20
Field capacity (%)	13.46	14.89	17.01	14.87	0.13	0.23	0.33	0.47	0.32
SOC (%)	0.45	0.53	0.60	0.62	0.25	0.31	0.41	0.50	0.53
CEC (C mol kg^{-1})	12.88	12.27	13.62	15.37	0.25	0.39	0.36	0.43	0.52
Available N (kg ha^{-1})	227.21	357.50	269.70	282.24	0.35	0.87	1.63	1.12	1.19
Available P (kg ha^{-1})	12.53	12.98	15.03	14.51	0.12	0.27	0.29	0.41	0.38
Available K (kg ha^{-1})	154.24	148.31	162.50	173.45	0.20	0.27	0.24	0.31	0.37
Microbial biomass (µ g g^{-1})	142.00	117.50	167.30	170.50	0.07	0.26	0.19	0.34	0.34
Dehydrogenase activity (µ g TPF g^{-1} day^{-1})	70.51	45.87	87.29	133.61	0.10	0.18	0.08	0.25	0.43
Porosity (%)	39.53	40.24	42.42	42.37	0.18	0.48	0.34	0.37	0.37
Infiltration rate (cm hr^{-1})	1.70	1.80	1.80	1.80	0.07	0.11	0.11	0.11	0.11
pH	6.85	7.05	6.86	7.23	0.33	0.55	0.48	0.55	0.42
EC (dS M^{-1})	0.09	0.05	0.05	0.12	0.92	1.03	1.04	1.04	1.02
Bulk density (g cm^{-3})	1.53	1.49	1.49	1.50	0.55	0.71	0.77	0.76	0.76
Pot N mineralization (kg ha^{-1} wk^{-1})	54.08	108.65	152.41	155.47	0.89	0.87	0.63	0.43	0.42
SQI					0.30	0.45	0.47	0.49	0.49

observed in pruning plots than control (0.45). The SQI value increased with increase in pruning levels and the improvement in SQI brought by pruning treatments ranged from 5.3 to 8.9% with a mean value of 7.4% over control (Table 18).

Table 18: Effect of pruning levels on soil quality index in *H. binata* based AF System (red soil)

Treatments	Soil Quality Index	% Over Baseline	% Over Control
Baseline	0.30		
Control	0.45	33.63	
25% Pruning	0.47	37.13	5.27
50% Pruning	0.49	38.68	7.61
75% Pruning	0.49	39.55	8.92
Mean	0.49	38.56	7.42

Effect of poplar based agroforestry on soil quality at AICRPAF centre Ludhiana, Punjab

Effort were made to calculate soil quality index of AICRPAF centre's soil data using SQI framework developed at CAFRI, Jhansi. Soil data from AICRPAF Centre, Ludhiana pertains to six year old poplar based agroforestry system comprises of two treatments *viz*. poplar + crop and sole crop. For crops, pearl millet – wheat rotation was followed. Except for rooting depth, values of all other soil indicators have been received from AICRPAF centre, Ludiana. Considering moderately deep soils of Ludhiana, the value of rooting depth has been assumed at 200cm. Regional threshold indicator values used for developing framework for SQI in CAFRI, Jhansi were also used as baseline for Ludhiana for calculating SQI. As evident from the data, the values of soil indicators were more in agroforestry plot than sole crop plot at both surface and sub-surface soil depths (Table 19). Similar trend was observed in respect to values of SQI. In comparison to SQI at the initial point of experimentation, poplar based agroforestry plot has shown 19.6% improvement in SQI of surface soil whereas sole crop plot had negligible gains (0.8%). Contrary to surface soil, the quality of sub surface soil deteriorated as indicated by negative value of percentage gain over initial soil quality and maximum deterioration was noticed in sole crop plot (-18.2%). However, degradation was negligible (-0.5%) in agroforestry plot (Table 20).

Table 19: SQI of poplar based agroforestry system at AICRPAF centre, Ludhiana

Soil Indicator	Indicator Values				Functional Score			
	Baseline (Jhansi)	Initial status (control)	Poplar + crop	Sole crop	Baseline (Jhansi)	Initial status (control)	Poplar + crop	Sole crop
Surface soil (0-15cm)								
Rooting depth (cm)	60.00	200.00	200.00	200.00	0.05	0.75	0.75	0.75
SOC (%)	0.40	0.31	0.373	0.28	0.25	0.14	0.22	0.10
CEC (C mol kg^{-1})	10.00	10.57	13.24	11.32	0.25	0.28	0.41	0.32
Available N (kg ha^{-1})	140.00	139	165	145	0.35	0.35	0.50	0.38
Available P (kg ha^{-1})	10.00	9.56	15	9.86	0.12	0.09	0.41	0.11
Available K (kg ha^{-1})	140.00	194	204	189	0.20	0.47	0.52	0.45
pH	6.50	8.19	8.12	8.18	0.33	0.10	0.13	0.11
EC (dS m^{-1})	0.50	0.44	0.42	0.46	0.92	0.94	0.94	0.93
Soil Quality Index		0.00	0.00	0.00	0.31	0.39	0.48	0.39
Surface soil (15-30cm)								
Rooting depth(cm)	60.00	200.00	200.00	200.00	0.05	0.75	0.75	0.75
SOC (%)	0.40	0.31	0.27	0.22	0.25	0.14	0.09	0.02
CEC (C mol kg^{-1})	10.00	10.57	10.39	9.17	0.25	0.28	0.27	0.21
Available N (kg ha^{-1})	140.00	139.00	139.00	124.00	0.35	0.35	0.35	0.26
Available P (kg ha^{-1})	10.00	9.56	10.98	7.39	0.12	0.09	0.18	-0.04
Available K (kg ha^{-1})	140.00	194.00	186.00	177.00	0.20	0.47	0.43	0.39
pH	6.50	8.19	8.23	8.20	0.33	0.10	0.09	0.10
EC (dS m^{-1})	0.50	0.44	0.38	0.39	0.92	0.94	0.95	0.95
Soil Quality Index		0.00	0.00	0.00	0.31	0.39	0.39	0.33

Table 20: Effects of poplar based AF System on soil quality index in Ludhiana

Treatments	Soil quality index	% Over baseline	% Over initial status (Control)	Soil Quality Index	% Over baseline	% Over initial status (Control)
Surface soil (0-15cm)				**Surface soil (15-30cm)**		
Baseline (Jhansi)	0.31	0.00	0.00	0.31	0.00	0.00
Initial status (control)	0.39	20.77	0.00	0.39	20.77	0.00
Poplar+ crop	0.49	36.29	19.59	0.39	20.36	-0.52
sole crop	0.39	21.37	0.76	0.33	6.36	-18.18

Evaluation of soil quality indexing method

Soil quality indexing procedure used in assessing SQI of *A. procera* based Agroforestry system was evaluated by the correlation coefficient between the SQI and biomass productivity. The sensitivity was calculated as sensitivity (S_i) = SQI_{max}/ SQI_{min} where, SQI_{max} and SQI_{min} are the maximum and minimum SQI calculated for *A. procera* based agroforestry system. The soil quality index based on linear scoring function was highly correlated with biomass yield with R^2 value of 0.847 (Fig. 16). The value of SQI ranged from 0.272 to 0.567 had sensitivity of 2.07.

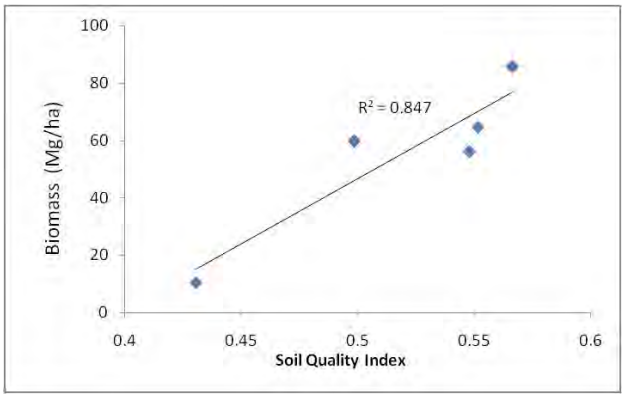


Fig. 16: Correlation between SQI and biomass yield in *A. procera* based Agroforestry system

AF 05.6: Model Watershed Project on Natural Resource Management through Agroforestry Interventions at Garhkundar, Tikamgarh, M.P.

(S K Dhyani, R K Tewari, Ramesh Singh, R P Dwivedi & R H Rizvi)

The Institute selected Garhkundar-Dabar watershed in 2005-06 to improve rural livelihood through participatory watershed management by cost-effective integrated natural resource management and agroforestry interventions besides establishing a site for learning for farmers, rural community and also for researchers and other stakeholders (development agencies and policy makers) to understand the impact of integrated watershed management interventions in Bundelkhand region. Progress made during the year 2014 under different heads is as follow:

Hydrological Monitoring

Several *in-situ* and *ex-situ* interventions were implemented in the watershed which have been described in the previous annual reports. Datalogger based automatic stage level recorders were installed at six sites, including control watershed, to measure runoff during rainy season. Besides this, manual and self-recording rain gauges were also installed in the watershed to measure the rainfall. Total 593.8 mm rainfall was received which spread over in 34 rainy days. Monthly rainfall and average water column were depicted in Fig. 17.

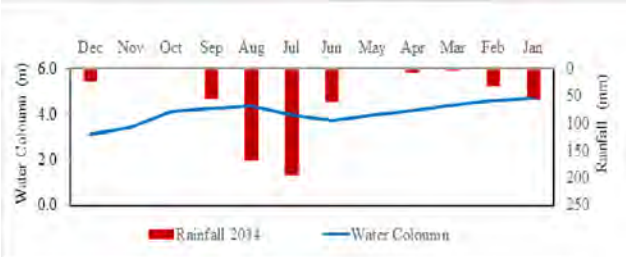


Fig. 17: Rainfall and water column recorded at Garhkundar-Dabar watershed

All open shallow dug wells in treated (109 Nos.) and untreated (42 Nos.) watershed were monitored fortnightly for water level. The average depth of the wells is 8.54 and 8.71 m in treated and untreated watershed, respectively. Due to conservation measures in treated watershed, the water column varied from 4.7 in January to 3.1 in December with an average of 4.1 m during the year 2014. During the month of October average water column was 4.1 m which is 28.69 % lower than water column recorded in October, 2013. However, the rainfall during 2014 (593.8 mm) was about 46 % lower than rainfall recorded during 2013 (1101.2 mm). This indicates that watershed interventions are more effective during drought year. Due to availability of water, *rabi* sowing was done in entire cultivable land of the watershed.

Crop and Agroforestry Demonstration

During the year no plantation works was taken up. Existing cropping practices, tree growth under agroforestry were recorded.

Seed exchange rate: Seed quality is key input in agriculture and this fact has been very well recognized by watershed farmers. However, wheat seed exchange rate showed variation with economic and social status. In OBC dominated village of Dabar more than 90 % farmers procure new seed from NSC every year atleast for 10 % area and re-use it up to 3 years. In SC dominated village of Shivrampur hardly 60 % farmers purchase new seed every year. However, they exchange seeds frequently from neighboring farmers and replace old seed after every three years. In ST dominated village of *Rauntiyana*, no farmer purchases wheat seed from NSC due to poor economic status (agricultural laborers). However, they also exchange seed from neighboring village quite often. In Kundar village with mixed population, seed exchange rate is moderately high. About 80 % farmers regularly procure wheat seed for at least 10 % area from NSC. Rest of the seed is managed through exchange within the village. Wheat seed rate also showed due variation in the watershed.

New seed	:	100 kg ha^{-1}
One year old seed	:	150 kg ha^{-1}
More than two years old seed	:	200 kg ha^{-1}

High seed rate of wheat in the watershed is associated with low tillering in old seeds. After three years every farmer changes seed. However, ST farmer's particularly migratory laborers often use old seed due to poverty.

Crop coverage: In light of low rainfall forecast by IMD during 2014 and mass awakening of farmers in this respect, farmers of the watershed devoted maximum area to sesame and blackgram in *kharif* season. Prior to project activities, the area under *kharif* was less than 10 % which increased to about 63 % in 2014. Groundnut area decreased due to delayed monsoon. Guar was sown in sizeable area for the first time in the watershed. Productivity under various *kharif* crops in 2014 and *rabi* crops 2013-14 is given below (Table 21).

Table 21:Productivity of different crops in Garhkundar-Dabar watershed

Crop	Productivity (kg ha^{-1})	
	Rabi, 2013-14	*Kharif*, 2014
	Productivity (kg ha^{-1})	Productivity (kg ha^{-1})
Groundnut	0.00	756.00
Sesame	0.00	110.00
Blackgram	0.00	54.00
Guar	0.00	Failed
Wheat	2550.00	0.00
Chickpea	608.00	0.00
Lentil	54.00	0.00
Pea	1138.00	0.00

Crop productivity: Wheat productivity in 2013-14 in the watershed was recorded 2550 kg ha^{-1}. Lower productivity than previous years was due to lodging of crop. High rainfall during winter affected crops like chickpea, lentil and production was hampered. However, pea production was 1138 kg ha^{-1}. This has encouraged farmers to grow pea in large area in coming years.

Plant growth under agroforestry: Growth of fruit plants planted in 2007 under agroforestry system on farmer's field are being monitored and data recorded is presented below in Table 22. Guava based agroforestry system was developed on two farmers field, while citrus and aonla based system in one farmer each. Average growth of guava plants on Sh. Dhani Ram's field was poor as compared to that of Sh. Salim due to variable soil. Guava plants yielded 24.3 (kg tree^{-1}) fruit on Sh.

Dhani Ram's field. Open space between tree rows permitted crop production in *kharif* as well as *rabi* season. Growth of citrus plants was comparatively better on his field. Citrus plants recorded 4.26 m height, 10.54 cm collar diameter, 4.34 m canopy spread and 15.4 kg tree^{-1} fruit productivity.

Table 22: Growth of fruit plants under agroforestry system on farmer's field

Farmer	Fruit Tree	Height (m)	Collar diameter (cm)	Canopy spread (m)	Fruit yield (kg tree^{-1})
Sh. Dhani Ram	Guava	3.48	10.92	3.64	24.3
	Citrus	4.26	10.54	4.34	15.4
Sh. Salim	Guava	4.78	13.72	5.12	39.4
Sh. Himmat	Aonla	4.72	13.26	4.70	35.8

On Sh. Salim's field growth of guava plants was better. Guava plants recorded 4.78 m height, 13.72 cm collar diameter and 5.12 m canopy spread. Fruit yield of guava on Salim's field was 39.4 kg plant^{-1}. Aonla plants on Sh. Himmat's field recorded 4.72 m height, 13.26 cm collar diameter and 4.7 m canopy spread. Aonla plants are now commercially yielding fruits to the tune of 35.8 kg tree^{-1}. During the year, crop production was adversely effected due to rains during late *rabi* season. As such, fruit plants supported farmers in bearing economic losses.

Crop production under agroforestry: Crop production under agroforestry system in *rabi*, 2013-14 and *kharif*, 2014 was recorded and presented in Table 23.

Table 23: Crop production under agroforestry system on farmer's field

Farmer	Fruit Tree	Crop *Rabi*, 2013-14	Yield (kg ha^{-1})	Crop *Kharif*, 2014	Yield (kg ha^{-1})
Sh. Dhani Ram	Guava	Wheat	1667	Sesame	40
	Citrus	Chickpea	393	Blackgram	27
Sh. Salim	Guava	Wheat	1450	Groundnut	667
Sh. Himmat	Aonla	Chickpea	453	Blackgram	67

Yield of crops reduced under agroforestry system as compared with sole crop. Wheat on Sh. Dhani Ram's field under guava plantation was recorded 1667 kg ha^{-1}, while that on Sh. Salim's field only 1450 kg ha^{-1}. This was due to tree shade under agroforestry system. Chickpea yield under citrus plantation was recorded 393 kg ha^{-1} while under aonla plantation 453 kg ha^{-1}. Higher yield of gram in aonla plantation may be because of deciduous nature of aonla which permits more sunlight for understorey crop.

During *kharif*, 2014 sesame was sown with guava by Sh. Dhani Ram, blackgram with aonla and citrus by Sh. Himmat and Sh. Dhani Ram, respectively while groundnut was sown by Sh. Salim in guava plantation. Groundnut is considered cash crop in the region wherever irrigation facility exists in red soil. Both sesame and blackgram recorded very low grain yield on Sh. Dhani Ram's field due to rains. Maximum 63 kg ha^{-1} blackgram yield was recorded under aonla plantation due to new seed. Groundnut recorded 667 kg ha^{-1} in guava plantation on Sh. Salim's field which is again lower than sole crop yield in the watershed.

Fruit plants supported farmers during adverse weather condition. As such, farmers now show inclination for the plantation under agroforestry system. During the year 2014 area under *rabi* crops outside the watershed reduced to half due to weather change and landscape dominated by lentil, chickpea and sesame till November end but inside watershed maximum area was sown under wheat. Outside watershed including control watershed, remaining crop area was sown under wheat after "Hudhud cyclone", as such, cropped area reached to near normal in spite of low deficit rainfall during monsoon. However, productivity is yet to come.

Capacity building and Self Help Group

The farmers of the watershed villages are being motivated and made aware about agroforestry practices. The SHGs are meeting regularly at weekly/fortnightly interval. Group members are taking up their own traditional activities, *i.e.*, Idol making and tent articles and pooling their savings. During 2014, total savings plus assets of women SHG Kundar was ₹ 1,14,160.00.

AF 05.11: Multi-Source Inventory Methods for Quantifying Carbon Stocks through Generalized Volume/ Biomass Equations for Prominent Agroforestry Species in India

(R H Rizvi, A K Handa & Ajit)

Generalized models for predicting volume of poplar spp.

A total of 16 equations on timber volume of poplar species were found in the literature out of which 8 equations were for Punjab state, 6 for Haryana state and two for Uttarakhand. These equations pertains to Jalandhar and Ludhiana in Punjab; Hisar, Karnal and Yamunanagar in Haryana and Dehradun in Uttrakhand. In these equations, diameter at breast height (D) and tree height (H) were used as independent variables. Only those equations which are based on D have been used for simulation purpose.

Out of 8 published equations on volume for state of Punjab, only four equations have been used for simulations. The observed range of dbh values for the harvested trees varied from 10.0 to 41.4 cm and the observed range for the volume varied from 0.039 to 1.554 (m^3 $tree^{-1}$). Total 101 datasets on diameter at breast height and volume have been generated which is then used for developing generalized volume equation. The model $V = 0.00257\ D^{1.65236}$ (R^2 = 0.819) has been developed for Punjab state and may be used for estimating timber volume of Poplar tree (Fig. 18).

A total of six published equations on volume could be traced for state of Haryana, out of which three have been used for simulation purpose. The observed range of dbh values for the harvested trees varied from 16.56 to 35.03 cm and the observed range for the volume varied from 0.094 to 0.632 (m^3 $tree^{-1}$). Total 45 datasets on dbh and volume have been generated which is then used for developing generalized volume equation. The model $V = 0.0002\ D^{2.1102}$ (R^2 = 0.910) has been developed for Haryana state and may be used for estimating timber volume of Poplar tree (Fig. 19).

Country Level Timber Volume Generalized Equation

The simulated data point (dbh and Timber volume) for these equations were clubbed into one data set for Country Level as a whole. Three non-linear models were fitted for timber volume of Poplar on this Country level data set. The model of the form $V = a\ [1 + \exp(p\text{-}b\ D)]^{-1}$ was found good fit with R^2 value of 0.789, where V- timber volume (m^3 $tree^{-1}$) and D- diameter at breast height (cm). Parameter estimates (a, p and b) along with their approx. standard error and Wald confidence limit has been given in (Table 24). The equation $V = 2.8443/\ [1+e^{(3.1012-0.0689\ D)}]$ is proposed to be used for predicting or estimating the timber volume of tree for the dbh range of 14.0 to 41.0 cm (Fig. 20).

Table 24: Fitted statistics for country-level generalized model for volume of Poplar

Parameter	Estimate	A.S.E.	Param/ ASE	Wald Confidence Interval	
				Lower < 95%> Upper	
a	2.84427	1.76473	1.61173	-0.64919	6.33772
p	3.10116	0.42732	7.25724	2.25524	3.94708
b	0.06895	0.01552	4.44349	0.03823	0.09967

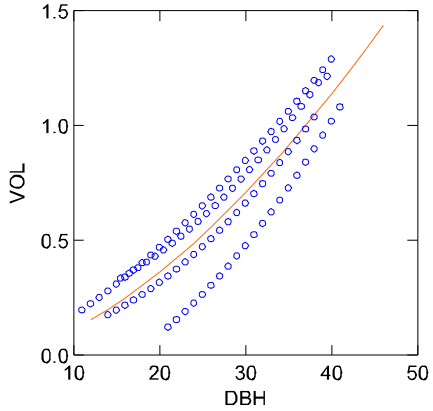


Fig.18: Fitted generalized volume model for Punjab

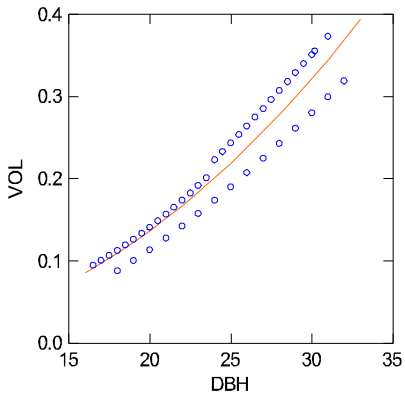


Fig.19: Fitted generalized volume model for Haryana

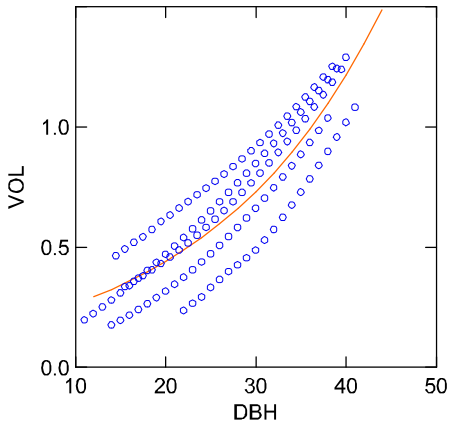


Fig.20: Country-level fitted generalized volume model for Poplar

AF 05.12: Agroforestry based Conservation Agriculture for Sustainable Landuse and Improved Productivity

(Inder Dev, R K Tewari, Ramesh Singh, Asha Ram, K B Sridhar, Anil Kumar, Mahendra Singh & A R Uthappa)

The Agroforestry based Conservation Agriculture for sustainable landuse and improved productivity project was approved during 2013, however due to land preparation and laser leveling operations, the experiments could be laid out during 2014.

Experiments details

Agroforestry based CA experiments were laid out at CAFRI Research Farm after having laser leveled an area of 3.0 ha. Three experiments *viz*., Bael based agroforestry (AF) system; Teak based Agroforestry system and Bael + Teak based Agroforestry system with 04 main plot treatments (Min. tillage-Blackgram-Mustard (CS-1); Min. tillage-Greengram-Barley (CS-2); CT-Blackgram-Mustard (CS-1) and CT-Greengram-Barley (CS-2) and 03 subplot treatments (with Crop Residue; without Crop Residue and with *Leucaena* (K-636) Residue).

Experimental Results

During *kharif,* 2014, sowing of greengram (PDM-139) and blackgram (Azad-2) was done as per treatment details in three experiments, results of which are presented here as follows:

Experiment I: Bael (*Aegle marmelos)* based conservation agriculture system

Bael (CISH B-2) was transplanted in July, 2014. The survival of the bael at six months of transplanting was observed to be 84.92% (Fig. 21). Data on growth and yield of greengram as influenced by tillage practices and residue management under bael based agroforestry system is presented in Table 25. A cursory glance on the data reveals that plant population varied in the range of 32.5 to 34.0 plants m^{-2} and 1000 grain weight was recorded as 34.7 to 35.2 g. Grain yield varied in the range of 879 to 952 kg ha^{-1}. By and large most of the growth and yield parameters were not influenced by different tillage and residue management practices. Data on growth and yield of blackgram as influenced by different treatments is presented in Table 26. Data indicated that by and large most of the parameters were not influenced by the treatment effects. Grain yield of blackgram varied in the range of 635 to 719 kg ha^{-1}. Residue management had significant influence on the grain yield.

Experiment II: Teak (*Tectona grandis*) based conservation agriculture system

Teak (MHEM-R-2) was transplanted in August, 2014. The survival of the teak at six months of transplanting was observed to be 97.22% (Fig. 21). Data on growth and yield of greengram as influenced by tillage practices and residue management under teak based agroforestry system is presented in Table 27. Data reveals that plant population varied in the range of 32.4 to 33.9 plants m^{-2} and 1000 grain weight was recorded as 33.2 to 34.1g. Grain yield varied in the range of 737 to 811 kg ha^{-1}. By and large most of the growth and yield parameters were not influenced by different tillage and residue management practices. Data on growth and yield of blackgram as influenced by different treatments is presented in Table 28. By and large most of the parameters were not influenced by the treatment effects. Grain yield of blackgram varied in the range of 631 to 689 kg ha^{-1}. Residue management had significant influence on the grain yield.

Experiment III: Bael (*Aegle marmelos*) + Teak (*Tectona grandis*) based conservation agriculture system

Bael (CISH-B-2) and Teak (MHEM-R-2) were transplanted during July and August, 2014, respectively. The survival of the bael and teak at six months of transplanting was observed to be 96.03 and 96.83%, respectively (Fig. 21). Data on growth and yield of greengram as influenced by tillage practices and residue management under teak based agroforestry system is presented in Table 29. Data reveals that plant population varied in the range of 32.6 to 33.8 plants m^{-2} and 1000 grain weight was recorded as 34.2 to 34.6 g. Grain yield varied in the range of 834 to 954 kg ha^{-1}. By and large most of the growth and yield parameters were not influenced by different tillage and residue management practices. Data on growth and yield of blackgram as influenced by different treatments is presented in Table 30. By and large most of the parameters were not influenced by the treatment effects. Grain yield of blackgram varied in the range of 638 to 681 kg ha^{-1}. Residue management had significant influence on the grain yield.

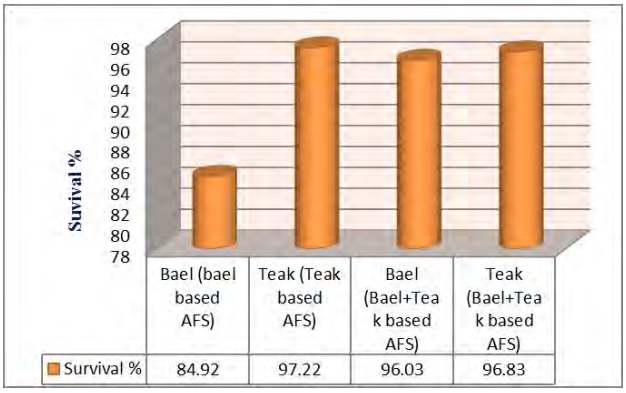


Fig. 21: Survival (%) of bael and teak under Agroforestry based CA

Table 25: Growth and yield of greengram as influenced by tillage practices under bael based agroforestry system

Treatment	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest (g m^{-2})	No. of pods $plant^{-1}$	Pod length (cm)	No. of grains pod^{-1}	1000-grain weight	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Main										
CT-Greengram-Mustard	34.0	58.2	304.0	14.6	6.50	10.0	34.7	952.0	1874.0	34.2
CT-Blackgram-Barley	-	-	-	-	-	-	-	-	-	-
MT- Greengram-Mustard	32.5	57.1	296.0	14.5	6.41	9.9	35.1	879.0	1806.0	33.0
MT-Blackgram-Barley	-	-	-	-	-	-	-	-	-	-
S Em±	0.5	0.7	2.0	0.1	0.02	0.1	0.5	10.0	16.0	0.6
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	60.0	NS	NS
Sub										
Without crop residue	32.7	56.4	289.0	13.6	6.33	9.7	34.7	852.0	1711.0	33.2
With crop residue	33.7	58.9	310.0	15.1	6.59	10.1	34.9	950.0	1932.0	32.8
With *leucaena* residue	33.3	57.7	301.0	14.8	6.45	10.1	35.2	945.0	1876.0	34.8
S Em±	0.4	0.9	3.0	0.2	0.05	0.2	0.4	31.0	49.0	0.7
LSD (*P*= 0.05)	NS	NS	9.0	0.7	0.16	NS	NS	NS	159.0	NS
Main x Sub										
S Em±	0.6	1.2	4.0	0.3	0.07	0.2	0.6	44.0	69.0	0.973
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; MT-Minimum tillage

Table 26: Growth and yield of blackgram as influenced by tillage practices under bael based agroforestry system

Treatment	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest ($g\ m^{-2}$)	No. of pods $plant^{-1}$	Pod length (cm)	No. of grains pod^{-1}	1000-grain weight	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	Harvest index (%)
Main										
CT-Greengram-Mustard	-	-	-	-	-	-	-	-	-	-
CT-Blackgram-Barley	32.0	34.0	246.0	13.5	3.38	5.32	34.1	687.0	1492.0	31.5
MT- Greengram-Mustard	-	-	-	-	-	-	-	-	-	-
MT-Blackgram-Barley	30.3	33.5	243.0	13.6	3.28	5.16	33.9	671.0	1466.0	31.4
S Em±	0.3	0.5	2.0	0.1	0.07	0.04	0.5	6.0	13.0	0.3
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub										
Without crop residue	30.0	34.5	237.0	13.0	3.24	5.00	33.3	635.0	1413.0	31.0
With crop residue	32.1	34.0	251.0	13.9	3.40	5.45	34.4	719.0	1534.0	31.9
With *leucaena* residue	31.3	32.8	246.0	13.7	3.34	5.28	34.4	683.0	1491.0	31.4
S Em±	0.5	0.5	3.0	0.2	0.07	0.08	0.5	15.0	11.0	0.5
LSD (*P*= 0.05)	NS	NS	9.0	0.5	NS	0.27	NS	50.0	34.0	NS
Main* x *Sub										
S Em±	0.8	0.7	4.0	0.2	0.10	0.12	0.7	22.0	15.0	0.7
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; MT-Minimum tillage

Table 27: Growth and yield of greengram as influenced by tillage practices under teak based agroforestry system

Treatment	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest ($g\ m^{-2}$)	No. of pods $plant^{-1}$	Pod length (cm)	No. of grains pod^{-1}	1000-grain weight	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	Harvest index (%)
Main										
CT-Greengram-Mustard	33.7	56.7	284.0	11.7	6.59	9.6	33.6	811.0	1675.0	32.6
CT-Blackgram-Barley	-	-	-	-	-	-	-	-	-	-
MT- Greengram-Mustard	33.0	55.7	281.0	11.8	6.48	10.0	33.9	762.0	1646.0	31.6
MT-Blackgram-Barley	-	-	-	-	-	-	-	-	-	-
SEm±	0.3	0.2	4.0	0.3	0.04	0.0	0.4	10.0	15.0	0.3
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	0.2	NS	NS	NS	NS
Sub										
Without crop residue	32.4	55.2	269.0	11.3	6.46	9.5	33.2	737.0	1553.0	32.2
With crop residue	33.7	57.2	290.0	12.2	6.54	10.0	34.0	814.0	1733.0	32.0
With *leucaena* residue	33.9	56.3	288.0	11.8	6.60	10.0	34.1	809.0	1697.0	32.3
SEm±	0.6	0.8	3.0	0.2	0.04	0.1	0.4	014.0	22.0	0.5
LSD (*P*= 0.05)	NS	NS	10.0	0.7	NS	0.3	NS	046.0	73.0	NS
Main* x *Sub										
SEm±	0.8	1.2	4.0	0.3	0.05	0.1	0.6	20.0	32.0	0.7
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; MT-Minimum tillage

Table 28: Growth and yield of blackgram as influenced by conservation agriculture practices under teak based agroforestry system

Treatment	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest ($g\ m^{-2}$)	No. of pods $plant^{-1}$	Pod length (cm)	No. of grains pod^{-1}	1000-grain weight	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	Harvest index (%)
Main										
CT-Greengram-Mustard	-	-	-	-	-	-	-	-	-	-
CT-Blackgram-Barley	31.7	32.6	239.0	14.0	3.38	5.46	33.1	668.0	1440.0	31.7
MT- Greengram-Mustard	-	-	-	-	-	-	-	-	-	-
MT-Blackgram-Barley	31.3	32.7	241.0	13.9	3.30	5.35	33.7	649.0	1436.0	31.1
S Em±	0.3	0.4	3.0	0.1	0.07	0.07	0.5	11.0	7.0	0.3
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub										
Without crop residue	32.0	31.9	235.0	13.3	3.16	5.20	32.9	631.0	1405.0	31.0
With crop residue	31.0	32.6	246.0	14.5	3.51	5.57	33.9	689.0	1470.0	31.9
With *leucaena* residue	31.5	33.4	240.0	14.1	3.33	5.44	33.5	656.0	1439.0	31.3
S Em±	0.6	0.7	2.0	0.2	0.07	0.08	0.5	11.0	15.0	0.4
LSD (*P*= 0.05)	NS	NS	8.0	0.7	0.23	0.27	NS	34.0	48.0	NS
Main* x *Sub										
S Em±	0.9	1.0	3.0	0.3	0.10	0.12	0.7	15.0	21.0	0.5
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; MT-Minimum tillage

Table 29: Growth and yield of greengram as influenced by conservation agriculture practices under bael + teak based agroforestry system

Treatment	Plant population (m^{-2})	Plant height (cm)	Dry matter accumulation at harvest ($g\ m^{-2}$)	No. of pods $plant^{-1}$	Pod length (cm)	No. of grains pod^{-1}	1000-grain weight	Grain yield ($kg\ ha^{-1}$)	Straw yield ($kg\ ha^{-1}$)	Harvest index (%)
Main										
CT-Green gram-Mustard	32.6	57.7	306.5	14.2	6.59	11.1	34.5	918.0	1923.0	32.3
CT-Black gram-Barley	-	-	-	-	-	-	-	-	-	-
MT- Green gram-Mustard	33.5	57.2	305.9	14.0	6.68	11.2	34.3	892.0	1904.0	31.9
MT-Black gram-Barley	-	-	-	-	-	-	-	-	-	-
SEm±	0.3	1.2	3.4	0.0	0.06	0.1	0.5	21.0	18.0	0.4
LSD (*P*= 0.05)	NS	NS	NS	0.1	NS	NS	NS	NS	NS	NS
Sub										
Without crop residue	32.5	55.8	292.5	13.1	6.58	10.8	34.4	834.0	1764.0	32.0
With crop residue	33.8	57.8	315.0	15.2	6.71	11.4	34.6	954.0	2033.0	31.9
With *leucaena* residue	32.9	58.8	311.2	14.1	6.63	11.1	34.2	928.0	1943.0	32.3
SEm±	0.6	0.7	3.2	0.2	0.07	0.2	0.5	23.0	33.0	0.4
LSD (*P*= 0.05)	NS	2.3	10.5	0.8	NS	NS	NS	76.0	108.0	NS
Main* x *Sub										
SEm±	0.8	1.0	4.5	0.4	0.09	0.3	0.7	33.0	47.0	0.6
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; MT-Minimum tillage

Table 30: Growth and yield of blackgram as influenced by conservation agriculture practices under bael+teak based agroforestry system

Treatment	Plant population (m^{-2})	Plant height (cm)	Dry matter accumu-lation at harvest (g m^{-2})	No. of pods $plant^{-1}$	Pod length (cm)	No. of grains pod^{-1}	1000-grain weight	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Main										
CT-Green gram-Mustard	-	-	-	-	-	-	-	-	-	-
CT-Blackgram-Barley	32.9	36.9	247.0	14.4	3.51	5.55	33.3	659.0	1455.0	31.2
MT- Greengram-Mustard	-	-	-	-	-	-	-	-	-	-
MT-Blackgram-Barley	33.6	34.7	246.0	14.1	3.39	5.44	33.2	653.0	1446.0	31.1
SEm±	0.5	0.5	1.0	0.1	0.06	0.06	0.3	7.0	10.0	0.2
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub										
Without crop residue	33.2	34.5	242.0	13.9	3.30	5.34	32.7	638.0	1419.0	31.0
With crop residue	33.8	37.0	252.0	14.8	3.60	5.61	33.7	681.0	1478.0	31.6
With *leucaena* residue	32.7	35.9	246.0	14.1	3.45	5.53	33.4	649.0	1453.0	30.9
SEm±	0.5	0.7	2.0	0.2	0.05	0.04	0.4	8.0	13.0	0.3
LSD (*P*= 0.05)	NS	NS	6.0	0.5	0.18	0.14	NS	25.0	42.0	NS
Main* x *Sub										
SEm±	0.7	1.0	3.0	0.2	0.08	0.06	0.5	11.0	18.0	0.4
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; MT-Minimum tillage


Field preparation


Laser levling and pit digging

Planting of saplings and teak based AF system

ICAR Net Work- NICRA Project

Assessment of Carbon Sequestration Potential of Agroforestry Systems

(S K Dhyani, Ram Newaj, Rajendra Prasad, A K Handa, Badre Alam, Ajit, R H Rizvi & S B Chavan)

Mapping of agroforestry area through GIS and Remote Sensing

Three districts each in Madhya Pradesh (Guna, Panna & Hoshangabad) and Rajasthan (Bikaner, Dausa & Pali) were surveyed during 2014 and data on existing agroforestry systems was collected through GPS and tree growth data was also recorded. GPS data collected during field survey is used for remote sensing analysis with respect land uses and land covers.

Agro-climatic region-wise estimated area under agroforestry

During 2014, districts have been selected from three agro-climatic regions *viz*. Lower Gangetic plains, Middle Gangetic plains and Central Plateau & Hill region. Twenty per cent of total districts from each region were 14, 61 and 60 out of which 3, 12 and 12 districts representing that region were selected. Land use and land cover analysis of the selected districts using RS2/ LISS-3 data has been done and agroforestry area was estimated.

Area under agroforestry in the selected districts in these agro-climatic zones was estimated to be 99631 ha (6.99%), 188257.24 ha (5.15%) and 196128.68 ha (2.98%), respectively (Table 31). This was extrapolated for whole agro-climatic region and area under agroforestry in Lower Gangetic plains, Middle Gangetic plains and Central Plateau & Hill region come out to be 0.47, 0.85 and 1.13 M ha, respectively. Land use and land cover analysis of the selected districts in these agro-climatic regions is depicted in Fig. 22, 23 and 24.

Table 31: Estimates of area under agroforestry in different agro-climatic regions of India

ACZ No.	Agro-climatic region	No. of districts (selected)	Geographical area of selected districts (ha)	AF area in selected districts (ha)
3	Lower Gangetic plains	14 (3)	1424203.70	99631.00 (6.99%)
4	Middle Gangetic Plains	61 (12)	3652055.50	188257.24 (5.15%)
8	Central Plateau & Hill region	60 (12)	6739823.69	196128.68 (2.98%)

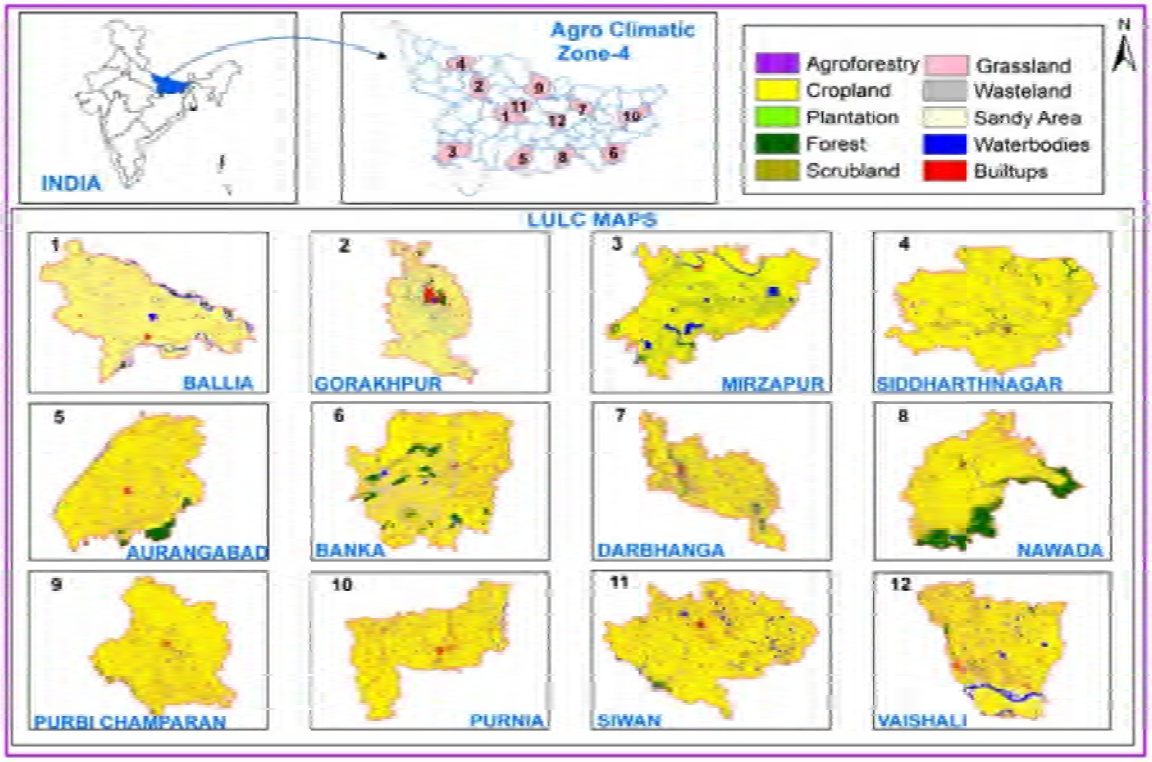


Fig. 22: Land uses and land covers in selected districts of agro-climatic region 3

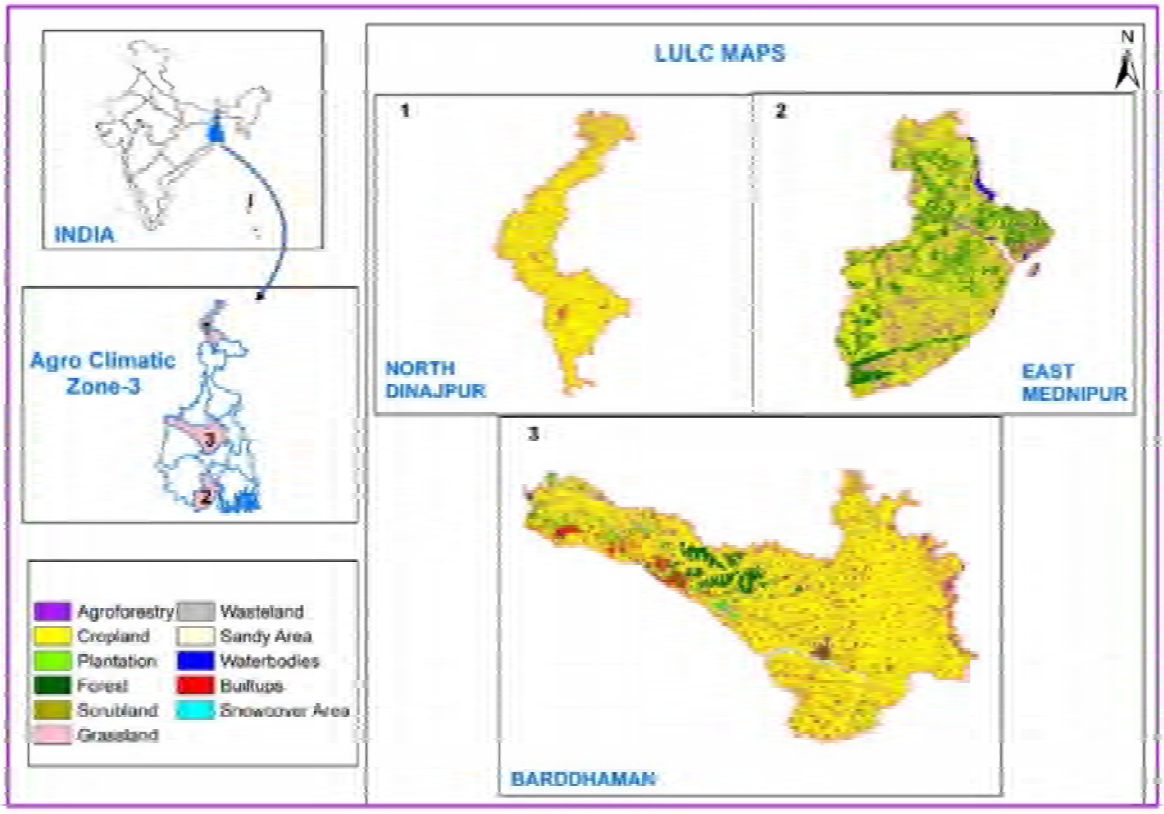


Fig. 23: Land uses and land covers in selected districts of agro-climatic region 4

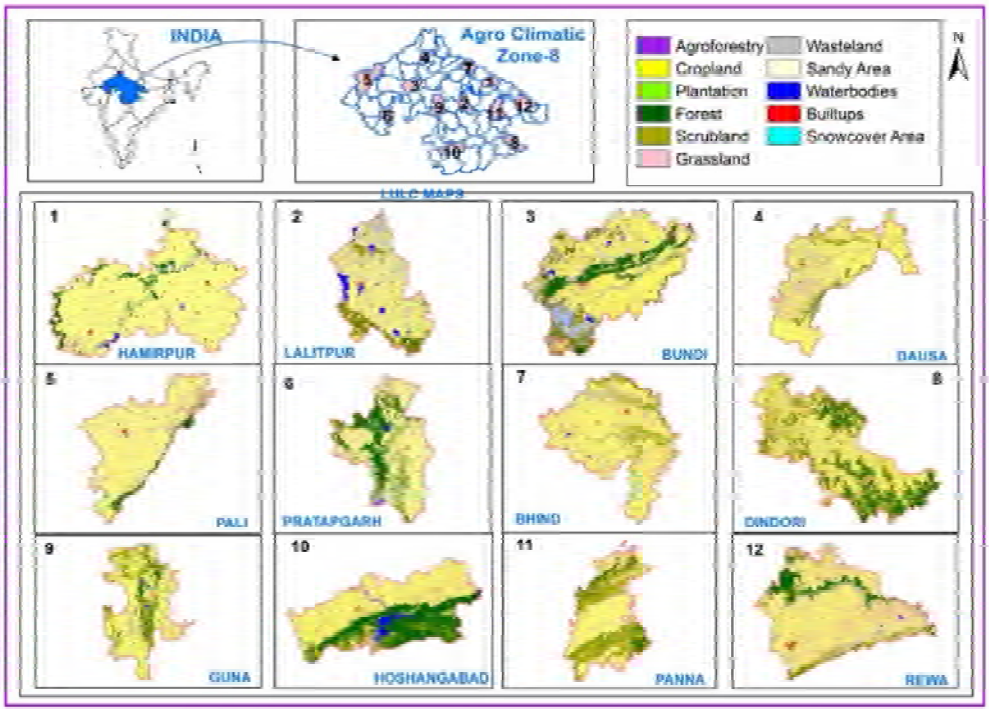


Fig. 24: Land uses and land covers in selected districts of agro-climatic region 8

1. Assessment of SOC pool in soils under different states

During the 2014, three districts each from Rajasthan (Dausa, Bikaner and Pali) and Madhya Pradesh (Guna, Hosangabad and Panna) were surveyed for information on existing agroforestry systems and collecting soil samples to assess soil organic carbon stock. In each selected district two or three blocks and in each block at least two villages were surveyed and soil samples collected from both land uses *viz.* agroforestry and pure agriculture. As for as possible, soil samples were collected up to depth of 90cm soil profile. District wise data on soil organic carbon (SOC) has been compiled and presented.

Exiting SOC pool in soils of Rajasthan

The data on SOC content (%) and bulk density of Rajasthan have been presented in Table 32. In general, maximum SOC content was found in 0-30 cm soil layer which declined in lower layers with increase in depth. In both agroforestry and agriculture land use systems, soil from Pali district had maximum SOC stock (Mg ha^{-1}) while Bikaner the minimum (Table 33). In general, more SOC stock was found in soil profile of agroforestry fields (0-90cm) than soil profile of agriculture fields (0-30cm).

Table 32: SOC content (%) and bulk density of soils of Rajasthan

Land use	District	SOC (%) at different soil depths (cm)			Bulk Density (g cm^{-3}) of different soil depths		
		0-30	30-60	60-90	0-30	30-60	60-90
Existing agroforestry	Dausa	0.41	0.23	0.22	1.54	1.55	1.56
	Bikaner	0.23	0.21	0.24	1.58	1.56	1.59
	Pali	0.47	0.33	0.29	1.53	1.47	1.47
Pure agriculture		**0-15**	**15-30**	**0.00**	**0-15**	**15-30**	**0.00**
	Dausa	0.44	0.28	0.00	1.55	1.57	0.00
	Bikaner	0.26	0.19	0.00	1.55	1.57	0.00
	Pali	0.40	0.36	0.00	1.51	1.52	0.00

Table 33: Soil carbon stock (Mg ha^{-1}) in soils of Rajasthan

Land use	District	Soil Carbon Stock (Mg ha^{-1}) at different soil depths (cm)		
		0-30	30-60	60-90
Existing agroforestry	Dausa	25.44	14.27	13.52
	Bikaner	14.20	12.68	14.95
	Pali	28.95	19.54	16.93
Pure agriculture		**0-15**	**15-30**	**0.00**
	Dausa	13.55	8.63	0.00
	Bikaner	8.12	5.87	0.00
	Pali	12.03	10.70	0.00

Exiting SOC pool in soils of Madhya Pradesh

The data on SOC content (%) and bulk density in different soil layers of soil profile was collected from Madhya Pradesh and presented in Table 34 and Table 35. In selected district of Madhya Pradesh, maximum SOC content was found in upper layer (0-15cm) and declined in lower layers in both the land use systems of agroforestry and pure agriculture. However, on an average, bulk density increased with depth of soil layers. Similar to SOC content, maximum SOC stock (Mg ha^{-1}) was found in upper layers of soil which decreased with increase in depth (Table 36). On an average, total SOC stock in soil profile of 0-90 cm in both the land use systems of agroforestry and pure agriculture was maximum in Guna and minimum in Panna district. In general, soil profile of agroforestry land use had shown more SOC stock than the soil profile of pure agriculture (Fig. 25).

Table 34: Soil organic carbon (%) content in soils of Madhya Pradesh

Land use	District	SOC (%) at different soil depths (cm)					
		0-15	15-30	30-45	45-60	60-75	75-90
Existing agroforestry	Guna	0.83	0.58	0.53	0.32	0.24	0.13
	Hoshangabad	0.62	0.36	0.30	0.23	0.16	0.11
	Panna	0.62	0.33	0.26	0.24	0.18	0.09
Pure agriculture	Guna	0.74	0.50	0.36	0.24	0.13	0.07
	Hoshangabad	0.48	0.39	0.33	0.25	0.16	0.12
	Panna	0.38	0.25	0.24	0.22	0.19	0.10

Table 35: Bulk density (g cm^{-3}) of soils of Madhya Pradesh

Land use	District	Bulk Density (g cm^{-3}) of different soil depths (cm)					
		0-15	15-30	30-45	45-60	60-75	75-90
Existing agroforestry	Guna	1.42	1.48	1.46	1.50	1.51	1.53
	Hoshangabad	1.44	1.48	1.51	1.53	1.54	1.54
	Panna	1.42	1.46	1.48	1.52	1.54	1.55
Pure agriculture	Guna	1.43	1.48	1.48	1.52	1.53	1.53
	Hoshangabad	1.47	1.45	1.49	1.50	1.52	1.53
	Panna	1.42	1.45	1.45	1.46	1.50	1.52

Table 36: Soil carbon stock (Mg ha^{-1}) in soils of Madhya Pradesh

Land use	District	Soil Organic carbon (Mg ha^{-1})					
		0-15 m	15-30cm	30-45 cm	45-60cm	60-75cm	75-90cm
Existing agroforestry	Guna	23.72	17.02	15.37	9.59	7.17	3.84
	Hoshangabad	17.76	11.29	9.67	7.49	4.98	3.69
	Panna	17.62	9.50	7.61	7.40	5.53	2.79
Pure agriculture	Guna	21.13	14.99	10.78	7.41	4.08	2.26
	Hoshangabad	14.14	10.56	9.11	7.05	4.80	3.31
	Panna	10.84	7.19	6.94	6.27	5.84	2.92

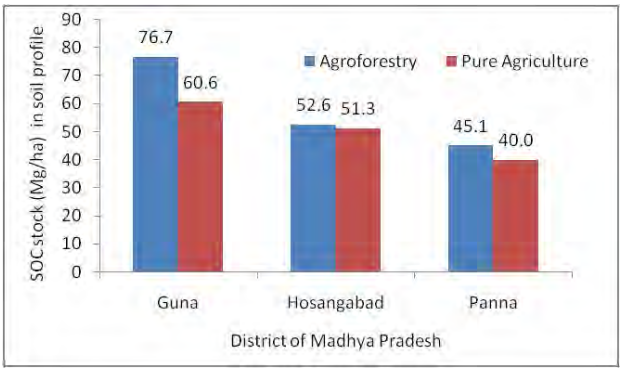


Fig. 25: SOC stock (Mg ha^{-1}) in soil profile (0-90cm) of Madhya Pradesh

2. Assessment of carbon sequestration potential of agroforestry system existing on farmer's field

The carbon sequestration potential of agroforestry system existing on farmer's field was studied in different districts of Rajasthan, Madhaya Pradesh and Karnataka using CO_2 FIX model, for which a field survey was conducted through transect walk in the districts. A sample of 20% villages per block and 20% blocks per districts was selected for the survey. The village head/local farmers/village youth were associated for field survey to have a clear picture of the village. The number and length of transect was decided according to area of a particular village. Generally 1000 m transect line with 10m × 10 m quadrate at every 100 m was set out to record tree species, number of trees per unit area (tree density), dbh, soil type, crops etc. Thus, the data was generated on number of tree species, tree density and dbh of tree of a particular village. The data was compiled at block and district level.

The major crops grown in Bikaner, Dausa and Pali district of Rajasthan are wheat, bajra, mustard, groundnut, barley and chickpea. The trees normally occur either on field bund or scattered in agriculture field. There was no systematic symmetry of trees in agriculture field but farmers are purposefully retaining trees for fuelwood, fodder and benefits to agricultural crop. In surveyed districts (Guna, Hoshangabad, Panna and Jabalpur) of Madhya Pradesh, the major crops are rice, wheat, chickpea, mustard, blackgram and greengram. In Hoshangabad, *Tectona grandis* was planted in systematic manner as a commercial plantation but other tree species normally occurs on field bunds. In Dharwad district of Karnataka, the major crops are rice, maize, sorghum, groundnut and blackgram. In this districts some tree like moringa, tamrind, sapota are grown by the farmers as commercial cultivation.

The major tree species existing on farmer's field in three districts of Rajasthan (Bikaner, Dausa and Pali) are *Prosopis cineraria, Acacia tortlis, Prosopis juliflora, Azadirachta indica, Dalbergia sissoo* and *Ziziphus mauritiana*. The contribution of *Prosopis cineraria* in Bikaner and Pali districts ranged from 45 to 59% in total tree species but contribution of *Azadirachta indica* is 31% in Dausa district (Table 37). It clearly indicates that tree species varied from one district to other district. Tree density also varied from 1.4 to 14.9 trees ha^{-1} in these districts. The Bikaner district was having 1.40 trees ha^{-1} on farmer's field but in Pali district, it was 14.9 trees ha^{-1} (Table 38). Similarly in four districts (Guna, Panna, Hoshangabad and Jabalpur) of Madhya Pradesh, the major trees existing on farmer's field are *Eucalyptus tereticornis, Acacia nilotica, Leucaena leucocephala, Azadirachta indica* and *Tectona grandis* (Table 37). The tree density in these districts also varied 4.37 to 29.49 trees ha^{-1}. In Dharwad districts of Karnataka, the dominant tree species existing on farmer's field are *Glyricidia sepium, Tectona grandis, Achrus sapota, Mangifera indica, Moringa oleifera, Tamairindus indica* and *Leucaena leucocephala* and their density is 5.83 trees ha^{-1}.

The biomass, biomass carbon, total carbon and net carbon sequestered in existing agroforestry system at district level in Karnataka, Rajasthan, and Madhaya Pradesh was estimated by using CO_2FIX model and extrapolated for next 30-years. The tree biomass, soil carbon and total carbon in baseline was 1.85 t DM ha^{-1}, 9.89 t C ha^{-1} and 14.97 t C ha^{-1}, respectively in Dharwad district of Karnataka (Table 39). It is expected that corresponding value of these parameters would increase up to 4.95 t DM ha^{-1}, 10.88 t C ha^{-1} and 17.64 t C ha^{-1}, respectively over the simulated period of 30-years. Net carbon sequestered in agroforestry systems over the simulated period of 30- years would be 2.67 t C ha^{-1} in the Dharwad

Table 37: Dominant trees species existing on farmer's field and their contribution in total tree population

State	District	Dominant tree species and their contribution (%)
Rajasthan	Bikaner	*Prosopis cineraria (45.17), Acacia tortlis (28.65), Ziziphus mauritiana (4.57),Prosopis juliflora (15.93), Dalbergia sissoo (2.95), Azadirachta indica (1.40)*
	Dausa	*Azadirachta indica (30.9), Acacia tortlis (19.44), Prosopis cineraria (8.05), Dalbergia sissoo (6.51), Prosopis juliflora (2.5)*
	Pali	*Prosopis cineraria (59.52), Prosopis juliflora (16.31), Ziziphus mauritiana (8.55), Azadirachta indica (7.84), Dalbergia sissoo 3.92), Acacia tortlis (2.96)*
Madhya Pradesh	Guna	*Acacia nilotica (21.16), Azadirachta indica (12.65), Leucaena leucocephala (9.57), Madhuca latifolia (8.12), Simaruba glauca (8.11)*
	Hoshangabad	*Leucaena leucocephala (17.3), Acacia nilotica (15.27), Tectona grandis(14.84), Mangifera indica (9.79), Eucalyptus tereticornis (7.08), Ziziphus mauritiana (4.58)*
	Panna	*Leucaena leucocephala (20), Acacia nilotica (12.2),Mangifera indica (7.75), Azadirachta indica (7.15), Ziziphus mauritiana (4.52)*
	Jabalpur	*Eucalyptus tereticornis(88.43), Leucaena leucocephala(4.61),Butea monosperma(1.78), Acacia nilotica(1.66)*
Karnataka	Dharwad	*Glyricidia sepium (31.40), Tectona grandis (16.57), Achrus sapota(9.35), Mangifera indica (7.86), Moringa oleifera (5.20),Leucaena leucocephala (4.14)*

Table 38: Tree density in agroforestry system existing on farmer's field under different districts

State	District	Tree density (trees ha^{-1})			
		Slow	Medium	Fast	Total
Rajasthan	Bikaner	0.09	1.26	0.04	1.40
	Dausa	0.08	12.52	0.26	12.87
	Pali	0.75	14.0	0.14	14.90
Madhya Pradesh	Guna	1.39	3.80	1.20	6.40
	Hoshangabad	0.73	4.04	2.00	6.78
	Panna	0.34	2.89	1.13	4.37
	Jabalpur	3.69	3.81	21.98	29.49
Karnataka	Dharwad	1.67	2.93	1.21	5.83

district. In case of Pali, Dausa and Bikaner districts of Rajasthan, total carbon stock available in baseline varied from 9.0 to 24.45 t C ha^{-1} and it is expected that over 30-years period the total carbon stock in agroforestry in these districts would be 13.32 to 35.39 t C ha^{-1}. Net carbon sequestered over the simulated period of 30-years would be 4.32 to 10.94 t C ha^{-1} (Table 39). The tree biomass, soil carbon and total carbon available in existing agroforestry system in different districts of Madhya Pradesh (Guna, Hoshangabad, Panna and Jabalpur) is 3.57 to 7.39 t DM ha^{-1}, 12.04 to 23.38 t C ha^{-1} and 16.10 to 27.61 t C ha^{-1}, respectively and its corresponding values over the simulated period of 30-years would be 7.75 to 11.99 t DM ha^{-1}, 12.74 to 24.80 t C ha^{-1} and 20.83 to 32.39 t C ha^{-1}, respectively (Table 40).

Table 39: Biomass accumulated and carbon sequestered under existing agroforestry system in different districts

Parameters			Observed number of existing (trees ha^{-1}) in the agroforestry at district level			
			Dharwad (5.83)	Pali (14.90)	Dausa (12.87)	Bikaner (1.40)
Tree Biomass (above and below around) Mg DM ha^{-1}	Baseline	Biomass	1.85	11.25	11.01	0.86
	Simulated		4.95	33.00	28.59	2.87
Total Biomass (tree+ crop) Mg DM ha^{-1}	Baseline		11.75	17.19	12.88	2.22
	Simulated		15.13	39.11	30.51	4.27
Soil carbon (Mg C ha^{-1})	Baseline	Carbon	9.89	16.5	16.49	8.00
	Simulated		10.88	16.92	17.01	11.34
Biomass carbon (Mg C ha^{-1})	Baseline		5.08	7.95	6.09	1.0
	Simulated		6.76	18.47	14.55	1.98
Total carbon (biomass + soil) (Mg C ha^{-1})	Baseline		14.97	24.45	22.58	9.0
	Simulated		17.64	35.39	31.56	13.32
Net carbon sequestered in agroforestry systems over the simulated period of thirty years (Mg C ha^{-1})		Carbon sequestered	2.67	10.94	8.98	4.32
Estimated annual carbon sequestration potential of agro-forestry system in different districts of India (Mg C ha^{-1} yr^{-1})			0.10	0.36	0.29	0.14

Table 40: Biomass accumulated and carbon sequestered under existing agroforestry system in different districts of Madhya Pradesh

Parameters			Observed number of existing (trees ha^{-1}) in the agroforestry at district level			
			Guna (6.40)	Hoshangabad (6.78)	Panna (4.37)	Jabalpur (29.49)
Tree Biomass (above and below ground) Mg DM ha^{-1}	Baseline	Biomass	3.99	5.37	3.57	7.39
	Simulated		10.67	10.93	7.75	11.99
Total Biomass (tree+ crop) Mg DM ha^{-1}	Baseline		9.55	11.16	7.83	12.66
	Simulated		16.45	16.88	12.13	17.41
Soil carbon (Mg C ha^{-1})	Baseline	Carbon	23.38	17.75	17.95	12.04
	Simulated		24.80	19.42	19.12	12.74
Biomass carbon (Mg C ha^{-1})	Baseline		4.31	5.06	3.54	5.56
	Simulated		7.59	7.80	5.61	8.09
Total carbon (biomass + soil) (Mg C ha^{-1})	Baseline		27.61	22.81	21.49	16.10
	Simulated		32.39	27.22	24.73	20.83
Net carbon sequestered in agroforestry systems over the simulated period of thirty years (Mg C ha^{-1})		Carbon sequestered	4.78	4.41	3.33	4.73
Estimated annual carbon sequestration potential of agroforestry system (Mg C ha^{-1}yr^{-1})			0.159	0.147	0.111	0.15

3. Studies on thermotolerance under TGT

Various physio-biochemical experiments related to growth, carbon assimilation and thermo tolerance were conducted with selected multipurpose tree species (MPTs) namely *Pongamia pinnata*, *Dalbergia sissoo*, *Albizia procera* and *Butea monosperma*. The experiments with *Albizia procera* and *Butea monosperma* were conducted during 2014. Physio-biochemical indices as emerged from the ongoing experiments were utilized to assess the growth, carbon assimilation and its association with thermos tolerance with respect to temporal variation in the grown tree seedlings in ambient conditions. TGT, the experiments on carbon assimilation and thermotolerance were conducted for evaluating the physiological and associated indices with respect to the temporal variation in the seedlings grown in polythene bags under ambient conditions using the referred techniques.

Under prevailing ambient climate, there is clear temporal variation with respect to seasonal changes. There are two extremes namely winter for low temperature and summer with extremely high atmospheric temperature. These provided a basis for analyzing the physiological responses at temporal scale *viz*. pre-winter, winter and post-winter seasons for determining growth, carbon assimilation and thermotolerance. Differential trend in leaf temperature (LT) with respect to ambient air temperature (AT) were noted through infrared thermometer in the MPTs (Fig. 26) and canopy temperature depression (CTD) were estimated (Fig. 27). From the primary experiments, higher CTD of *A. procera* indicated its relatively better thermotolerance capacity than *B. monosperma* under ambient conditions. Growth trait in *A. procera* and *B. monosperma* was also shown through its height increment (Fig. 28).

Phenomenon of lipid peroxidation is related to thermal effect. Malondialdehyde (MDA) concentration is an indicator of lipid peroxidation in cell. This has been noted in our experiments that with increase in atmospheric temperature there was an increasing trend in MDA content in leaves of the MPTs as shown in pre-winter and post-winter time period (Fig. 29). Trend in MDA concentration at temporal scale suggested that lipid peroxidation is interconnected with temperature variation and may be used as an index of thermo tolerance.

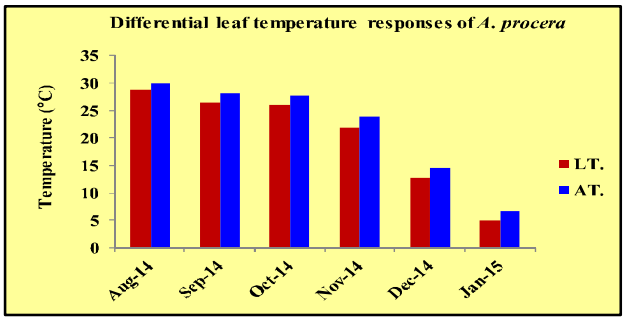


Fig.26: Differential leaf temperature responses with temporal variation in *A. procera* under ambient conditions

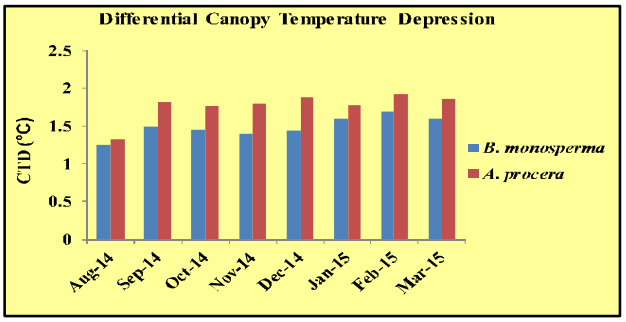


Fig. 27: Temporal variation in canopy temperature depression (CTD) of *B. monosperma* and *A. procera* under ambient condition

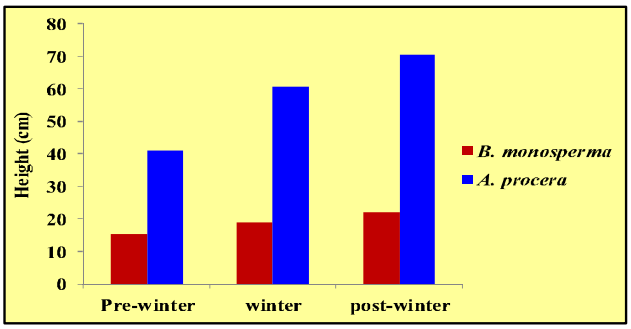


Fig. 28: Height increment of *B. monosperma* and *A. procera* in pre winter, winter and post winter seasons under ambient conditions

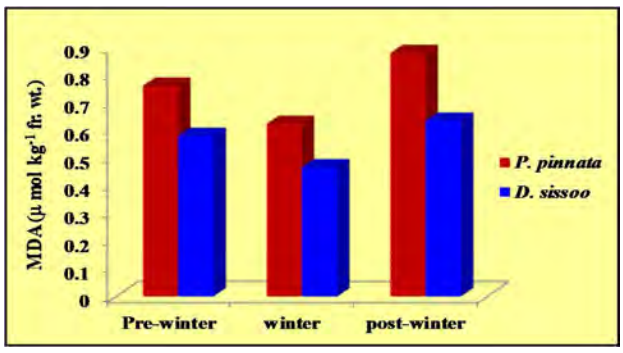


Fig. 29: Malondialdehyde concentration in leaves of *Pongamia pinnata* and *Dalbergia sissoo*

Rates of CO_2 assimilation or carbon gain by the MPTs in temporal scale are recorded as reference data for comparison with temporal scale from pre-winter to summer through post-winter time (Fig. 30). Similar trends were observed in thylakoid electron transport rate of both the MPTs (Fig. 31). Growth parameters, CCM index and antioxidant component like anthocyanin were also analysed in temporal scale in the MPTs and illustrated in Fig. 32, 33 and 34. Analysis of some important spectral indices such as Normalized Difference Vegetation Index (NDVI) of *P. pinnata* and *D. sissoo* at temporal scale were also evaluated for their use as relevant indices (Fig. 35).

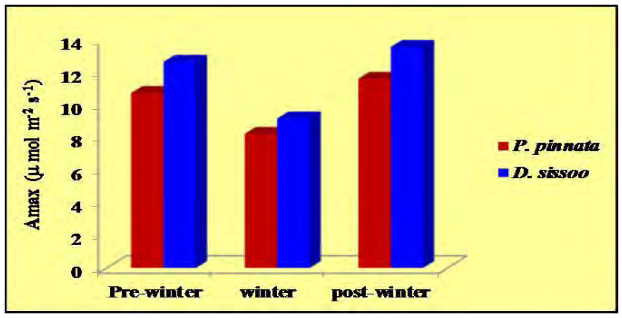


Fig. 30: Maximum rate of CO_2 assimilation of *Pongamia pinnata* and *Dalbergia sissoo*

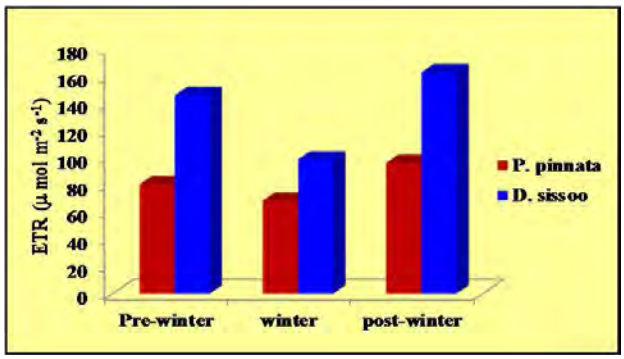


Fig. 31: Thylakoid electron transport rate (ETR) of *Pongamia pinnata* and *Dalbergia sissoo*

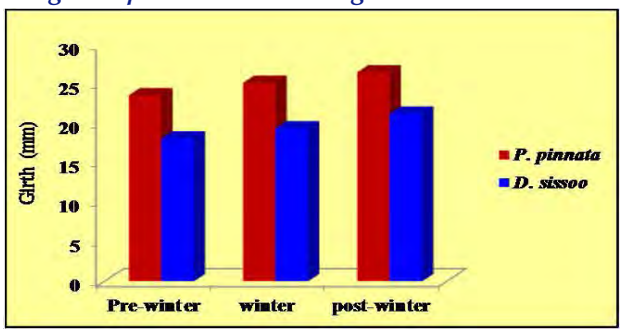


Fig. 32: Growth response of *Pongamia pinnata* and *Dalbergia sissoo* in temporal scale

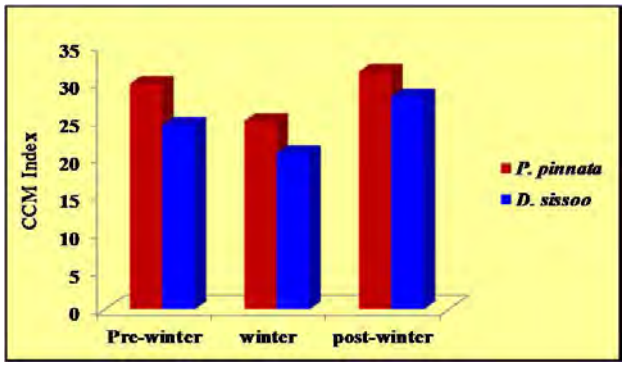


Fig. 33: Chlorophyll content meter index of *Pongamia pinnata* and *Dalbergia sissoo*

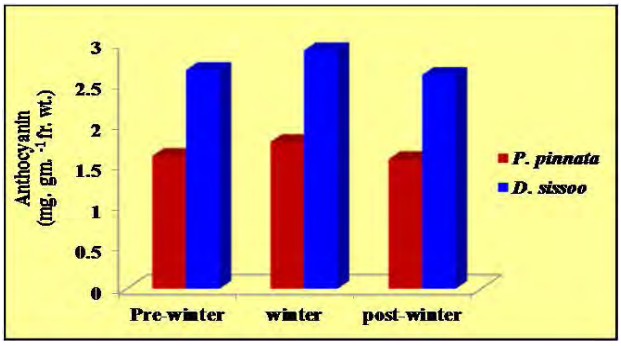


Fig. 34: Anthocyanin of *Pongamia pinnata* and *Dalbergia sissoo*

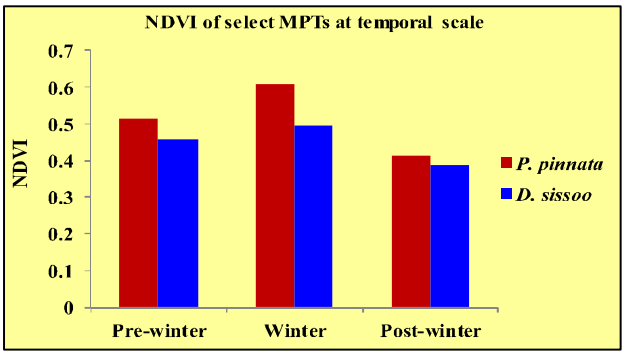


Fig. 35: Normalized Difference Vegetation Index (NDVI) of *P. pinnata* and *D. sissoo* at temporal scale

MoRD, New Delhi

(a) Model Watershed for Sustaining Agricultural Productivity and Improved Livelihoods- Domagor Pahuj Watershed

(S K Dhyani, Ramesh Singh, R K Tewari & R H Rizvi)

On the basis of criteria mentioned in Common Guidelines for Watershed Development Projects, GOI, 2008, Domagor-Pahuj watershed was selected to improve rural livelihood through watershed interventions and act as a site for learning. The details of its background and basic information were indicated in previous reports. During the period under report, works on the aspects of Strengthening of livelihood through Women Self Help Groups (WSHGs), water resource development, Productivity enhancement, exposure visit and convergence was taken up. The brief report under different heads is as follows:

Strengthening of livelihood through Women Self Help Groups (WSHGs)

Total 26 WSHGs have been formed in three villages of model watershed area comprising 269 members. All WSHGs are linked with bank. Total saving of WSHGs is about ₹ 6.00 lakh. They are mainly involved in goat rearing and vegetable cultivation. These WSHGs are linked with Federation of SHGs for better livelihood options. Out of 26 SHGs, 20 SHGs were helped through revolving fund to start their activities. On an average each member of 10 SHGs involved in goatary is earning more than ₹ 8000.00 annum^{-1}. Village wise no. of WSHGs and their activities are given in Table 41.

Table 41: Village-wise WSHGs and their activities

S.N.	Village	Total Group	Utilization of revolving fund through SHGs for creating enterprise			
			Goa-tary	Vege-table	Stiching	Vege-table trolley
1	Nayakheda	4	2	2		
2	Dhikoli	11	6	6	1 member	1 member
3	Domagor	11	2	2		
	Total	**26**	**10**	**10**	**1**	**1**

Water resource development

Open shallow dug wells are the only means of irrigation to the crops in watershed. These wells are situated in weathered zone (unconfined aquifer) above granite rock and have slow rate of recharge due to low water column. To augment the ground water recharge, total 12 rainwater harvesting structures (09 in 2010-11, 02 in 2011-12 and 01 in 2013-14) were constructed mainly on first and second order drains. To see the impact of rainwater harvesting (RWH), all the open

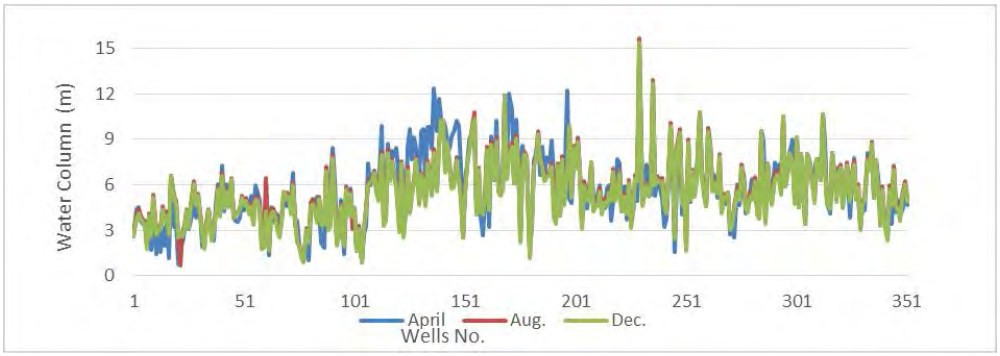


Fig. 36: Water column during different months in watershed

shallow dug wells (351 nos.) are being monitored for water table on monthly basis. The average water column during April, August and December were 5.72, 5.60 and 5.42 m, respectively (Fig. 36). It was observed that about 147 % higher water column was recorded in open wells during the month of December for post-interventions scenario as compared to pre-interventions. Water column buildup improves the water yield of the open wells.

Productivity enhancement and agroforestry

To improve the productivity, 105 trials on different crops were conducted during 2014-15 (Table 42). Due to delayed monsoon, groundnut was sown in limited area and its productivity was 236 kg ha^{-1}. To assess the general productivity of different crops during *rabi*, 2013-14, 72, 24, 24, 24 samples of wheat, chickpea, lentil and pea, respectively were taken and processed. Productivity of wheat, chickpea, lentil and pea was 2125, 536, 60 and 958 kg ha^{-1}, respectively. Productivity of wheat was lower than previous years due to lodging of crop. High rainfall during winter affected crops like chickpea and lentil and production was hampered.

For better climate resilience, 10 agri-horticulture, each in one acre, system was developed in 10 acre of land in Dhikauli and Domagor village.

Animal health camp

An animal health camp is organized in model watershed at Domagior village. Lecture was also delivered by veterinary doctors on improved livestock practices with special emphasis on goat farming and related issues. Animal husbandry has been identified as a major livelihood generating activity other than agriculture and goats contribute greatly in the agrarian economy particularly in semi-arid areas like Bundelkhand. Therefore, this sector needs to have special attention and care. Two hundred goats were vaccinated during the camp.

Exposure Visit

To improve the skills of stakeholder's different trainings and exposure visit were organized during 2014. Details are given in Table 43.

Table 42: Details of crop trials and productivity during 2014-15

S.N.	Demonstration	No. of demo	Season	Convergence from	Area in Acre	Var.	Productivity (kg ha^{-1})
1	Maize (Fodder)	20	Summer	IGFRI, Jhansi	20	MP Chari	75000.0
2	Sesame	4	*Kharif*	KVK Jhansi	4	Sekhar	95.0
3	Greengram	6	*Kharif*	KVK Jhansi	6	PDM-39	41.0
4	Maize	10	*Kharif*	KVK Jhansi	10	Hybrid	1221.0
5	Wheat	50	*Rabi*-2014-15	-	50	Lok-1, Swarna, HI-1479	-
6	Chickpea	15	*Rabi*-2014-15	Dept. of Agriculture, Jhansi	15	RSG-888	-

Table 43: Details of training and exposure visits organized during 2014

Particulars	No.	No. of Beneficiaries	Funding agency
Training on Vegetable cultivation	03	200	DA, Pahuj, Jhansi
Exposer visit to Village Mohangarh, Shivpuri (well known for vegetable cultivation)-12 km from Shivpuri district headquarter	01	30	Watershed Committee
-do-	01	30	Dept. of Horticulture, Jhansi
Training on Vermicomposting at Ganeshgarh, Jhansi	01	30	DA, Pahuj, Jhansi
Exposer visit to CIRG, Maqdoom, Mathura	01	20	Watershed Committee
Training on Capacity & Leadership Development at Taragram Orchha and Pahuj	22	300	DA, Pahuj, Jhansi
Krishak Gosthi	10	500	Kribhaco, KVK, Jhansi, Dept. of Ag., Dept. of Horticulture, IGFRI, Jhansi
Workshop on Environment & Cleanliness	03	200	DST
Exposure visit to ICRISAT, Hyderabad	01	05 (Women)	ICRISAT, Hyderabad

Cost-effective rainwater harvesting in watershed

Fodder demonstrations in watershed

Demonstration of sprinkler irrigation in wheat

Irrigation through solar pump

Fruiting in desi budded ber in watershed

Visit to ICRISAT, Hyderabad

B. Enhancing Groundwater Recharge and Water Use Efficiency in SAT Region through Watershed Interventions-Parasai-Sindh Watershed, Jhansi

(S K Dhyani, Ramesh Singh, R K Tewari, Inder Dev, R H Rizvi, K B Sridhar & R P Dwivedi)

Parasai-Sindh watershed is being developed in consortia mode with ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi and International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad since 2011. The watershed comprises three villages namely Parasai, Chhatpur and Bachhauni and located between 25^0 23′ 56" to 25^0 27′ 9.34" N and 78^0 19′ 45.71" to 78^0 22′ 42.57′′ E in Babina block of Jhansi district. The overall objectives and other details were presented in previous annual reports. Water resources development, agroforestry interventions, productivity enhancement and Self Help Groups and capacity building are discussed in subsequent section.

Water Resources Development

Construction of rainwater harvesting structures

To augment groundwater recharge, one community pond and one farm pond with 10,000 and 600 m^3 capacity, respectively were constructed during 2014. Till now, about 1-10 lakh m^3 surface water storage has been created in the watershed through 12 rainwater harvesting structures.

Monitoring runoff and water table

To measure runoff, divers were installed at six locations of different land use and catchment size. To analyze the impact of watershed interventions in Parasai-Sindh watershed, one control watershed near village Hatlab in MP was also selected and gauged for runoff at its outlet.

All the open shallow dug wells (388 Nos.), which are only means of irrigation in the watershed were monitored for water table on monthly interval. The monthly rainfall and average water column during 2014 was depicted in Fig. 37. The average water column during post monsoon (October) in 2014 was 6.26 m and this is 36.19% higher than the water column (4.63 m)

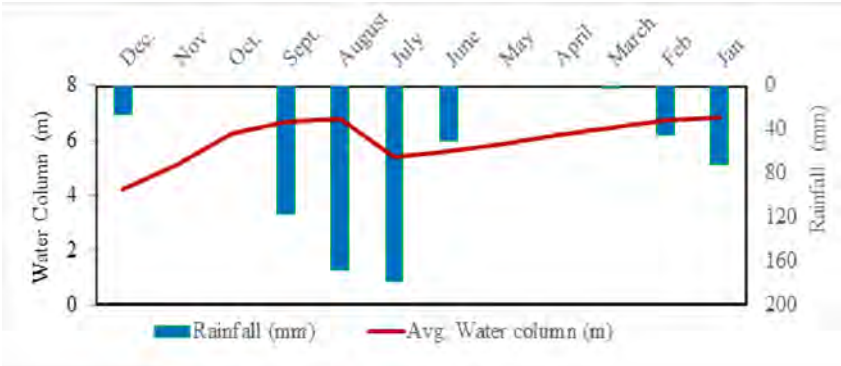


Fig. 37: Rainfall vs water column in open wells in Parasai-Sindh watershed, Jhansi

during pre-interventions phase (October-2011) in spite of about 49% less rainfall in 2014 (659.5 mm) as compared to 2011 (1289.2 mm). The average water column during the year varied in the range of 4.19 to 6.85 m with average value of 6.0 m. These water columns are indeed sufficient to cater needs of drinking and irrigation.

Development of Agroforestry Interventions

To develop agroforestry interventions in the watershed, 2928 saplings of different species were planted on 92 farmers' fields during 2013-14. Brief account of seedling of different species planted in watershed is given in Table 44.

Table 44: Details of seedlings planted in watershed during 2014

	Village			Total
	Parasai	Chattpur	Bachouni	
No. of Beneficiaries	29	55	8	92
Lemon	90	475	18	583
Jack-Fruit	6	21	4	31
Bamboo	37	27	16	80
Aonla	89	100	6	195
Karonda	24	63	7	94
Jamun	19	11	0	30
Mango	30	14	8	52
Shisham	9	8	4	21
Guava (grafted)	160	477	21	658
Anar	45	43	6	94
Teak	20	1070	0	1090
			Grand Total	**3020**

Survival of different species varied from 66 to 95 % by the end of November 2014. Apart from this, total 45 deshi ber were budded with improved varieties and survival was about 39 per cent by November, 2014.

Productivity Enhancement

Crop productivity assessment of Parasai Sindh Watershed

Most of the watershed area was covered by groundnut and wheat during *kharif* and *rabi* season. Due to deficit in rainfall (24.8%) during 2014, it was observed that there was about 30 and 32% decrease in seed yield in blackgram and greengram, however the groundnut was severely affected, and losses were recorded to the tune of about 75%. The crop losses were attributed to low rainfall. During *rabi* season (2013-14) an increase in wheat yield to the tune of 24.76% was observed as compared to pre-watershed intervention (Fig. 38).

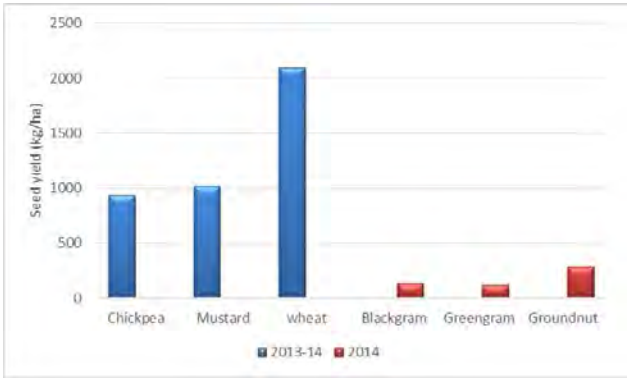


Fig. 38: Crop productivity of Parasai Sindh Watershed during 2013-14 (*rabi*) and 2014 (*kharif*)

Participatory crop demonstrations

A total number of 55 participatory demonstrations (13-Parasai; 32-Chhatpur; 10-Bachhauni) during 2013-14 (*rabi* season) were laidout at farmers' fields with improved varieties. About 28% increase was observed in barley (RD-2552), 17% increase in mustard (Maya) and 29% increase in chickpea (JG-130) over local varieties. During 2014-15 (*kharif* and *rabi*) a total of 109 participatory demonstrations 33-Parasai; 56-Chhatpur; 20-Bachhauni) were laid out at farmer's fields. About 11% higher yield was observed in case of greengram as compared to local varieties. The detail about the number of demonstrations in each villages and crop varieties is presented in Table 45.

Forage resource enhancement

About 37,000 rooted slips of Napier bajra hybrid, guinea grass and TSH were transplanted on bunds, near checkdams and around ponds during 2014. Due to deficit in rainfall single cut could be obtained from the pasture established areas. On an average biomass yield of (2.87 DMY) t ha^{-1} could be obtained from the mixed pasture.

Table 45: Participatory demonstrations at Parasai-Sindh watershed

Year	Crop	Varieties introduced	Demonstration			Total No. of trials	Av. grain yield (kg ha^{-1})	Increase over local varieties
			Parasai	Chhatpur	Bachhauni			
2013-14	Barley	RD-2552	9	20		29	2395.00	62.59% (1871)
	Chickpea	JG-130	-	4	4	8	1210.00	29.55% (934)
	Mustard	Maya	4	8	6	18	1194.00	17.14% (1019)
Total			**13**	**32**	**10**	**55**		
2014-15	Pigeonpea	ICPL-85063 (Lakshmi), ICPL-88039	3	3	-	6	762.00	21.33% (628)
	Greengram	Samrat	12	9	2	23	146.00	11.45% (131)
	Barley	RD-2552	6	20	-	26		
	Chickpea	JG-130	-	4	4	8		
	Mustard	NRC HB-101, NRC HB-506, NRC DR-02	4	8	6	18		
	Wheat	Lok-1	8	12	8	28		
Total			**33**	**56**	**20**	**109**		
Grand total			46	88	30	164		

Figures in the parenthesis shows the average yield of local varieties with traditional practices

Self Help Groups and Capacity Building

Farmers of the villages Parasai, Chhatpur and Bachhauni were motivated to adopt agroforestry practices at their field. A van mahotsava was organized at Parasai-Sindh watershed on 3rd week of July, 2014. In which farmers were made aware and motivated about the role of agroforestry in the rural livelihood. A one day training on dona (platter) making was organized on 30th August, 2014 at village Bachchauni in Jhansi district in which tribal farmers from village Bachhauni participated. One SHG has been provided with semi-automatic plotter machining machine. The group is earning its livelihood through this interventions. Six Self Help Groups (SHGs) were formed namely Shri Hit Swayam Sahayata Samooh, Parasai, Jai Mata Di Swayam Sahayata Samooh, Bachhauni (Tribal), Jai Pathan Baba Swayam Sahayata Samooh, Bachhauni, Jai khati baba swayam sahayata samooh, Chhatpur, Shri Ganeshay Namah Swayam Sahayata Samooh, Bachhauni (Tribal) and Shri Radhe-Radhe Swayam Sahayata Samooh, Bachhauni.

To strengthen the capacity of women, two days exposure visit of five tribal women to ICRISAT, Hyderabad was organized. They interacted with the SHGs of Kothapalli watershed developed by ICRISAT. They had also visited experimental farm of the institute.

Dugout community pond at the main drain in watershed

Visit of DM, Jhansi and CDO along with officers of line departments for scaling up of the models (9th June, 2014)

Lemon based agroforestry at Parasai

Inauguration of Dona making machine at Bachhauni

Home-stead agroforestry at Chhatpur village

Observational trial

Weed Dynamics Studies in Different Agroforestry Systems

(Inder Dev)

The observational trial to study the weed dynamics in different agroforestry system was initiated during 2012. The observations recorded on weed density and biomass for *rabi*, 2013-14 and *kharif*, 2014 are presented hereunder.

Weed density and biomass during *rabi* season (2013-14)

The observations on weed density and biomass were recorded in different agroforestry systems and under wasteland conditions. *Chenopodium album*, *Anagallis arvensis* among many others were some of the most dominant weeds prevalent in different agroforestry systems including the wasteland conditions.

Weed density and biomass in Bamboo (*D. strictus*) + chickpea agroforestry system

Data presented in the Table 46 reveals that *Chenopodium album* was the most dominant weed with an average density of 12.58 No. m^{-2} followed by *Anagallis arvensis* (9.12 No. m^{-2}) at 60 DAS. Similarly at harvest stage *Chenopodium album* (20.34 No. m^{-2}) was the most dominant weed. Biomass accumulation was maximum in *C. album* at 60 DAS and at harvest stage. Average density of weeds was 26.16 and 24.30 No. m^{-2} at 60 DAS and at harvest stage.

Table 46: Weed density and biomass in Bamboo (*D. stricuts*) + chickpea agroforestry system

Weed species	Av. density (No. m^{-2})		Av. biomass (D.W. g m^{-2})	
	60 DAS	At Harvest	60 DAS	At Harvest
Anagallis arvensis	9.12	1.24	11.15	2.24
Chenopodium album	12.58	20.34	14.28	32.54
Sonchus oleraceous	3.22	1.85	2.58	2.27
Vicia sativa	1.24	0.87	1.85	1.20
Av. density/ biomass	26.16	24.3	29.86	36.01

Weed density and biomass in Ber + lentil based agroforestry system

Data presented in the Table 47 reveals that in ber + lentil agroforestry system *Chenopodium album* was the most dominant weed with an average density of 32.57 and 48.75 No. m^{-2} at 60 DAS and harvest stage, respectively. Similarly maximum biomass accumulation was observed in *C. album*. Average density of weeds was 38.88 and 53.37 No. m^{-2} at 60 DAS and at harvest stage.

Table 47: Weed density and biomass in Ber+ Lentil agroforestry system

Weed species	Av. density (No. m^{-2})		Av. biomass (D.W. g m^{-2})	
	60 DAS	At Harvest	60 DAS	At Harvest
Chenopodium album	32.57	48.75	28.72	70.21
Sonchus oleraceous	2.45	-	2.06	-
Spergula arvensis	3.86	4.62	3.08	3.71
Av. density/ biomass	38.88	53.37	33.86	73.92

Weed density and biomass in Eucalyptus + wheat agroforestry system

Data presented in Table 48 reveals that *C. album* (8.72 No. m^{-2}) and *Fuamria parviflora* (6.14 No. m^{-2}) were the most dominant weed at 60 DAS. Similar trend was observed at harvest stage. Maximum biomass accumulation was observed in *C. album*. Average density of weeds was 28.97 and 18.88 No. m^{-2} at 60 DAS and at harvest stage, respectively.

Table 48: Weed density and biomass in Eucalyptus+ wheat agroforestry system

Weed species	Av. density (No. m^{-2})		Av. biomass (D.W. g m^{-2})	
	60 DAS	At Harvest	60 DAS	At Harvest
Chenopodium album	8.72	12.22	10.22	15.21
Fumaria parviflora	6.14	2.05	8.74	3.47
Lathyrus aphaca	7.62	1.52	6.33	2.25
Melilotus indica	3.28	-	4.06	-
P. hysterophorus	3.21	3.09	1.28	4.64
Av. density/ biomass	28.97	18.88	30.63	25.57

Weed density and biomass in Shisham + barley based agroforestry system

Data presented in Table 49 reveals that *C. album* (6.28 No. m^{-2}) and *Anagallis arvensis* (4.76 No. m^{-2}) were the most dominant weeds at 60 DAS. At harvest stage *C. album* (8.24 No. m^{-2}) was the most dominant weed. By and large similar trend was observed with respect to biomass accumulation by different weeds. Average density of weeds was 13.42 and 9.96 No. m^{-2} at 60 DAS and at harvest stage.

Table 49: Weed density and biomass in Shisham + barley agroforestry system

Weed species	Av. density (No. m^{-2})		Av. biomass (D.W. g m^{-2})	
	60 DAS	At Harvest	60 DAS	At Harvest
Anagallis arvensis	4.76	-	3.72	-
Chenopodium album	6.28	8.24	4.18	7.92
Lathyrus aphaca	2.38	1.72	3.84	2.08
Av. density/ biomass	13.42	9.96	11.74	10

Weed density and biomass in Neem + wheat based agroforestry system

In neem + wheat agroforestry system C. *album* was the most dominant weed with an average density of 10.67 No. m^{-2} at 60DAS and 17.25 No. m^{-2} at harvest stage. Similarly biomass accumulation was also observed maximum in *C. album*. Average density of weeds was 23.28 and 24.76 No. m^{-2} at 60 DAS and at harvest stage (Table 50).

Table 50: Weed density and biomass in Neem+wheat agroforestry system

Weed species	Av. density (No. m^{-2})		Av. biomass (D.W. g m^{-2})	
	60 DAS	At Harvest	60 DAS	At Harvest
Chenopodium album	10.67	17.25	13.74	25.84
Fumaria parviflora	9.33	2.14	2.85	1.03
Spergula arvensis	3.28	5.37	2.17	4.25
Av. density/ biomass	23.28	24.76	18.76	31.12

Weed density and biomass in wasteland conditions

Data presented in Table 51 reveals that *Fumaria parviflora* (11.42 No. m^{-2}), *C. album* (10.0 No. m^{-2}) and *P. hysterphorus* (6.40 No. m^{-2}) were the most dominant weeds under wasteland conditions. Maximum Biomass accumulation was recorded in *P. hysterophorus* (13.08 g m^{-2}) followed by *C. album* (12.21 g m^{-2}) at maximum growth stage. Average density of weeds was 31.87 No. m^{-2} and with an average biomass accumulation of 44.80 g m^{-2}.

Table 51: Wasteland weeds (at max growth stage)

Weed species	Av. density (No. m^{-2})	Av. biomass (D.W. g m^{-2})
Chenopodium album	10.00	12.21
Cirsium arvensis	2.33	6.52
Euphorbia hirta	1.72	2.37
Fumaria parviflora	11.42	10.62
Parthenium hysterophorus	6.40	13.08
Av. density/biomass	31.87	44.80

Weed density and biomass during *kharif* , 2014 under different agroforestry systems

The observations on weed density and biomass recorded in different agroforestry systems and in wasteland conditions are presented hereunder

Weed density and biomass in Bamboo (*D. strictus*) + blackgram agroforestry system

Data presented in Table 52 reveals that *E. crusgalli* (15.33 No. m^{-2}) and *Commelina benghalensis* (1.23 No. m^{-2}) were the most dominant weeds at 60 DAS. Average density of weeds was 23.82 No. m^{-2} with an average biomass accumulation of 57.04 g m^{-2} at 60 DAS. By and large weed density and biomass accumulation was higher in case of sole crop (blackgram) as compared to the Bamboo+ blackgram agroforestry system.

Table 52: Weed density and biomass in Bamboo (*D. strictus*) + blackgram based agroforestry system at 60 DAS

Weed species	*D. strictus* + blackgram		Sole crop (blackgram)	
	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})
Commelina benghalensis	4.08	3.70	6.49	5.82
Commelina diffusa	1.23	1.92	4. 00	6.07
Echinochloa crusgalli	15.33	46.15	21.33	57.03
Digitaria sanguinalis	3.18	5.27	6.52	11.64
Av. density/ biomass	23.82	57.04	34.34	80.56

Weed density and biomass in Bamboo (*B. vulgaris*) + sesame agroforestry system

Data presented in the Table 53 reveals that the ***B. vulgaris*** based agroforestry system was infested predominantly by *E. crusgalli* (11.48 No. m^{-2}), *E. crusgalli* (11.48 weeds m^{-2}) and D. *sanguinalis* (5.29 No. m^{-2}). Average density of weeds was 20.51No. m^{-2} with an average biomass accumulation of 49.97 g m^{-2} at 60 DAS. Weed density and biomass accumulation was higher in case of sole crop (sesame) as compared to the Bamboo+ blackgram agroforestry system.

Table 53: Weed density and biomass in Bamboo (*B. vulgaris*) + sesame based agroforestry system at 60 DAS

Weed species	*B. vulgaris* + sesame		Sole crop (sesame)	
	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})
Commelina benghalensis	3.74	4.27	9.28	8.39
Echinochloa crusgalli	11.48	37.24	28.97	68.73
Digitaria sanguinalis	5.29	8.46	9.69	16.44
Av. density/ biomass	20.51	49.97	47.94	93.56

Weed density and biomass in Aonla + blackgram agroforestry system

Data presented in Table 54 reveals that *E. crusgalli* (13.33 No. m^{-2}) and *D. sanguinalis* (7.37 No. m^{-2}) were most dominant weeds at 60 DAS and similar trend was also observed in biomass accumulation. Average density of weeds was 20.51 No. m^{-2} with an average biomass accumulation of 49.97 g m^{-2} at 60 DAS, while average density of weeds was recorded as 47.94 No. m^{-2} with an average biomass accumulation of 93.56 g m^{-2} at 60 DAS under sole crop (backgram) situation.

Table 54: Weed density and biomass in Aonla + blackgram based agroforestry system at 60 DAS

Weed species	Aonla + blackgram		Sole crop (blackgram)	
	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})
Digitaria sanguinalis	7.37	11.58	8.75	14.82
Echinochloa crusgalli	13.33	18.28	17.33	24.31
Physalis minima	2.00	4.61	4.06	5.88
Av. density/ biomass	20.51	49.97	47.94	93.56

Weed density and biomass in neem + blackgram agroforestry system

Data presented in Table 55 reveals that *E. crusgalli* (16.68 No. m^{-2}) and *D. sanguinalis* (8.27 No. m^{-2}) were most dominant weeds at 60 DAS. Average density of weeds was 24.95 No. m^{-2} with an average biomass accumulation of 25.73 g m^{-2} at 60 DAS. However, average density of weeds was recorded as 32.93 No. m^{-2} with an average biomass accumulation of 55.35 g m^{-2} at 60 DAS under sole crop (blackgram) situation.

Table 55 : Weed density and biomass in Neem + blackgram based agroforestry system at 60 DAS

Weed species	Neem + blackgram		Sole crop (blackgram)	
	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})
Digitaria sanguinalis	8.27	11.53	11.46	20.73
Echinochloa crusgalli	16.68	25.73	21.47	34.62
Av. density/ biomass	24.95	37.26	32.93	55.35

Weed density and biomass in shisham + pigeonpea agroforestry system

Data presented in Table 56 reveals that *E. crusgalli* (13.33 No. m^{-2}) and *C. benghalensis* (9.41 No. m^{-2}) were most dominant weeds at 60 DAS. Average density of weeds was 24.74 No. m^{-2} with an average biomass accumulation of 38.68 g m^{-2} at 60 DAS. Average density of weeds was recorded as 72.63 No. m^{-2} with an average biomass accumulation of 115.784 g m^{-2} at 60 DAS under sole crop (pigeonpea) situation.

Table 56: Weed density and biomass in Shisham + pigeonpea based agroforestry system at 60 DAS

Weed species	Shisham + blackgram		Sole crop (blackgram)	
	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})	Av. density) (No. m^{-2})	Av. biomass (DW g m^{-2})
Commelina benghalensis	9.41	15.26	16.48	27.53
Echinochloa crusgalli	13.33	19.15	48.67	75.29
Physalis minima	2.00	4.27	7.48	12.92
Av. density/ biomass	24.74	38.68	72.63	115.74

Weed density and biomass under wasteland conditions

Weed density and biomass under wasteland conditions was recorded at maximum growth stage. Data presented in Table 57 reveals that *Cynodon dactylon* was the most dominant weed with an average density of 23.76 No. m^{-2}, followed by *Parthenium hysterophors* and *Ageratum conyzoides* among many others. Average density of weeds was 44.49 No. m^{-2} with an average biomass accumulation of 48.59 g m^{-2}.

Table 57: Wasteland weeds during *kharif* season at maximum growth stage

Name of the weeds	Av. density (No. m^{-2})	Av. biomass (D.W. g m^{-2})
Ageratum conyzoides	5.47	11.52
Borreria hispida	1.23	1.78
Cyperus rotundus	3.08	1.29
Cynodon dactylon	23.76	9.47
Echinochloa crusgalli	1.56	1.08
Mollugo pentaphylla	1.06	1.98
Parthenium hysterophorus	8.33	21.47
Av. density/biomass	44.49	48.59

2. Research Achievements

Tree Improvement, Post-Harvest and Value Addition Programme

AF01.23: Comparative Studies on Seedling and Clonal Plants of *Pongamia pinnata* with Special Reference to Their Adaptability to Rainfed Dry Agroclimate

(Badre Alam, A K Handa & S Vimala Devi)

Various physio-biochemical and spectral traits were studied to examine the adaptability of clonal and seedling plants of *Pongamia pinnata*. Growth traits like annual height increment and annual increment in collar diameter indicated better adaptability of clonal plants to dry hot summer (Fig. 39 & 40). Clonal plants of *P. pinnata* has significant higher rate of increment in growth traits including canopy diameter and it was relatively more than seedling plants (Fig. 41). Productivity in terms of number of flowering bunches and pods plant^{-1} were also better in clonal plants than seedlings (Fig. 42).

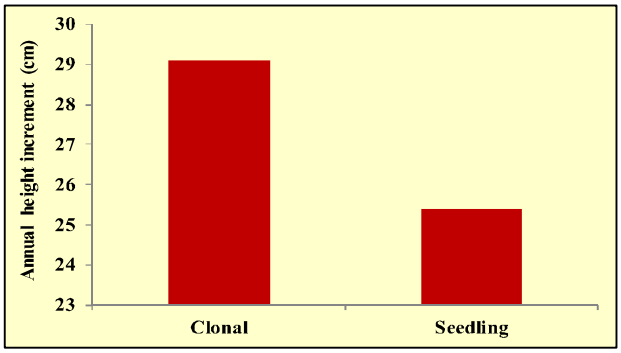


Fig. 39: Annual hight increment of clonal and seedling plants of *P. pinnata*

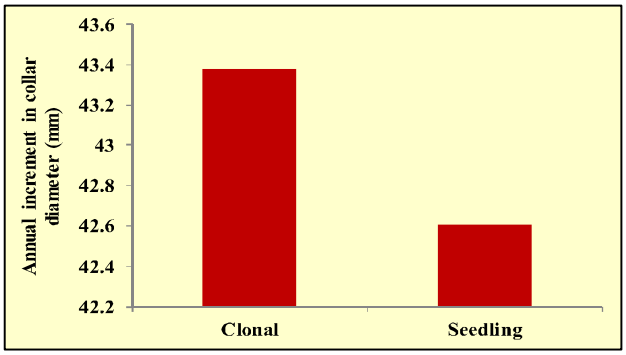


Fig. 40: Annual increment in collar diameter of clonal and seedling plants of *P. pinnata*

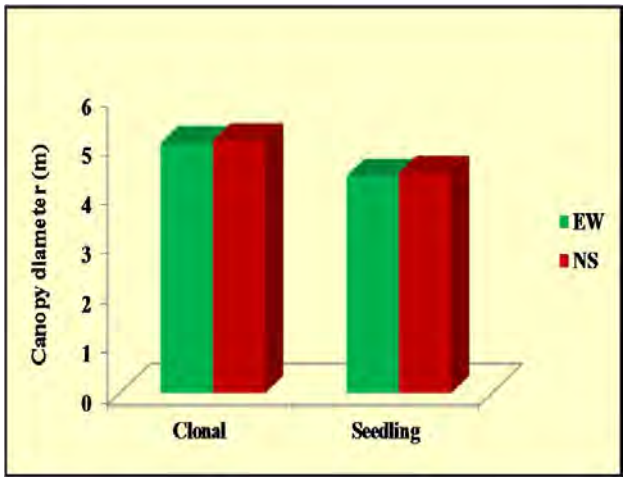


Fig. 41: Canopy diameter of clonal and seedling plants of *P. pinnata*

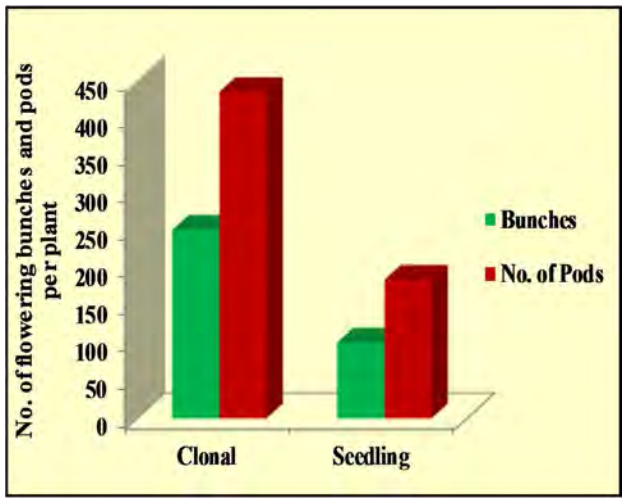


Fig. 42: Number of flowering bunches and pods plant^{-1} in clonal and seedling plants of *P. pinnata*

Monitoring the plant stand, there are eighty plants surviving under the experiment at present. Better physiological efficiency as in the rate of CO_2 assimilation was also observed in the rate of thylakoid electron transport in clonal plants (Fig. 43 and Fig. 44). Comparative quantum yield of CO_2 assimilation suggested better adaptability of clonal plants to dry hot summer conditions (Fig. 45). Chlorophyll content meter index (CCM Index) of seedling and clonal plants were also worked out (Fig. 46).

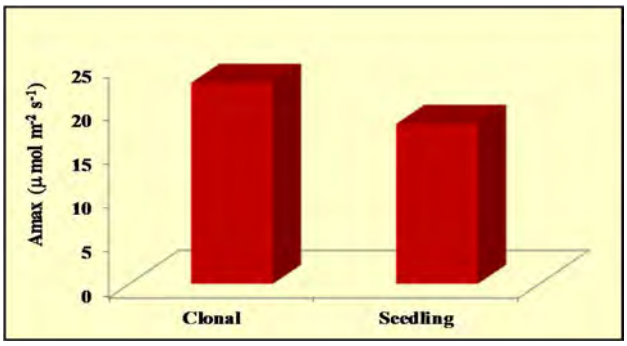


Fig. 43: Light saturated rate of CO_2 assimilation (Amax) in clonal and seedling plants of *P. pinnata*

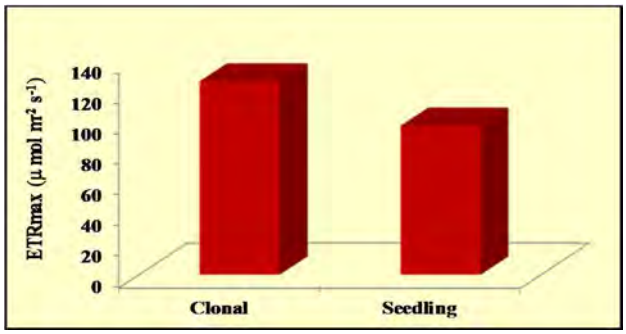


Fig. 44: Maximum rate of thylakoid electron transport in clonal and seedling plants of *P. pinnata*

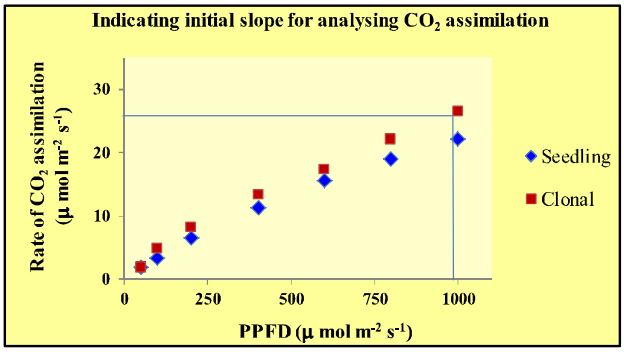


Fig. 45: Comparative quantum yield of CO_2 assimilation in clonal and seedling plants of *P. pinnata*

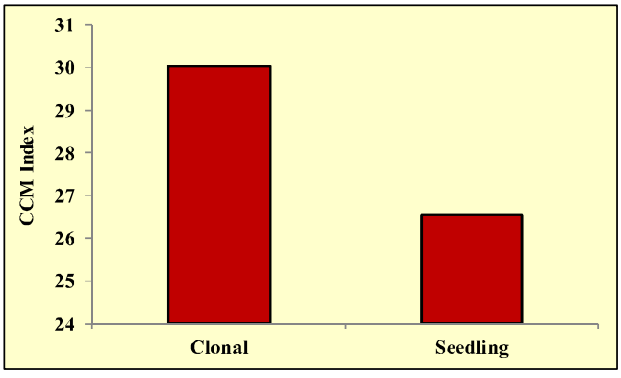


Fig. 46: Chlorophyll content meter index in clonal and seedling plants of *P. pinnata*

Some important leaf spectral traits have also been studied in both seedling and clonal plants of *P. pinnata*. The spectral indices like Normalized Difference Vegetation Index (NDVI) and Photochemical Reflectance Index (PRI) indicated that clonal plants have better light use efficiency than seedling plants of *P. pinnata* (Fig. 47 & 48).

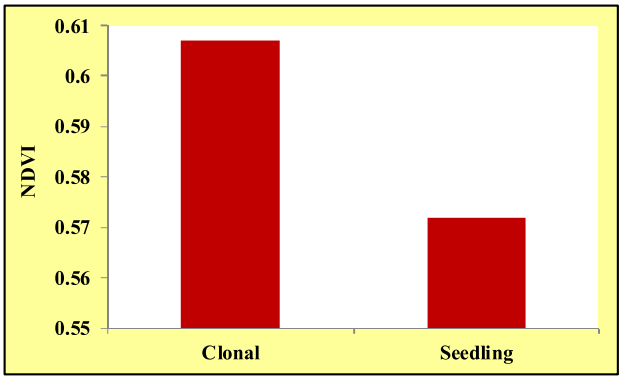


Fig. 47: Normalized difference vegatative index of clonal and seedling plants of *P. pinnata*

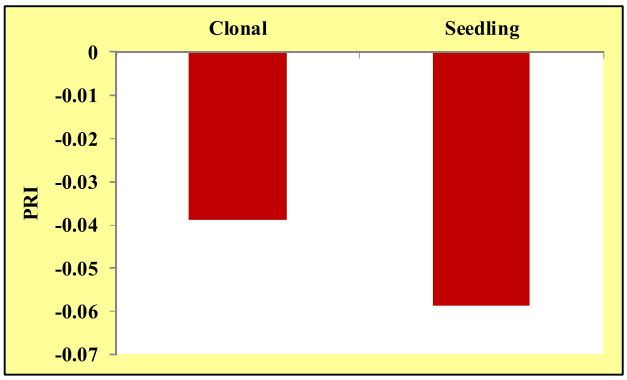


Fig. 48: Photochemical reflectance index of clonal and seedling plants of *P. pinnata*

AF 04.1b: Exploration, Evaluation and Conservation of Germplasm of *Acacia nilotica* spp. *indica*

(S Vimala Devi & Badre Alam)

A. Provenance Progeny Trial (Established in 2004)

Extensive survey was conducted in the states of Chattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh & Rajasthan between 20° 42'N to 25° 27'North latitude and 75° 39'E to 81°39'East longitude and progeny trail was established in August 2004 in randomized block design with

three replications. The growth parameters *viz.* tree height, dbh, canopy diameter and clean bole height of 20 provenance progenies were recorded on three randomly selected plants from each replication. Principal component analysis (PCA) was carried out using mean values of the morphological characters. Cluster analysis was performed based on significant principle component (PC) using SAS- Version 8.1.

A dendrogram (Fig. 49) constructed using cluster analysis conducted for 20 provenance selections used in the study were grouped into four well differentiated clusters at the average distance of 1.0. The cluster composition based on the morphological traits is given below in Table 58:

Table 58: The cluster composition of different provenance accessions based on morphological characters

Cluster No	No. of Accessions	Accession identity
I	1	PR-19
II	7	PR-2,PR-20,PR-13,PR-18,PR-16,PR-15 & PR-17
III	2	PR-4 & PR-14
IV	10	PR-1, PR-5, PR-9, PR-11, PR-2, PR-3,PR-6,PR-10,PR-7& PR-8

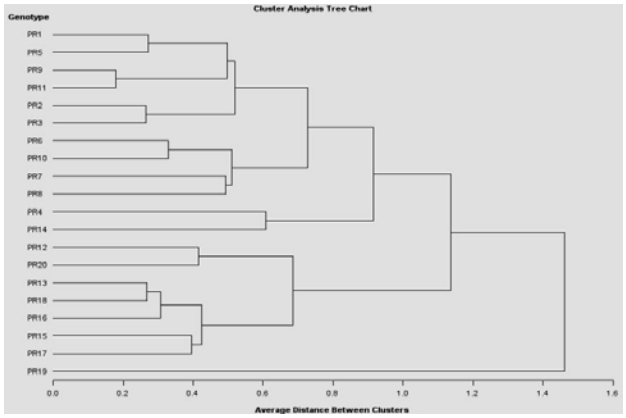


Fig.49: Cluster composition of different provenance accessions based on morphological traits

B. Plus tree progeny trial

The plus tree progeny trials were established in a randomized block design in three replications at CAFRI research farm consisting of candidate plus trees collected from the states of Uttar Pradesh, Madhya Pradesh, Rajasthan and Haryana. The observations recorded on morphological traits at an uniform age of plantation were subjected to PCA using mean values to assess the diversity.

A dendrogram (Fig. 50) constructed using cluster analysis conducted for candidate plus trees used in the study were grouped into four well differentiated clusters at the average distance of 1.0. The cluster composition based on the morphological traits is given in Table 59. This reflects the diversity present in the germplasm across and within the geographical selections.

Table 59: The cluster composition of different candidate plus trees based on morphological characters

Cluster No.	No. of Accessions	Accession identity
I	6	PT-2,PT-3, PT-12, PT-26, PT-31, PT-16,
II	1	PT-14
III	13	PT-4, PT-20, PT-5, PT-24, PT-10, PT-18, PT-19, PT-7, PT-9, PT-11, PT-27, PT-30, PT-14
IV	13	PT-1, PT-13, PT-21, PT-26, PT-32, PT-6, PT-25, PT-29, PT-8, PT-33, PT-15, PT-23, PT-22

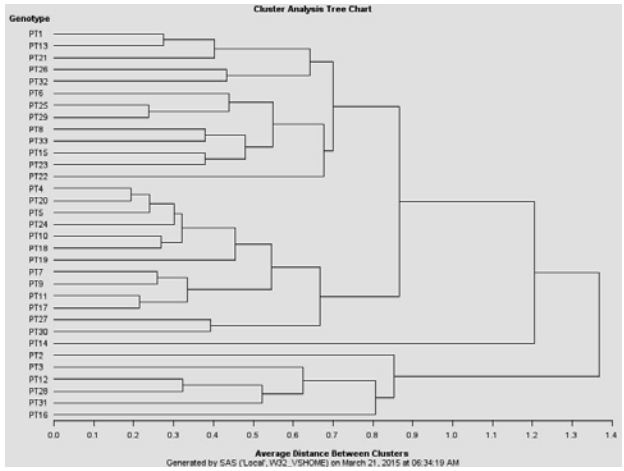


Fig. 50: Cluster analysis conducted for candidate plus trees

AF 04.5: Genetics and breeding of *Jatropha* species

(S Vimala Devi & S B Chavan)

A. Evaluation of hybrids in *Jatropha curcas*

In hybrid evaluation trial, 45 different intraspecific crosses of *Jatropha curcas* were established in July, 2006. The crosses were made in half-diallel method using ten best parents. Progeny of all the 45 crosses along with 10 parents were planted at the spacing of 4m x 4m. Each genotype was planted in three replications and each genotype having 5 plants in each replication. During the reporting period, all the plants were pruned in the month of February - March upto 50% and the new sprouts emerged during April-May. In September-October, plants were evaluated for morphological traits and were recorded. The mean and the range for the parents and hybrids for all the morphological data collected is given in the Table 60 (a & b).

Table 60a: Mean Performance of morphological traits in Parents and Hybrids in *Jatropha curcas*

	PH (m)	BD (m)	PB #	SB #	TB #	Pr B #	CD (m)	PBD (cm)	N-PBD (cm)
Parent	2.89	0.78	4.62	17.02	30.05	12.33	2.33	4.75	4.87
Hybrid	2.95	0.80	5.60	23.74	31.57	15.59	2.46	4.78	4.70

The mean performance was slightly higher than the parents for all the traits except non-productive branch diameter *viz.*, plant height, bole diameter, number of primary, secondary and total branches, branch length and the productive branch diameter. Though the difference among the parents and hybrids are marginal for all the characters, there is significant difference in the number of secondary branches produced. The minimum and maximum heterosis range in hybrids was observed for bole diameter, number of primary, secondary and total number of branches and also for productive branches and productive and non-productive branch diameter. It is observed that there is wide range for secondary branches and also for number of productive braches after pruning in hybrids, this gives scope for selection.

The fruits were collected at two times during Aug.-Sept. and Dec.-Jan., the combined yield and its related parameters were recorded. The mean and the range for the parents and hybrids of the cumulative fruit and seed data collected are given in the Table 61 (a & b).

The mean fruit and seed yield of the hybrids were 131.04 and 71.40 (g plant^{-1}), which were higher after pruning, also the range was significantly higher in hybrids when compared to

Table 60b: The range of Performance of morphological traits in Parents and Hybrids in *Jatropha curcas* for different morphological traits

	PH (m)	BD (m)	PB #	SB #	TB #	Pr B #	CD (m)	PBD (cm)	N-PBD (cm)
Parents	2.56-3.30	0.58-0.91	3.25-6	11.75-22.25	23-37	7.33-23.25	1.79-2.71	4.38-5.33	4.44-5.20
Hybrid	2.45-3.33	0.22-1.79	3-40	7-84	13-47	8-47	1.45-2.89	4.19-6.67	5.61-50.77

PH- Plant height; BD-Bole diameter; PB-No. of primary branches; SB-No. of secondary branches; TB-No. of total branches, PrB-No. of Productive branches; BL-Branch length; CD-Canopy diameter, PBD-Productive branch Diameter; N-PBD-Non-Productive branch Diameter

Table 61a: Mean Performance of fruit and seed characters in Parents and Hybrids in *Jatropha curcas*

Mean	Fruit yield (g plant^{-1})	Seed yield (g plant^{-1})	100 Seed wt. (g)	Av. fruit length (cm)	Av. fruit width (cm)	Av. seed length (cm)	Av. seed width (cm)	Av. seed thick (cm)
Parents	113.33	64.58	40.83	0.24	0.20	0.17	0.11	0.08
Hybrids	131.04	71.40	36.06	0.25	0.21	0.14	0.11	0.09

Table 61b: The range of performance of fruit and seed characters in parents and hybrids in *Jatropha curcas* for different morphological traits

Range	Fruit yield (g plant^{-1})	Seed yield (g plant^{-1})	100 seed wt.	Av. fruit length (cm)	Av. fruit width (cm)	Av. seed length (cm)	Av. seed width (cm)	Av. seed thick (cm)
Parents	75-145	45-85	35-45	0.24-0.26	0.20-0.21	0.17-0.18	0.11-0.12	0.82-0.10
Hybrids	35-230	15-120	15-45	0.24-0.26	0.18-0.23	0.13-0.16	0.09-0.13	0.07-0.10

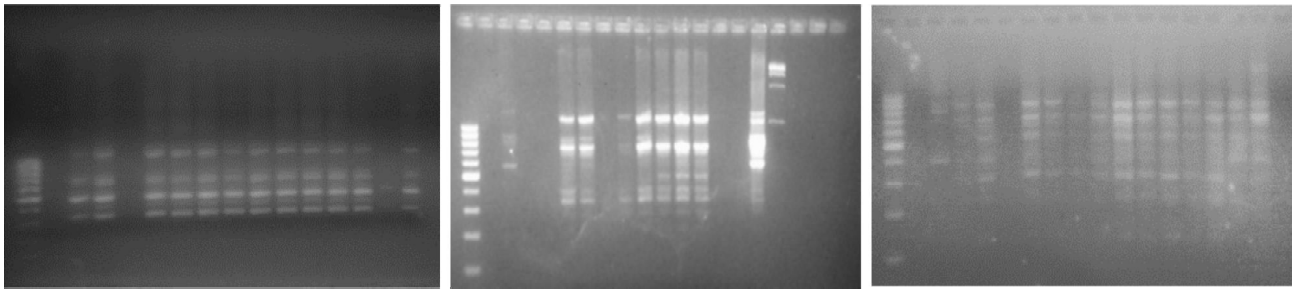


Fig. 51: Molecular characterization of *Jatropha curcas* using RAPD primers OPC 06, OPT 18 & OPT 4

parents, which gives scope for selection. It also indicates, that hybrids respond better to the management practices.

B. Molecular Characterization of *Jatropha curcas*

In order to assess the molecular diversity in the germplasm collections at CAFRI research farm, the molecular characterization with RAPD primers were initiated in previous year and 15 superior performing genotypes were analyzed 45 rapid primers of OPA, OPC, OPD OPE,OPN & OPT series and out of which 20 primers had shown polymorphic band across the accessions. In the reporting year, the same primers were used for another 15 genotypes and similar polymorphic bands were observed (Fig. 51).

AF 04.9: Assessment of Candidate Genes for Oil Biosynthesis in *Pongamia pinnata* using Eco-Tilling Approach

(S Vimala Devi, A K Handa & Sudhir Kumar)

Genes involved in fatty acid biosynthesis, modification and oil body formation are expected to be conserved in structure and function in different plant species. However, significant differences in the composition of fatty acids and total oil content in seeds are observed across the diverse oil bearing plants, which indicate the possible gene structure variations. The candidate genes from other known source are assessed in *P. pinnata* to generate molecular information of the crop of interest w. r.t to oil biosynthesis.

The phenotypic traits of all the 71 germplams accessions being maintained and evaluated at CAFRI, Jhansi were recorded and analyzed. The range of variation in the accessions w. r. t to morphological observations on the plant habit, seed yield, seed oil content and fatty acid contents were analyzed and are presented in the Table 62.

With respect to genotyping the DNA from all the accessions are being isolated and the PCR amplification of the gene-specific primers are standardized. Once the process is standardized the germplasm will be evaluated at the molecular level.

Table 62: Range of phenotypic traits measured in the CAFRI germplasm collections

S. No.	Phenotyping traits	Minimum	Germplasm accession number	Maximum	Germplasm accession number
1	*Morphological characters*				
	Plant height (m)	3.03	NRCP-82	6.17	NRCK-16
	Clean bole height (m)	0.25	NRCP-6	1.19	NRCK-6
	dbh (m)	0.31	NRCP-93	0.80	NRCK-15
	Canopy diameter (m)	2.46	NRCP-104	6.84	NRCK-25
	No of primary branches (plant^{-1})	2.00	NRCP-94	4.25	NRCP-16
2	*Seed characters*				
	No. of pods	28.00	NRCP-93	147.93	NRCK-16
	Pod yield (kg plant^{-1})	14.00	NRCP 14	8293.00	NRCP 26
	Seed yield (cm)	0.05	NRCK 23	18.98	NRCP 26
	Pod length (cm)	0.02	NRCK 9	7.745	NRCP 26
	Pod breadth (cm)	3.76	NRCK 4	6.25	NRCK 7
	Pod thickness (cm)	1.82	NRCK 4	2.76	NRCP 23

S. No.	Phenotyping traits	Minimum	Germplasm accession number	Maximum	Germplasm accession number
	Seed length (cm)	0.74	NRCK 9	1.26	NRCP 13
	Seed width (cm)	1.74	NRCK 24	2.40	NRCP 23
	Seed thickness (mm)	1.30	NRCK 90	1.84	NRCP 23
	No. of seeds pod^{-1}	0.46	NRCK 7	0.88	NRCP 13
	100 seed weight (kg)	0.10	NRCP 7,22, 23 …	0.20	NRCP 13
3	***Oil characteristics***				
	Oil Content (%)	27.00	NRCK 107,88	43.00	NRCP 11
	Fatty acid profile				
	Palmitic acid (%)	9.00	NRCP-13	23.70	NRCK107
	Stearic acid (%)	3.90	NRCK-85	10.10	NRCK-41
	Arachidic acid (%)	39.60	NRCP23	67.60	NRCP20
	Behenic acid (%)	0.00	NRCK-85	3.70	NRCK44,NRCK 65
	Linolenic acid (%)	2.50	NRCK22	3.90	NRCP13
	Oleic acid (%)	0.20	NRCK10	3.70	NRCP10
	Linoleic acid (%)	0.10	NRCK32	0.40	NRCK107, 92,94
4	***Physical properties of oil***				
	Free Fatty acid value	2.20	NRCK 24	24.50	NRCK 72
	Saponification value	185.00	NRCK 65	195.00	NRCK 68
	Iodine value	86.00	NRCK 75	91.00	NRCK 105

AF 05.10: Lac based Agroforestry in Bundelkhand Region: Introduction and Evaluation

(K B Sridhar, Sudhir Kumar, Rajendra Singh, S Ghosal & Md. Monobrullah, IINRG, Ranchi, Mahendra Singh & R P Dwivedi)

The survey and marking of trees were done during the month of January. Selected both young trees and matured trees for inoculation. Trees were pruned at the end of January. Due to good production last year, this time we had sufficient brood material for inoculation. However, at Parasai Sindh Watershed, we lost brood material due to felling of inoculated trees by few farmers (30 No.) to meet out immediate financial needs.

Due to bad weather conditions during the crop cycle, the insect showed minimal sign of swarming and even the brood insect also collapsed there itself. Hence, there was complete crop failure. Hence, leave crop was left for self-inoculation. There was 100 % mortality. However, to our surprise in two trees located at the campus insects survived and a sum of 2.4 kg of lac material was collected. The same had been exchanged to PI HPVA& RG. Under severe extremities of climate, how insect survived is being decoded.

ICAR Network Project, IINR&G, Ranchi

Harvest and Post-Harvest Processing and Value Addition of Natural Resins, Gums and Gum Resins

(Rajendra Prasad, A K Handa, Ajit, Ramesh Singh & Badre Alam)

The main objective of the project is to develop agroforestry models including gum and resin yielding trees for livelihood security and horizontal dissemination of technologies. During the year growth of established gum yielding tree based AF models was monitored. Besides, a gum garden of *A. senegal* has been planted and depth of knotching or incision for tapping gum-butea standardized. The growth of existing plantation of *A. pendula* and *A. latifolia* was also monitored. The observations were recorded on survival of lac insect on butea trees during summer in relation to temperature and relative humidity.

1. Agroforestry Models

Data on survival and plant growth in AF models (5.5 years old) raised at CAFRI farm are given in Table 63.

Table 63: Growth and survival of trees in the agroforestry models at CAFRI farm (66 MAP)

Agroforestry models	Collar diameter (cm)	Height (m)	Canopy (m^2)	Survival (%)
Agri-horti-silviculture (Field No 25)				
Acacia senegal (Kumat)	26 (GBH)	4.39	16.46	96
Citrus limon (Lemon)	6.70	2.75	7.22	96
Aegle marmelos (Bael)	20.37 (GBH)	3.76	9.76	91
Carrissa carandus (Karonda)	1.71	1.13	0.63	75
Horti-silviculture I (Field 20)				
Acacia nilotica (Babul)*	1.47	1.26	0.00	52
Terminalia arjuna (Arjun)	10.42	4.24	4.52	100
Acacia senegal (Kumat) (boundary)	9.19	4.59	10.02	90
Horti-Silviculture II (Field 20)				
Acacia nilotica (Babul)	63.19 (GBH)	7.08	37.81	96
Terminalia arjuna (Arjun)	9.71	4.32	6.92	100
Acacia senegal (Kumat) (boundary)	5.47	3.28	7.08	90
Block plantation				
Acacia senegal (Kumat)	6.91	3.45	7.82	100
Field No. 40 & 41 (2012 planation)				
Acacia senegal (Kumat) (10x10m)	4.44	205.65	3.33	86
Acacia nilotica (Babul) (10x10m)	3.57	1.89	2.57	95
Acacia senegal (Kumat) (10x5m)	2.65	1.16	1.41	90
Acacia nilotica (Babul) (10x5m)	3.44	1.87	2.73	77
Acacia senegal (Kumat) (5x5m)	3.38	1.63	3.00	94
Acacia nilotica (Babul) (5x5m)	4.95	2.610	5.61	93

* Plantation in July 2014

In agri-horti-silviculture model maximum survival and plant height was recorded in *Acacia senegal* while minimum survival and growth in *Carrisa carandus*. Out of 28 citrus plants, 12 started yielding fruits. Similarly karonda planted boundary also started fruiting. During the year 36 kg lemon and 6 kg karonda fruits were harvested from the agri-horti-silviculture (Field No 25). The weight of lemon fruit varied from 10 to 52g with an average value of 28g. During the *rabi* season wheat (HUW 234 Z-1) has been sown as an intercrop. After six years of planting natural oozing of gum was observed in *A. senegal* first time. In horti-silviculture-I model, due to severe casualty of *A. senegal*, it was replaced with *Acacia nilotica* in July 2014. Maximum survival was recorded in *T. arjuna* (100%), while *A. senegal* (boundary plantation) recorded maximum height (4.59 m). In horti-silviculture –II model, *Acacia nilotica* showed maximum growth. Survival of *Acacia senegal* in block plantation on rocky site was 100% and plants attained mean height of 3.45 m with collar diameter of 6.91 cm. In general, survival and growth of *A. nilotica* was better than *A. senegal*. In agri-silvi model (Field No. 40 and 41), maximum survival was recorded by *A. nilotica* at 10m X 10m spacing, while least by *A. nilotica* at 10m X 5m spacing. On an average, *A. senegal* showed better survival and growth than *A. nilotica*.

View of Agri-horti-silviculture (Field No 25)

Natural gum oozing from *A. senegal* in Agri-horti-silviculture (Field No. 25)

Farmers field view at GKD watershed area

View of agri-silvi model (Field No. 40 & 41)

Data on survival and growth of various tree species planted in different agroforestry models at farmers' field in GKD watershed and Ambabai village are given in Table 64.

Table 64: Growth parameters of trees in the agroforestry models at GKD Watershed (66 MAP) and Village Ambabai (42 MAP)

Plantation/Farmer	Collar diameter (cm)	Height (m)	Canopy (m^2)	Survival (%)
Sh. Thakur Das				
Acacia nilotica (Babul)	3.86	2.82	3.42	53
Psidium guajava (Guava)	4.99	2.53	4.38	98
Carrissa carandus (Karonda)	0.70	0.90	0.17	12
Sh. Himmat				
Acacia senegal (Kumat)	22.56 (GBH)	3.51	6.35	78
Emblica officinalis (Anola)	42.13 (GBH)	4.73	17.40	54
Carrissa carandus (Karonda)	0.84	0.60	0.16	18
Sh. Ghanshyam				
Acacia senegal (Kumat) (boundary) (Planted in 2012)	1.73	0.76		100
Sh. Mani Ram (Village Ambabai)				
Acacia senegal (Kumat)	6.13	2.33	4.16	54

After 5.5 years of planting, *Acacia senegal* recorded more survival (78%) than *A. nilotica* (53%) in GKD watershed. Out of planted horti-cultural species, guava showed maximum survival (98%) while, karonda the least (12%). However, anola recorded maximum gbh and plant height. To motivate farmers for undertaking gum based agroforestry, the aonla based model was demonstrated to visiting farmers of other villages (Plate 5). In terms of plant height *A. senegal* was better than *A. nilotica*. At Ambabai village after 3.5 years of planting, survival of *A. senegal* was 54% with plant height of 2.33 m and collar diameter 6.13 cm. The survival percentage of newly planted *A. senegal* on field bunds ranged from 50 to 100% in GKD watershed (Table 65).

Table 65: Survival of boundary plantation of *A. senegal* (Kumat) planted at farmers field in GKD watershed in 2012

S. No.	Farmer's Name	No. of tree planted	Spacing	Survival (%)
1	Lakhan	50	2.5 m apart	76
2	Shambhu	50	2.5 m apart	84
3	Gangadhar	50	2.5 m apart	60
4	Soni Pal	50	2.5 m apart	86
5	Saligram	10	4 m apart	80
6	Ghanshyam	50	2.5 m apart	100
7	Ram Swarup	20	3 m apart	60
8	Sumer	20	3 m apart	70
9	Manoj	10	4 m apart	50
	Total	310	---	----

Gum Garden

A gum garden of *A. senegal* was developed in July, 2014 at central research farm of CAFRI, Jhansi at a spacing of 3m x 3m. *Butea monosperma* was planted as border row. A total of 180 plants were planted. After six months of planting the survival percentage of *A. senegal* (95%) was better than *B. monosperma* (67%).

Growth of *Anogeissus pendula* plantation

The growth of existing plantations of *A. pendula,* which is now used for standardizing gum tapping techniques was monitored. This plantation of September, 1994 consists of tissue culture raised progenies of 5 plus trees of *A. pendula* planted in RBD with four replications. Each progeny had 25 plants in a plot. Net plot size was 15m x 10m with the spacing of 3m x 2m. On an average, the recorded girth at breast height (gbh) of AP S-2, AP-35, AP-12, AP-28 and AP-52 progenies was 29.58, 31.18, 28.53, 29.59 and 30.54 cm, respectively. The maximum gbh was recorded by AP-35, progeny while minimum by AP-12. Growth of trees was also recorded in experimental field wherein seven progenies of *A. pendula* raised through tissue culture were planted in August 1995 along with check in RBD with 4 replications having plot size of 15 x 10m with a spacing of 3m x 2m. Plus trees were selected from plants of Haryana (Bandwari) and Rajasthan (Jodhpur and Udaipur) based on fast growth. The gbh of AP-20, J-205, J-124, J-185, J-62, J-241 and NRC-5 progenies was 28.07, 33.28, 29.49, 30.96, 32.08, 28.68 and 26.60 cm, respectively. Maximum gbh was recorded by J-205 progeny while minimum was recorded in NRC-5. Growth of another plantation of *Anogeissus pendula* and *A. latifolia* was also monitored. This plantation was established during 1990 and now is being used as agroforestry models (Field No. 33 and 34) for tapping gum and raising intercrops. The trees are planted at 5m x 5m spacing. After 24 years, the better survival (90%) was recorded in *A. pendula* while, better gbh, canopy spread and height was observed in *A. latifolia* (Table 66).

Table 66: Growth of *A. pendula* and *A. latifolia* after 24 years

Gum yielding tree species	GBH (cm)	Height (m)	Canopy (m^2)	Survival (%)
A. pendula (kardhai)	37.82	6.29	16.52	90
A. latifolia (Dhau)	42.04	6.59	18.19	85

2. Standardization of Gum Tapping Techniques

Depth of Knotching or Incision on Stem of *B. monosperma*

A field trial was conducted on naturally occurring 15-20 years old trees of *B. monosperma* for assessing whether depth of knotching on stem bark had any effect on yield of gum-butea. To regulate depth of cuts, a bill hook was purposely designed and got fabricated locally with the help of scientist, Farm Machinery, IGFRI, Jhansi. The field trial consisted of three depths of cuts *viz*. 0.5 cm, 1.0 cm and 1.5 cm each replicated on three trees. It was conducted in the month of February 2015 and exuded gum yield was evaluated. Findings revealed that maximum gum-butea was obtained when knotching was done up to 1.0 cm depth on stem bark of the trees. The knotching done up to depth of 0.5 cm yielded minimum gum-butea (Fig. 52).

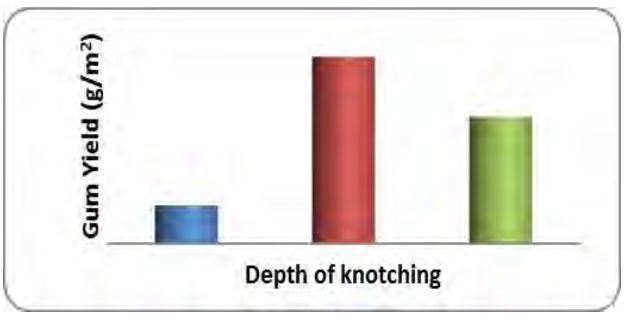


Fig. 52: Effect of different depths of incision on stem-bark on gum yield of *B. monosperma*

In addition to above trial, on advice of project coordination committee, the experiment on use of ethephon for inducing gummosis was repeated on *B. monosperma*. However, the exuded gum was washed away by winter rain and hence, gum yield data could not be recorded. The moisture content of exuded gum-butea ranged from 1.71 to 3.38% (Table 67).

Table 67: Effect of Ethephon on moisture (%) of gum-butea

Method of Ethephon application	Dose of Ethephon (4 ml)			
	10%	20%	30%	Mean
Spray of ethephon on tree surface before knotching	1.71	2.12	2.66	2.16
Spray of ethephon on tree surface after knotching	3.38	3.32	3.10	3.25
Injection of ethephon at the base of tree trunk+ knotching	2.36	2.34	2.43	2.38
Control (only knotching)	2.44	2.44	2.44	2.44
Mean	**2.47**	**2.55**	**2.65**	---

3. Factors of survival of lac insect on *B. monosperma* in summer

Butea monosperma is an important host for lac insect and offers good potential for lac cultivation in Bundelkhand region, where sizable numbers of trees exist on farmers' field and forest land. Our previous year studies on effect of lac cultivation on gum yield and vice versa on butea trees had revealed that the trees, where production of both lac and gum was taken yielded less lac than trees having inoculated with only lac insect. The main constraint in lac cultivation is the mortality of lac insect in scorching heat of summer thus leaving no brood lac for inoculation in July for next crop. Therefore, during current year observations were recorded on temperature, relative humidity and survival of lac insect to assess critical levels of temperature and humidity instrumental for survival of lac insect on butea trees. As revealed from data (Fig. 53), in general, the survival of lac insect was more on trees, where only lac insect was inoculated without tapping of gum than on those trees where production of both lac and gum was taken simultaneously. However, with increase in temperature and decline in RH in summer season the survival of lac insect declined progressively till complete mortality in second week of June. Rising summer temperature more than 45^{0}C associated with decline in RH below 12% appears to be crucial for survival of lac insect in summer.

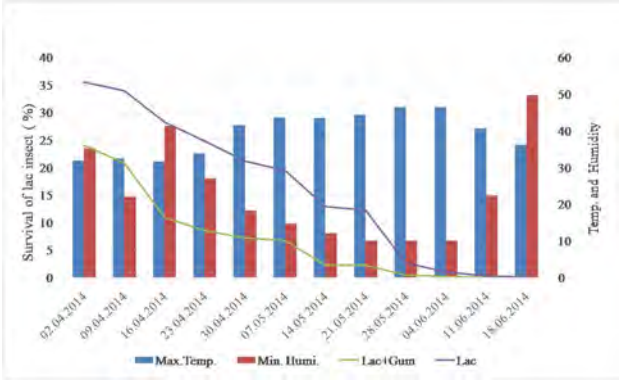


Fig. 53: Effect of temperature and RH on survival of lac insect on butea trees in summer

NOVOD Board Project

National Network on Integrated Development of Jatropha and Karanja

(S Vimala Devi & S B Chavan)

[I] *Jatropha curcas*

A. Progeny trials

Explorations were conducted during 2003-2005 in different eco-geographical regions of the country and seeds of *Jatropha curcas* were collected from various parts of Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Maharashtra, Andhra Pradesh and Chhattisgarh. Seedlings of different sources were raised in nursery and were planted in field for progeny evaluation. A total of 5 progeny trials with 27, 23, 9, 12 and 85 accessions in RBD in three replications were raised between 2004-06. The progenies were evaluated for morphological traits as well as for seed yield and oil content during each year. The fruit and seed yield for different progeny trials is given in Table 68.

Table 68: The average fruit and seed yield in different progeny trials of *Jatropha curcas*

Establishment	Genotypes (No.)	Fruits yield (g)	Seed yield (g plant^{-1})
PT (Aug, 04)	27	138.02	78.02
PT-I (Aug, 05)	23	116.36	62.27
PT-II (Aug, 05)	9	126.00	75.76
PT-IV (Aug, 06)	85	126.00	71.38

B. National multilocation trial II(2007)

The seeds of selected 17 superior genotypes of 14 different research centres (including CAFRI) of the network project were received in Feb., 2007 and their nursery was raised. Their progeny was planted in field during August, 2007, following RBD with four replications. Each replication had 16 plants of each genotypes and planted at 3m x 3m spacing as suggested by the NOVOD board to the centers. During 2012, due to heavy rains three accessions died and hence the data for the current year is recorded for 14 genotypes. The morphological and yield parameters were recorded and results are being presented here at the age of six years (Table 69).

The mean plant height among the accessions was 2.75m with a range of 2.14-3.44m, the average bole diameter 0.65m with a range of 0.34-1.07m. The average number of primary and secondary branches was 4.76 and 14.43. The average canopy diameter was 2.67m. The main trait, which determines the yield of plant is the number of productive branches, it has an average of 15.23 with a range of 8.33 -24.00. An effort to assess the branch thickness to be productive, the branch diameter for both productive and non-productive branches was recorded and the analysis showed that there is no significant difference between the average diameters. The average fruit yield in the national multilocation trial was 0.26 kg plant^{-1} and the average seed yield was 0.15 kg plant^{-1} (Table 70).

C. National multilocation trial III (2008)

The seeds of selected 18 superior genotypes of 12 different centers (including CAFRI) of the network project were received in March, 2008 and their nursery was raised. Their progeny was planted in field during August, 2008, following RBD with four replications. Each replication had 16 plants of each genotype and planted at 3mx3m spacing as suggested by the NOVOD board to the centers. All the accessions were evaluated at the age of five years and data were recorded for different morphological and yield parameters (Table 71).

Table 69: Growth performance of *Jatropha curcas* under NMT II

Genotypes	PH(m)	BD (m)	NP	ABL	SB	CD	TB	Pr B	PBD	N-PBD
NRCJ2	3.09	0.62	5.60	2.60	14.60	2.78	24.20	12.60	6.60	6.13
PantJ03103	2.15	0.55	3.33	1.71	10.33	1.94	23.50	8.33	6.67	5.44
MPJ55	3.15	0.59	3.00	2.49	14.00	3.25	23.00	12.00	7.33	6.33
PDKVNov3	3.44	0.68	6.50	3.06	36.50	3.28	41.00	17.50	9.50	8.00
Bawal Sel	2.45	0.34	3.17	1.97	9.17	2.35	16.00	13.67	6.39	6.00
Orissa2	2.14	0.80	5.00	1.52	8.00	2.41	16.00	12.00	6.83	6.67
NBJ1	2.56	1.07	6.00	2.13	14.00	2.40	25.00	17.00	6.67	6.67
HAUJ39	3.07	0.59	6.00	2.46	10.00	2.35	21.00	24.00	6.00	7.33
NBJ9	2.91	0.57	6.00	2.54	16.00	3.08	26.50	16.00	6.50	6.67
TNMC8	2.50	0.71	3.00	2.07	11.00	2.86	23.00	18.00	6.00	6.00
TNMC19	2.83	0.60	4.75	2.41	15.17	2.70	27.50	16.42	7.42	6.83
Mean	**2.75**	**0.65**	**4.76**	**2.27**	**14.43**	**2.67**	**24.25**	**15.23**	**6.90**	**6.55**
Minimum	2.14	0.34	3.00	1.52	8.00	1.94	16.00	8.33	6.00	5.44
Maximum	3.44	1.07	6.50	3.06	36.50	3.28	41.00	24.00	9.50	8.00

PH- Plant height; BD-Bole diameter; PB-No. of primary branches; SB-No. of secondary branches; TB-No. of total branches, PrB- No. of Productive branches; ABL-Average Branch length; CD-Canopy diameter, PBD-Productive branch Diameter; N-PBD-Non-Productive branch Diameter.

Table 70: Fruit and seed related traits of *Jatropha curcas* under NMT II

Genotype	Fruit yield (kg plant^{-1})	Seed yield (kg plant^{-1})	Av. fruit length (cm)	Av. fruit width (cm)	Av. No. Seeds fruit^{-1}	Av. seed length (cm)	Av. seed width (cm)	Av. seed thickness (cm)
NRCJ2	0.28	0.21	0.24	0.20	3.20	0.17	0.10	0.08
PantJ03103	0.17	0.10	0.25	0.20	3.00	0.17	0.11	0.08
PDKVNov3	0.21	0.12	0.24	0.19	2.50	0.18	0.11	0.09
Bawal Sel	0.24	0.13	0.25	0.20	2.80	0.18	0.11	0.08
Orissa2	0.09	0.05	0.24	0.19	2.64	0.17	0.11	0.08
NBJ1	0.00	0.00	0.24	0.19	3.00	0.17	0.10	0.08
HAUJ39	0.42	0.24	0.24	0.19	3.00	0.17	0.10	0.08
NBJ9	0.33	0.18	0.24	0.19	3.00	0.17	0.10	0.08
TNMC19	0.33	0.19	0.24	0.20	2.74	0.17	0.11	0.08
Mean	**0.26**	**0.15**	**0.24**	**0.20**	**2.88**	**0.17**	**0.10**	**0.08**
Minimum	0.09	0.05	0.24	0.19	2.50	0.17	0.10	0.08
Maximum	0.42	0.24	0.25	0.20	3.20	0.18	0.11	0.09
SD ±	0.10	0.07	0.00	0.00	0.22	0.00	0.00	0.00

Table 71: Growth performance of *Jatropha curcas* under NMT III

Genotypes	PH (m)	BD (m)	PB	NO SB	No TB	No PB	ABL (m)	CD (m)	PBD (cm)	N-PBD (cm)
PDKV Nov19	2.84	0.54	5.41	16.12	32.41	9.90	2.61	3.53	5.93	5.59
NRCJ2	2.48	0.44	4.06	13.88	26.44	6.86	2.12	2.93	5.05	5.04
NRCJ18	2.46	0.51	4.38	12.88	24.00	5.83	2.22	3.08	5.06	5.08
NRCJ89	2.66	0.51	5.43	18.14	32.86	6.29	2.37	3.73	4.94	4.95
TFRI07	2.94	0.60	5.88	21.75	40.00	4.40	2.56	3.86	4.27	5.08
JJ2	2.82	0.57	6.31	18.69	37.92	6.67	2.45	3.84	5.20	5.03
CRJ29	2.80	0.64	4.33	16.33	31.67	8.25	2.43	3.77	5.58	4.94
LBJJ23	3.08	0.53	4.67	17.33	34.75	8.00	2.59	3.64	5.78	4.83
CALD14	2.81	0.53	6.38	21.88	40.25	5.75	2.42	3.64	5.08	4.86
TNCJC19	2.82	0.61	5.61	18.00	37.39	7.80	2.42	3.24	5.00	5.21
TNCJC20	2.91	0.60	5.48	17.21	36.33	9.50	2.55	3.79	4.78	4.78
TNCJC25	2.63	0.47	4.50	16.50	33.33	6.40	2.25	3.46	5.27	5.50
PantJCP1	2.79	0.58	4.43	15.29	30.00	5.75	2.33	3.63	4.67	5.28
PantJCP2	2.93	0.66	6.40	18.60	36.73	18.22	2.63	3.74	6.26	5.91
TR4	2.78	0.55	5.00	16.00	31.25	7.00	2.47	3.55	5.33	4.92
MNJ001	2.70	0.65	6.80	17.00	32.00	3.00	2.37	3.35	4.33	4.87
MNJ006	2.45	0.74	5.50	13.00	25.75	6.50	2.18	3.07	5.00	4.83
NDJC1	2.55	0.47	4.14	13.57	24.43	8.33	2.14	3.09	6.67	5.78
Mean	**2.75**	**0.57**	**5.26**	**16.79**	**32.64**	**7.47**	**2.39**	**3.50**	**5.23**	**5.14**
Minimum	2.45	0.44	4.06	12.88	24.00	3.00	2.12	2.93	4.27	4.78
Maximum	3.08	0.74	6.80	21.88	40.25	18.22	2.63	3.86	6.67	5.91

The mean plant height among the accessions was 2.75m with a range of 2.45-3.08m, the average bole diameter 0. 57m with a range of 0.44- 0.47m and the average number of primary and secondary branches was 5.26 and 16.79. The average canopy diameter was 3.50m. Average number of productive branches was 7.47 with a wide range of 3.00-18.22, which shows large variability present for this trait. The average diameter of productive and non-productive branches did not vary significantly indicating that the productivity does not depend on the branch thickness, which indirectly indicates that management of pruning may not influence the yield performance in Jatropha (Table 72).

Table 72: Fruit and Seed related traits of *Jatropha curcas* under NMT III

Genotypes	Fruit yield (kg plant^{-1})	Seed yield (kg plant-1)	Fruit length (cm)	Fruit width (cm)	Seeds fruit^{-1}	Seed length (cm)	Seed width (cm)	Seed thickness (cm)	100 Seed weight (g)
PDKV Nov19	1.34	0.71	0.24	0.21	2.89	0.17	0.11	0.08	38.89
NRCJ2	0.65	0.33	0.24	0.19	2.86	0.17	0.10	0.08	39.29
NRCJ18	1.00	0.50	0.22	0.18	2.80	0.17	0.11	0.08	40.00
NRCJ89	0.68	0.38	0.23	0.19	2.70	0.17	0.11	0.08	42.50
TFRI07	0.90	0.50	0.23	0.20	2.90	0.16	0.10	0.08	37.50
JJ2	1.12	0.57	0.24	0.19	2.90	0.16	0.11	0.08	40.00
CRJ29	0.85	0.45	0.23	0.18	3.00	0.16	0.10	0.08	40.00
LBJJ23	1.11	0.59	0.24	0.20	2.98	0.17	0.10	0.08	38.89
CALD14	1.39	0.73	0.24	0.19	3.00	0.17	0.10	0.08	39.00
TNCJC19	0.98	0.51	0.24	0.19	3.00	0.17	0.10	0.08	37.50
TNCJC20	1.40	0.73	0.24	0.19	2.91	0.17	0.10	0.08	37.69
TNCJC25	2.25	1.10	0.23	0.19	2.80	0.17	0.10	0.08	40.00
PantJCP1	0.88	0.45	0.23	0.19	2.85	0.17	0.10	0.08	36.25
PantJCP2	1.32	0.69	0.24	0.19	2.76	0.17	0.11	0.08	34.00
TR4	1.51	0.91	0.24	0.19	2.85	0.17	0.10	0.08	36.25
MNJ001	1.38	0.68	0.24	0.20	3.10	0.16	0.10	0.08	45.00
MNJ006	0.98	0.52	0.24	0.20	2.93	0.17	0.11	0.08	35.00
NDJC1	0.70	0.40	0.24	0.19	3.00	0.17	0.11	0.08	40.00
Mean	**1.14**	**0.60**	**0.24**	**0.19**	**2.90**	**0.17**	**0.10**	**0.08**	**38.76**

The average fruit and seed yield in the National multilocation trials III are 1.14 and 0.60 kg plant^{-1}, respectively and the average 100 seed weight was 38.76g. Large variability was not observed for the trait 100 seed weight, indicating less scope for selection w.r.t. to the size of seeds.

[II] Karanja (*Pongamia pinnata* L.)

(A) Plus tree progeny trial (August, 2005)

Seeds of 18 CPT of Karanja collected during April 2005 from different parts of Uttar Pradesh, Madhya Pradesh, Rajasthan and Haryana were planted in the field during August, 2005 for evaluation on the basis of growth and yield parameters. The saplings were planted at the spacing of 5m apart following RBD with three replications.

Data pertaining to morphological traits are presented in Table 73. The traits like plant height, bole dbh, canopy diameter and number of primary branches showed significant differences among the genotype. At the age of eight years, average tree height was 5.18 m, average clean bole height was 55.58 cm with average dbh of 60.52 cm .The average canopy diameter was 5.59 m with average primary branches of 2.48. A total of 10 accessions were recorded above the population mean w. r. t plant height.

Table 73: The mean of different morphological traits in *Pongamia pinnata* germplasm accessions

Germplasm accessions	Plant Ht (m)	Clean bole Ht (cm)	dbh	# Pri branches	Canopy diameter (m)
NRCP6	4.76	79.75	64.00	2.60	5.11
NRCP7	5.44	45.00	54.50	2.43	6.06
NRCP9	5.57	56.20	58.81	**3.07**	5.64
NRCP10	4.64	64.40	47.75	2.50	4.96
NRCP11	4.86	41.50	56.73	2.18	5.79
NRCP12	5.12	48.50	66.75	2.50	5.87
NRCP13	5.53	34.00	72.25	2.50	5.71
NRCP14	4.37	55.57	48.67	2.22	4.10
NRCP16	**6.08**	41.14	71.67	2.47	6.71
NRCP17	5.08	56.17	53.38	2.88	5.35
NRCP18	4.65	47.75	56.08	2.46	4.84
NRCP20	5.55	**101.00**	57.04	2.14	5.27
NRCP21	4.61	38.75	69.06	2.75	5.95
NRCP22	5.11	67.40	53.45	2.50	4.97
NRCP23	5.43	85.50	62.50	2.00	5.01
NRCP24	5.54	71.00	63.78	2.22	5.39
NRCP25	5.27	26.00	90.50	2.50	6.76
NRCP26	5.48	35.00	68.83	2.22	5.90
Mean	**5.18**	**55.58**	**60.52**	**2.48**	**5.59**

The yield related traits like number of pod plant^{-1}, average pod weight and seed weight showed a lot of variation across the accessions (Table 74). The average number of pods plant^{-1} is 1192.22, the average weight of pods plant^{-1} was 3.70 kg and the average seed weight was 1.33 kg plant^{-1}. In terms of seed yield, NRCP-7 and NRCP-26 are performed better with seed yield of 5.90 kg and 7.75 kg plant^{-1}, respectively. The oil content in these accessions varied between 34-40 %.

Table 74: The mean of different pod and seed yield in *Pongamia pinnata* germplasm accessions

Accession No.	Av.no of pods plant^{-1}	Av. pod wt (kg plant^{-1})	Av. seed wt (kg plant^{-1})	Oil Content (%)
NRCP 6	609.50	2.03	0.91	38
NRCP 7	4030.00	13.88	5.90	37
NRCP 9	176.00	0.48	0.15	34
NRCP 10	36.00	0.13	0.06	40
NRCP 11	669.67	2.05	0.66	43
NRCP 12	39.00	0.10	0.04	37
NRCP 13	32.00	0.13	0.05	35
NRCP 14	14.00	0.06	0.03	37
NRCP 16	210.00	0.87	0.32	37
NRCP 17	38.00	0.18	0.05	40
NRCP 18	132.00	0.34	0.17	41
NRCP 20	2894.00	9.27	3.14	37
NRCP 21	1456.33	6.86	1.82	38
NRCP 22	135.00	0.43	0.20	39
NRCP 23	315.00	1.05	0.43	35
NRCP 24	2319.00	9.54	2.20	38
NRCP 25	61.50	0.28	0.13	41
NRCP 26	8293.00	18.98	7.75	41
Mean	**1192.22**	**3.70**	**1.33**	**38**
Minimum	14.00	0.06	0.03	34
Maximum	8293.00	18.98	7.75	43

Germplasm Evaluation of Leucaena at CAFRI, Jhansi

(A R Uthappa)

Leucaena is an important MPTS under

agroforestry systems specifically for silvipasture systems in semi-arid regions. In this context a study was initiated at CAFRI with different Leucaena species for their growth characteristics and seedlings belonging to five different species *viz*., *Leucaena diversifolia, L. shannoni, L. lanceolata, L. collinsii L. leucocephala* and a hybrid (*L. shannoni* X *L. leucocephala*) obtained from IGFRI, Jhansi and planted at CAFRI, experimental field during August, 2006 for evaluation and their selections for superior growth characters. The seedlings were planted at a spacing of 3m x 3m with three replications. The data for tree height and dbh at the age of nine years were recorded (Table 75). The average tree height was 11.78 m and it ranged from 8 to 14.57 m and the value for eighteen accessions was higher compared to population mean. The maximum height was recorded in *L. leucocephala* S-18 and *L. leucocephala* S-22 (14.57m) and minimum height in *L. leucocephala* Silvi-4 (8 m). The average dbh was 11.59 cm and it ranged from 5.94 to 20.38 cm. Seventeen accessions recorded diameter over the population mean. The maximum dbh was recorded in *L. shannoni*-22/83 (20.38 cm) and minimum dbh was in *L.leucocephala* Silvi-4 (5.94 cm).

Table 75: Growth parameters of different leucaena accessions

Accession No.	Accession name	dbh (cm)	Total height (m)	Accession No.	Accession name	dbh (cm)	Total height (m)
1	*L. diversifolia*-504	13.64	12.10	19	*L. leucocephala* S-12	15.24	14.45
2	*L. diversifolia*- 83/92	7.20	9.67	20	*L. leucocephala* S-13	12.36	12.35
3	*L. diversifolia*-46/87	8.11	10.30	21	*L. leucocephala* S-14	7.74	9.07
4	*L.shannoni*-22/83	20.38	13.65	22	*L. leucocephala* S-15	12.60	12.70
5	*L. lanceolata*	12.55	11.80	23	*L. leucocephala* S-18	18.77	14.57
6	*L. lanceolata*-49/37	10.31	10.17	24	*L. leucocephala* S-22	6.94	14.57
7	*L.collinsii*-18/84	11.74	11.40	25	*L. leucocephala* S-23	9.08	10.12
8	*L.collinsii*-56/88	12.42	13.80	26	*L. leucocephala* S-24	8.11	11.30
9	*L.collinsii*- 15/83	11.74	10.73	27	*L. leucocephala* IGFRI-23-1	12.57	12.77
10	*L. shannoni* X *L. leucocephala*	13.18	13.63	28	*L. leucocephala* IGFRI-78	9.71	12.00
11	*L.leucocephala* S-1	14.20	14.00	29	*L. leucocephala* IGFRI-96	9.46	8.70
12	*L. leucocephala* S-2	18.06	10.40	30	*L. leucocephala* Conn-3	10.06	9.80
13	*L.leucocephala* S-4	11.39	11.27	31	*L. leucocephala* Silvi-4	5.94	8.00
14	*L. leucocephala* S-6	14.24	13.77	33	*L. leucocephala* K-29	13.22	12.30
15	*L. leucocephala* S-7	10.94	12.43	34	*L. leucocephala* K-217	11.34	11.90
17	*L. leucocephala* S-10	8.79	11.55	35	*L. leucocephala* K-340	7.39	9.90
18	*L. leucocephala* S-11	13.16	13.63				

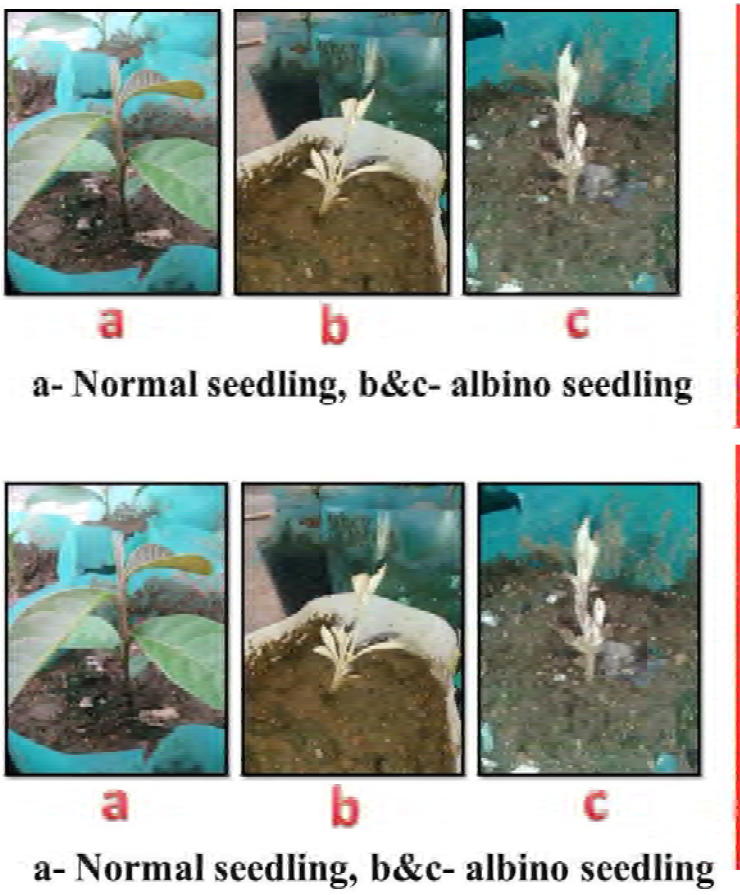
L. shannoni x L. leucocephala | *L. shannoni* | *L. leucocephala* | *L. lanceolata* | *L. diversifolia*

Variation in leaf characters among different species

(A) Occurrence of Albino and Polyembryony in *Madhuca indica*

(S B Chavan)

A nursery study on mahua (*Madhuca indica*) seeds was carried out in 2014 for preparation of seedlings. Seeds were collected from trees grown at CAFRI experimental farm in the month of July, 2014. Seeds were sown in nursery and seedling behavior was observed regularly to calculate germination percentage. The germination percentage was 90%. But, some type of abnormality in mahua seedlings were also observed *i.e.* albino and polyembryony. Out of 272 seedlings germinated, 2 albino seedlings, 22 twin seedlings and 7 triplet seedlings were found. As albino is characterized by partial or complete loss of chlorophyll pigments and incomplete differentiation of chloroplast membranes that in turn impairs photosynthesis and the plants eventually, die at a young stage without reaching maturity (within 40-45 days). Polyembryony is the occurrence of more than one seedling from single seed. During this study, the polyembryony was observed in the form of twin, triplet and multiple seedlings. The triplet seedlings had independent shoot portion but the root portion was conjointed. Similar type of observation was noticed for twin seedling as well. In addition, one of the twin seedlings had emerged with separate well-developed root systems. The percentage of twin and triplet seedlings recorded was 8 and 2%, respectively. Reporting of such abnormality will be helpful in conducting future tree improvement programmes in Mahua.



Albino and polyemryony seedlings in *Madhuca indica*

(B) A Preliminary Survey and Physical Characterization of Fuelwood Species Preferred by Farmer's in Bundelkhand region of Uttar Pradesh

The socio economic fuelwood survey and fuel wood properties was carried out in Jaluan district of Bundelkhand during 2013-2014. Using interviews and questionnaires for key respondents in the local community, the study identified the villager's dependence on forest for fuelwood and supported with socio economic stability of villagers in Bundelkhand region of India (Table 76). The survey revealed that 70 % of local people were heavily dependent on forests mainly for fuelwood due to easy availability and cost free. Based on matrix and preferential ranking, 10n fuelwood species selected by key informants used for scientific assessment on fuelwood properties *viz*., basic density, moisture content, ash content, volatile matter, fixed carbon, lignin content, calorific value, heating value and fuelwood value index were carried out to select ideal fuelwood species. Out of various laboratory tests, the fuelwood value index is an emerged tool for identifying new and reinforcing the traditionally used fuelwood species as quality fuelwood (Table 77). Based on this, *Acacia catechu, Acacia senegal, Anogeissus pendula* and *Prosopis juliflora* can be listed as desirable fuelwood species. In a holistic perspective, the comparative analysis of survey and scientific assessment indicated that *Prosopis juliflora* was most commonly preferred due to its easy availability in forest and community lands. This extensive study concluded that plantation of locally available multipurpose tree species can be promoted in the region in the wasteland, community and private land. Moreover, the promotion to use biomass as one of the source of energy (through agro-forestry, for example) in the semi-arid Bundelkhand region, will not only improve the livelihood condition, but will also bring better ecological health in this area.

Table 76: Matrix ranking of preferential fuelwood tree species by farmers of Bundelkhand region

Species	Preferential frequency	A	B	C	D	E	Total	Rank
Acacia catechu	20.00	5	3	2	3	2	15	3
Acacia leucophloea	12.50	4	2	2	3	2	13	6
Acacia nilotica	55.83	5	3	3	3	3	17	2
Acacia senegal	12.50	4	2	2	2	3	13	7
Anogeissus pendula	5.83	3	2	1	2	2	10	8
Azadirachta indica	15.83	4	3	2	2	3	14	4
Dalbergia sissoo	9.17	3	1	2	2	1	9	9
Eucalyptus tereticornis	2.50	1	2	0	1	0	4	10
Leucaena leucocephala	13.33	3	5	2	2	2	14	5
Prosopis juliflora	76.67	4	5	4	4	3	20	1

(A- Burning base; B- Availability; C- Smoke less; D- Slow burning, E- No Sparking)

Table 77: Physical and Chemical properties of selected fuelwood species of Bundelkhand region

Tree Species	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)	Basic density (g cm^{-3})	Heating value (M j kg^{-1})	Calorific value (Kcal Kg^{-1})	Lignin content (%)	Fuel value Index
Acacia catechu	35.44	2.36	23.38	74.26	0.815	33.32	4946.06	34.13	3885.93
Acacia leucophloea	46.96	2.45	12.24	85.30	0.744	33.39	4968.59	22.13	1759.45
Acacia nilotica	42.62	1.58	12.68	85.73	0.630	33.68	4957.26	33.27	2439.04
Acacia senegal	22.12	3.51	19.65	76.83	0.729	32.96	4954.66	22.19	3625.41
Anogeissus pendula	27.25	3.68	14.80	81.51	0.701	32.94	4938.77	23.35	2969.40
Azadirachta indica	31.25	3.49	15.31	81.19	0.646	33.01	4536.83	27.50	2579.82
Dalbergia sissoo	36.93	1.69	11.74	86.55	0.646	33.65	4926.30	23.37	2014.93
Eucalyptus tereticornis	42.43	1.61	22.80	75.58	0.642	33.59	4835.6	21.78	1594.27
Leucaena leucocephala	35.29	1.70	14.51	83.79	0.647	33.63	4433.89	19.58	1593.07
Prosopis juliflora	36.26	2.25	13.35	84.39	0.736	33.45	4973.20	26.38	2661.66
Mean	**35.66**	**2.44**	**16.05**	**81.52**	**0.69**	**33.36**	**4847.11**	**25.37**	**2512.30**
SEd ±	1.42	0.13	0.68	0.68	0.02	0.04	30.43	0.56	108.11
CD 0.05	2.94	0.27	1.42	1.41	0.04	0.09	63.48	1.16	225.51
CD 0.01	4.02	0.37	1.93	1.93	0.05	0.13	86.59	1.59	307.62

2. Research Achievements

2.4. HRD, Technology Transfer & Refinement Programme

The Institute organized a number of Farmer's training programmes and other activities for transfer of agroforestry technologies to increase the awareness and knowledge for speedy adoption of agroforestry.

Vanmahotsava

Organised Vanmahotsava at Parasai-Sindh watershed in the 3rd week of July, 2014. Farmers have shown keen interest in tree plantation and agroforestry based interventions. MPTS were planted on field' bunds and boundaries.

Training

One day training programme on Dona making was organized on 30th August, 2014 at village Bachchauni for the tribal farmers of Parasail-Sindh watershed. Sami automatic platter making machine from glazed paper was demonstrated to SHGs members.

Trainings on Agroforestry

During the year total 14 trainings were organized, there by training nearly 430 farmers. They included horticulture development, watershed development and agroforestry development. Farmers from U.P., M.P. and Bihar underwent trainings on various subjects leading to agroforestry development. Several trainees contacted resource person afterwards to seek guidance (Table 78).

Table 78: List of trainings conducted at the institute

S. No.	Subject	Sponsored by	Duration	No. of trainings and Partici-pants
1	Udhyaniki Vikas	Jila Udyaniki Mission Samiti, Datia (M.P.)	29-31 January, 2014	01(50)
2	Jalagam Vikas hetu Karyacram ke Antargat Bhujal Sanrakshan, Phasalotapadan, Jeevanyapan evam Prabhav Mapan	LDWR, Department Jhansi	March to April, 2014	08 (240)
3	Kisan Study Tour and Krishivaniki Vikas	Forestry Research and Extension Centre, Patna	July to December, 2014	05 (140)

Exhibitions

Institute participated in District *kharif* Kisan mela, Baruasagar, Jhansi on 3rd October, 2014 and IGFRI foundation day on 1st November, 2014 at Jhansi. CAFRI organized exhibitions during two days Kissan Mela/Gosthi at villages Rasalpur Jattan and Barwala of Muzzafarnagar District (U.P.) on 13th -14th December, 2014. AICRP on Agroforestry Pantnagar also participated and assisted in exhibition.

VISITS

A Number of farmers, students and Govt./ NGOs officers from different parts of the country, *e.g.* CSWCR&TI, Dehradun, Agril. Department, Guna, Dhar (M.P.), Students from College of Forestry, JNKVV, Jabalpur, College of agriculture, JNKVV, Tikamgarh, AIR, Chhatarpur and State department official of different parts of the country and Bundelkhand region visited the Institute and demonstration sites during the period under report. These visits have increased the awareness of farmers towards the agroforestry practices.

Technology Transferred

Transferred the technology for construction of cost effective rainwater harvesting structures in Bundelkhand region to the officers and officials of state line departments of Jhansi district on 9th June, 2014 through one day training organized by CDO, Jhansi at Vikas Bhavan, Jhansi.

AICRP on Agroforestry

A. Research Achievements

Mettupalayam centre studied the carbon sequestration and assessment of soil fertility status under *Ceiba pentandra* based system. Among 32 districts in Tamil Nadu, Theni district recorded maximum area under *Ceiba* plantation (4650 hectares). 212 geo referenced soil samples from eight blocks covering 113 villages were collected at 0-15 and 15-30 cm depth under *Ceiba* plantation. On the basis of field and analytical findings, it was found that *Ceiba* based agroforestry system improved the soil fertility status over the agricultural cropping system. In all the eight blocks, available nitrogen was low to medium even under plantation. In order to enhance the nitrogen status of the soil, sustained application of organic manures or supplementation through inorganic fertilizers is recommended. *C. pentandra* having the capacity to sequester more carbon in the tree as well as in the soil, it can be recommended for agroforestry system to sustain the soil fertility and productivity. Among different agricultural crops, maize and pulses are grown as intercrops. The centre also standardized the nutrient management for *Ceiba* and found that application of N, P and K @ 200, 80 and 80 kg ha^{-1}, FYM @ 10 kg $tree^{-1}$, biofertilizers (Azophos and phosphobacteria) @ 25 g $tree^{-1}$ recorded the highest basal diameter (35.1 cm), tree height (9.22 m), pod yield (4236 kg ha^{-1}) and floss yield (1083 kg ha^{-1}).

The major recommendations for Konkan region of Maharashtra by Daploi centre included that *Dendrocalamus stocksii* (Managa) is more adaptable and more profitable followed by *Bambusa nutans* and *Bambusa arudinace*. In well drained lateritic soils groundnut and niger are most suitable intercrops for mango (10m x 10m spacing) and cashew (7m x 7m spacing) plantations, respectively.

Tamarind is one of the mandate tree species on which the Dharwad centre is working and there are 14 clonal materials being evaluated. Of the 14 clone the University has already released two clones (NTI-14 & NTI-79). The performance of NTI-14 (31.60 kg fruit $tree^{-1}$) and SMG-13 is good (30 kg fruit $tree^{-1}$) and these two clones are being vegetative propagated for demonstration under farmers field. The centre is also having the clones of red tamarind and sweet tamarind for which there is demand by the farmers. The centre is having 20 provenance collection of Neem being evaluated for their growth under transitional tract of Dharwad. Among these 20 collections, Bijapur, Gulbaraga, Raichur and Dharwad sources are identified as better sources and they are being used to develop Agroforestry models. Highest neem seed yield was observed in Bijapur (2.85 kg $plant^{-1}$) and Bhimarayangudi provenances (2.75 kg $plant^{-1}$). The centre is also working on different aspects of biofuel and is raising quality planting material of important tree borne oil seed species *viz*. pongamia, simarouba, neem, mahua, calophyllum etc. and a Biofuel Information and Demonstration Centre is in operation with an objective to cater various needs of the region. Large scale clonal orchard of important biofuel species is being developed.

Among the six clones of *Populus deltoides* evaluated in sodic soils by Faizabad centre, the clone L-49 performed better than the other clones. Under these clones, wheat variety NW-1067 and paddy variety Sarjoo-52 showed greater grain yield than the other wheat and paddy varieties grown during *rabi* and *kharif* seasons, respectively. Under *Casuarina equisetifolia-Psidium guajava* based agri-silvi-horticulture system, the fruit yield of *P. guajava* and turmeric yield was greater under the fertilizer treatment of 50% NPK (60N, 40P, 40K kg ha^{-1}) + 50% recommended dose of FYM (10 t ha^{-1}) than the other fertilizer treatments applied to this system. Under *Dalbergia sissoo* based silvipastoral system three grasses *viz*., *Pennisetum purpureum*, *Brachiaria mutica* and *Panicum maximum* were evaluated for their yield potential. Among these three grasses *P. purpureum* indicated maximum herbage yield (51 t ha^{-1}).

Fatehpur Shekhawati centre collected 24 candidate plus trees of *Prosopis cineraria* from different parts of the state and found that

maximum tree height, crown diameter and clean bole length registered for CPT BI-5 (10.5 m, 12.9 m and 4.6 m, respectively), however maximum dbh registered for CPT SI-1 (5.40 cm). Studies on intercropping of rainfed Kharif crop varieties with *Prosopis cineraria* and open field indicated that clusterbean varieties 936 and 197 gave highest gross returns as compared to other crop varieties, when intercropped with *Prosopis cineraria* and based on three years data it was observed that gross return of cluster bean crop was 15-30% more, when intercropped with *P. cineraria* in comparison to open field, especially in dry arid condition. This year the centre selected 40 more farmers in Banswara district under TSP component of the project. At present a total 120 farmers have been registered with this centre under this programme.

After seven years of plantation at Hisar, poplar has been found to attain significantly more girth at 5m x 4m and 10m x 2m spacing than paired row planting (18m x 2m x 2m). It was observed that poplar planted on field bunds affect the green fodder yield of sorghum up to 9 m distance and wheat grain yield up to 3 m distance from the tree line. The system found to sequester 97 % more carbon than sole agriculture. The rate of carbon storage was found to be 29.3 t ha^{-1} $year^{-1}$ in poplar based agroforestry system and 14.9 t ha^{-1} $year^{-1}$ in sole agriculture. Breeding behavior of *Melia composita* has been studied in detail and found that the species is predominantly self-pollinated resulting in narrow genetic base in the germplasm collected from northern India using RAPD molecular markers. Among different clones (C-1, C-3, C-7, C-10, C-52, C-72, C-83, C-130, C-271, C-288, C-316, C-405, C-413, C-526, HC-2045, HC-2049, HC-2070 and control) of eucalypts, clone HC-2070 was found promising w.r.t plant height (15.7 m) and dbh (21.3 cm) after 5.5 years of transplantation in the field.

A total of 29 germplasm lines of Pongamia were collected by Hyderabad centre in collaboration with NBPGR, regional center. The maximum height and girth of 5.8 m and 54.5 cm is recorded in the germplasm line SRJ-39, followed by line SRJ-43 with 5.7 m height and 46.3 cm girth. There was a general belief that there is no major problem of pests and diseases in Jatropha. However, all the 28 Jatropha germplasm lines at the centre were severely infested with the attack of multiple pests and diseases like mealy bug, root rot, mildew etc. due to which the flowering and fruit set is totally absent this year. The application of copper oxychloride as trenching in the basins is also found to be not effective in controlling the disease The mortality in most of the germplasm lines is 60-70% due to the attack of pests and diseases, except the lines RAJ-2, RAJ-3, RAJ-6, RAJ-9 and RAJ-10, where most of the plants are survived and appearance of new flush is under progress in these lines. *Melia dubia* is performing very well even under slightly alkaline (pH 8.3) conditions and the growth of plants was fast. After 15 months of plantation, the mean height recorded with different manurial treatments like FYM vermicompost, neemcake 2.0 kg $plant^{-1}$ along with 1.0 kg gypsum $plant^{-1}$ produced significantly higher mean height (4.2, 4.3, 4.4 m, respectively) and girth $plant^{-1}$ (15.3, 16.2, 16.4 cm, respectively) which was superior over control (1.8 m, 7.5 cm).

A lactation trial was conducted in cross bred dairy cows (Jersey x Sindhi) for 60 days to study the effect of feeding *Gliricidia sepium* leaves from silvipasture model on the milk yield and its composition at Kattupakkam. The edible fresh fodder biomass yield from *Gliricidia sepium* (4 harvests/year) was about 8 kg $tree^{-1}$. It was concluded that *Gliricidia sepium* could replace 15% of green fodder in lactating crossbred cows without affecting the milk yield and its composition and could sustain the milk production during scarcity of fodder. In another tree fodder trial, it was concluded that the *Leucaena leucocephala* + *Gliricidia sepium* leaf meal mixture could be used as a protein supplement to replace 30% of the conventional concentrate feed for goats. The centre also it is concluded that *Moringa oliefera* can be used as an alternative feed supplement without deleterious effects in goats.

Under poplar tree improvement at Ludhiana, significant differences among the ten clones were observed noticed for the DBH. The lowest value (17.6 cm) was in case of PIP- 321. The top rank was observed in case of L-48/89 and was closely followed by FNR 318 and FNR 55. Five clones registered higher diameter than that of G-48. A multi-locational trial for evaluation of 15 clones of poplar (5 from Pantnagar, 3 from

HAU and 7 from PAU) has been established at PAU Ludhiana and RRS Bathinda in January 2014. The Wheat variety HD 2967 recorded maximum grain yield than PBW 550 and PBW 343 when sown on 16th Nov. than 15th Oct. under 5 year old poplar plantation spaced at 5m x 4m. In turmeric based cropping systems in poplar, cultivation of moong and cowpea in between turmeric rows during initial period of its growth gave additional yield of intercrops (225 & 1243 kg ha^{-1}, respectively) without causing any adverse effect on turmeric. In weed control experiment in turmeric under 3 year old poplar block plantations spaced at 4m x3m; pendimethalin @ 0.975kg ha^{-1} and oxyfluorfen @ 0.235 kg ha^{-1} gave effective control of weeds, enhanced the crop yield and were safe to poplars. Under eucalyptus improvement trial involving 19 clones, all the traits differed significantly among the clones. The dbh ranged from 4.6 to 7.65 cm. Clones P-23 and C-413 were found to be superior by recording top rank and were followed by C-3020, 2013 and C-316. Clone 2188 was having the bottom rank. The centre has also put the ten new clones from previously selected elite genotypes for further investigation.

Studies conducted at Kahikuchi showed that *Acacia mangium* is most promising species for the region and attained 16.90 m height and 35.20 cm dbh at the age of 13 years. Timber volume was maximum (146.34 m^3 ha^{-1}) in 5 m x 4 m spacing. Maximum annual increment with regard to dbh (26.05%), timber volume (67.90%), tree biomass (53.83%) and canopy diameter (10.54%) were observed under 5 m x 6 m spacing. Nineteen seed sources of *Gmelina arborea* attained plant height of 11.20 to 13.78 m with their corresponding dbh of 15.5cm to 40cm in 13 years. Two bamboo species were evaluated by the centre, *Bambusa tulda* recorded plant height (12.39m), spread (2.95m), total culms (50.7Nos.) and canopy diameter (8.11m) at the age of 6 years. Maximum plant height (13.44m), spread (2.18m), average culms (34.6Nos.) and canopy diameter (7.54m) of *Bambusa balcooa* was recorded in the intercrop plot with turmeric in comparison to 11.01m,1.45m, 30.05Nos. and 5.77m in sole bamboo.

In a study on the evaluation of teak clones at Nagpur, clones PDKV/AF/1 and PDKV/AF/2 were significantly superior in respect of height (15.88 m) and dbh (20.05 cm) over local clone and respectively, produced 43.71 and 35.52 m^3ha^{-1} timber compared to seed raised (24.47 m^3 ha^{-1}) teak. Experiment conducted on the effect of soil and water conservation practices and felling intensity on production of bamboo showed that SWC treatment circular trench along with 20% felling intensity of bamboo have produced significantly higher number of new culms (6.66 Nos.).

The Pantnagar centre selected five mortality resistant and straight bole elite genotypes (PS-20, PS-38, PS-52, PS-54 and PS-90) of *Dalbergia sissoo* after II generation testing (based on 20 years evaluation) for establishment of seed orchard. A new stable variegated mutant has been identified in *Dendrocalamus asper* for ornamental purpose and a new genotype (PBN selection 12-1) of *Bambusa nutans* has been identified for water logged conditions. The centre achieved *in vitro* micro-propagation in the endangered species Phaldu (*Mirtagyna parvifola*). A first ever report on antibacterial activity of leaf, root and bark of *Adina cordifolia* was analyzed against *Escherichia coli*, *Bacillus subtilis* and *Pseudomonas aeruginosa*. Similarly, natural antioxidant activity was recorded in leaf, root and bark of *Adina cordifolia*. Efforts are in progress on revival of famous peepal (*Ficus religiosa*) at Kakrighat under which Swami Vivekanand meditated during his visit to Kumaun hills and new plants got propagated through macro-culture.

Comparative performance of promising poplar clones under agroforestry system at Pusa showed that at the age of the ten-year, L-52 attained the maximum height (15.02 m) and minimum in L-188 (12.46 m). A slight decrease in pH and EC was recorded under the poplar plantations of different clones. Organic carbon, total N and available P were built up under these three plantation and these nutrients were maximum under L-52 clones. The highest rate of decomposition in terms of % weight remaining was observed in the leaf litter of L-52 clone followed by L-49. Total above ground carbon stock in agroforestry system (Tree+Crop) varied from 34.18 (L-188) to 62.68 t ha^{-1} (L-52). An intercropping trial was conducted in 5-year-old Litchi (var. China) orchard planted at 7m x7m

spacing to identify the suitable and profitable intercrops. The results indicated that the production of fruits significantly increased due to intercrops and was maximum in association with turmeric (6.3 t ha^{-1}) followed by ginger (5.4 t ha^{-1}). On the other hand, reduction in yield of intercrops was 6.5 – 23.6% for turmeric, 12.4 – 38.2% for ginger, 9.8 – 30.2% for colocassia and 22.5 – 40.5% for elephant foot yam compared to the yield in open area.

In the second coppice after the age of tenth years of eucalyptus, the coppice of entry FRI-4 recorded maximum plant height, while *E. hybrida* recorded highest collar diameter and dbh at Rahuri. In ten plus trees of neem, the entry RHRAI-9 showed highest plant height, while RHRAI-10 recorded highest collar diameter and dbh. Selection RHRAI-5 recorded significantly highest bole height. Among the germplasm of *Acacia nilotica* var. *cupressiformis* and *Acacia nilotica* var. *indica*, the entry RHRANC-5 was found promising for all the growth parameters. Under multilocation trial of neem, the entry line -117 recorded highest plant height, collar diameter and dbh. In the germplasm of *Prosopis juliflora*, the entry RHRPJ-34 recorded significantly highest plant height and the genotype RHRPJ-32 was found promising for collar diameter. During the first year of second coppice of tissue culture propagated four elite eucalyptus clones, SRY-16 recorded significantly highest plant height, collar diameter and dbh.

The cyclone damaged all the agroforestry experiments located at OUAT, Bhubaneswar. There is large scale destruction and trees, which were planted after the super cyclone of 1999 were completely uprooted. The centre has developed agrisilvicultural system, four intercrops *viz*. one fruit crop pineapple (*Ananus comosus*) and three medicinal crops ghee kuanri (*Aloe vera*), kalmegh (*Andrographis paniculata*) and mango ginger (*Curcuma amda*) grown in the alleys (8.0 m wide) of two fast growing timber species (*Acacia mangium* and *Gmelina arborea*) at 625 trees ha^{-1}. Pineapple has been identified as the most suitable inter crop with mean net returns of ₹ 1,62,150 and 1,16,550 ha^{-1} $year^{-1}$ with B:C ratios 3.70 and 2.94 when intercropped with *Acacia mangium* and *Gmelina arborea*, respectively during 13th year of tree plantation, as against a net return of ₹ 76,860 with B:C ratio 2.28 when grown as a sole crop. In silvipastoral system, three fodder grasses (hybrid Napier, Guinea grass and thin Napier) were grown in association with three fast growing timber species (*Acacia mangium*, *Gmelina arborea* and *Tectona grandis*). The maximum green forage yield was obtained from guinea (30.56 t ha^{-1}) from three cuttings. In mango based agri-horti-silvicultural system involving 3 MPTs (*Acacia mangium, Dalbergia sissoo* and *Gmelina arborea*), the growth and yield of four inter crops (pineapple, Aloe vera, kalmeg and mango ginger) were assessed. Highest *Aloe vera* fresh leave and pineapple fruit yields were recorded in association with *Acacia mangium*. Pineapple was the best suitable crop to be included in the mango based agrihortisilvicultural system with net returns of ₹ 1,76,110, 1,61,590 and 1,25,465 /ha/year with B:C ratios 3.52, 3.31 and 2.79 when intercropped with *Dalbergia sissoo, Gmelina arborea* and *Acacia mangium*, respectively, as against a net return of ₹ 76,860 with B:C ratio 2.28 when grown as a sole crop.

Under horti-silvipasture system at Ranchi, it was observed that the plant height and diameter of gamhar (*Gmelina arborea*) and *Acacia mangium* was more with intercrops of forage crops Dinnanath grass and Guinea grass. It has also been observed that the green yield of forage crops decreased about 20-25% in compare to sole forage crop at the age of 9 years. Whereas, the organic carbon and nitrogen content (370 Kg ha^{-1}) has increased in the system.

The D & D survey in hill zone of Karnataka conducted by Bangalore centre revealed that agroforestry component among the farmers was mainly for monitory purpose and good number of trees were planted by the farmers for providing shade and protection to the coffee and as a livelihood security especially in the case of home gardens. The centre established clonal seed orchard of simarouba and tamarind, comprising of 14 germplasms 7 each in Kaali and Gouri. Among 40 tamarind selections established at ARS, Chintamani, H-2, H-3, H-11, H-12, GKVK-4, GKVK-10, GKVK-13 and GKVK-17 were identified as high yielding selections, however, GKVK-17 recorded higher cumulative and average yield $tree^{-1}$. In agroforestry management studies, fingermillet was grown as an associate crop along

with different TBO's, dry land orchards and *Melia dubia*. Though there was appreciable reduction in yield, the net income, carbon sequestration and water use efficiency was higher with agroforestry system as compared to sole fingermillet. Agroforestry based integrated farming system, sesbania (Agase) found to be good fodder tree during the lean period. In addition, IFS under rainfed and irrigated system recorded sustained production, improvement in soil health, increased mandays for employment opportunity and finally enhanced farm income. Tribal sub plan was implemented in Ganigamangala village, chamarajnagar district comprising of 126 farmers. Major activities implemented were supply and planting of Agroforestry trees including dryland fruit crops. Totally 6449 seedlings comprising of *Melia dubia*, *Grevelia robusta, Syzygium cumini, Mangifera indica, Emblica officinalis, Achras sapota, Psidium gujava* and *Citrus limon* were planted and their establishment is satisfactory.

At SK Nagar, among the 17 provenances of neem provenance from Bharuch recorded highest CD (32.80 cm). Under multi-location trial of 10 elite progenies of neem, line 108 recorded highest plant height (7.17 cm) after 10th year of plantation. In aonla based agroforestry system with different moisture conservation techniques, the organic mulch treatment recorded significantly higher seed and fodder yield in greengram and gross income over control after seven year of experiment. Under custard apple based horticultural system, the combination of custard apple + cowpea recorded higher green fodder production (2777 kg ha^{-1}) and gross income over other combinations. The centre adopted four villages of Amirgadh taluka (Tribal area) under TSP and seeds, seedlings and fertilizers were distributed to the tribal farmers.

Early results of understorey productivity trial at Thrissur in four land management systems *viz.* homegarden, coconut, rubber and cashew plantations by growing four medicinal herbs *viz.* ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), kacholam (*Kaemferia galangal*) and chittaratha (*Alpinea calcarata*) revealed that intercrop performance were better in the mature rubber plantation and homegarden while the best performer among the intercrops was turmeric. Considering the scarcity of green fodder and high cost of feeds in Kerala, an intensive and sustainable fodder cultivation trial was initiated through 3-tier silvopastoral systems to cater the fodder demands of small scale farmers. Preliminary observations revealed that, three- tier silvopasture systems including mulberry/ calliandra + hybrid napier + stylosanthes/ desmanthus is a better option for improving the productivity (18 t dry matter ha^{-1}) and quality (2 t of crude protein ha^{-1} on dry matter basis) of forage in comparison with pure hybrid napier cultivation (15 t of dry yield and 1.4 t of crude protein ha^{-1}), for profitable milk production. Among the 10 *Acacia mangium* provenances, Kuranda and Upper Aramia showed better growth performance. Teak provenances trial after 12 years of stand age showed that Nilambur provenances *viz.* Cherupuzha, Nedumkayam-1 and Nedumkayam-2 were better performers in height, diameter and volume production. In the silvopastoral trial involving 4 fodder trees and 4 fodder grasses, the tree growth was highest for *Gmelina arborea* (height, 5.19 m; collar diameter, 13.41 cm), while the hybrid napier recorded the highest fodder yield (13.41 Mg ha^{-1}). Interestingly, the highest understorey fodder yield was with *Gmelina arborea* (10.11 Mg ha^{-1}).

Different agroforestry technologies developed through on-station experimentations, have been disseminated to the farmers' field for its validation through adaptive trials by Jhargram centre. The most preferred system by farmers are mango and guava-based agroforestry systems, alongwith timber species as boundary plantation such *Dysoxylum binectariferum* which is self-pruning and bole length is also very good. The mango + *Dysoxylum binectariferum* + arable / vegetables crops system has been highly accepted by the farmers of 24-Parganas, Paschim Medinipur, Hoogly, Nadia districts of West Bengal and found very much profitable.

Ten new selections of *Salix alba* collected by Srinagar centre from Anantnag and Pulwama districts grown in nursery for a period of two years revealed that P7 attained maximum increment of 0.23m in height and 3.10mm in collar diameter. The centre studied potential of *Paulownia* for carbon sequestration and found that a

plantation of 400 trees ha^{-1} fixes about 17,200 kg of elemental carbon (dry weight basis) by removing nearly 63,067 kg of carbon dioxide from the atmosphere. The average air dried wood density was 90 and 353 kg m^{-3} at the age of 1 and 9 years, respectively. The specific gravity of wood increased from 0.11 at the age of one year to 0.39 after nine years of growth. Despite these wood characteristics, the species has a hollow stem and thus can not be recommended for use as timber. During 5th year of evaluation, the yield of apple fruit was 12.39 t ha^{-1} when intercropped with lucerne followed by 12.07 t ha^{-1} in combination with Artemisia as compared with 6.28t ha^{-1} recorded in control (apple alone). The yield of green grass under horti-pastoral system was 22 t ha^{-1} for Orchard grass and 20 t ha^{-1} for lucerne.

Solan centre evaluated eleven clones of *Morus alba* for growth and developmental and found that after 7 years of plantation the collar diameter growth was maximum in the clone 7, whereas the plant height growth was maximum in the clone No. 5. Maximum leaf (10.03 t ha^{-1}) was displayed by clone No. 5. Whereas, total biomass (leaf+ branch wood biomass) (41.99 t ha^{-1}) was displayed by the clone No. 6, which was closely followed by clone no.5. Centre investigated the rooting behaviour of *Morus indica* stem cuttings in response to auxin formulations, cutting diameter and provenance. It was found that maximum rooting (74%), when the propagules were treated with 0.6% IBA. The cuttings of stem diameter > 1.25cm gave significantly higher rooting response. In the provenances, the propagule drawn from the Solan gave the best rooting response (74%). Investigations were carried out to study the impact of distance and direction of plum tree on maize yield production. The maize character *viz.* supporting roots $plant^{-1}$, number of cobs $plant^{-1}$ number of plant m^{-2} were non-significantly influenced due to distance and direction effect of plum tree. However, plum plant height, grain weight, grain yield and straw yield were significantly influenced. The grain weight, grain yield and straw yield followed the trend: south> west> east> north. These traits enhanced with increasing distance from tree row. The yield traits at 3 m from tree almost attained the values as are in the open field.

Inventory of the status of traditional agroforestry systems of Kangra valley prepared by Palampur centre showed that in Zone I farmers have been practicing agri-silviculture, agri-horti-silviiculture system in general and in the upper slopes they were practicing Horti-silviculture and silvipasture system. In zone II, the order of predominance of the agroforestry system was agrisilviculture, silvipastoral and horti-silviculture. Agro forestry system had been maintained as a part of rural survival system for generation with their multi storey vegetation structure and diverse type of plant community. Morus and Setaria and Napier grasss based system yielded 12.5 t ha^{-1} leaf fodder and grass yield of 32.0 t ha^{-1} from setaria indicating that on wastelands producing only 7.5 t ha^{-1} with traditional systems can be enhanced to 52.5 t ha^{-1}.

Annual Group Meeting

On 26th July, 2014 Prof. M Kar, Hon'ble Vice Chancellor of OUAT, Bhubaneswar inaugurated the three days Annual Group Meeting of All India Coordinated Research Project on Agroforestry organized at OUAT, Bhubaneswar. In his inaugural speech Prof. Kar stressed upon dissemination of appropriate agroforestry models for the benefit of small and marginal farmers. He emphasized the need for integrating livelihood options in the agroforestry models. Mr. R S Gopalan, IAS, Director of Agriculture and Food Production, Govt. of Odisha emphasized on the need to initiate work on tree borne legumes and ecosystem services of agroforestry. Dr. S K Dhyani, Project Coordinator and Director, CAFRI, Jhansi presented the Coordinator's Report and brief summary of the research achievements of the project for the year 2013-14 and thrust areas for the XII Plan. In the beginning, Dr. P K Das, OUAT welcomed the dignitaries and delegates. During the occasion a Souvenir and one Technical Bulletin on *Acacia mangium* was released. The AICRP on Agroforestry was initiated in 1983 and it has 37 centres at present. The meet was attended by 24 coordinating centres located in SAUs and three volunteer centres in ICAR Institutes. During the three days meeting there were 9 Technical sessions including inaugural and plenary sessions in addition to field visit to the agroforestry

Annual Group Meeting of AICRP on Agroforestry 2014 at OUAT, Bhubaneswar

experimental area of the University. The group meet emphasized upon the dissemination of agroforestry technologies for benefit of the farmers. One of the sessions was devoted for formulating workable linkages between AICRP on AF and AICRPs of Dryland Agriculture, Forage Crops and Integrated Farming System.

Training programme on Willow mortality in Lahual & Spiti Distt. of Himachal Pradesh under Tribal sub Plan

The farmer's training programme on "Modern cultivation of seed potato, wheat and agroforestry" was organized at Dalang Maidan, Lahual & Spiti from 5th to 7th August, 2014. The training was jointly organized by Regional Station, DWR, Dalang Maidan, NRCAF, Jhansi and CPRI, Shimla alongwith the coordinating centre of AICRP on Agroforestry at YSP UHF, Solan and CSK HPKV, Palampur. The training was attended by about 50 farmers from different villages of Lahaul-Spiti valley. The training was organized as a follow up action of the scientist-farmer's interface meet organized last year at this venue during the visit of Dr. S Ayyappan, Secretary, DARE and DG, ICAR, where farmers raised the question of Salix mortality in the region. After the registration of the participating farmers, the inauguration session was held under the chairmanship of Dr. S K Dhyani, Director, CAFRI, Jhansi. After brief introduction of farmers and experts, Dr. Dhayni briefed the gathering about the role of agroforestry in providing livelihood support and income generation in the region and how the farmers of the valley can utilize different tree species and resistant clones of willow to solve their problems. Dr. A K Handa, Pr. Scientist, CAFRI informed about the agroforestry activities undertaken under Tribal Sub Plan of the Project and suitable agroforestry systems for the region.

Dr. N K Pandey and Dr. Dhurv Kumar from Regional Station, CPRI, Meerut also interacted with the farmers. The scientists visited the Lahaul-Spiti valley from 5th to 7th August, 2014. During the visit, the willow trees were found drying on a large scale in the valley. There were wide stretches of dried willow trees especially in the villages Sissoo (70-80%), Gondhla (75-85%), Tandi (50-60%), Kargha (70-80%) and Keylong and adjoining areas (50-60%). In Tholang, Tilling, Keylong, Karding and Gondhla villages also high mortality was observed. In addition, trees were also seen drying in varying proportions at other localities in the valley. Unlike the tree trunk, branches were severely affected having cankerous lesions (3-15cm) at emergence point of branches. A large number of branches were seen dried resembling die-back symptoms as a result of girdling due to canker. The affected part was depressed, somewhat flattened, light brown to dark brown with raised edges (callus) and split bark. The dried branches were light brown to yellow in colour with tight skin having pimples in which amber yellow or orange coloured exudations of spore masses in cirrhi (thread like spore tendrils) pushing through the epidermis were commonly observed.

The severely cut/lopped and water stressed trees were found more affected than the trees near

water channels or in the irrigated area. In addition to it, the trees were also found severely infested with white scale insects. The infestation of giant willow aphid was also reported by the scientists of Himalayan Forest Research Institute (ICFRE), Shimla. The association of the sap sucking insects (scale and aphid) and water stress may have rendered the plants vulnerable to the attack of the *Cytospora* fungus. Moreover, the injuries inflicted as a result of unscientific cutting/ lopping of the trees have further aggravated the situation as the associated fungus is otherwise a weak pathogen which attacks the stressed/ weakened plants and requires injuries for infection. The observations gathered from time to time during the previous survey/visits of the valley since 1999 by the scientists of YSP UHF, Solan conclusively revealed that water stress, changes in weather conditions, ageing of the trees, nutrient depletion, infestation of sucking insects and injuries inflicted as a result of unscientific cutting/lopping of the trees have rendered the willow plantation weak and vulnerable to the attack of the *Cytospora* fungus. The ultimate drying of the trees is due to the attack of this fungus causing cankers and girdling of the branches/shoots.

With the changing environment scenario farmers were advised to use improved management practices like lopping of fully crown tree, use of disease free saplings plants. Planting of single sapling in place of three in a pit and also use of improved clones of willow developed by the YSP UHF, Solan is recommended. In addition the following suggestions were given to the farmers to overcome the problem of Salix mortality;

- Farmers were advised to plant other fodder species like higher altitude Mulbrery (*Morus laevigata*).
- Planting trees in good/deep soil on a proper site.
- Water stress to the plants should be avoided and adequate moisture in the root zone may be maintained through adequate irrigation.
- Avoid excessive lopping or pruning of bigger branches.
- Bark of the young planted seedling/cutting should be protected from animal damage.
- Avoid south-west facing slopes; sandy and gravelly soils.
- Select only healthy sticks for plantation purpose which are free from canker and scale infestation.
- Replacement of the existing poor stock with superior clones developed by YSP UHF, Solan.
- Creating awareness for proper planting stock among the growers. Since wild willow is least affected by disease, therefore its potential in plantation and producing new resistant willow planting material needs further investigations.
- New plantations may be raised through entire transplantation instead of cuttings from old existing plantations.

An action plan with the involvement of the AICRP on Agroforestry Centres at YSPHUF, Solan and CSK HPKV, Palampur was also developed to tackle the willow mortality and providing alternate sources for fuel-fodder.

Willow plants drying

Scientists interacting with farmers

Scientists visiting the villages reporting high mortality of willows

4. Awards and Recognitions

- संस्थान के डॉ. अरूण कुमार हाण्डा, प्रधान वैज्ञानिक को भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली द्वारा वर्ष 2013 में आयोजित हिन्दी चेतना मास के दौरान उनके द्वारा लिखित स्लोगन को सांत्वना पुरस्कार दिया गया। यह पुरस्कार नास कॉम्प्लैक्स, नई दिल्ली में 1 जनवरी, 2014 को आयोजित कार्यक्रम में महानिदेशक, भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली द्वारा प्रदान किया गया।
- Dr. Inder Dev, Pr. Scientist received the best poster presentation award during ISTS-IUFRO Conference (13th -15th March, 2014) on "Sustainable Resource Management for Climate Change Mitigation and Social Security" held at Chandigarh. He presented the research poster entitled "Participatory evaluation of groundnut as a tool to enhance productivity under SAT region of Central India" authored by Inder Dev, Ramesh Singh, Kaushal K Garg, R K Tewari, S K Dhyani, R H Rizvi, K B Sridher, R P Dwivedi, Rajendra Singh and R K Singh.
- Dr. Asha Ram, Scientist was received the Second Prize of Dhiru Morarji Memorial Award for Best Article in Agricultural Sciences 2013-14 for his article on "Direct and Residual Effect of S on Productivity, Protein Content and Nutrient Uptake in Wheat under Aerobic Rice- Wheat Cropping System" published in March, 2014 issue of Indian Journal of Fertilizers, New Delhi.
- Dr. S Vimala Devi, Sr. Scientist awarded INSA Visiting Scientist Fellowship for the year 2014-15 by the Indian National Science Academy, New Delhi.

5. Visit Abroad

The Indian Council of Agricultural Research (ICAR), New Delhi and World Agroforestry Centre (ICRAF), Nairobi, Kenya signed a collaborative Work Plan for enhanced focus in R&D in agroforestry. Under ICAR- ICRAF collaborative Work Plan Dr. Ramesh Singh, Pr. Scientist and Dr. R H Rizvi, Sr. Scientists participated in the International Training Progamme on "Use of Geoinformatics in mapping Agroforestry" organized during 1st - 5th December, 2014 at World Agroforestry Centre, Nairobi, Kenya.

6. Linkages and Consultancy

A. Linkage

Linkage between AICRP on Agroforestry and AICRP on Integrated Farming System was initiated for strengthening partnerships between two AICRP on agroforestry and integrated farming system'

1. Workshops held

In total five workshops were organsied on strengthening partnerships at different regions by IIFSR, Modipuram. However, there were three workshops held on strengthening partnerships where CAFRI was one of the partner for convergence and these workshops were held on 9th June, 2014 (ICAR Research Complex for Eastern Region, Patna), on 11th August, 2014 (CCS, HAU, Hisar) and on 29th August, 2014 at S.K. Nagar, Gujrat.

2. Expected deliverables

Specified points of collaboration and its location with expected deliverables

2.1. For Eastern region; Centre: AICRP on AF, OUAT, Bhubaneshwar

Specified work in SoU/MoU	Location of collaborative work	Expected deliverables in 2014-15 Indicator / Unit	Target
Work on agro-forestry component in the farming system models	Bhubaneswar	No. of studies	1
Demonstration of MPTS based agro-forestry systems at on-farm	Angul Kendrapara	No. of demonstra-tions	6
Need based capacity building for the AICRP-IFS staff and farm families	Bhubaneswar Angul Kendrapara	No. of trainings	3
Recording of observations on agroforestry component	Bhubaneswar	No. of times	2

2.2. For Northern region; Centre: AICRP on AF, PAU, Ludhiana

Specified work in SoU/MoU	Location of collabora-tive work	Expected deliverables in 2014-15	
		Indicator / Unit	Target
Work on agro-forestry component in the farming system models	Ludhiana	No. of studies	1
Demonstration of MPTS based agro-forestry systems at on-farm	Amritsar	No. of demonstrat ions	2
Need based capacity building for the AICRP-IFS staff and farm families	Amritsar	No. of trainings	1
Recording of observations on agroforestry component	Ludhiana	No. of times	2

2.3. For Western region; Centre: AICRP on AF, *SKDAU, S.K. Nagar*

Specified work in SoU/MoU	Location of collabora-tive work	Expected deliverables in 2014-15	
		Indicator / Unit	Target
Work on agro-forestry component in the farming system models	Ludhiana	No. of studies	1
Demonstration of MPTS based agro-forestry systems at on-farm	Amritsar	No. of demonstra tions	2
Need based capacity building for the AICRP-IFS staff and farm families	Amritsar	No. of trainings	1
Recording of observations on agroforestry component	Ludhiana	No. of times	2

B. Consultancy Services

CAFRI initiated work on the consultancy project entitled 'Impact assessment of soil and water conservation measures in forest fringe in Bundelkhand region of Uttar Pradesh' for the period of April, 2014 to October, 2015. Project is sponsored by Uttar Pradesh Forest Department. The team of Scientists conducted the survey in the districts of Lalitpur and Jalaun.

7. Ongoing Research Projects (2014-15)

Institute code	Title	Duration	Principal investigator	Associates
Systems Research: (Programme Leader: Dr. Anil Kumar)				
AF02.12	Effect of irrigation on performance of aonla under agroforestry systems	2005-2015	Dr. R K Tewari	Dr. Ramesh Singh
AF02.14	Nutrient management in ber based agri-horti system	2010-2020	Dr. Sudhir Kumar	Dr. Anil Kumar, Dr. Rajendra Prasad & Dr. Inder Dev
AF03.9	Initiation of pruning and its intensity on productivity of *Albizia procera*	2006-2020	Dr. Inder Dev	Dr. K B Sridhar
Observational Trial	Development of bamboo based agroforestry systems	2007-2014	Dr. Inder Dev	Dr. K B Sridhar
Natural Resource & Environment Management: (Programme Leader: Dr. Ram Newaj)				
AF01.16	Evaluation of shade tolerance of crop species for agroforestry systems	2007-2016	Dr. Badre Alam	Dr. Ram Newaj
AF01.24	Studies on arbuscular mycorrhizal fungi of important MPT's	2008-2016	Dr. Anil Kumar	Dr. Rajendra Prasad
AF01.25	Development of soil quality index for assessing soil health of different agroforestry systems.	2008-2015	Dr. Rajendra Prasad	Dr. Ram Newaj & Dr. Ramesh Singh
AF 05.6	Model watershed project on natural resource management through agroforestry interventions at Garhkundar, Tikamgarh, M.P. **Programme Coordinator: Dr. S K Dhyani**	2005-2016	Dr. R K Tewari	Dr. Ramesh Singh, Dr. R P Dwivedi & Dr. R H Rizvi
AF 05.11	Multi-source inventory methods for quantifying carbon stocks through generalized volume/ biomass equations for prominent agroforestry species in India	2011-2017	Dr. Ajit	Dr. A K Handa & Dr. R H Rizvi
AF 05.12	Agroforestry based conservation agriculture for sustainable land use and improved productivity	2013-2018	Dr. Inder Dev	Dr. R K Tewari, Dr. Ramesh Singh, Dr. Asha Ram, Dr. K B Sridhar, Dr. Anil Kumar, Dr. ahendra Singh & Sh. A R Uthappa
NICRA	Assessment of carbon sequestration potential of agroforestry systems (National Initiative on Climate Resilient Agriculture) **Programme Coordinator: Dr. S K Dhyani** **Lead Institute: CRIDA, Hyderabad**	2011-2017	Dr. Ram Newaj	Dr. Rajendra Prasad, Dr. A K Handa, Dr. Badre Alam, Dr. Ajit, Dr. R H Rizvi & Sh. S B Chavan
MoRD, New Delhi	Model watershed for sustaining agricultural productivity and improved livelihoods. a) Domagor-Pahuj b) Parasai-Sindh **Programme Coordinator: Dr. S K Dhyani** **Lead Institute: ICRISAT, Hyderabad**	 2009-2015 2011-2016	 Dr. Ramesh Singh Dr. Ramesh Singh	 Dr. R K Tewari & Dr. R H Rizvi Dr. R K Tewari, Dr. Inder Dev, Dr. R H Rizvi, Dr. K B Sridhar & Dr. R P Dwivedi

Institute code	Title	Duration	Principal investigator	Associates
Inter Institutional project	Evaluation of aonla based horti-pasture system under different soil & water conservation practices in Central India. **Lead Instt.:IGFRI, Jhansi**	2007-2017	Dr. Sunil Kumar	Dr. Ramesh Singh, Dr. Sunil Tiwari & Dr. A K Shukla
Observational trial	Weed dynamics studies in different agroforestry systems	2012-2015	Dr. Inder Dev	---
AF 04: Tree Improvement, Post-Harvest and Value Addition (Programme Leader: Dr. A K Handa)				
AF01.23	Comparative studies on seedling and clonal plants of *Pongamia pinnata* with special reference to their adaptability to rainfed dry agroclimate	2007-2017	Dr. Badre Alam	Dr. A K Handa & Dr. S Vimala Devi
AF 04.1b	Exploration, evaluation and conservation of germplasm of *Acacia nilotica*	2002-2016	Dr. S Vimala Devi	Dr. Badre Alam
AF 04.5	Genetics and breeding of *Jatropha* species	2004-2017	Dr. S Vimala Devi	Mr. S B Chavan
AF 04.9	Assessment of candidate genes for oil biosynthesis in *P. pinnata* using eco-tilling approach	2012-2015	Dr. S Vimala Devi	Dr. A K Handa & Dr. Sudhir Kumar
AF 05.10	Lac based agroforestry in Bundelkhand region: Introduction and evaluation	2008-2015	Dr. K B Sridhar	Dr. Sudhir Kumar, Dr. Rajendra Prasad, Mr. Rajendra Singh, Dr. S Ghosal, Dr. Md. Monobrullah, Dr. Mahendra Singh & Dr. R P Dwivedi
ICAR, IINR&G, Ranchi	Development of agroforestry models based on gum yielding trees for livelihood security and horizontal dissemination of technologies	2008-2017	Dr. Rajendra Prasad	Dr. A K Handa, Dr. Ajit, Dr. Ramesh Singh & Dr. Badre Alam
NOVOD Board Project	National network on integrated development of Jatropha and Karanj	2005-2015	Dr. S Vimala Devi	Mr. S B Chavan
AF 05: HRD, Technology Transfer & Refinement (Programme Leader: Dr. R K Tewari)				

Concluded Projects

Concluded Projects				
AF01.17	Analysis of Eucalyptus based agroforestry for crop- lands in Jhansi	2003-2014	Dr. A K Handa	Dr. Ram Newaj, Dr. Badre Alam, Dr. Anil Kumar, Dr. Ajit & Dr. Ramesh Singh
AF01.22	Studies for augmenting pistillate flowers with exogenous application of growth regulators and chemicals in *Jatropha curcas*	2007-2014	Dr. Badre Alam	Dr. Sudhir Kumar
AF 04.6	Age- age correlation model for juvenile selection of trees in agroforestry	2004-2014	Dr. R H Rizvi	Dr. Ajit & Dr. K B Sridhar

8. Publications

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Dev, I, Dhyani, S K, Handa, A K and Tiwari, Rupali (2014). Intellectual Property Rights in Agroforestry: Issues and Concerns for the Farmers. *Indian Journal of Agroforestry,* 16(2): 86-98.

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Dwivedi, R P, Kareemulla, K and Rizvi, R H (2013). Agroforestry Systems in Saharanpur and Aligarh Districts of Uttar Pradesh: A Socio-Economic Analysis. *Indian Journal of Extension Education,* 49 (3&4): 121-125.

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Newaj, Ram, Dhyani, S K, Nikhar, Shikha and Jha, Ankur (2014). Bundelkhand Chetra Men Krishi Bhoomi Par Mishrit Pedon Men Jaivpunj Va Carbon Bhandaran Ke Vartman Eisthiti. *Krashika*, 2(2):19-23.

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(B) Technical Journals

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Kumar, Anil (2014). Uchch Shiksha Par Kendra Kee Pahal avam Yogdan. *Krishivaniki Alok,* Vol.8, published by CAFRI, Jhansi:11-12.

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(D) Chapters in Book

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Ajit (2014). Modeling Carbon Sequestration Potential of Existing Agroforestry Systems: A Case Study of Three Districts under Indo- Gangatic Plains in India: ***In:*** Training Manual of ICAR sponsored Short Course on Agroforestry for Biofuels and Bioenergy (Eds. S Vimala Devi, K B Sridhar, S B Chavan, A K Handa and S K Dhyani) during 15th -24th September, 2014 held at CAFRI, Jhansi: pp191-204.

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9. Important Meetings / Activities

ICAR Industry Day and Agricultural Education Day

ICAR Industry Day and Agricultural Education Day was organized at CAFRI, Jhansi on 28th February, 2014. Almost 150 participants

including thirty post-graduation students along with faculty member from Bipin Bihari Post Graduate College, Jhansi, SRF, RA, M.Sc. students and Ph. D. Scholars participated in the function. Lectures on Agricultural Education Scenario in India and status of agri-based industries in Jhansi were delivered. Present scenario of agri-based industries in the region is bleak and mostly confines to sale of produces and agri-inputs. Scope of fruit and vegetable preservation, value addition, creating alternate livelihood support systems through cultivation of lac, gum/resin, medicinal/aromatic plants and floriculture in Bundelkhand region was discussed at length. Bamboo/Date palm based small cottage industry need promotion in the region as they are commonly found in wastelands and under agroforestry system on field bunds. CAFRI, Jhansi can contribute in this direction by way of identifying quality germplasm and ensuring availability of mother plants, imparting training on lac cultivation, fruit and vegetable preservation, vermin composting etc. However, agri-based industry development requires greater input from various State Agencies, NGO and Societies. Students were taken to laboratory and farm visit.

Training Programme on "Protection of Plant Varieties and Farmers Rights Act"

An awareness cum training programme on "Protection of Plant Varieties and Farmers Rights Act" was conducted on 28th February, 2014. During the training program detailed information was given on the topics *viz*., Plant variety protection and farmers rights- an introduction and their

objectives, Introduction to Intellectual Property Right and Plant protection rights and Farmers rewards and covering the plant variety development process and uses, local land races and extant varieties, breeders rights, registration and duration of protection under act, depositing the samples, Indian plant variety journal, notification of varieties, gene bank, profit sharing, national gene fund, submission of application, recognition and rewards, etc. The Impact of the training was realized by the different categories of participant *viz*., scientist, development workers,

research scholars and farmers, from different district of Bundelkhand.

Foundation Day and Observation of National Agroforestry Day

26th Foundation Day and National Agroforestry was celebrated on 8th May, 2014. Dr. D N Tewari, Former Member, Planning Commission, Govt. of India and Ex-DG, ICFRE was the Chief Guest. In the inaugural function salient activities and achievements of the Institute

were presented. Employees of the Centre, guests, progressive farmers, research scholars, students and officers of line departments participated in the function. On the occasion, best paper, best worker awards were given to Scientific, Technical and supporting staff.

Round table scientific exchange workshop on "Drought Proofing Strategy for Semi-Arid Region of Bundelkhand"

In order to help the farming communities of Bundelkhand to manage drought like conditions in semi-arid region, scientific experts and civil society experts working in drought prone region of Bundelkhand participated in the round table scientific exchange workshop, "Drought Proofing Strategy for Semi-Arid Region of Bundelkhand" on 4th July, 2014 at CAFRI, Jhansi. The workshop was organized by the Development Alternatives in association with India Water Partnership and Global Water Partnership under the Water and Climate Resilience Programme. Scientific experts from ICAR institutions *viz.* CAFRI, IGFRI, CSWCR & TI, Regional Station, Datia, National Institute

of Disaster Management, Krishi Vigyan Kendras, Bundelkhand University and Development Alternatives participated in the workshop to provide expertise for drought preparedness and sharing experiences for drought mitigation in the region. Scientists participating in the workshop with vast knowledge on the subject and experience from field helped us to develop a package of robust adaptation options for drought mitigation in the region. Subsequent to the presentations by the speakers, the participants discussed to identify key adaptation strategies for increasing the resilience of communities against drought like situations.

Institute Management Committee (IMC)

The 18th IMC meeting was held on 5th July, 2014 at CAFRI, Jhansi under the chairmanship of Dr. S K Dhyani, Director, CAFRI, Jhansi. Dr. Ramesh Singh made a presentation on watershed management in the semi-arid region. In his presentation, he informed that there were severe droughts in Bundelkhand region from 2004 to 2007. More than 81% wells became dry resulting into

severe scarcity of drinking water. There was huge migration towards metros in search of livelihoods. CAFRI took up the initiative to develop technological options in participatory mode for sustainable agriculture production through integrated watershed interventions. All members appreciated the efforts of the CAFRI particularly for dissemination of the technology to the stakeholders. They emphasized that technology should be developed for small farmers, need of strong linkages between the Centre and State departments and collaboration with KVKs. After the discussion, the Committee confirmed the proceedings of 17th IMC. The Committee thereafter discussed the new proposals.

Short Course on "Agroforestry for Biofuels and Bioenergy"

ICAR sponsored 10-days short course on "Agroforestry for Biofuels and Bioenergy" was organized at Central Agroforestry Research Institute, Jhansi during 15th to 24th September, 2014. Dr. D N Tewari, Ex-DG, ICFRE, Ex. Member Planning commission and QRT Chairman inaugurated short course and Dr. S K Dhyani gave the inaugural lecture. Lectures on biofuels and bioenergy were delivered by resource persons. Practical demonstrations on the oil properties for biofuels including the saponification value, free fatty acids value and the method of trans-esterification of oil to produce biofuels were demonstrated. Field visits were organized to Development Alternatives and watershed program of CAFRI. The industrial experience on biofuel production and processing was shared by the resource person from Ruchi biofuels.

Coordination Committee Meeting

The 6th Coordination Committee Meeting of the Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums was held on 17th & 18th October, 2014 at ICAR-CAFRI, Jhansi to review the annual progress of the centres and discuss their technical programme for the year 2014-15. The representative scientists from all the networking centres namely IINRG, Ranchi (Jharkhand); CAFRI, Jhansi (Uttar Pradesh); CAZRI, Jodhpur (Rajasthan); Dr. YSPUH & F, Solan (Himachal Pradesh); IGKVV, Raipur (Chhattisgarh); JNKVV, Jabalpur (Madhya Pradesh); MAU, Prabhani (Maharashtra); TNAU, Mettupalayam (Tamil Nadu): KAU, Thrissur (Kerla) and ICAR Research Complex for NEH Region, Uminan (Meghalaya) participated in the meet. Delegates also visited gum based agroforestry models established at CAFRI farm.

Research Advisory Committee

17th RAC meeting of CAFRI was held on 6th & 7th November, 2014. The chairman and all members of RAC, Programme Leaders and Scientists were participated in the meeting. The

RAC members interacted with the scientists, reviewed the ATR and visited the Research farm.

Farm Innovators Day & World Toilet Day

CAFRI observed Farm Innovators Day and World Toilet Day on 19th November, 2014 at Parasai-Sindh watershed in Babina block of Jhansi district.

Dr. Javed Rizvi, Regional Director and Dr. Rajendra Choudhary, Senior Liaison & Monitoring Officer, South Asia Programme, ICRAF, New Delhi visited the Parasai-Sindh watershed and interacted with the farmers. They observed the interventions taken up in watershed and discussed the impact of the measures with the accompanying farmers. The ICRAF team was overwhelmed after seeing the surface water in ephemeral drains in about 2.0 km length, large scale adoption of teak based agroforestry (more than 200 acre) on field boundaries and homestead agroforestry in majority of the households. The team held interactions with community and realized that virtually there is no impact of deficit rainfall (31% less than long term average rainfall) on agricultural activities. More than 90% area of the watershed is cultivated. Villagers opined that hardly 40% area is expected to be cultivated outside watershed during *rabi,* 2014-15 due to deficit rainfall.

The issue of sanitation and cleanliness was also raised and the team advised the villagers about benefits of having plants of guava, aonla, drumstick, tulsi and giloy in the backyard of the household. There was an interaction with the students of middle school and farmers at Chhatpur regarding World Toilet Day and general cleanliness as well as importance of agroforestry in day to day life along with its role in mitigating climate change.

International Training programmes on Agroforestry at Central Agroforestry Research Institute, Jhansi and World Agroforestry Centre, Nairobi, Kenya

In current scenario, agroforestry is being looked upon as a solution to problems related to low agricultural productivity, nutritional, energy and environmental security. To achieve full potential of the agroforestry and to remove the hurdles in the large scale adoption of the land use by the farmers across the country, the Government of India approved National Agroforestry Policy which was launched on 10th February, 2014 by the Hon'ble President of India Sh. Pranab Mukherjee while inaugurating the 3rd World Agroforestry Congress in New Delhi. To achieve the goals of this policy and for its implementation in true sense

there is a need of trained manpower in the subject. The Indian Council of Agricultural Research (ICAR), New Delhi and World Agroforestry Centre (ICRAF), Nairobi, Kenya signed a collaborative Work Plan for enhanced focus in R & D in agroforestry. Two simultaneous five days International training programmes were conducted under ICAR- ICRAF collaborative Work Plan during 1st -5th December, 2014. The training programme on Research Methods in Agroforestry was organized at Central Agroforestry Research Institute (CAFRI), Jhansi, India and the training programme on "Use of Geo-informatics for Mapping Agroforestry" was held at World Agroforestry Centre, Nairobi, Kenya. For the first time training progarmmes on agroforestry were formulated involving researchers from SAARC countries, ICAR Institutes and State Agricultural Universities of

India. Dr. Javed Rizvi, Regional Director, South Asia Progarmme, ICRAF, New Delhi and Dr. S K Dhyani, Director, CAFRI, Jhansi were instrumental in formulation and organization of the two training programmes.

Research Methods in Agroforestry at CAFRI, Jhansi

The training programme on "Research Methods in Agroforestry" commenced on 1st Dec. 2014 at Central Agroforestry Research Institute (CAFRI). Dr. Richard Coe, Principal Scientist (Research Methods) at World Agroforestry Centre (ICRAF) having more than 24 years of experience in designing agroforestry experiments and Dr. Ajit, Principal Scientist at Indian Agricultural Statistics Research Institute (IASRI), New Delhi an expert in agroforestry modeling were the resource persons for the training programme. The training progarmme evolved around interactive sessions between the resource persons and the participants enabling them to understand the

general principles of experimental design of agroforestry including participatory trials. During the training a field visit to the experimental farm of CAFRI was also conducted.

Use of Geoinformatics in Mapping Agroforestry

The International Training Progamme on Use of Geoinformatics in mapping Agroforestry was organized during 1st to 5th December, 2014 at World Agroforestry Centre, Nairobi, Kenya. Two scientists from CAFRI, Jhansi participated in this programme.

The faculty included Dr. Tor-G Vagen, Geospatial Specialist and Course Director; Dr. Muhammad N Ahmad, Geoportal Developer both from Geoscience Lab of ICRAF and Dr. Leigh Winoweicki, Soil Scientist, International Centre for Tropical Agriculture. The training included lectures, laboratory visits, hands on exercises and interactive sessions. The participants expressed happiness on the exposure to advanced techniques and instrumentation in the field.

Republic Day and Independence Day

Republic Day (26th January, 2014) and Independence Day (15th August, 2014), respectively were celebrated at CAFRI, Jhansi. Flag hoisting ceremony was observed on both the occasions. Cultural programmes, sport events were organized for the staff along with their family members on the occasions.

10. Participation in Workshop/Coordination/Training/ Meetings/Symposia

Sh. S B Chavan, Scientist participated in the annual meeting of National Initiatives on Climate Resilient Agriculture (NICRA) on 5th January, 2014 held at CRIDA, Hyderabad (A. P.).

Dr. Ram Newaj, Pr. Scientist and Sh. S B Chavan, Scientist participated in Carbon Footprint Meeting on 7th January, 2014 held at CRIDA, Hyderabad (A. P.).

All Scientists, Technical Officers, RAs and SRFs participated in the 3rd World Congress on Agroforestry from 10th to 14th February, 2014 held at Delhi. The Congress was organized by ICRAF, ICAR, ISAF and CAFRI, Jhansi (U. P.).

Dr. Inder Dev, Pr. Scientist; Sh. K Rajrajan and Sh. S B Chavan, Scientists participated in the ISTS- IUFRO Conference on Sustainable Resource Management for Climate Change in Mitigation & Social Security from 13th to 15th March, 2014 held at Chandigarh.

Sh. S B Chavan, Scientist participated in the National meeting on Simulation Modelling Group on 19th March, 2014 organized by NRM division ICAR held at NASC Complex, New Delhi.

Dr. S Vimala Devi, Sr. Scientist participated National Conference on Computational Techniques in Analysing from 24th to 26th March, 2014 sponsored by DBT held at AKMU, IARI, New Delhi.

Dr. S K Dhyani, Director participated in the Interactive meeting of ICARs Director & Vice-Chancellor of SAUs on 28th April, 2014 held at NASC Complex, New Delhi.

Dr. S K Dhyani, Director participated in the BSS on Alternate Land Use System in Rainfed Agriculture on 9th &10th May, 2014 held at NASC Complex, New Delhi.

Dr. K B Sridhar, Scientist participated in a 4-weeks Training Course on Introduction to GIS during 5th to 30th May, 2014 held at National Remote Sensing Centre, Hyderabad (A. P.).

Sh. A R Uthappa, Scientist participated in the Three months attachment training from 12th May to 11th August, 2014 at IFGTB, Coimbatore (T.N.).

Dr. S K Dhyani, Director participated in the Meeting of Directors & Project Coordinators of NRM Division on 4th June, 2014 held at NASC Complex, New Delhi.

Dr. S K Dhyani, Director participated in the NAAS- AGM meeting on 5th June, 2014 held at NASC Complex, New Delhi.

Dr. S K Dhyani, Director and Dr. Badre Alam, Pr. Scientist participated in the NAIP-IFPRI Workshop on Impact of Capacity Building Programmes under NAIP held on 6th & 7th June, 2014 at NASC Complex, New Delhi.

Dr. R K Tewari and Dr. Ramesh Singh, Pr. Scientists delivered lecture on Construction of Cost Effective Rain Water Harvesting Structures in Bundelkhand Region in the training programme for the officers/ officials of State Line Departments of Jhansi district on 9th June, 2014 held at Vikas Bhavan, Jhansi (U.P.).

Dr. A K Handa, Pr. Scientist participated in the 5th meeting of National Advisory Board for Management of Genetic Resources on Status of Conservation of Genetic Resources on 16th June, 2014 held at NBPGR, New Delhi.

Dr. R P Dwivedi, Pr. Scientist (Agricultural Extension) participated in the District *Kharif* Gosthi organized by U.P. Govt. on 30th June, 2014 held at Deen Dayal Auditorium, Jhansi (U. P.).

Dr. Badre Alam, Pr. Scientist participated in the Annual Workshop of NICRA during 3rd to

5th July, 2014 held at NASC Complex, New Delhi.

Dr. S K Dhyani, Director and Dr. A K Handa, Pr. Scientist participated in the EFC Meeting under the Chairmanship of Hon'ble DG on 15th July, 2014 held at Krishi Bhavan, New Delhi.

Dr. S K Dhyani, Director participated in the BSS on Tree Cover Mapping organized by ICARDA & ICRAF on 17th July, 2014 held at New Delhi.

Dr. Rajendra Prasad, Dr. Sudhir Kumar, Dr. A K Handa and Dr. Inder Dev, Pr. Scientists; Dr. Mahendra Singh, Sr. Scientist and Sh. S B Chavan, Scientist participated in the Annual Group Meeting of All India Coordinated Research Project on Agroforestry from 26th to 28th July, 2014 held at OUAT, Bhubaneswar (Odisha).

Dr. S K Dhyani, Director participated in the ICAR Foundation Day & Director's Conference on 29th & 30th July, 2014 held at New Delhi.

Sh. S B Chavan, Scientist participated in the 21 days Summer School on Temperate Agroforestry for Sustenance and Climate Moderation from 5th to 25th August, 2014 held at SKUAST-K, Main Campus Shalimar, Srinagar (J&K).

Dr. S K Dhyani, Director and Dr. A K Handa, Principal Scientist delivered the lecture in Training Programme on Agroforestry and Mortality of Salix under Tribal Sub-Plan for Tribal Farmers on 6th & 7th August, 2014 held at DWR, Regional Station, Dalang Maidan (Lahaul Spiti), H.P. in association with AICRP on AF Centres located at YSP UHF, Solan and CSK HPKV, Palampur (H. P.).

Dr. A K Handa, Pr. Scientist and Dr. R H Rizvi, Sr. Scientist delivered the lectures in Summer School on Temperate Agroforestry for Sustenance and Climate Change Moderation on 8th & 20th August, 2014, respectively held at SKUAST-K, Main Campus Shalimar, Srinagar (J&K).

Dr. Mahendra Singh, Sr. Scientist participated in the training on MDP on Consultancy Services from 22nd to 27th August, 2014 held at NAARM, Hyderabad (A. P.).

Dr. Inder Dev, Pr. Scientist participated in the regional workshop on Strengthening Partnerships and Refined Methodology for On-Station Experiments of AICRP on IFS during 26th to 29th August, 2014 held at S. K. Nagar (Gujarat).

Dr. S K Dhyani, Director participated in the XXII Meeting of ICAR Regional Committee No. IV on 5th & 6th September, 2014 held at IISR, Lucknow (U. P.).

Dr. S K Dhyani, Director participated in the Lecture of Dr. Jose Graziano Da Silva, DG, FAO delivered on 8th September, 2014 held at NASC, New Delhi.

Dr. Asha Ram and Sh. A R Uthappa, Scientists participated in the Short Course on Agroforestry for Biofuels and Biodiesel from 15th to 24th September 2014 held at CAFRI, Jhansi (U. P.).

Dr. Asha Ram, Scientist participated in the Training Programme on Conservation Agriculture Developing Resilient Systems from 27th September to 4th October, 2014 held at CSSRI, Karnal (H. R.).

Dr. S K Dhyani, Director participated in the Consultation Meeting for organizing Regional Conference on Agroforestry on 10th October, 2014, 8th December, 2014 and 7th January, 2015 held under the Chairmanship of Dr. R S Paroda, Ex. DG (ICAR) at New Delhi.

Dr. Badre Alam, Pr. Scientist participated in the Annual workshop/Coordination Committee Meeting of the Network Project on Harvest and Post-Harvest processing and value addition of natural resins, gums and gum resins during 17th -18th October, 2014 held at CAFRI, Jhansi (U. P.).

Dr. S K Dhyani, Director participated in the NRM Directors Meeting with DG, ICAR for the Vision 2050 on 27th & 28th October, 2014 held at Krishi Bhawan, New Delhi.

Dr. Asha Ram, Scientist participated in the Training Course on Strengthening Ecosystem Services through Integrated Natural Resources Management for Building Climate-Resilient Communities from 27th to 31st October, 2014 held at ICRISAT, Hyderabad (A. P.).

Dr. R K Tewari, Pr. Scientist & Nodal Officer (RFD) and Dr. Rajeev Tiwari, Chief Tech. Officer participated in the RFD Meeting of NRM Division on 28th October, 2014 held at NASC, New Delhi.

Dr. S K Dhyani, Director delivered Keynote address in the Open Access to Agricultural Knowledge for Inclusive Growth and Development at NAARM-GFAR, FAO Workshop on 29th & 30th October, 2014 held at NAARM, Hyderabad (A. P.).

Dr. R P Dwivedi, Pr. Scientist (Agricultural Extension) participated in the National Extension Education Congress-2014 on Translational Research-Extension for Sustainable Small Farm Development 8th to 11th November, 2014 at ICAR Research Complex for NEH Region, Barapani (Meghalaya).

Dr. S K Dhyani, Director and Dr. R P Dwivedi, Pr. Scientist participated in the National Symposium on Climate Resilient Fodder Production and Its Utilization organized by RMSI during 12th & 13th November, 2014 held at BCKVV, Kalyani (W. B.). Dr. S K Dhyani, Director delivered Key note address in the Symposium.

Sh. A R Uthappa, Scientist participated in a training course on Ecosystem Services of Agroforestry Systems during 17th to 21st November, 2014 held at ICRISAT, Patencheru (Telangana).

Dr. Badre Alam, Pr. Scientist participated and presented a research paper in the National Conference of Plant Physiology (NCPP 2014) on Frontiers of Plant Physiology Research: Food Security and Environmental Challenges during 23rd to 25th November, 2014 held at OUAT, Bhubaneswar (Odisha).

Dr. Anil Kumar, Dr. Ram Newaj, Dr. Rajendra Prasad, Dr. R P Dwivedi, Pr. Scientists; Dr. S Vimala Devi, Sr. Scientist, Sh. S B Chavan, Sh. A R Uthappa and Dr. Asha Ram, Scientists attended International training on Research Methods in Agroforestry from 1st to 5th December, 2014 held at ICAR-CAFRI, Jhansi (U. P.).

Dr. Sudhir Kumar, Pr. Scientist presented poster on "Improving productivity, profitability and sustainability through agroforestry intervention in fruit orchards" in National Seminar on Strategies for Conservation, Improvement and Utilization of Underutilized Fruits held at CHES, Chettalli, during 1st to 3rd December, 2014 organized by Central Horticultural Experiment Station (CHES), ICAR-IIHR, Chettalli, Kodagu and Society for Promotion of Horticulture (SPH) ICAR-IIHR, Bengaluru (Karnataka).

Dr. Ramesh Singh, Pr. Scientist and Dr. R H Rizvi, Sr. Scientists participated in the International Training Progamme on Use of Geoinformatics in mapping Agroforestry during 1st to 5th December, 2014 at World Agroforestry Centre, Nairobi, Kenya.

11. राजभाषा गतिविधियां

हिन्दी पखवाड़ा

दिनांक 15 सितम्बर, 2014 को हिन्दी पखवाड़ें (15–27 सितम्बर, 2014) का शुभारम्भ किया गया। कार्यक्रम के मुख्य अतिथि डा. डी. एन. तिवारी, पूर्व सदस्य, योजना आयोग, नई दिल्ली थे। डा. तिवारी ने सभी वैज्ञानिकों एवं अधिकारियों से अपील की कि हिन्दी में अधिक से अधिक पुस्तकें, तकनीकी पत्रिकाओं तथा प्रसार बुलेटिनों का प्रकाशन किया जाऐं जिससे आपके अनुसंधान को किसान समाज पढ़कर उसका भरपूर लाभ उठा सकें। कार्यक्रम में

माननीय कृषि मंत्री, भारत सरकार का हिन्दी दिवस पर संदेश तथा महानिदेशक, भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली का सरकारी कामकाज में राजभाषा का अधिक से अधिक कार्य करने की अपील को पढ़कर सुनायी गयी। कार्यक्रम की अध्यक्षता करते हुए केन्द्र निदेशक ने सरकारी कामकाज में पत्राचार को बढ़ावा देने के लिए केन्द्र के समस्त वैज्ञानिकों एवं अधिकारियों से अपील की कि पत्राचार को बढाने में अपना सहयोग प्रदान करें जिससे राजभाषा विभाग द्वारा दिये गये लक्ष्यों को पूरा किया जा सके। निदेशक द्वारा केन्द्र पर राजभाषा में किये जा रहे कार्यों की सराहना करते हुए अवगत कराया गया कि केन्द्र द्वारा जलागम पर बुन्देलखण्ड के भूमि संरक्षण अधिकारियों, स्वयं सहायता समूहों के प्रतिनिधियों एवं किसानों के लिए अनेकों प्रशिक्षण हिन्दी माध्यम से आयोजित किये गये है, जिसका विषयवस्तु तथा प्रशिक्षण सामग्री हिन्दी में तैयार की गई।

हिन्दी पखवाड़े के दौरान वाद–विवाद प्रतियोगिता जिसका शीर्षक ''कृषि बेरोजगारी का सक्षम समाधान'' तथा निबन्ध प्रतियोगिता जिसका शीर्षक ''बदलती जलवायु में कृषिवानिकी का योगदान'' को आयोजित किया । इन प्रतियोगिताओं में केन्द्र के वैज्ञानिकों, अधिकारियों, कर्मचारियों, शोध अध्येता, शोध छात्र एवं छात्राओं ने बढ़–चढ़ कर भाग लिया। केन्द्र के तकनीकी एवं प्रशासनिक श्रेणी के अधिकारियों एवं कर्मचारियों के लिये सुलेख एवं इमला प्रतियोगिता का आयोजन किया गया जिसमें केन्द्र के तकनीकी, प्रशासनिक, कुशल सहायक एवं समान वेतन के अधिकारियों एवं कर्मचारियों ने भाग लिया। केन्द्र के तकनीकी एवं प्रशासनिक श्रेणी के अधिकारियों एवं कर्मचारियों के लिये अनुवाद प्रतियोगिता तथा अहिन्दी भाषी क्षेत्र के अधिकारियों/कर्मचारियों के लिए पत्र लेखन/प्रार्थना पत्र प्रतियोगिता तथा कुशल सहायक एवं समान वेतन कर्मचारियों के लिए अवकाश प्रार्थना पत्र प्रतियोगिता का आयोजन किया गया। प्रश्नोंत्तरी प्रतियोगिता का आयोजन किया। प्रश्नोंत्तरी प्रतियोगिता में केन्द्र के वैज्ञानिकों, अधिकारियों, कर्मचारियों, अनुसंधान अध्येता, शोध छात्र एवं छात्राओं ने बढ़–चढ़ कर भाग लिया। शोध–पत्र पोस्टर प्रतियोगिता का आयोजन किया गया जो कि केन्द्र के वरिष्ठ वैज्ञानिक एवं उसके नीचे स्तर के प्रतिभागियों के लिए थी। एक वर्ष (अक्टूबर, 2013 से सितम्बर, 2014) के दौरान प्रशासनिक वर्ग से 20,000 शब्द हिन्दी टिप्पणी लेखन प्रतियोगिता तथा वैज्ञानिकों एवं तकनीकी वर्ग से हिन्दी में टिप्पणी एवं पत्राचार प्रतियोगिता का मूल्यांकन किया गया। दिनांक 27 सितम्बर, 2014 को हिन्दी पखवाड़ा का समापन समारोह सम्पन्न हुआ। समापन समारोह के मुख्य अतिथि श्री धीरेन्द्र कुमार सक्सेना, राजभाषा अधिकारी, भारत संचार निगम लिमिटेड, झाँसी थे। इस अवसर पर मुख्य अतिथि महोदय द्वारा प्रतियोगिता में विजयी प्रतिभागियों को पुरस्कार वितरित किये गये। कार्यक्रम में वार्षिक राजभाषा पत्रिका ''कृषिवानिकी आलोक–2014'' अष्टम अंक का विमोचन भी मुख्य अतिथि महोदय द्वारा किया गया।

हिन्दी कार्यशालायें

संस्थान पर वर्ष 2014 में चार हिन्दी कार्यशालाओं का आयोजन किया गया। इन कार्यशालाओं के आयोजन का मुख्य उद्देश्य हिन्दी में सरकारी कामकाज करने में अधिकारियों एवं कर्मचारियों को होने वाली झिझक को दूर करना था। कार्यशाला में

संस्थान के समस्त वैज्ञानिकों, अधिकारियों एवं कर्मचारियों ने भाग लिया। वर्ष 2014 के दौरान आयोजित कार्यशालाओं का विवरण इस प्रकार है :

दिनांक	विषय	वक्ता
29 मार्च, 2014	परिणाम फ्रेमवर्क दस्तावेज की उपयोगिता	डा. आर. के. तिवारी, प्रधान वैज्ञानिक
21 जून, 2014	भौगोलिक सूचना प्रणाली एवं कृषिवानिकी नीति	डा. के.बी. श्रीधर, वैज्ञानिक
29 सितम्बर, 2014	मृदा स्वास्थ्य	डा. राजेन्द्र प्रसाद, प्रधान वैज्ञानिक
30 दिसम्बर, 2014	जियो इनफोरमेटिक्स	डा. रमेश सिहं, प्रधान वैज्ञानिक एवं डा. आर.एच. रिजवी, वरि. वैज्ञानिक

राजभाषा कार्यान्वयन समिति की बैठकें

संस्थान में वर्ष 2014 के दौरान राजभाषा कार्यान्वयन समिति की कुल चार बैठकें सम्पन्न हुई जिसमें सरकारी कामकाज में राजभाषा को बढ़ावा देने हु अनेक बिन्दुओं पर विस्तृत विचार–विमर्श किया गया और सर्वसम्मत से निर्णय लिया गया। बैठकों की अध्यक्षता करते हुए निदेशक द्वारा संस्थान के सभी वैज्ञानिकों, अधिकारियों एवं कर्मचारियों से धारा 3(3), पत्राचार एवं फाइलों पर टिप्पणियां हिन्दी में लिखने के लिए अपील की गयी।

12. Women in Agriculture

As per the ICAR guidelines CAFRI continued to emphasize on harnessing women power in agriculture to encourage gender equity. Even at the Institute, regular meetings of Women Cell is organized under the Chairmanship of Director. Gender equality and congenial environment in the office was appreciated by all the members. The Institute has a number of Women research scholars, research fellows, students in addition to its women staff.

In Domagor Pahuj watershed 26 Women Self Help Groups (WSHGs) has been formed in three villages of model watershed area comprising 269 members. All WSHGs are linked with bank. Total saving of WSHGs is about ₹ 6.00lakh. They are mainly involved in goat rearing and vegetable cultivation. These WSHGs are linked with Federation of SHGs for better livelihood options. Out of 26 SHGs, 20 SHGs were helped through revolving fund to start their activities. On an average each member of 10 SHGs involved in goatary is earning more than ₹ 8000=00 per annum.

Success of homestead agroforestry depends on active participation of women

Vegetable cultivation by Women SHG in Domagor-Pahuj watershed using revolving fund

A exposure visit of 30 women from Domagor-Pahuj watershed organized for preparation vermicomposting at village Ganeshgarh, Babina block, Jhansi

13. Distinguish Visitors

Hon'ble Secretary, DARE & DG, ICAR, New Delhi visits

Hon'ble Dr. S Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi along with Dr. A K Sikka, DDG (NRM), Dr. Arvind Kumar, Vice Chancellar, CAU, Jhansi visited the Institute on November 17th, 2014. They visited the

Office building, laboratories and also planted saplings on this occasion. The Hon'ble Director General discussed about the Agroforestry research initiative with particular reference to Bundelkhand region.

- Dr. A K Singh, Vice Chancellor, RVSKV, Gwalior (M. P.).
- Dr. Avinash C Pandey, Vice Chancellor, Bundelkhand University, Jhansi (U. P.).
- Dr. D N Tiwari, Former Member, Planning Commission & DG, ICFRE, Allahabad (U. P.).
- Dr. V P Singh, Regional Representative for South Asia, WAC, New Delhi.
- Dr. Javed Rizvi, Regional Director, South Asia Progarmme, ICRAF, New Delhi.
- Dr. B Mohan Kumar, ADG (AAF & CC), NRM Division, ICAR, New Delhi.
- Dr. R Ramani, Director, ICAR – IINRG, Ranchi (B. R.).
- Dr. Y S Ramakrishna, Ex. Director, CRIDA, Hyderabad (A. P.).
- Sh. S Verma (IAS), District Magistrate, Jhansi visited at Parasai- Sindh watershed area, Jhansi (U.P.).
- Dr. Rajendra Choudhary, Sr. Liaison & Monitoring Officer, South Asia Programme, ICRAF, New Delhi.
- Dr. Brahma Singh, Advisor, Nauni Foundation, Chennai (T. N.).
- Dr. S D Kashyap, Dean, Dr. Y.S. P. U. of Horti. & Forestry, Solan (H. P.).
- Dr. D K Das, Former Head, IARI, Pusa, New Delhi.
- Dr. V K Gupta, Rtd. Pr. Scientist (NRCAF), Bangalore (Karnataka).
- Prof. S B Nahatkar, Division of Agriculture Economics, JNKV, Jabalpur (M. P.).
- Prof. Samir Pal, Dir. Extension, CSAUA&T, Kanpur (U. P.).
- Dr. Richard Coe, Pr. Scientist (Research Methods), ICRAF, Nairobi, Kenya.
- Dr. P K Ghosh, Director, IGFRI, Jhansi (U. P.).
- Dr. P S Pathak, Ex. ADG (AF), ICAR, New Delhi.
- Sh. Satyapal Singh Verma, Labour Colony, Saharanpur (U. P.).
- Dr. S N Pandey, Project Coordinator, Taragram, Jhansi (U. P.).

14. Personnel

Dr. S K Dhyani, Director

Scientific

1. Dr. Anil Kumar, Pr. Scientist (Plant Pathology)
2. Dr. R K Tewari, Pr. Scientist (Horticulture)
3. Dr. Ram Newaj, Pr. Scientist (Agronomy)
4. Dr. Rajendra Prasad, Pr. Scientist (Soil Science)
5. Dr. Sudhir Kumar, Pr. Scientist (Horticulture)
6. Dr. A K Handa, Pr. Scientist (Forestry/ Agroforestry)
7. Dr. R P Dwivedi, Pr. Scientist (Agriculture Extension)
8. Dr. Inder Dev, Pr. Scientist (Agronomy)
9. Dr. Badre Alam, Pr. Scientist (Plant Physiology)
10. Dr. (Er.) Ramesh Singh, Pr. Scientist (SWE)
11. Dr. R H Rizvi, Sr. Scientist (Computer Application)
12. Dr. S Vimala Devi, Sr. Scientist (Plant Breeding)
13. Dr. Mahendra Singh, Sr. Scientist (Agriculture Economics)
14. Dr. K B Sridhar, Scientist (Forestry)
15. Sh. K Rajarajan, Scientist (Genetics & Plant Breeding)
16. Sh. S B Chavan, Scientist (Forestry)
17. Dr. Asha Ram, Scientist (Agronomy)
18. Sh. A R Uthappa, Scientist (Forestry)

Technical

1. Sh. B Singh, Chief Technical Officer (Farm Manager)
2. Dr. Rajeev Tiwari, Chief Technical Officer
3. Dr. C K Bajpai, Chief Technical Officer
4. Dr. A Datta, Chief Technical Officer
5. Sh. Sunil Kumar, Assit. Chief Technical Officer
6. Sh. Rajendra Singh, Assit. Chief Technical Officer
7. Smt. Uma, Assit. Chief Technical Officer
8. Sh. Rajesh Srivastava, Sr. Technical Officer (Art & Photo)
9. Sh. R K Singh, Sr. Technical Officer
10. Sh. Prabhu Dayal, Technical Officer
11. Sh. S P Singh, Technical Officer
12. Sh. Ram Bahadur, Technical Officer
13. Km. Shelja Tamrkar, Technical Assistant (Library)
14. Sh. Het Ram, (T-3), Driver
15. Sh. Kashi Ram, (T-3), Driver
16. Sh. Prince, (T-2), Mechanic

Administrative

1. Sh. J L Sharma, A O
2. Sh. S B Sharma, A F& A O
3. Sh. K P Sharma, AAO
4. Sh. A K Chaturvedi, Personal Secretary
5. Sh. Hoob Lal, Personal Assistant
6. Sh. Om Prakash, Personal Assistant
7. Sh. Mahendra Kumar, Assistant
8. Sh. Birendra Singh, Assistant
9. Sh. Jai Janardan Singh, Assistant
10. Sh. Deepak Vij, Stenographer (Grade-III)
11. Sh. Tridev Chaturvedi, Stenographer (Grade-III)
12. Sh. Vir Singh Pal, Sr. Clerk
13. Smt. Kaushalya Devi, Jr. Clerk

Skilled Supporting Staff

1. Sh. Attar Singh
2. Sh. Tulsi Das
3. Sh. Ram Singh
4. Sh. Jagdish Singh
5. Sh. Ram Din
6. Sh. Pramod Kumar
7. Sh. Munna Lal

15. Miscellaneous

New Scientist/ Staff

- Sh. A R Uthappa joined the institute as Scientist (Agroforestry).
- Shri J L Sharma joined the institute as Administrative Officer.

Institute Joint Staff Council

Institute Joint Staff Council (IJSC) meetings were held under the Chairmanship of Director Dr. S K Dhyani. Various issues related to welfare of the staff were discussed.

Internal Inspection by the Team of IPAI

Internal Inspection was conducted by the Team of Institute of Public Auditors of India (IPAI), for the period of 2013-14 of the Institute.

Zonal Sports Meet at ICAR-CAZRI, Jodhpur

A contingent of 19 players from CAFRI, Jhansi participated in ICAR Zonal Tournament-2014 at Jodhpur held during 20th to 24th November, 2014 organized by ICAR- Central Arid Zone Research Institute. CAFRI performed best in the cycle race where in Mr. Attar Singh got 2nd position and Mr. Munna Lal got 3rd position and in chess where Mr. Rajesh Srivastava got 2nd position in the tournament.

Retirement

Sh. D S Rawat, AAO of the Institute retired on 30th September, 2014. The staff members bid a grand farewell to the officer.

Transfer

Dr. Ajit, Pr. Scientist (Agriculture Statistics) has been transferred to IASRI, New Delhi.

Annexure-I

Results-Framework Document for ICAR-Central Agroforestry Research Institute (2014 - 2015)

Section1: Vision, Mission, Objectives and Functions

Vision

Integration of woody perennials in the farming systems to improve land productivity through conservation of soils, nutrients and biodiversity to augment natural resource conservation, restoration of ecological balance, alleviation of poverty and to mitigate risks of weather vagaries.

Mission

To improve quality of life of rural people through integration of perennials on agriculture landscape for economic, environmental and social benefits.

Objectives

- Enhancing productivity, profitability and livelihood through agroforestry interventions.
- Creation of awareness and technology transfer of agroforestry.

Functions

- To undertake basic and applied research for developing and delivering technologies based on sustainable agroforestry practices for farms, marginal land and wastelands in different agroclimatic zones in India.
- To coordinate network research with the State Agricultural Universities/ICAR Institutes/other related research Institutes for identifying technologies which can be transferred from one region to another.
- To provide training in (a) research methodologies and (b) use and application of technologies developed, at various levels.
- To develop technological packages of different agroforestry practices for various agro-climatic zones for transfer to farm, field and wastelands.
- To act as repository of information on the subject.
- To collaborate with relevant national and international agencies for achieving the mandate.
- To provide consultancy.

Section 2: *Inter se* priorities among Key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target/Criteria Value				
							Excellent	V. Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Enhancing productivity, profitability and livelihood through agroforestry interventions	60	Development of agroforestry systems	Agroforestry models/systems identified/refined/developed	No.	25	5	4	3	2	1
				Improved agronomic practices developed for agroforestry systems	No.	20	3	2	1	0	-
			Germplasm maintenance & evaluation	Characterization /selection of improved germplasm/strains (*Pongamia* spp.)	No.	15	4	3	2	1	0
2	Creation of awareness and technology transfer of agroforestry	20	Transfer of technology	Kisan mela/gosthi /demonstrations	No.	10	7	6	5	4	3
			Capacity building	Trainings / Workshop	No.	10	6	5	4	3	2
	Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	8	7	6	5	4
			Timely publication of the Institute Annual Report (2014-2015)	Annual Report published	Date	2	30.06.2015	02.07.2015	04.07.2015	07.07.2015	09.07.2015
	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90
	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2015-2016 for Approval	On-time submission	Date	2	May 15, 2015	May 16, 2015	May 19, 2015	May 20, 2015	May 21, 2015
			Timely submission of Results for 2014-2015	On-time submission	Date	1	May 1, 2015	May 2, 2015	May 5, 2015	May 6, 2015	May 7, 2015
	Enhanced Transparency / Improved Service delivery of Ministry/Dep	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80

S. No.	Object-ives	Weight	Actions	Success Indicators	Unit	Weight	Target/Criteria Value				
							Excellent	V. Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80
	Administ-rative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1, 2015	Nov.2, 2015	Nov.3, 2015	Nov.4, 2015	Nov.5, 2015
			Implementation of agreed milestones of approved mitigating strategies for reduction of potential risk of corruption (MSC)	% of Implementation	%	1	100	90	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAP)	% of implementation	%	2	100	90	80	70	60

Section 3: Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual value for FY12/13	Actual value for FY13/14	Target value for FY14/15	Projected value for FY15/16	Projected value for FY16/17
1	Enhancing productivity, profitability and livelihood through agroforestry interventions	Development of agroforestry systems	Agroforestry models/ systems identified/ refined/developed	No.	3	2	4	4	4
			Improved agronomic practices developed for agroforestry systems	No.	2	2	2	3	3
		Germplasm maintenance & evaluation	Characterization /selection of improved germplasm/ strains (*Pongamia* spp.)	No.	1	2	3	5	6
2	Creation of awareness and technology transfer of agroforestry	Transfer of technology	Kisan mela/gosthi /demonstrations	No.	4	4	6	8	10
		Capacity building	Trainings / Workshop	No.	4	4	5	8	8
	Publication/Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	7	6	7	7	8
		Timely publication of the Institute Annual Report (2014-2015)	Annual Report published	Date	-	-	2.7.2015	-	-

S. No.	Objectives	Actions	Success Indicators	Unit	Actual value for FY12/13	Actual value for FY13/14	Target value for FY14/15	Projected value for FY15/16	Projected value for FY16/17
	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	99.54	99.51	96	98	98
	Efficient Functioning of the RFD System	Timely submission of Draft RFD for 2015-2016 for Approval	On-time submission	Date	-	-	May 16, 2015	-	-
		Timely submission of Results for 2014-2015	On-time submission	Date	-	-	May 2, 2015	-	-
	Enhanced Transparency / Improved Service delivery of Ministry/Department	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
	Administrative Reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	Nov.2, 2015	-	-
		Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of Implementation	%	-	-	90	-	-
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	-	-	90	-	-

Section 4 (a): Acronyms

S. No.	Acronym	Description
1	A F	Agroforestry
2	SAUs	State Agricultural Universities
3	MoEF	Ministry of Environment and Forests
4	R&D	Research and Development
5	ICAR	Indian Council of Agricultural Research
6	LDWR	Land Development and Water Resources

Section 4(b) : Description and definition of success indicators and proposed measurement methodology

S No.	Success indicator	Description	Definition	Measurement	General Comments
1.	Agroforestry models/ systems identified/refined/ developed	Identification of tree crop combinations	Agroforestry systems development & refinement	Number	---
2.	Improved agronomic practices developed for agroforestry systems	Agronomic practices modified &/or standardized	Modification in agronomic practices of trees &/or crops under agroforestry systems	Number	---
3	Characterization /selection of improved germplasm/strains	Germplasm morphologically &/or molecularly characterized and tagged	Establishment of morphological &/or molecular identity of collected germplasm	Number	---
4	Kisan mela/gosthi /demonstrations	Mass awakening of client farmers through Kisan mela/gosthi /demonstrations	Capacity building of stakeholders through face to face interaction	Number of events & farmers	---
5	Trainings / Workshop	Organizing Trainings / Workshop / Sem./Sym./Group meeting	Human resource development & knowledge updating in agroforestry	Number of events	---

Section 5 : Specific performance requirements from other departments that are critical for delivering agreed results

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this Organization	What happens if your requirement is not met.
Bundelkhand Region	U.P. & M.P.	Govt.	LDWR, Dept. of Ag.	Trainings/ workshop	Sponsorship	No separate fund is available at the Centre	05 Trainings	Access to stakeholders will be limited/

Section 6: Outcome/ Impact of activities of Department/ Ministry

S. No.	Outcome/ Impact	Jointly responsible for influencing this outcome/ impact with the following organization (s)/ department(s)/ ministry(ies)	Success Indicator (s)	Unit	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
1	Increase in tree cover	SAUs/State Line Departments/ MoEF/R&D institutions	Higher production and microclimate resilience	%	-	2	3	3	4
2	Increase in biomass productivity & livelihood opportunity through AF	----	Increase in income and livelihood options	%	-	1	3	3	4

Classification of Success Indicators according to its Category

S. No.	Success Indicator(s)	Input	Activity	Internal Output	External Output	Outcome	Measures Qualitative Aspects
1.	Agroforestry models/systems identified/refined/developed	False	False	True	False	False	False
2.	Improved agronomic practices developed for agroforestry systems	True	False	False	False	False	False
3.	Characterization /selection of improved germplasm/ strains	True	False	False	False	False	True
4.	Kisanmela/gosthi /demonstrations	False	False	False	True	False	True
5.	Trainings / Workshop	False	False	False	True	False	True

Target Setting of RFD 2014-15

S. No.	Success indicator (s)	Past Achievements of the Success Indicators				Mean of the Achievements	Projected value of the success indicator for 2014-15 as per the approved RFD 2013-14
		2010-11	2011-12	2012-13	2013-2014		
1	Agroforestry models/systems identified/refined/developed	1	2	3	2	2	4
2	Improved agronomic practices developed for agroforestry systems	2	1	2	2	1.75	2
3	Characterization /selection of improved germplasm/strains	3	2	2	2	2.25	3
4	Kisan mela/gosthi /demonstrations	5	17	08	5	6	6
5	Trainings / Workshop	2	18	08	5	5	5

*While computing mean of the achievement, extreme values have been ignored.

Annexure-II

Research Advisory Committee

S. No.	Name	S. No.	Name
1	**Dr. V P Singh (Chairman)**, Regional Representative for South Asia, World Agroforestry Centre, New Delhi.	2	**Dr. B Mohan Kumar**, (Member), ADG (AAF/CC), NRM Division, ICAR, New Delhi.
3	**Dr. S D Kashyap** (Member), Dean, Dr. Y.S. Parmar Univ. of Horti. & Forestry, Solan (H.P.).	3	**Dr. D K Das**, (Member), Former Head, IARI, Pusa, New Delhi.
5	**Prof. S B Nahatkar,** (Member), Division of Agriculture Economics, J.N.K.V., Jabalpur (M.P.).	6	**Prof. Brahma Singh**, (Member), Advisor, Nauni Foundation, Chennai (T.N.)
7	**Dr. V K Gupta** (Member), Rtd. Pr. Scientist (CAFRI), Bangalore (Karnataka).	8	**Dr. S K Dhyani**, Director (Member) CAFRI, Jhansi (U.P.)
9	**Dr. Anil Kumar**, Pr. Scientist & Member Secretary, CAFRI, Jhansi (U.P.)		

Annexure-III

Institute Management Committee

S. No.	Name	S. No.	Name
1	**Dr. S K Dhyani, (Chairman)** Director, CAFRI, Jhansi (U P.)	7	**Dr. (Mrs.) S Vimala Devi** Sr. Scientist, CAFRI, Jhansi
2	**Dr. Pankaj Kaushal** Head (C I Div.), IGFRI, Jhansi (U. P.)	8	**Dr. M J Kaledhokar** Pr. Scientist, NIASM, Baramat (M. H.)
3	**Dr. Prem Singh** Principal Scientist, IIFSR, Modipuram (U. P.)	9	**Sh. Satyapal Singh Verma** House No. 29/3, Labour Colony, Saharanpur (U.P.)
4	**Dr. B Mohan Kumar** **A D G (AAF/CC)** ICAR, KAB-II, New Delhi – 110 012	10	**Director of Agriculture** Govt. of U.P., Krishi Bhawan, Lucknow (U. P.)
5	**Sh. K N Gupta** F&AO , IIPR, Kanpur (U. P.)	11	**Director Extension** C S Azad University of Agriculture & Technology, Kanpur (U.P.)
6	**Deputy Director (Horticulture)** State Horticulture, Narayan Bagh, Jhansi (U. P.)	12	**Dr. Inder Dev** Pr. Scientist, H.O. & Member Secretary, CAFRI, Jhansi (U. P.)

Annexure-IV

Institute Joint Staff Council

Chairman : Dr. S K Dhyani (Director)		
	Staff Side	**Office Side**
Category	**Name and Designation of the Govt. Servant**	**Name and Designation of the Govt. servant**
Technical	Sh. Kashi Ram, Driver, Tech. Asstt. - **Secretary**	Sh. J L Sharma, A.O. & Member Secretary
	Sh, Ram Bahadur, Tech. Officer - Member	Sh. S B Sharma, AF&AO - Member
Administration	Sh, Birendra Singh, Assistant - Member, **CJSC**	Sh. A K Chaturvedi, Personal Secretary - Member
	Sh. Tridev Chaturvedi, Stenographer (Gr.-III) - Member	Dr. Anil Kumar, Pr. Scientist - Member
Supporting	Sh. Attar Singh, SSS- Member	Dr. Rajendra Prasad, Pr. Scientist - Member
	Sh. Ram Singh, SSS- Member	Dr. Inder Dev, Pr. Scientist - Member
		Dr. S Vimala Devi, Sr. Scientist - Member
		Smt. Uma, Asst. Chief Tech. Officer - Member

Annexure-V

Women Cell

S. No.	Name	S. No.	Name
1	**Dr. S Vimala Devi**, Sr. Scientist - **Chairperson**	2	**Smt. Uma,** Asst. Chief Tech. Officer- Member
3	**Km. Shelja Tamrkar**, Tech. Assistant - Member	4	**Smt. Kaushalya Devi**, Jr. Clerk- Member
5	**Smt. Sadhna Pandey**, Sr. Scientist, IGFRI, Jhansi (U. P.) - Member	6	**Dr. Inder Dev**, Pr. Scientist - Member
7	**Sh. J L Sharma**, A.O. & Member Secretary	8	**Sh. Kashi Ram**, Sec. IJSC - Member

Swachh Bharat Abhiyan

Human chain

Oath for cleanliness at different Villages

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