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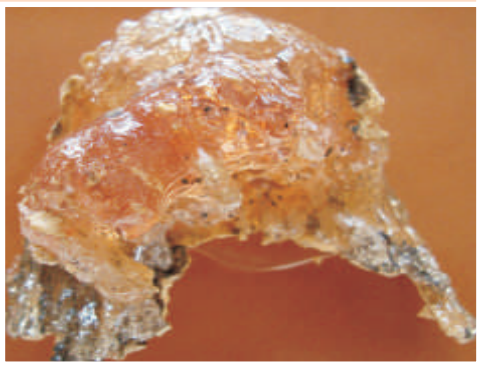
Agroforestry
ANNUAL REPORT
2015-16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CAFRI

ICAR-Central Agroforestry Research Institute
Jhansi-Gwalior Road, Jhansi - 284 003 (U.P.) India

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2016

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PREFACE

ICAR-Central Agroforestry Research Institute is working on basic and applied aspects of agroforestry research and development within house as well as outside funded projects from various agencies such as ICRISAT, NICRA, MORD, DAC&FW, IINR&G, NMSHE (DST), Young Scientist & Woman Scientist (DST). The new initiatives include enhancing productivity, profitability and livelihood through agroforestry interventions, creation of awareness and technology transfer, application of GIS and RS techniques for assessing area under agroforestry, database development on Agroforestry research and development in the country, molecular studies for characterization of important MPTS germplasm, agroforestry as livelihood option for tribal areas through TSP and Network project on Tree Fodder.

ICAR-CAFRI organized Soil Health Day and distributed Soil Health cards to the farmers. The Institute has been recognized as a model Institute under National Mission on Oilseed and Oil Palm (NMOOP) - Mini Mission-III for imparting training to farmers and trainers on TBOs.

Institute is actively involved in designing and conducting research and development programmes on agroforestry models through 37 AICRP on AF centres located throughout India representing different agroclimatic conditions.

Institute has a strong linkage with World Agroforestry Centre and both the organizations are working together not only for India, but for the whole SAARC region and Institute successfully organized two SAARC programmes (one at Jhansi and another at NASC Complex, New Delhi) in which all participants from SAARC countries participated.

I express my gratitude to Hon'ble Dr. Trilochan Mohapatra, 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. S Bhaskar, ADG (Agron., AF & CC), Dr. S K Chaudhari, ADG (S & WM), NRM Division, ICAR, New Delhi and to other staff members of NRM Division for cooperation and support. The help of the PME Cell and Editors in compiling and timely publication of the report is highly appreciated. I am thankful to the Director, ICAR-IGFRI, Jhansi for sharing the infrastructure from time to time.

(O P Chaturvedi)
Director

EXECUTIVE SUMMARY

The executive summary of the research and deployment activities carried during 2015 is presented here under:

- In nutrient management in ber based agri-horti system fruit length (3.12 cm), number of fruits (1481 pl^{-1}) and fruit yield (23.02 kg pl^{-1}) were significantly higher in treatments T_3- Ber (75% RDF), T_1 -Ber (100% RDF) and T_8-Ber (75% RDF) + *Trichoderma* + Sesame- Lentil, respectively. However, plant growth parameters and dry biomass of pruned material of ber were non-significant. During *kharif* season, T_{10}-(pure crop) and T_6-(Ber with 75% RDF + VAM + Sesame-Lentil) recorded highest sesame seed yield of 704 and 695 kg ha^{-1}, respectively. Similarly, lentil grown during *rabi* season recorded significantly higher seed yield of 1069 (T_{10}- Pure crop) and 1017 kg ha^{-1} (T_6- Ber with 75% RDF + VAM + Sesame- Lentil). Soil analysis revealed that all the treatments had better soil test values than control at both depths (0-15 & 15-30 cm) of the soil. Estimated protein content was observed higher in foliage than the fruits.
- In *Albizia procera* based silvipastoral system pruning of the tree component was done at 25, 50 and 75% intensity (during 2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} 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* attained height in the range of 12.03 to13.92 m, DBH (15.08 to 17.15 cm), canopy spread (2.17 to 3.98 m). The growth parameters of *C. fulvus* varied in the range of 1.29 to 1.48 m (height), 28.58 to 32.46 cm (tussock dia), 52.17 to 58.43 (tillers $tussock^{-1}$), whereas *S. seabrana* gained 1.15 to 1.31m (height) and 51.56 to 55.64 (branches $plant^{-1}$). Leaf fodder production was significantly affected by different levels of pruning. Total biomass production from the silvipastoral system varied in the range of 7.38 to 8.14 D.W t ha^{-1} and was significantly affected by the levels of pruning intensity.
- To evaluate shade tolerance of important crop species in agroforestry, various experiments and analysis were carried out with pigeon pea (*Cajanus cajan*), blackgram (*Vigna mungo*) and barley (*Hordeum vulgare*) under three different shade-net houses of varying shade and in open (without shade) as control. Some important spectral indices such as Normalized Difference Vegetative Index (NDVI), Photochemical reflectance index (PRI) and Water Balancing Unit (WBU) were studied and their correlation with physiological and photosynthetic traits were also determined. The results consistently indicated that 33% shade would be critical limit and intensity of shade more than that have alarming detrimental impacts, which reflected in the reduction of crop yield. Use of spectral indices can lead to estimate physiological and photosynthetic traits for crop evaluation.
- A total of six equations on timber biomass of *Acacia nilotica* were found in the literature, two each for Haryana, Uttar Pradesh and Karnataka. Data set on DBH and wood biomass was simulated using these biomass equations, which were then used for developing generalized models. High correlation

coefficient between DBH and timber biomass of 0.909 indicated that DBH would be good predictor. Two types of model were fitted *viz.* $B = a. D^b$ and $B = a + b1. D + b2. D^2$; where B- wood biomass, D-DBH, however, the model $B = 0.36015 D^{1.59835}$ was found good fit. This model gives a mean prediction error of 0.54 kg tree^{-1} in wood biomass.

- The Agroforestry based Conservation Agriculture for Sustainable Landuse and Improved Productivity consisted of three experiments *viz.* Bael based agroforestry system, Teak based agroforestry system and Bael + Teak based agroforestry system. In bael (*Aegle marmelos*) based conservation agriculture system neither tillage practice nor the residue management practices influenced the CD and plant height. The seed yield of mustard varied from 1285 kg ha^{-1} under minimum tillage (MT) to 1321 kg ha^{-1} under conventional tillage (CT). Similarly, in case of barley, the grain yield ranged between 2939 (MT) and 2988 kg ha^{-1} (CT), however, the tillage effects were non-significant.
- Among tillage practices, conventional tillage recorded seed yield of 243.3 (CT) and minimum 233.9 kg ha^{-1} (MT) in blackgram. Similarly, in greengram the seed yield under CT was recorded as 422 kg ha^{-1}, while in MT seed yield of 412.6 kg ha^{-1} was recorded. The effects of residue management showed that the seed and straw yield of blackgram was significantly influenced in leucaena residue treated plots. Similar trend was observed in greengram under varied tillage and residue management options.
- In Teak (*Tectona grandis*) based conservation agriculture system, the tillage and residue management practices did not influence the CD and plant height. Seed yield of mustard as influenced by tillage practices varied in the range of 1275 to 1310 kg ha^{-1}. Among residue management, seed yield varied from 1173 to 1365 kg ha^{-1} and leucaena residue had significant influence on seed yield as compared to with crop residue and without any residue. In barley, tillage and residue practices, had similar trend as to that of mustard. Further, the growth and yield attributes of mustard and barley varied significantly with residue management practices, however the effects were non-significant with tillage practices.
- In Bael + Teak based conservation agriculture system, the bael and teak seedlings gained average height of about 72 and 97 cm, respectively. The seed yield of mustard was not influenced by tillage practices, however the residue management had significant influence on seed and straw yield of mustard in the system. Seed yield of blackgram recorded non-significant effect of tillage, however the residue management practices recorded significant influence. By and large similar trend was observed both in case of tillage and residue management options for greengram.
- Mapping of agroforestry area was undertaken in two agro-climatic regions *viz.* Western Dry region and Western Plateau & Hills region. Area under agroforestry in Western Dry region and Western Plateau & Hills region, was calculated as 0.43 and 1.55 M ha, respectively.
- The soil organic carbon (SOC) in agroforestry system existing on farmers field under 0-90 cm soil depth varied from 40.97 to 62.57 t C ha^{-1} in Bellary and Tumkur districts of Karnataka, Kurdha (Odisha), Pusa (Bihar), Chittoor

(Andhra Pradesh), Ahmad Nagar (Maharashtra) and Himachal Pradesh (Solan).

- The tree biomass, soil carbon and total carbon in baseline varied from 2.86 - 45.13 t DM ha^{-1}, 6.17-19.24 t C ha^{-1} and 29.14 - 44.17 t C ha^{-1}, respectively in Bellary, Tumkur and Kolar district of Karnataka. It is expected that the corresponding value of these parameters would increase up to 5.06 - 80.59 t DM ha^{-1}, 26.17 - 93.68 t C ha^{-1} and 31.62 - 63.94 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 2.48, 19.77 and 17.26 t C ha^{-1}, respectively in Bellary, Tumkur and Kolar districts of Karnataka. In case of Solan, Kurdha and Pusa districts, the total carbon stock available in baseline varied from 13.30 to 32.58 t C ha^{-1} and it is expected that over 30 years of simulated period, the total carbon stock in agroforestry in these districts would be 17.37 to 47.46 t C ha^{-1}. Net carbon sequestered over the simulated period of 30 years would be 4.07 to 14.88 t C ha^{-1}.
- The tree biomass, soil carbon and total carbon available in existing agroforestry system in different districts of Maharashtra (Latur, Wardha, Thane, Ahmed Nagar and Nashik) varied from 1.36 to 11.11 t DM ha^{-1}, 12.04 to 18.65 t C ha^{-1} and 16.07 to 22.94 t C ha^{-1}, respectively and its corresponding values over the simulated period of 30 years would be 3.85 to 29.06 t DM ha^{-1}, 14.51 to 20.80 t C ha^{-1} and 27.00 to 41.68 t C ha^{-1}, respectively. The tree biomass, soil carbon and total carbon available in existing agroforestry system in Chittoor district of Andhra Pradesh were observed 21.10 DM ha^{-1}, 16.36 t C ha^{-1} and 35.13 t C ha^{-1}, respectively and its corresponding values over the simulated period of 30 years would be 49.26 t DM ha^{-1}, 18.15 t C ha^{-1} and 50.68 t C ha^{-1}, respectively.
- Clear trends in physiological traits associated with thermotolerance in temporal and seasonal scale in the multipurpose tree species (MPTS). Canopy temperature depression (CTD), rate of CO_2 assimilation and spectral indices were relatively more responsive towards temperature changes across the seasons.
- In Garhkundar-Dabar watershed of Tikamgarh district of Madhya Pradesh 749.1 mm rainfall (14.6% deficit than normal), was received and it was spread over in 41 rainy days. Peak discharge from treated watershed was 49.13% lower than untreated watershed for the event and it was delayed by 1.0 hour 10.0 minutes. The base flow from treated watershed was longer by about 3 hours 30 minutes as compared to untreated watershed for the event of 34.6 mm rainfall. During the year 670 saplings of different Agroforestry tree species were planted on 21 farmers' fields as well as on field bunds and the species were 386 *Acacia senegal*, 80 *Bambusa vulgaris*, 114 *Tectona grandis* and 90 *Acacia nilotica* saplings.
- Keeping in view the low rainfall forecast during 2015 and mass awakening of farmers was done and as a result farmers of the watershed devoted maximum area to sesame and blackgram in *Kharif* season. Wheat productivity in 2014-15 was recorded 1640 kg ha^{-1}. Lower productivity was due to lodging of crop due to winter rains. Guava based agroforestry system was developed on two farmers' fields,

while citrus and aonla based system in one farmer each in Garhkundar - Dabar watershed.

- In Domagor Pahuj Watershed of Jhansi district, strengthening of livelihood through Women Self Help Groups (WSHGs), water resource development, productivity enhancement, exposure visits and convergence were taken up. Maximum area was recorded in sesame and blackgram in *kharif* season and barley during *rabi*. *Kharif* crop trials were carried out in 25 farmers' fields while *rabi* trials were conducted at 30 farmers' fields. Wheat trials of Lok-1 and HI 1479 were carried out with 20 farmers in 50 acre land. The response in terms of productivity was 10-15% higher as compared to local varieties. A number of capacity building programmes were organized for developing knowledge, understanding and skills of the farmers.
- In Parasai-Sindh Watershed of Jhansi district total rainfall recorded during the year was 481.5 mm (about 45% less than the normal) spread over in 46 rainy days. Not even a single day rainfall was sufficient to generate runoff in any land use system. The average water column during the year varied from 3.42 m in January to 2.04 m in December with 2.68 m in October. However, average water column in Hatlab, (untreated watershed), was 1.44 m in October. The water table was about 86% higher in treated watershed as compared to untreated watershed during post monsoon. The effective groundwater recharge during the year was about 9 cm only as the rainfall was significantly lower than normal. Therefore, higher water column in treated watershed was due to residual effect of 2013.
- Due to delayed monsoon and long dry spell during rainy season, *kharif* crops were affected badly. During *rabi*, 2014-15, majority of the area was under wheat crop (var. Lok-1, HI 1544, HI-1479 and WH-147). Due to residual effect of ground water recharge during 2013, farmers were able to harvest *rabi* crops satisfactorily during 2014-15. The productivity of *rabi* season crops in treated watershed was significantly higher than productivity of untreated watershed.
- Clonal plants of *Pongamia pinnata* indicated better physiological adaptability than seedling plants. Physiological traits as revealed through various physio-biochemical analysis including leaf spectral indices supported the comparative physiological efficiency of clonal plants in the field.
- In *Acacia nilotica* one provenance progeny trial (20) and two candidate plus tree trial (22 + 11 CPTs) are being evaluated morphologically. This year, a DNA extraction protocol was standardized for initiation of molecular characterization. A modified CTAB method yielded good quality DNA, which was visibly quantified on the agarose gel. All the other standard protocols yielded DNA, which could not be visualized on agarose gel.
- In Jatropha breeding program, 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.15 accessions were characterized with these 20 primers.
- In the candidate gene based analysis of the *Pongamia* genotypes, the primers based on the *Jatropha curcas* candidate genes did not show amplification in

Pongamia. Hence, the transcriptome analysis based on seed source was done for the first time globally using illumina Hiseq 2500 platform. 6.8 Gb data were generated and assembled into 215858 unitranscitps with the length ranging from 200bp to >5000bp. The transcript expression analysis revealed 106832 unigenes that are considered for downstream analysis.

- Under the 'National network on integrated development of Jatropha, Karanj and Mahua' funded by NMOOP-MM-III, the evaluation of the National Multilocation Trials and the progeny trials were continued for both Jatropha and Karanj. High yielding genotypes of Karanj *viz.*, NRCP- 24, NRCP-26, NRCP- 92, NRCP- 95, NRCP-123, NRCP- 124 and NRCP-156 were identified.
- In agri- horti- silviculture and horti-silviculture –II models, the gum yield of *A. senegal* ranged from 26.10 to 134.71 g tree^{-1} with an average value of 58.70 g tree^{-1}. The gum tears varied in shape and size. In horti-silviculture-II model, the gum yield of *A. nilotica* ranged between 11.66 to 90.63 g tree^{-1}, with an average of 40.15 g tree^{-1}. The numbers of gum tear varied from 4 to 20 tree^{-1} with mean 9.67 tears tree^{-1}.
- During *rabi* season wheat (var. HUW 234 Z-1) sown in agri- horti- silviculture model showed that different tree species had significantly reduced grain yield up to 1.0m distance from tree trunk, while yield at 2.5 m and 4. 5m distance was not affected. In tree-line comparatively more plant population was observed under *A. senegal* (57 plants m^{-2}), while the control (64 plants m^{-2}) recorded maximum. Maximum total biomass was recorded under *A. marmelos*, however the grain yield was not affected. In *B. monosperma* maximum gum-butea was obtained when notching was done up to 1.0 cm depth on stem bark of the trees. The notching done up to depth of 0.5 cm yielded minimum gum-butea.

1. INTRODUCTION

Agroforestry has traditionally been a way of life and livelihood in India for centuries. The country has also been in the forefront since organized agroforestry research started worldwide. Agroforestry is playing the greatest role in maintaining the resource base and increasing overall productivity in the rainfed areas in general and the arid and semi- arid regions in particular. Overall productivity, soil fertility improvement, soil conservation, nutrient cycling, microclimate improvement, and carbon sequestration potential of an agroforestry system is generally greater than that of an annual system. Agroforestry has the potential to provide most or all the ecosystem services.

After 27 years of successful research and development activities on agroforestry ICAR-CAFRI is striving hard to meet the technological challenges and gearing up to become global leader in the field of Agroforestry research and development. The efforts are in full swing to develop adoption friendly agroforestry techniques for non-arable, non-forest lands and arable lands under agroforestry system and increase number of trees outside the forest so that micro- climate mediation is achieved and degradation of natural resources halted.

Mission

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

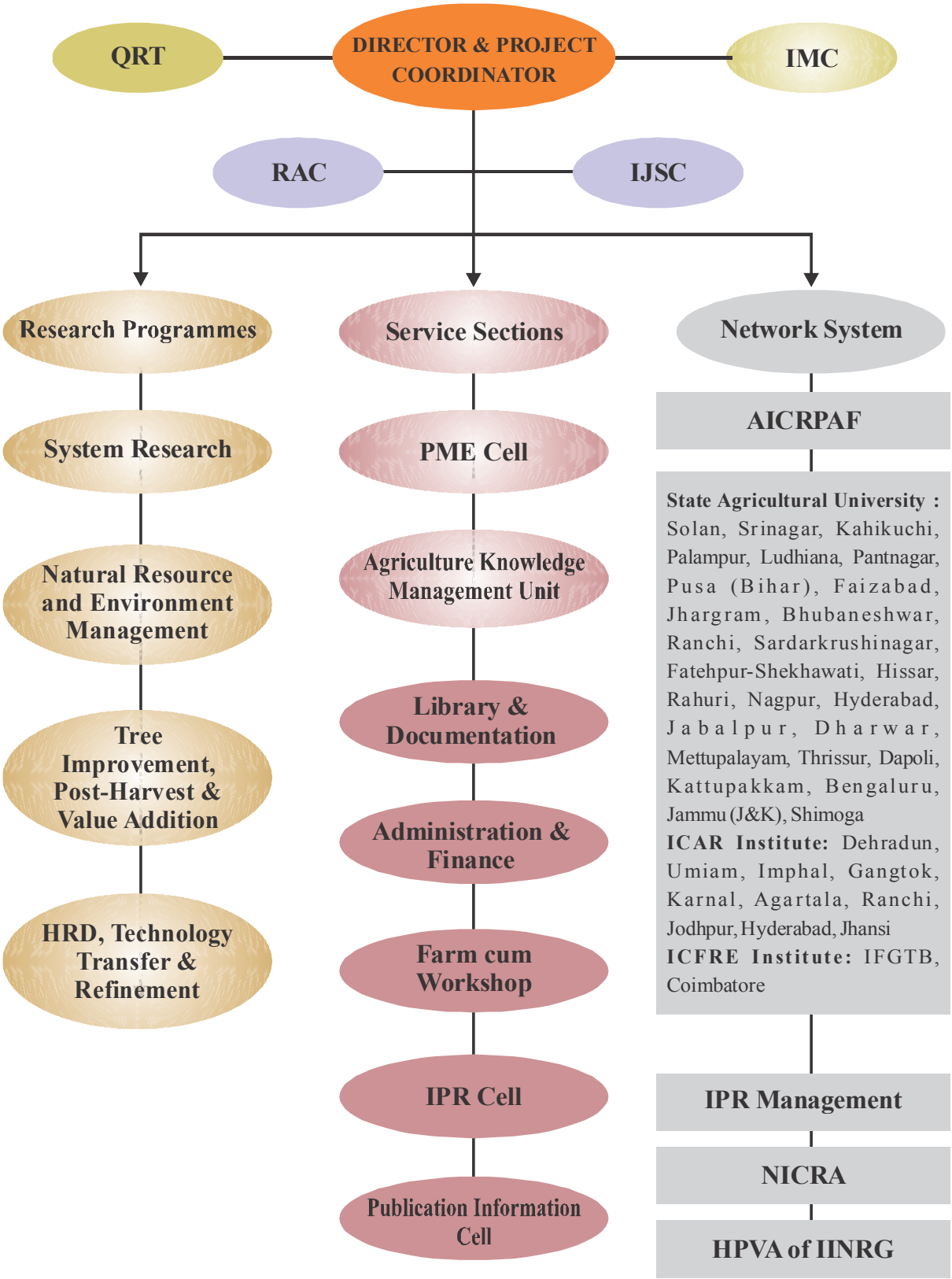
Vision

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.

Mandate

- Develop sustainable agroforestry practices for farms, marginal land and wastelands in different agro climatic zones of India.
- Coordinate network research for identifying agroforestry technologies for inter-region.
- Training in agroforestry research for ecosystem analysis.
- Transfer of agroforestry technology in various agro climatic zones.

Organizational Setup



Library

The Institute's library has more than 4505 books (including Hindi books), bounded back volumes of research journals and subscribes 15 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.

Laboratories

ICAR- CAFRI has a main office building with six well-equipped laboratories. The Institute has conference hall, computer laboratory, committee room and conference hall of 100 sitting-capacity.

Agriculture Knowledge Management Unit

The Institute has its own web server and regularly updated website (www.nrcaf.res.in). This year, Modified, updated and hosted web site in hindi on web server. 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. ERDAS Imagine 2015 and Arc GIS server software for online use have be procured and installed in GIS lab.

Academic

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. Institute contributing to education through UG teaching under collaborate programme with Rani Laxmibai Central Agriculture University, Jhansi.

Research Farm and facilities

The Institutes possess about 86 ha land. Major area is rocky and degraded land which was gradually developed. About 85% arable land have been utilized after phase development for various agroforestry experiments, bulk 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 and operation of canal. During *kharif* season drought like situation exist in the region. *Kharif* crops were badly affected due to drought and majority of crops were almost dried at growth stage and ploughed up. Due to drought year crop area under minimum irrigation requirement was increased and area under wheat crop was restricted during *rabi,* 2015-16. Crops shown during *rabi,* 2015-16 could be sustained with minimum irrigation from Pahuj canal as well as from shallow wells. Crop wise area and production during *rabi,* 2014-15 (received in 2015) and *Kharif,* 2015-16 are given below:

Season / Crop & Variety	Area (ha)	Production (t)
***Rabi* 2014-15**		
Wheat-WH147/HUW-234/ Lok-1/HI-1418	7.43	9.81
Barley-Jagrati/RD2552	6.26	9.61
Gram-Samrat/Avrodhi	2.30	0.11
Mustard-Varuna/RH749	2.90	1.23
Lentil-DPL62	2.10	0.23
Pea-Sapana	0.31	0.01
Taramira-Karan	5.65	Failed
Linseed-Garima	-	0.06
Mustard-(wild)	-	0.20
Straw	-	23.70
***Kharif* 2015-16**		
Blackgram-T-9, Shekhar, Azad.2	9.36	0.24
Moong-PDM-139	3.50	0.14
Til-G-1	8.37	0.06
Arhar-UPAS- 120	0.26	Crop failed
Cowpea-Komal	0.80	Crop failed
Sorghum	0.50	Crop failed

During *rabi*,2015-16 about 22.81 ha area have been sown which include 7.20 ha experimental and 15.61 ha general cropping in concluded agroforestry projects. Crop wise area sown in *rabi* season is given below:

Crop	Sown Area		Total
***Rabi* 2014-15**	**Experimental**	**General**	
Wheat HUW-234	0.90	3.85	4.75
Barley-Jagrati/RD2552	2.25	4.75	7.00
Gram-Jaki 9218	0.25	3.20	3.45
Mustard-RH749	2.6	2.90	5.50
Lentil-DPL62	0.70	0.91	1.61
Linseed-Garima	0.50	-	0.50
Total	**7.20**	**15.61**	**22.81**

During the year, two (nos.) spring tines cultivators (9 tines), two disc plough (3 discs), one trailed harrow (14 discs) and one shrub master were added in farm facilities. The central research farm facilitated with most improved farm machineries and implements for mechanized farm operations. A mini workshop equipped with welding plants, drill machine, car washer, grinder etc. besides other tools for repair and maintenance of farm machineries is available at the Institute.

During the year a revenue of ₹4.72 lakhs have been generated from Central Research Farm and details thereof is as under:

S. No	Farm Produce	Total (₹)
1.	Grains	3,35,446
2.	Fruits(aonla/bael/ber/lemon/guava)	36,233
3.	Tree/Fuel wood	26,500
4.	Straw	71,100
5.	Miscellaneous (transportation, water tanker charges etc.)	2460
	Grand Total	**4,71,739**

Budget (2015-16)

(₹ in Lakhs)

S. No.	Head of Account	NON- PLAN		PLAN	
		Allocation	Expenditure	Allocation	Expenditure
A.	**Main Institute**				
1.	Establishment charges including LSP & PF	525.00	524.97	0.00	0.00
2.	Wages	3.00	2.98	0.00	0.00
3	Overtime allowance	0.05	0.03	0.00	0.00
4.	Traveling expenses	3.00	2.98	3.15	3.14
5.	A. Other charges including HRD	54.95	54.95	134.20	134.14
	B. Capital	6.00	5.48	52.82	49.40
6.	**Works**	--	--	--	--
	Major(Original)	0.00	0.00	55.00	53.84
	Miner incl. R & M	9.00	9.00	12.65	12.64
	Total	**601.00**	**600.39**	**257.82**	**253.16**
1	Pension	2.00	1.97	0.00	0.00
2	P-Loans & Advances	1.50	1.29	0.00	0.00
B.	**Plan Scheme**				
1.	AICRP on Agroforestry, Coordinating Unit: ICAR- CAFRI, Jhansi				1304.40
2.	Harvest and post-harvest processing and value addition of natural resins, gums and gum resins(ICAR, New Delhi)				11.34
3.	IPR Management in agroforestry (ICAR, New Delhi)				8.58
4.	National Initiative on Climate Resilient Agriculture (NICRA; ICAR, New Delhi)				71.13
5	Development of digital library of spectral signatures for major agroforestry tree species				12.32
6	Microclimate dynamics, advanced ecophysiological, physio-biochemical traits and indicators for evaluating component limitations in agroforestry system with special reference to understory crops				4.33
C.	**Externally Funded Projects**				
1.	National Network on Integrated Development of Jatropha and Karanja (NMOOP-MM-III Project) & One training				9.28
2.	Integrated Nutrient Management in Blackgram and Bengal gram in Central Indian Conditions (Science and Engineering Research Board, DST, India)				7.75
3	Development of insecticide resistant strain of Trichogramma for the management of lepidopterous pest in semi-arid Central India (DST Project)				5.43
D	**Revenue Receipt**			**Target**	**Achievement**
				25.50	24.56

2. RESEARCH ACHIEVEMENTS

2.1: System Research Programme

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. The treatments were imposed in the field during *kharif*, 2013 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, by adopting RBD with three replications at a spacing of 6m x 8m and each treatment is having six plants. The treatments were imposed before the onset of monsoon. 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.

Effect on ber

The observation recorded on fruits (plant age 4.5 years) is presented in Table 1. All the fruit characters were found non-significant except fruit length, number of fruits and fruit yield plant^{-1}. However, maximum average fruit weight (15.59 g) was recorded in treatment $T_{8,}$ whereas it was minimum (12.27 g) in treatment T_4. Average bigger size fruits were harvested in treatment T_3 (3.12 cm x 3.00 cm) followed by T_8 (3.02 cm x 2.95 cm) and T_1 (2.98 cm x 2.95 cm). Fruit volume ranged from 12.59 cc (T_9) to 17.12 cc (T_3). Likewise pulp weight was more in T_3 (15.89 g), stone weight in T_3 (1.14 g) and pulp/stone ratio in T_2 (15.68), whereas it was recorded lowest in T_4 (11.59 g), T_4 (0.77 g) and T_3 (14.03), respectively. Maximum total soluble solids (TSS) were recorded in the juice of T_9 (17.63^{0}B), Number of fruits plant^{-1} were found significantly more in T_1 (1481.22), however, at par with T_8 (1477.53), whereas fruit yield was statistically significant in T_8 (23.02 kg plant^{-1}), however, was at par with T_1 (22.56 kg plant^{-1}) and T_3 (22.66 kg plant^{-1}).

The plants were pruned in the month of May (in 5th year after planting) and pruned material ranged from 3.72 to 8.35 kg plant^{-1} being a minimum in T_4 and maximum in T_7 on fresh weight basis, however on dry weight

Table 1: Effect of treatments on fruit characters and yield of ber (cv Seo) fruits

Treatment	Weight (g)	Size (cm)		Volume (cc)	Pulp wt (g)	Stone wt (g)	Pulp/ stone ratio	TSS ^{0}B	No. of fruits plant^{-1}	Yield (kg plant^{-1})
		L	W							
T_1	15.19	2.98	2.95	15.45	14.25	0.94	15.18	17.25	1481.22	22.56
T_2	14.34	2.87	2.88	14.45	13.48	0.87	15.68	16.71	1181.39	16.88
T_3	17.09	3.12	3.00	17.12	15.89	1.14	14.03	16.14	1326.07	22.66
T_4	12.27	2.72	2.77	12.72	11.59	0.77	15.06	16.98	1026.75	12.60
T_5	13.45	2.82	2.82	13.57	12.57	0.88	14.17	16.30	1280.11	17.39
T_6	14.16	2.90	2.87	14.34	13.28	0.88	15.23	16.83	1239.99	17.54
T_7	14.77	2.95	2.92	15.20	13.86	0.91	15.41	14.89	1149.53	17.17
T_8	15.59	3.02	2.95	15.90	14.60	0.99	14.86	16.06	1477.53	23.02
T_9	12.44	2.76	2.75	12.59	11.65	0.79	14.80	17.63	1412.43	17.44
CD $_{(0.05)}$	NS	0.24	NS	NS	NS	NS	NS	NS	182.50	4.96

basis it ranged from 2.20 to 4.80 kg plant^{-1} in the same treatments, respectively. After pruning cent percent survival % was observed in the field. The observations recorded in the month of December, 2015 reveals maximum collar diameter in T_1 (10.29 cm) and minimum in T_4 (7.76 cm), while canopy spread was more in T_1 (451.33 cm) for East-West direction and in treatment T_6 (454.75 cm) for North-South direction (Table 2).

Effect on sesame – lentil cropping sequence

Lentil (DPL-62) sown on November 12, 2014 (*rabi* season) was harvested during 1st fortnight of March, 2015. Seed yield was recorded in the range of 815 to 1069 kg ha^{-1} and straw yield of 1051 to 1379 kg ha^{-1} under different treatments. The treatments T_{10} (pure crop) and T_6 (Ber with 75% RDF + VAM + Sesame + Lentil) recorded highest seed yield of 1069 and 1017 kg ha^{-1} and was significantly higher w. r. t other treatments. Similar trend was observed for straw yield (Table 3). During *rabi*, 2015-16, lentil variety (DPL-62) was sown on November 2, 2015 (40 kg ha^{-1}) on residual fertility. During reporting period the data recorded on growth parameters are presented in Table 3. Table indicates that plant population varied in the range of 15.78 to 19.88 plants m^{-2} at 60 DAS (days after sowing). Plant height, root length and root + shoot dry matter accumulation varied in the range of 13.98 to 16.27 cm, 5.48 to 7.43 cm and 0.38 to 0.48 g plant^{-1}, respectively.

Table 2: Effect of treatments on pruned material and plant growth characters of ber fruits (cv Seo)

Treatments	Pruned materials (kg plant^{-1})		Collar diameter (cm)	Canopy spread (cm)	
	Fresh	Dry		EW	NS
T_1	7.13	3.94	10.29	451.33	444.28
T_2	6.42	3.47	9.19	421.19	414.11
T_3	5.89	3.40	9.34	423.01	420.34
T_4	3.72	2.20	7.76	347.50	334.17
T_5	5.72	3.37	9.37	430.06	425.50
T_6	6.61	3.65	10.13	439.42	454.75
T_7	8.35	4.80	8.83	406.67	418.67
T_8	8.03	4.30	8.96	450.61	448.39
T_9	7.22	3.67	8.89	383.78	394.00
$CD_{(0.05)}$	2.48	NS	NS	NS	NS

Table 3: Lentil yield (*rabi*, 2014-15) and growth parameters (*rabi*, 2015) at 60 DAS

Treatments	Seed yield (kg ha^{-1}): *Rabi*, 2014-15		Growth parameters of lentil at 60 DAS: *Rabi*, 2015 (upto Dec., 2015)			
	Seed	Straw	Plant population (m^{-2})	Plant height (cm)	Root length (cm)	Root+ shoot (DW g plant^{-1})
T_2	854	1127	18.63	16.27	5.65	0.43
T_4	874	1152	19.88	15.65	6.49	0.40
T_6	1017	1312	18.25	16.01	6.24	0.44
T_8	815	1059	15.78	15.34	5.48	0.41
T_9	821	1051	16.96	13.98	5.87	0.38
T_{10}	1069	1379	16.21	15.12	7.43	0.48
CV (%)	17	18	16.65	16.95	11.83	17.72
$CD_{(0.05)}$	141	223	NS	NS	NS	NS

During *kharif* season, sesame variety G-1 was sown on July 14, 2015 (4.5 kg ha^{-1}) with recommended dose of nutrients (30 Kg N, 15 Kg P ha^{-1}). Plant population, plant height and test weight were observed to be non-significant, however No. of capsules/plant and seeds/capsule were significantly influenced by different treatments. Crop was harvested during September 30, 2015 to October 2, 2015. The seed yield varied in the range of 562-704 kg ha^{-1}. The treatments T_{10} (pure crop) and T_6 (Ber (75% RDF) + VAM + Sesame + Lentil) recorded highest seed yield of 704 and 695 kg ha^{-1} and was significantly higher w.r.t other treatments. Similar trend was observed for straw yield (Table 4).

Effect on Soil Properties

All the treatments caused significant variation in SOC built up, available N and K in surface (0-15 cm) and sub- surface (15- 30 cm) soil (Table 5). The treatments had no effect on soil pH. However, EC of surface soil varied significantly with treatments. In general, all the treatments had better soil test values than control at both depths of the soil.

Protein Content in Ber Foliage and Fruits along with Stone

Significant variation was observed in protein content of ber foliage and fruits due to different treatments. In foliage, maximum protein content was recorded in T_6, while

Table 4: Yield and yield contributing characters of sesame during *kharif*, 2015

Treatments	Plant population (m^{-2})	Plant height (cm)	Test weight (g)	Capsules $plant^{-1}$	Seeds $capsules^{-1}$	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_2	15.44	54.97	3.05	39.83	31.35	573	733
T_4	16.13	50.71	3.08	38.90	30.84	562	711
T_6	17.37	58.47	3.15	41.25	31.79	695	886
T_8	16.59	56.33	3.02	39.60	31.26	601	737
T_9	16.54	59.67	3.07	39.49	30.36	593	776
T_{10}	17.17	57.08	3.11	43.22	33.75	704	913
$CD_{(0.05)}$	NS	NS	NS	1.38	0.82	92	101

Table 5: Effect of treatments on soil properties (rhizosphere soil taken 0.5m away from tree trunk in tree-saucer) during 2015

Treatments	Surface soil (0-15 cm)					Sub-surface soil (15-30 cm)				
	pH1:2	EC (µ Sm^{-1})	SOC (%)	Available N (kg ha^{-1})	Available K (kg ha^{-1})	pH1:2	EC (µ Sm^{-1})	SOC (%)	Available N (kg ha^{-1})	Available K (kg ha^{-1})
T_1	7.10	379.33	0.86	296.88	202.85	6.80	183.67	0.66	259.24	140.59
T_2	6.60	245.00	0.76	263.42	218.00	6.38	136.33	0.36	255.06	141.43
T_3	6.76	275.67	0.83	250.88	220.52	6.67	172.00	0.50	246.70	164.15
T_4	6.63	324.67	0.80	253.42	214.63	6.31	176.33	0.65	259.24	159.94
T_5	6.45	242.67	0.77	280.15	217.16	6.34	190.67	0.49	263.42	171.72
T_6	6.98	285.67	0.78	280.15	234.83	6.82	171.33	0.46	246.70	199.49
T_7	6.39	390.33	0.91	290.15	221.37	6.03	209.33	0.60	250.88	197.81
T_8	6.35	279.67	0.73	258.45	272.69	6.44	154.00	0.50	252.85	181.82
T_9	6.48	250.00	0.66	273.48	208.74	5.74	125.67	0.42	242.52	172.56
T_{10}	5.98	164.33	0.49	246.70	119.55	6.05	136.30	0.29	230.09	108.62
$CD_{(0.05)}$	NS	105.96	0.10	19.31	37.71	NS	48.50	0.12	NS	26.27

minimum in T_3. However, in fruits, T_7 gave maximum protein, while T_2 minimum. In general, protein content was higher in foliage than the fruits (Fig.1).

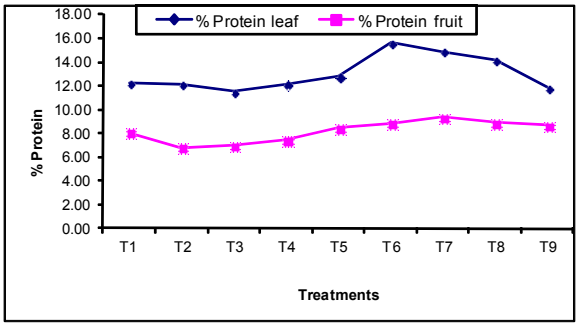


Fig. 1: Effect of treatments on protein content in ber leaf and fruits during 2015

Ber + Lentil

Ber + Sesame

Ber Pruning

New flush after pruning

AF 03.9: Initiation of Pruning and its Intensity on Productivity of *Albizia procera* based Silvipastaoral System

(Inder Dev, K B Sridhar & Asha Ram)

Initiation of pruning and its intensity on productivity of *Albizia procera* based silvipastoral system was started initiated 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 December, 2015. The data on survival (%), growth and biomass production are presented in Table 6, 7 and 8. 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 12.03 to13.92 m, dbh (15.08 to 17.15 cm), canopy spread (2.17 to 3.98 m). The growth parameters of *C. fulvus* varied in the range of 1.29 to 1.48 m (height), 28.58 to 32.46 cm (tussock diameter), 52.17 to 58.43 (tillers tussock^{-1}), whereas *S. seabrana* gained 1.15 to 1.31m (height) and 51.56 to 55.64 (branches plant^{-1}) (Table 7). Leaf fodder production was significantly affected by different levels of pruning. Total biomass production from the silvipastoral system varied in the range of 7.38 to 8.14 D.W. t ha^{-1} and was significantly affected by the levels of pruning intensity (Table 8).

Table 6: 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	63.21	14.08	17.15	2.17
3rd year	51.78	13.92	16.89	2.43
4th year	46.58	13.51	16.48	2.72
5th year	44.63	13.07	15.76	2.89
6th year	32.08	12.88	15.08	3.98
$CD_{(0.05)}$	NS	NS	NS	0.92
Intensity of pruning				
25%	51.43	12.03	16.21	2.14
50%	52.74	16.67	15.43	2.39
75%	41.24	13.24	15.87	2.76
$CD_{(0.05)}$	NS	NS	NS	NS

Table 7: Growth of pasture component influenced by age and intensity of pruning in *A. procera* based silvipastoral system

Treatments	*Chrysopogon fulvus*			*Stylosanthes seabrana*	
	Height (m)	Tussock diameter (cm)	Tillers tussock^{-1}	Height (m)	Branches plant^{-1}
Initiation of pruning					
2nd year	1.38	30.84	57.18	1.18	52.53
3rd year	1.45	31.25	58.43	1.15	53.71
4th year	1.48	32.46	53.27	1.24	52.17
5th year	1.35	29.57	52.17	1.21	51.56
6th year	1.29	30.17	55.35	1.19	52.18
$CD_{(0.05)}$	NS	NS	NS	NS	NS
Intensity of pruning					
25%	1.37	31.19	56.42	1.24	54.85
50%	1.32	29.54	52.43	1.29	55.64
75%	1.29	28.58	55.87	1.31	53.68
$CD_{(0.05)}$	NS	NS	NS	NS	NS

Table 8: Fuelwood and forage production (D.W. t ha^{-1}) influenced by age and intensity of pruning in *A. procera* based silvipastoral system

Treatments	Tree		Pasture			Total fodder	Total biomass
	1	2	3	4	5 (3+4)	6 (2+3+4)	7 (1+6)
	Fuelwood	Leaf fodder	Grass fodder	Legume fodder	Total pasture		
Initiation of pruning							
2nd year	1.31	0.71	2.42	2.94	5.36	6.07	7.38
3rd year	1.34	0.78	2.78	2.87	5.65	6.43	7.77
4th year	1.37	0.63	2.84	2.71	5.55	6.18	7.55
5th year	1.41	0.74	2.79	2.84	5.63	6.37	7.78
6th year	1.64	0.85	2.64	3.01	5.65	6.5	8.14
$CD_{(0.05)}$	0.15	NS	NS	NS	NS	NS	NS
Intensity of pruning							
25%	1.37	0.64	2.51	2.92	5.43	6.07	7.44
50%	1.35	0.69	2.53	2.85	5.38	6.07	7.42
75%	1.51	0.72	2.65	3.05	5.70	6.42	7.93
$CD_{(0.05)}$	0.06	NS	NS	NS	NS	NS	0.35

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)

Important spectral indices like Normalized Difference Vegetative Index (NDVI), Photochemical Reflectance Index (PRI) and Water Balancing Unit (WBU) were systematically studied in the selected crops namely blackgram, pigeon pea and barley along with physiological traits. In black gram, plant height was increased in deep shade (50% shade) than in 33% shade and open field. With increse in shade intensity number of pods per plant and crop yield reduced significantly. Physiological traits such as biomass index reduced more in 50% and 75% shade, whereas marginal reduction in 33% shade as compare to open grown crops (Fig. 2).

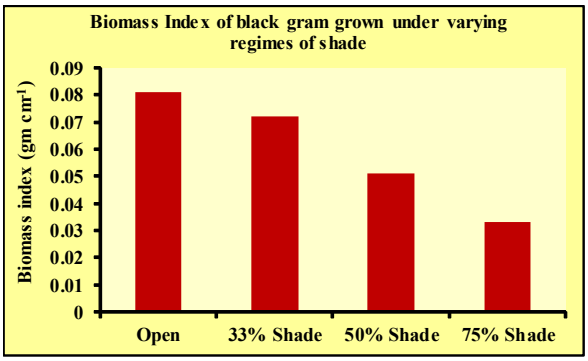


Fig. 2: Biomass index of black gram grown under varying regimes of shade

In case of pigeon pea, leaf area index increased with increase in shade intensity which is an important adaptive feature of crops under shade (Fig. 3). Plant height decreased with increase in shade intensity (Fig. 4). Canopy temperature depression (CTD) gradually increased with increase in shade intensity. Rate of CO_2 assimilation decreased under shade (Fig. 5) and similar pattern was followed by thylakoid electron transport also. These photosynthetic traits clerified the reduction of crop yield under shade or in low light intensity. NDVI and WBU decreased, whereas PRI gradually incresed with increse in shade intensity (Fig. 6). NDVI was positively corrleated with Canopy temperature depression (CTD) in all the intensity of shade and in open. These correlations clearly indicates the interconnected phenomenon of these traits under low light intensity or in shade grown crops.

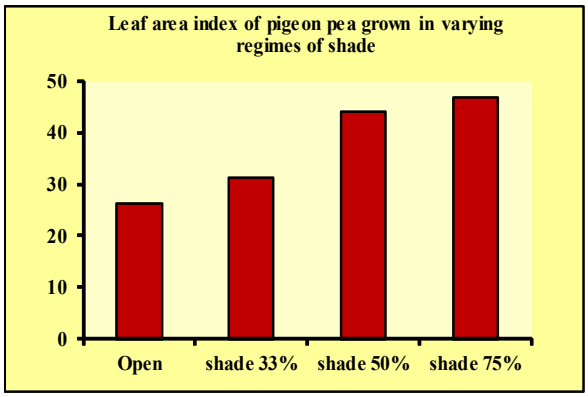


Fig. 3: Leaf area index of pigeon pea grown under varying regimes of shade

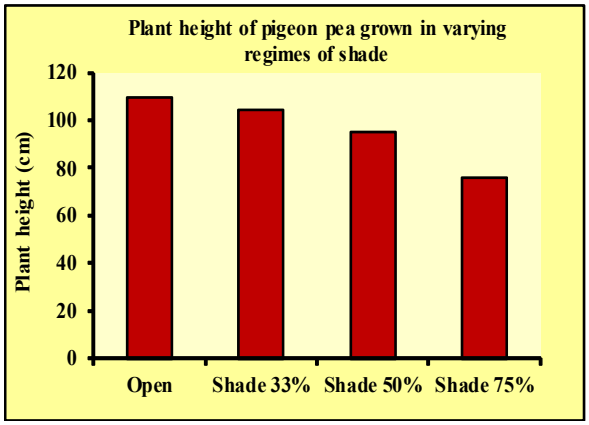


Fig. 4: Plant height of pigeon pea grown under varying regimes of shade

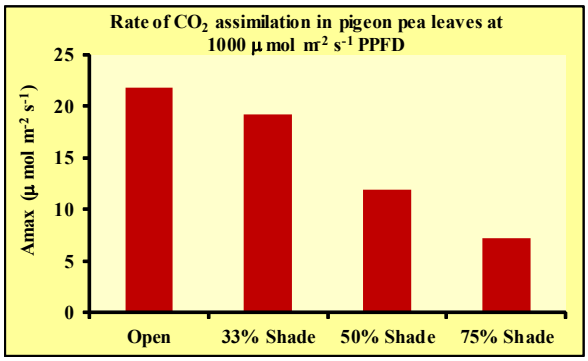


Fig. 5: Rate of CO_2 assimilation of pigeon pea grown under varying regimes of shade

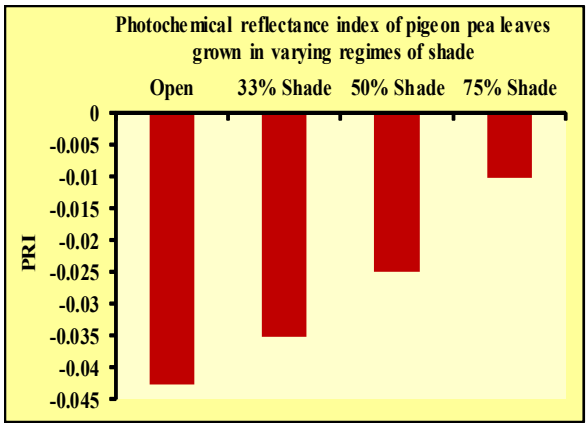


Fig. 6: Photochemical reflectance index of pigeon pea grown under varying regimes of shade

In barley, leaf photosynthetic pigments like chlorophyll a, chlorophyll b and total chlorophyll was higher in deep (50% shade) or deeper shade (75% shade). Biomass index was highest in open grown plants and decreased as the shade intensity increased (Fig. 7). Yield and number of seeds per plant of barley were reduced as shade intensity increased (Fig. 8). With increase in shade intensity NDVI and WBU decreased whereas PRI incresed (Fig. 9). Rate of CO_2 assimilation was positively correlated with NDVI in all the intensity of shade and in open. This positive corrleation was clearly indicates the effect of shade intensity on photosynthetic activity of plants.

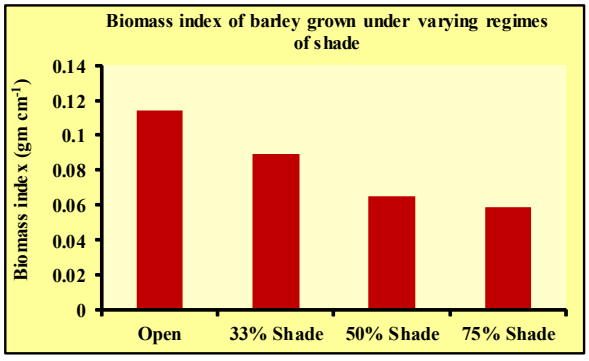


Fig. 7: Biomass index of barley grown under varying regimes of shade

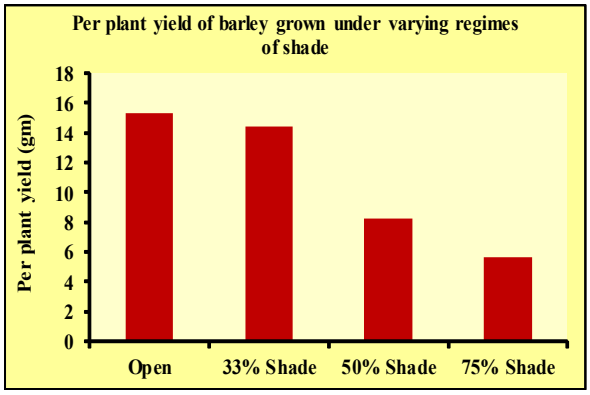


Fig. 8: Per plant grain yield of barley grown under varying regimes of shade

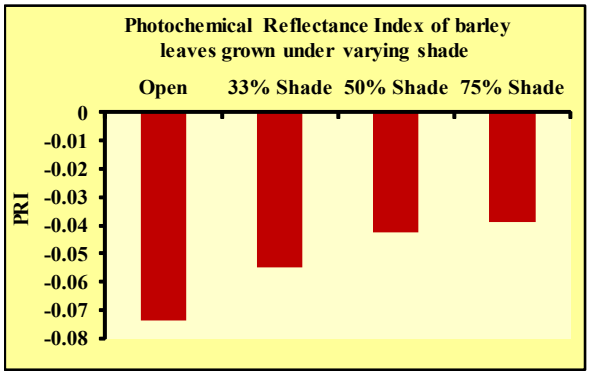


Fig. 9: Photochemical reflectance index of barley grown under varying regimes of shade

AF01.24: Studies on Arbuscular Mycorrhizal Fungi of Important Agroforestry Plant Species of Bundelkhand Region

(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 performance of bio-fertilizers

when applied along with chemical fertilizers, were conducted in important pulses at institute farm and farmers' field during last year. Separate experiments were conducted in chickpea, pea and lentil during *rabi*, 2015-16 and greengram, blackgram and groundnut during *kharif*, 2015 in randomized block design under field conditions. Each experiment consisted of six treatments *viz.*, DAP + AMF, DAP + rhizobium, DAP + PSB, DAP + rhizobium + PSB, DAP + AMF + rhizobium + PSB and control (DAP). The data was recorded on yield and other plant growth parameters. Due to drought like conditions during *kharif*, 2015, sufficient water was not available for greengram and blackgram trials, conducted at Bhojla and Parasai villages (Table 9). Main results were as follows:

- Plot yield was significantly increased in all treatments studied in *rabi* crops, except DAP+PSB in chickpea. Per cent increase in yield in treated plots varied from 13-25.6% in chickpea, 14.4-67.5% in pea and 19.1-38.0% in lentil (Table 10).
- Plot yield was significantly increased in all treatments in green-gram and black-gram, except DAP + rhizobium in green-gram trial at village Parasai.
- In groundnut, DAP + AMF, DAP + PSB and DAP + AMF + rhizobium + PSB significantly increased plot yield.
- The results further indicated that AMF alone or along with other bio-inoculants gave better results than rhizobium and PSB under water stress conditions.

Table 9: Performance of bio-fertilizers in *kharif* crops during 2015 under field conditions

Treatments	Plot yield (g m^{-2} area) in			
	Greengram at village Bhojla	Greengram at village Parasai	Blackgram at village Bhojla	Groundnut at Institute farm
DAP	170.5	158.8	250.0	208.2
DAP+ AMF	217.9 (27.8)	227.7 (43.4)	359.2 (43.7)	237.0 (13.8)
DAP+ rhizobium	211.6 (24.1)	197.2 (24.2)	306.8 (22.7)	223.7 (7.4)
DAP+ PSB	204.7 (20.1)	207.8 (30.9)	325.2 (30.1)	231.8 (11.3)
DAP+ rhizobium+ PSB	211.4 (24.0)	204.6 (28.9)	352.0 (40.8)	214.8 (3.2)
DAP+ AMF+ rhizobium+ PSB	234.1 (37.3)	246.4 (55.2)	393.4 (57.4)	260.8 (25.3)
	$LSD_{0.05}$			
Block	NS	31.86	18.31	NS
Treatments	31.0	39.0	22.4	21.7

*Figures in parenthesis indicate per cent increase over control

Table 10: Performance of bio-fertilizers in *rabi* crops during 2015-16 under field conditions

Treatments	Chickpea	Pea	Lentil
DAP	391.5	515.7	597.5
DAP +AMF	483.9 (23.6)	705.1 (36.7)	816.5 (36.6)
DAP +rhizobium	491.9 (25.6)	864.0 (67.5)	769.2 (28.7)
DAP +PSB	442.5 (13.0)	590.0 (14.4)	711.7 (19.1)
DAP +rhizobium +PSB	474.6 (21.2)	695.4 (34.9)	824.7 (38.0)
DAP + AMF+ rhizobium+ PSB	452.5 (15.6)	586.2 (13.7)	767.4 (28.5)
	$LSD_{0.05}$		
Block	NS	NS	NS
Treatments	59.5	100.4	80.8

*Figures in parenthesis indicate *per cent* increase over control

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

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

Institute has selected Garhkundar-Dabar watershed in 2005-06 to improve rural livelihood through participatory watershed management by cost-effective integrated natural resource management and to establish 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. The details of watershed interventions were described in previous annual reports. Progress made during the year 2015 under different heads is as follow:

Hydrological Monitoring

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 749.1 mm rainfall, 14.6% deficit than normal, was received and it was spread over in 41 rainy days.

The hydrograph recorded on July 24, 2015 is depicted in Fig. 10. Peak discharge from treated watershed was 49.13% lower than untreated watershed for the event and it was delayed by one hour ten minutes. The base flow from treated watershed was longer by about 3 hours 30 minutes as compared to untreated watershed for the event of 34.6 mm rainfall (Fig. 10).

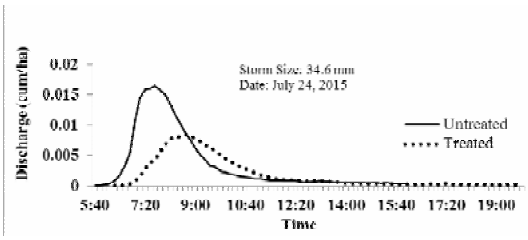


Fig. 10: Hydrographs recorded at outlets of treated and untreated watershed in Garhkundar

All open shallow dug wells in treated (116 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. During the month of October average water column was 3.24 m which is 32% higher than the average water column of open wells situated in untreated watershed.

Crop and Agroforestry Demonstration

During the year 670 saplings of accepted species were planted on 21 farmer's field on field bunds. They included 386 *Acacia senegal*, 80 *Bambusa vulgaris*, 114 *Tectona grandis* and 90 *Acacia nilotica* saplings (Table 11).

Table 11: species planted on farmers' field during 2015

Species	Number of saplings	Number of beneficiaries
Acacia senegal	386	15
Bambusa vulgaris	80	17
Tectona grandis	114	15
Acacia nilotica	90	7
Total	670	21*

*Absolute number of beneficiaries

Existing cropping practices, tree growth under agroforestry were recorded. In light of low rainfall forecast during 2015 and mass awakening of farmers in this respect, farmers of the watershed devoted maximum area to til and blackgram in *Kharif* season. Productivity of different crops sown in the watershed during *kharif*, 2015 and *rabi*, 2014-15 is given below (Table 12).

Wheat productivity in 2014-15 in the watershed was recorded 1640 kg ha^{-1}. Lower

Table 12: Productivity of different crops in Garhkundar-Dabar watershed

Rabi, 2014-15		*Kharif*, 2015	
Crop	Productivity (kg ha^{-1})	Crop	Productivity (kg ha^{-1})
Wheat	1640.0	Groundnut	936.0
Chickpea	384.0	Blackgram	234.0
Lentil	228.0	Greengram	266.0
Pea	794.0	Sesame	86.0

productivity than previous years was due to lodging of crop due to winter rains. High rainfall during winter affected crops like chickpea and lentil and production was hampered. However, pea production was 794 kg ha^{-1}.

Plant growth under agroforestry: Growth of fruit plants planted in 2007 under agroforestry system on farmers field are being monitored and presented below in table 13. 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 poor soil. Guava plants yielded 30.6 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.

Table 13: Growth of fruit plants under agroforestry system on farmer's field

Farmer	Fruit Tree	Height (m)	Collar Diameter (cm)	Spread (m)	Fruit Yield (kg tree^{-1})
Sh. Dhani Ram	Guava	4.26	12.1	3.94	30.6
Sh. Salim	Guava	4.96	15.2	6.22	44.3
Sh. Himmat	Aonla	5.21	15.4	5.35	37.4

On Salim's field growth of guava plants was better. Guava plants recorded 4.96 m height, 15.2 cm collar diameter and 6.22 m canopy spread. The average fruit yield of guava on Salim's field was 44.3 kg plant^{-1}. Aonla plants on Sh. Himmat's field recorded 5.21 m height, 15.4 cm collar diameter and 5.35 m canopy spread. Aonla plants are now commercially yielding fruits to the tune of 37.4 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 during the year.

Crop production under agroforestry system in *rabi*, 2014-15 and *kharif*, 2015 was recorded and it was observed that wheat production under guava based agroforestry system was reduced by more than 50%. This was due to tree shade under agroforestry system. Fruit plants supported farmers during adverse weather conditions.

Capacity Building and Self Help Group (SHG)

The women SHG is meeting regularly at fortnightly interval. Group members are taking up their own traditional activities, *i.e.* idol making and tent articles and pooling their savings. In 2015, total savings plus assets of women SHG Kundar is ₹ 1,38,435 (₹ one lakh thirty eight thousand four hundred thirty five only). The farmers of the watershed villages are being motivated and made aware about agroforestry practices. In November-December, 2015 the soil samples from watershed villages were collected and soil health cards are being prepared.

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)

Generalized models for wood biomass of *Acacia nilotica*

A total of 6 equations on timber biomass

of *Acacia nilotica* were found in the literature, two each for Haryana, Uttar Pradesh and Karnataka. These equations pertains to Hisar in Haryana and Jhansi in Uttar Pradesh. In all these equations, diameter at breast height (D) was used as independent variable for predicting timber biomass of tree. From these equations, data set was simulated for DBH and biomass, which was then used for developing generalized models at state level.

DBH range for equations of Karnataka was 6.45-10.77 cm, with the simulated data set of DBH and biomass, an equation of type $B = a. D^b$ has been fitted. The model $B = 0.0109 D^{3.2408}$ was found good fit with R^2 value of 0.715. Therefore this fitted model may be used for estimating biomass of *Acacia nilotica* trees in Karnataka.

Similarly, simulated data set for Haryana has been used for fitting generalized biomass model of *Acacia nilotica*. The fitted model $B = 0.2372 D^{1.7248}$ was found good fit with R^2 value of 0.987 for estimating biomass of *Acacia nilotica* trees for DBH range of 3.70-9.90 cm.

Similarly, simulated data set for Uttar Pradesh has been used for fitting generalized biomass model of *Acacia nilotica*. The fitted model $B = 0.7646 D^{1.7913}$ was found good fit with R^2 value of 0.994 for estimating biomass of *Acacia nilotica* trees for DBH range of 1.20-9.30 cm.

Country Level Wood Biomass Generalized Equation

Three dataset simulated from state level equations were pooled to get a single dataset on DBH and timber biomass. This dataset was used for developing country level generalized models for wood biomass of *Acacia nilotica*. High correlation coefficient between DBH and timber biomass of 0.909 indicate that DBH would be good predictor. Two types of model were fitted *viz*. $B = a. D^b$ and $B = a + b1. D + b2. D^2$; where B- wood biomass, D- diameter at breast height, but the model $B = 0.36015 D^{1.59835}$ was found good fit. The fitted curve and statistics for model are given in table 14 and Fig. 11. The developed model was validated on an independent data set for predicting biomass. Mean absolute error was found to be 0.54 and hence may be used for predicting wood biomass of standing *A. nilotica* trees for the DBH range of 1.20-9.90 cm.

Table 14: Fitted statistics for country-level generalized model for timber biomass

		Wald Confidence Interval			
Parameter	Estimate	A.S.E.	Param/ASE	Lower < 95%	>Upper
A	0.36015	0.10082	3.57219	0.15841	0.56190
B	1.59835	0.11281	14.16800	1.37261	1.82409

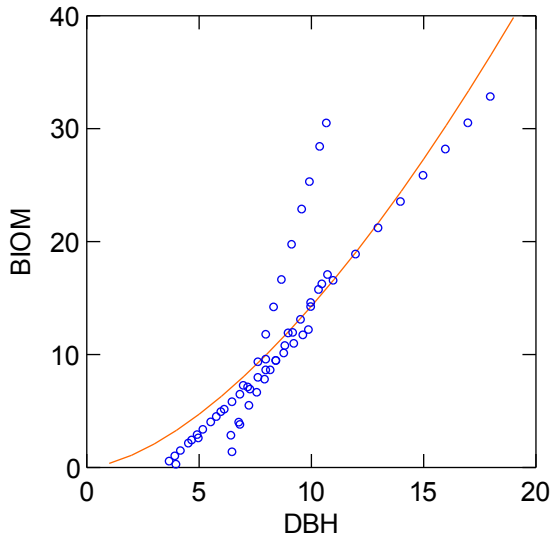


Fig. 11: Fitted Curve for biomass equation of *A. nilotica*

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

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

The project entitled "Agroforestry based Conservation Agriculture for sustainable landuse and improved productivity" was initiated during July, 2014 with 03

experiments *viz*., Bael based Agroforestry (AF) system; Teak based Agroforestry system and Bael + Teak based Agroforestry system. Each experiment comprising of 04 main plot treatments *viz*. 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 *rabi* 2014-15, mustard (RH-749) and barley (RD-2552) and during *kharif*, 2015, greengram (PDM-139) and blackgram (Azad-2) and were sown as per the treatment details, results of which are presented here as follows:

Experiment 1: Bael (*Aegle marmelos*) based Conservation Agriculture System

The bael seedlings planted during 2014 gained average height of about 69.14 cm and collar diameter (CD) of 15.56 mm (Fig. 12). It was observed that neither tillage practice nor the residue management practices influenced the CD and plant height. The seed yield of mustard varied from 1285 kg ha^{-1} under minimum tillage (MT) to 1321 kg ha^{-1} under conventional tillage (CT) (Fig. 13). Among the residue management practices, significant increase in seed yield of mustard under leucaena residue treated plots (1409 kg ha^{-1}) was observed followed by 1383 kg ha^{-1} under crop residue treated plots followed by 1118 kg ha^{-1} in without residue. The data on straw yield of mustard (Fig. 14), depicts straw yield of 4497 (MT) to 4575 kg ha^{-1} (CT), though were non-significant. Straw yield was recorded significantly higher in leucaena residue treated plots (4889 kg ha^{-1}) as compared to residue added plot (4775 kg ha^{-1}) and control (3944 kg ha^{-1}). Similarly, in case of barley, tillage and residue management effects had more or less similar trend (Fig. 15) as observed in mustard. The grain yield of barley ranged between 2939 (MT) and 2988 kg ha^{-1} (CT) and straw yield varied from 3313 (without crop residual) to 3483 kg ha^{-1} (with leucaena residue), however the tillage effects were non-significant. The data on growth and yield attributes of mustard (Table 15) showed non-

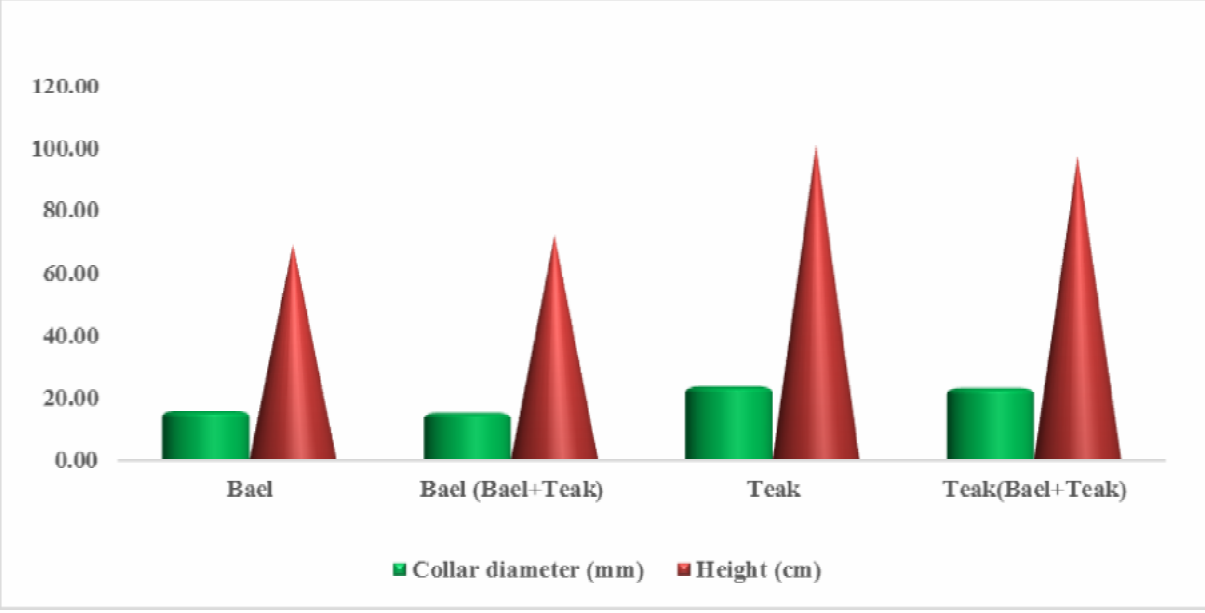


Fig.12: Average CD and height gained by bael and teak in different AFS

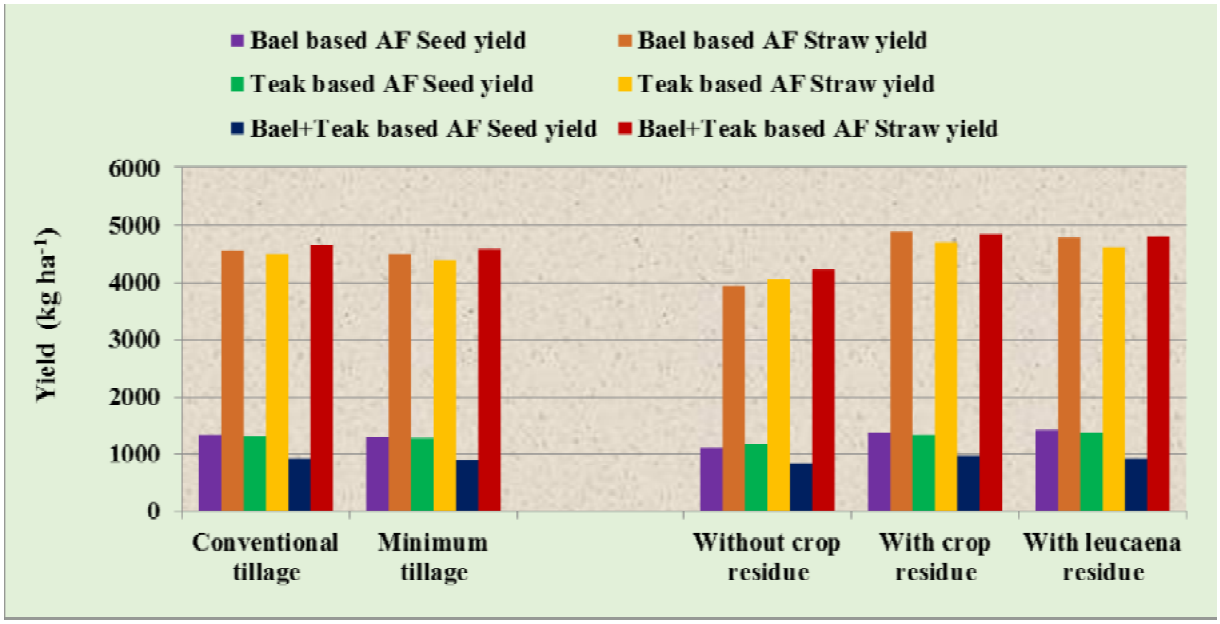


Fig. 13: Yield of mustard as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

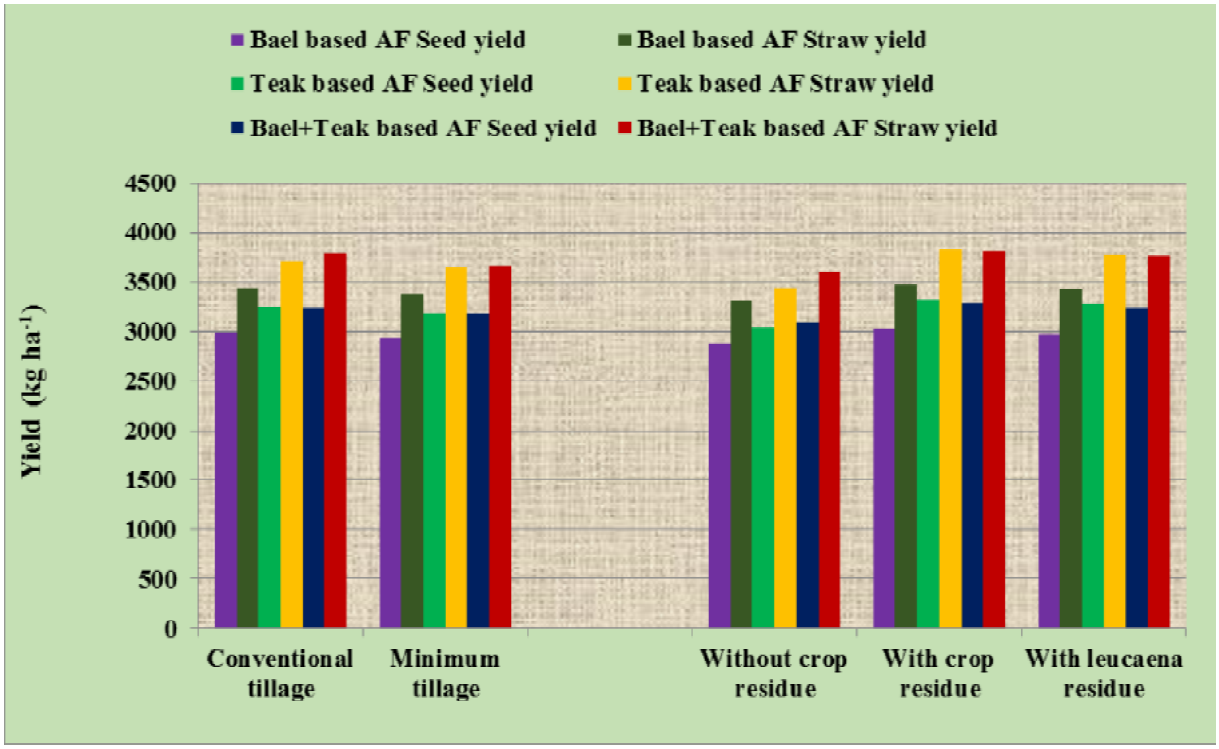


Fig. 14: Yield of barley as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

significant effects of tillage, however, among residue management practices, leucaena based plots had significant influence on plant population and yield attributing characters. Data presented in table 16 showed similar trend in barley and it was also observed that residue management had significant influence and yield contributing characters.

The data on seed and straw yield of blackgram and greengram are depicted in

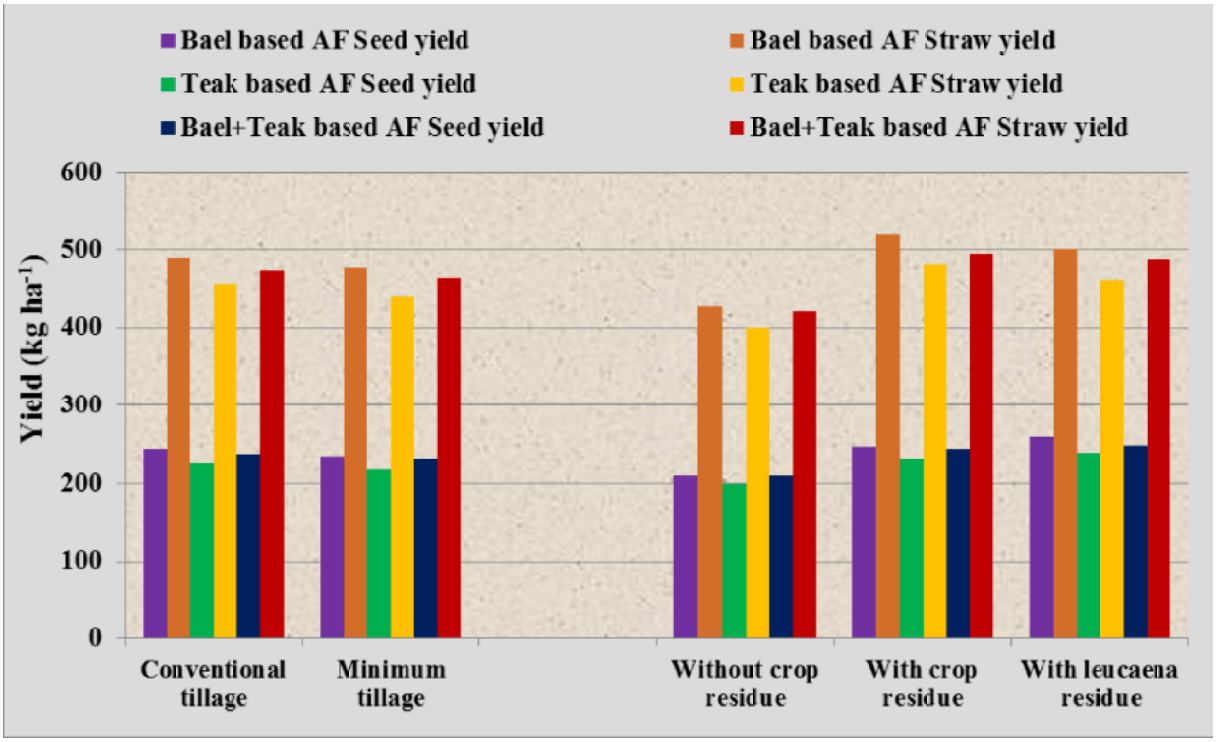


Fig. 15: Yield of blackgram as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

(Fig. 16 and 17). Among tillage practices, conventional tillage recorded seed yield of 243.3 (CT) and 233.9 kg ha^{-1} with minimum tillage (MT) in blackgram. Similarly, in greengram the seed yield under CT was recorded as 422 kg ha^{-1} while in MT seed yield of 412.6 kg ha^{-1} was recorded. The effects of residue management showed that the seed and straw yield of blackgram was significantly influenced by leucaena residue

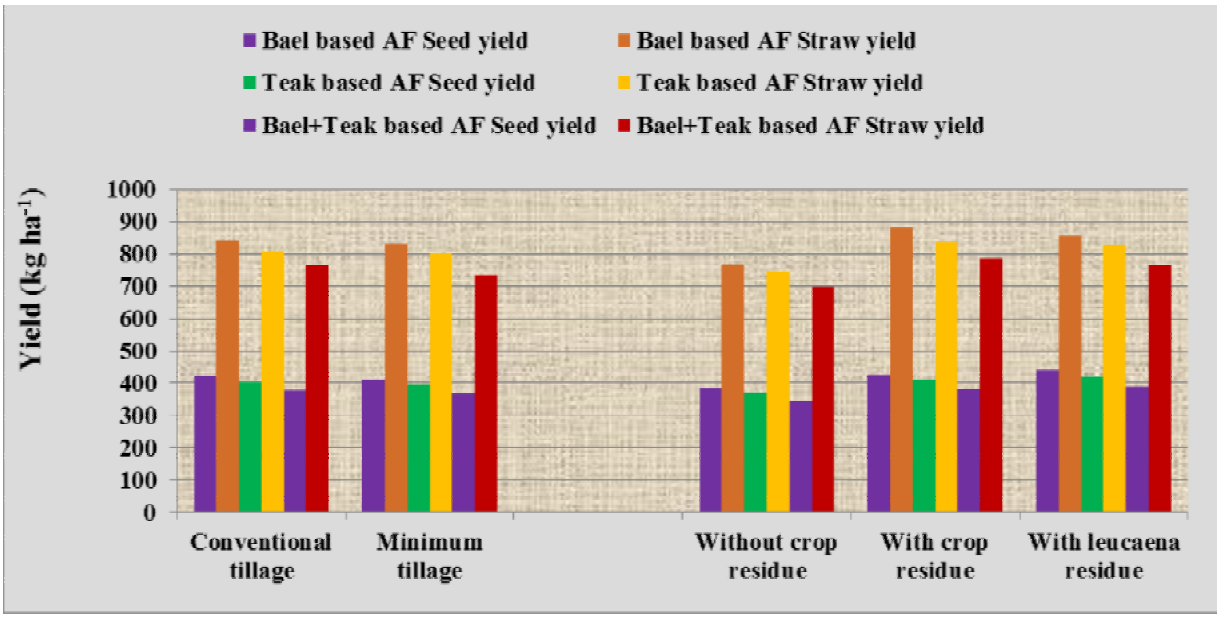


Fig. 16: Yield of greengram as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

treated plots. Similar trend was observed in greengram under varied tillage and residue management options. Data on growth and yield attributes of blackgram (Table 17) depicts that tillage practice did not influence the growth and yield contributing characters, however it was observed that among residue management options, leucaena treated plots had significant influence on growth and yield contributing characters. The growth and yield attributes of greengram (Table 18) depicts more or less similar trend for growth and yield contributing characters as that observed in blackgram.

Experiment II: Teak (*Tectona grandis*) based Conservation Agriculture System

The teak seedlings planted during 2014 gained average height of about 101 cm and collar diameter of 23 mm (Fig. 12). Tillage practice and residue management practices did not influence the CD and plant height in teak. Seed yield of mustard as influenced by tillage practices (Fig. 13) varied in the range of 1275 to 1310 kg ha^{-1}. Among residue management options, seed yield varied from 1173 to 1365 kg ha^{-1} and it was observed that the leucaena residue had significant influence on seed yield as compared to with crop

Table 15: Growth, yield attributes and straw yield of mustard as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

Treatments	Bael			Teak			Bael + Teak		
	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}
Main									
CT-Blackgram-Mustard	22.0	194.3	12.67	21.5	187.4	12.2	21.6	209.4	11.9
CT-Greengram-Barley	-	-	-	-	-	-	-	-	-
MT-Blackgram-Mustard	21.5	185.6	12.58	21.3	180.5	11.9	21.3	203.9	11.7
MT-Greengram-Barley	-	-	-	-	-	-	-	-	-
S Em±	0.4	1.8	0.02	0.2	1.1	0.1	0.0	1.3	0.1
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	0.2	NS	NS
Sub									
Without crop residue	20.9	174.0	11.24	20.4	172.7	11.1	20.8	186.4	11.3
With crop residue	21.7	193.4	13.08	21.8	186.5	12.4	21.6	212.3	12.0
With *leucaena* residue	22.8	202.5	13.56	22.0	192.6	12.6	22.0	221.3	12.2
S Em±	0.38	2.8	0.12	0.2	1.6	0.2	0.2	2.3	0.1
LSD (*P*= 0.05)	1.2	9.0	0.41	0.7	5.1	0.5	0.7	7.4	0.2
Main* x *Sub									
S Em±	0.5	3.9	0.18	0.3	2.2	0.2	0.3	3.2	0.1
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

residue and without any residue. The straw yield of mustard varied from 4400 to 4498 kg ha^{-1} though non-significant. In barley, tillage and residue practices, had similar trend as to that of mustard (Fig. 14). Further, the growth and yield attributes of mustard (Table 15) and barley (Table 16) varied significantly with residue management practices, however the effects were non-significant with tillage practices.

Seed yield of blackgram (Fig. 15) depicts variation of 226.7 (CT) to 219 kg ha^{-1} (MT), though non-significant. Residue management had significant effect on seed yield. More or less similar trend was found in yield of greengram (Fig. 16). Growth and yield attributes of blackgram were better under CT over MT, though the effects were non-significant and the residue management effects showed significant effect on yield attributes of blackgram (Table 17). By and large similar trend was observed on influence of tillage practices and residue management on growth and yield attributes of greengram (Table 18) as it was observed in case of blackgram (Table 17).

Experiment III: Bael + Teak based Conservation Agriculture System

In bael+teak based AFS, the bael and teak seedlings gained average height of about 72 and 97 cm, respectively. The average CD of bael and teak was found as 15 and 23 mm, respectively (Fig. 12). No significant difference were observed w.r.t height and CD as influenced by tillage and residue management

Table 16: Growth, yield attributes and straw yield of barley as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

Treatments	Bael			Teak			Bael + Teak		
	No. of tillers (m^{-2})	Spike weight (g)	No. of grains spike^{-1}	No. of tillers (m^{-2})	Spike weight (g)	No. of grains spike^{-1}	No. of tillers (m^{-2})	Spike weight (g)	No. of grains spike^{-1}
Main									
CT-Blackgram-Mustard	-	-	-	-	-	-	-	-	-
CT-Greengram-Barley	242.9	3.37	43.0	243.6	3.22	41.57	235.3	3.27	42.0
MT- Blackgram-Mustard		-	-		-	-		-	-
MT- Greengram-Barley	233.3	3.29	42.0	237.8	3.17	41.13	229.4	3.24	41.9
S Em±	0.2	0.03	0.3	1.1	0.04	0.48	1.5	0.01	0.3
LSD (*P*= 0.05)	1.2	NS	NS	NS	NS	NS	NS	NS	NS
Sub									
Without crop residue	219.9	3.18	39.6	214.9	3.07	38.01	216.6	3.13	38.7
With crop residue	249.6	3.35	43.6	255.7	3.23	42.80	242.4	3.30	43.4
With *leucaena* residue	244.9	3.46	44.4	251.4	3.28	43.23	238.0	3.34	43.8
S Em±	3.7	0.03	0.5	2.8	0.02	0.52	3.4	0.05	0.5
LSD (*P*= 0.05)	12.0	0.11	1.5	9.1	0.08	1.68	11.0	0.17	1.6
Main* x *Sub									
S Em±	5.2	0.05	0.7	4.0	0.03	0.73	4.8	0.07	0.7
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

practices. The seed yield of mustard was not influenced by tillage practices, however the residue management had significant influence on seed and straw yield of mustard in bael+teak based system (Fig. 13). Similar trend was observed in case of barley grain and straw production (Fig. 14). Most of the growth and yield attributing parameters of mustard were not influenced much under tillage practices, however, the residue management practices had significant effect (Table 15). Similarly, most of the growth and yield parameters of barley, recorded similar trend as obtained in case of mustard (Table 16).

Seed yield of blackgram (Fig. 15) showed non-significant effect of tillage, however, the residue management practices recorded significant influence. Similar trend was observed both in case of tillage and residue management options for greengram (Fig. 16). The data on growth and yield attributes of blackgram revealed positive but non-significant effect of tillage, however, residue management had positive and significant effect on growth and yield attributes of blackgram (Table 17). Further, similar to the trend observed in blackgram, the greengram had similar trend as observed in case of blackgram (Table 18).

Table 17: Growth, yield attributes and straw yield of blackgram as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

Treatments	Bael			Teak			Bael + Teak		
	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}
Main									
CT-Blackgram-Mustard	22.8	13.2	5.19	21.9	13.63	5.11	22.8	13.3	5.40
CT-Greengram-Barley	-	-	-	-	-	-	-	-	-
MT-Blackgram-Mustard	21.7	13.1	5.12	21.6	13.10	5.04	22.5	12.8	5.26
MT-Greengram-Barley	-	-	-	-	-	-	-	-	-
S Em±	0.2	0.0	0.04	0.2	0.09	0.05	0.1	0.1	0.03
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub									
Without crop residue	20.6	12.0	4.97	20.2	11.89	4.88	21.3	11.8	5.10
With crop residue	22.9	13.5	5.20	22.3	13.95	5.15	23.2	13.5	5.41
With *leucaena* residue	23.4	14.1	5.30	22.8	14.25	5.20	23.5	13.9	5.48
S Em±	0.3	0.2	0.08	0.4	0.14	0.07	0.4	0.2	0.08
LSD (*P*= 0.05)	1.0	0.6	0.25	1.1	0.45	0.22	1.3	0.6	0.27
Main* x *Sub									
S Em±	0.4	0.3	0.11	0.5	0.19	0.09	0.6	0.3	0.12
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 18: Growth, yield attributes and straw yield of greengram as influenced by tillage and residue management practices under bael, teak and bael + teak based agroforestry systems

Treatments	Bael			Teak			Bael+Teak		
	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}	Plant population (m^{-2})	Pods $plant^{-1}$	Seeds pod^{-1}
Main									
CT-Blackgram-Mustard	-	-	-	-	-	-	-	-	-
CT-Greengram-Barley	25.1	13.1	10.11	26.0	12.83	9.90	23.4	11.59	9.59
MT- Blackgram-Mustard	-	-	-	-	-	-	-	-	-
MT- Greengram-Barley	24.4	13.0	9.77	25.6	12.57	9.73	23.2	11.23	9.26
SEm±	0.4	0.1	0.09	0.2	0.07	0.05	0.0	0.09	0.09
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub									
Without crop residue	23.1	12.4	9.26	23.8	12.01	9.21	22.1	10.28	8.70
With crop residue	25.3	13.3	10.22	27.1	12.98	10.13	23.7	11.81	9.69
With *leucaena* residue	25.8	13.6	10.34	26.6	13.11	10.11	24.2	12.15	9.90
SEm±	0.4	0.2	0.14	0.5	0.08	0.08	0.4	0.12	0.13
LSD (*P*= 0.05)	1.2	0.6	0.45	1.7	0.25	0.27	1.3	0.40	0.41
Main* x *Sub									
SEm±	0.5	0.2	0.20	0.7	0.11	0.12	0.6	0.17	0.18
LSD (*P*= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Greengram in bael based AFS

Mustard and Barley in teak based AFS

AF 5.15: Management of Sulphur and Boron Deficiency in Mungbean-Mustard Cropping Sequence under Teak Based Agroforestry System

(Asha Ram, Inder Dev, Dhiraj Kumar & A R Uthappa)

The study on management of sulphur and boron deficiency in mungbean-mustard cropping sequence under teak based agroforestry system was initiated during *kharif,* 2015. Nine treatments comprising three levels of sulphur (0, 30, and 60 kg ha^{-1}) and three levels of boron (0, 1 and 2 kg ha^{-1}) were applied to mungbean *(kharif)* in Randomized Block Design and replicated thrice.

Initial height and collar diameter of teak were ranged from 103 to 126 cm and 20 to 25 mm, respectively (Fig. 17). Plant height of mungbean was significantly improved with sulphur and boron application. Sulphur @ 60 kg and Boron @ 2 kg ha^{-1} increased the dry matter accumulation by 28.2% over the control (S_0B_0). Yield attributes *viz.* pods plant^{-1}, seeds pod^{-1} and 1000-seed weight was observed significantly higher in all the treatment combinations of sulphur and boron over the control. Application of sulphur and boron at varying rate increased the seed yield

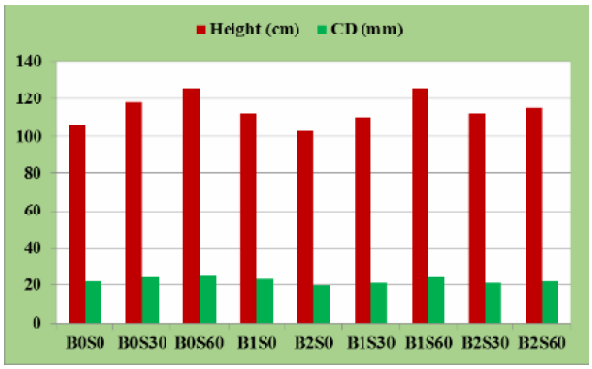


Fig. 17: Initial height and collar diameter of teak

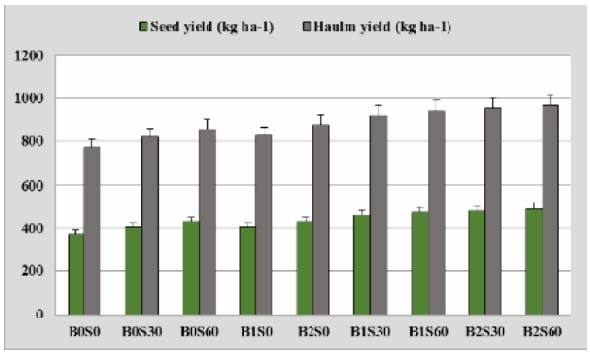


Fig. 18: Effect of sulphur and boron application on seed and haulm yield of mungbean

significantly over the control. Application of sulphur @ 60 kg ha^{-1} and boron @ 2 kg ha^{-1} recorded highest seed yield of 490.2 kg ha^{-1} (Fig. 18), however the yield was at par with B_2S_{30} (Sulphur @ 30 kg and Boron @ 2 kg ha^{-1}) and B_1S_{60} (Sulphur @ 60 kg and Boron @ 1 kg ha^{-1}). By and large similar trend was followed in haulm yield.

Table 19: Effect of sulphur and boron on growth, yield attributes and yield of mungbean in mungbean – mustard cropping sequence under teak based agroforestry system

Treatment	Plant population at harvest (m^{-2})	Plant height at harvest (cm)	Dry matter accumulation at harvest (g m^{-2})	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed weight (g)	Harvest index (%)
B_0S_0	24.0	32.5	138.0	10.49	5.50	8.50	31.89	32.65
B_0S_{30}	26.0	33.9	166.0	11.85	5.83	9.00	32.49	32.98
B_0S_{60}	27.0	35.1	169.0	12.16	6.00	9.50	32.30	33.35
B_1S_0	26.2	33.5	165.0	12.02	5.76	9.21	32.99	32.88
B_2S_0	28.0	34.8	187.9	12.52	5.89	9.23	32.80	32.85
B_1S_{30}	27.8	36.1	188.8	14.83	6.10	10.08	32.12	33.34
B_1S_{60}	27.5	36.4	179.4	13.50	6.30	11.53	33.22	33.38
B_2S_{30}	28.5	38.0	190.2	14.50	5.90	10.20	33.79	33.49
B_2S_{60}	28.0	38.4	193.9	14.46	6.20	11.00	34.00	33.66
SEm±	0.52	0.62	3.48	0.23	0.11	0.16	0.50	0.27
LSD (*P=0.05*)	NS	1.87	10.43	0.70	0.32	0.49	1.50	0.80

*B= Boron, S= Sulphur

2. RESEARCH ACHIEVEMENTS

2.3: Tree Improvement, Post-Harvest and Value Addition Programme

AF 01.23: 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)

The adaptability of clonal and seedling plants of *Pongamia pinnata* was studied under rainfed dry agroclimate with different physio-biochemical and spectral traits. Annual height and girth increment clearly indicated the superiority of clonal plants than seedling plants under dry agroclimatic conditions (Fig. 19 and 20). Canopy diameter increment of clonal plants of *P. pinnata* was higher than seedling plants (Fig. 21). Number of flowering bunches and number of pods of seedling plants were far low, when compared with clonal plants (Fig. 22). Similar pattern was noticed in per plant pod weight also. These results showed better adaptation of clonal plants under dry climatic conditions as compare to seedlings plants.

In case of average reflectance percentage and average transmittance percentage seedling plants indicated higher values than clonal plants, which reflected that seedling plants have lower absorbance capacity than clonal plants of *P. pinnata*. Clonal plants of *P. pinnata* have higher CO_2 assimilation capacity than seedling plants. Similar pattern was observed in thylakoid electron transport rate also.

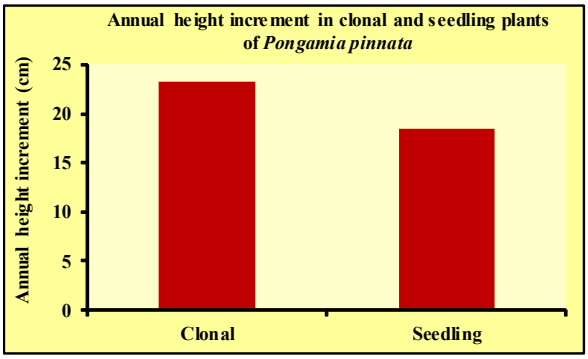


Fig. 19: Annual increment in height of clonal and seedling plants of *P. pinnata*

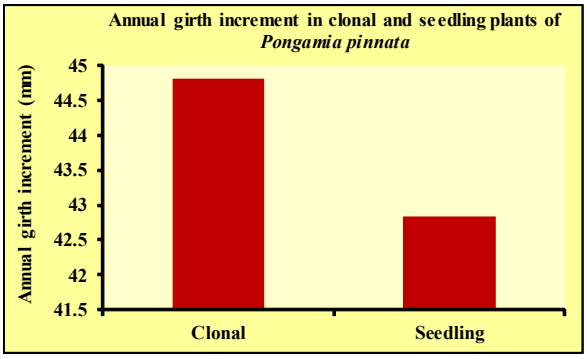


Fig. 20: Annual increment in girth of clonal and seedling plants of *P. pinnata*

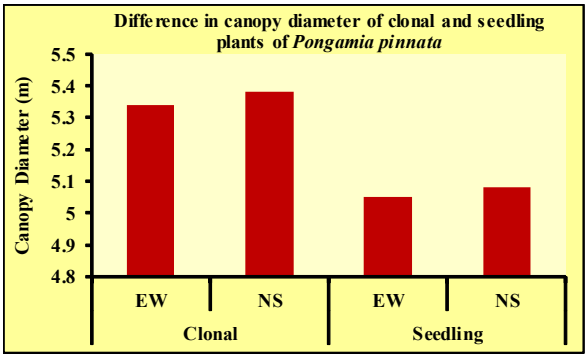


Fig. 21: Difference in canopy diameter of clonal and seedling plants of *P. pinnata*

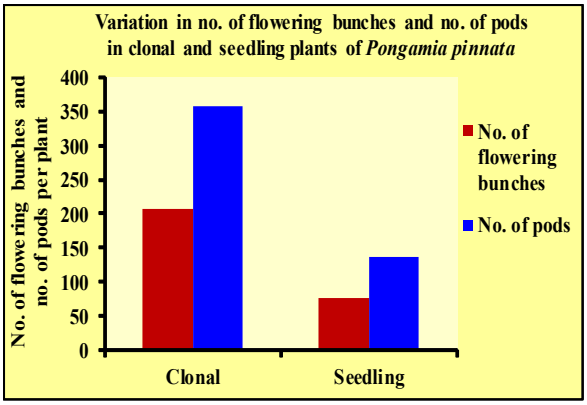


Fig. 22: Number of flowering bunches and pods per plant in clonal and seedling plants of *P. pinnata*

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

(S Vimala Devi, Badre Alam & A R Uthappa)

A provenance progeny trial (20 Provenances) and two Candidate Plus tree trials (22 & 11 CPTs) were established by following randomized block design with three replications in 2004- 2006. The germplasm, used for establishing these trials, was collected by exploration surveys in the states of Chhattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh & Rajasthan which lie between 20° 42'N to 25° 27'North latitude and 75° 39'E to 81°39'East longitude. The evaluation for the morphological growth parameters is being conducted every year since its establishment. In addition to its morphological characterization, in the reporting year, molecular characterization was initiated.

Quality DNA extraction is an important protocol for characterization of germplasm at molecular level. *Acacia nilotica* is known to contain various alkaloids like Tryptamine and its derivatives like N-Methyltryptamine N, N-Dimethyltryptamine, 5-MeO-DMT, Eleagnine and others, which hinder the extraction of DNA. DNA extraction protocol standardization was essential and hence in the reporting perior, this work was initiated with the standard protocols like CTAB method, SDS method, Kit method, *etc.* All the methods yielded DNA in the visible thread forms, which has extracted as pellets and then redissolved in TE buffer but was not visualized of the bands on the agarose gel. Hence, the basic CTAB method was modified at various steps including extraction buffer, incubating time, DNA precipitating solution, *etc.* The only standardized protocol which showed clear bands on the agarose gel was CTAB method with extraction buffer (3 % CTAB, 4 m NaCl, 100mM Tris, 20mmEDTA, 3 % PVP and 0.2 % ME) incubated for 30 min, the DNA was precipitated with 5 M NaCl, Ammonium acetate and Isopropanol. The spools, thus, obtained showed clear bands on the agarose quality check. By using this standardized protocol, DNA was extracted from 11 accessions (CPT-23 to CPT-33) (Fig. 23). The process of standardization of PCR amplification protocol is being carried out.

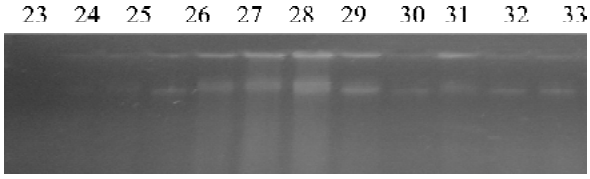


Fig. 23: Genomic DNA of *Acacia nilotica* Candidate Plus Trees

AF 04.5: Genetics and Breeding of *Jatropha* species

(S Vimala Devi, S B Chavan & A R Uthappa)

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 4x4m. Each genotype was planted in three replications and each genotype was having 5 plants in each replication. During the year 2013-14, all plants were pruned upto 50 % and the morphological and yield related traits were reported in the year 2015. In the current reporting period, no seed set was observed in any of the plants. The experiment was terminated with keeping only the promising hybrid lines for further breeding work.

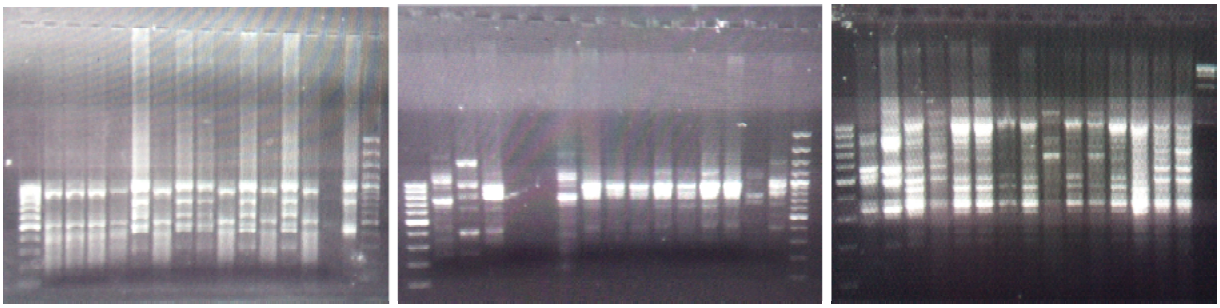


Fig. 24: Molecular characterization of *Jatropha curcas* using RAPD primers OPM 04, OPM 10 & OPT 7

B. Molecular Characterization of *Jatropha curcas*

In order to assess the molecular diversity in the germplasm collections at CAFRI research farm, Jhansi the molecular characterization of parental lines with RAPD primers were continued with few more of the accessions of Jatropha with the 20 primers which had shown polymorphic band across the accessions. (Fig. 24).

C. Inbreds

For the initiation of the new breeding program, inbreds were developed in the year 2014-15 from the accessions NRCP 158 & NRCP 159, which were diverse as per molecular characterization and also high yielding. The selfed seeds were raised in breeding block in nursery for evaluation. The morphological traits were recorded at the age of one year and the data was analyzed (Table 20). The traits had significant differences among the inbred lines.

Table 20: Descriptive statistics for *Jatropha curcas* inbreds

	TH (m)	BD (m)	# PB
Average	1.697	0.12	1.5
Minimum Value	1.1	0.1	1.0
Maximum Value	2.25	0.16	4.0
Standard Deviation	0.379	0.014	0.834
Co-efficient of Variation	22.366	11.52	55.604
Test of Significance	**	**	**

AF04.9: 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 like *Jatropha curcas* were assessed in *Pongamia pinnata* to generate molecular information of the crop of interest with respect to oil biosynthesis. But, there was no amplification using the primers generated with the candidate genes of *J. curcas* in *P. pinnata.*

In the reporting year, for the first time in the world, the seed transcriptome analysis was made in *P. pinnata* using seed source to identify the genes and promoters expressing in seed development. The tissue samples used were from mature seeds, but still in green condition on the trees in replication. These samples were sequenced using illumina Hiseq 2500 platform. Large number of reads were generated for seed samples (67,953,026). More than 6.7 Gb data were generated and assembled into unitranscripts and unigenes

for annotation, discovery of stage specific genes, gene expression and functional analysis. The de novo transcriptome assembly generated 215858 transcripts when all isoforms were considered. All assembled transcripts were found to be of length more than 200bp and it varied from 200 bp to > 5000bp with the mean GC content of 38.37 %. These transcripts represent a total of 106832 unigenes that were considered for downstream analysis. The assembled transcripts when compared with NCBI non-redundant protein database using BLASTX program, 106831 transcripts have atleast one significant hit in the database. The Gene Ontology (GO) terms for transcripts extracted showed 2620 terms identified in biological processes, 2542 terms for molecular functions and 1319 for cellular components. The top 25 terms representing GO in each category is given in the Fig.25 (a, b, c). Detailed analysis of genes is in progress.

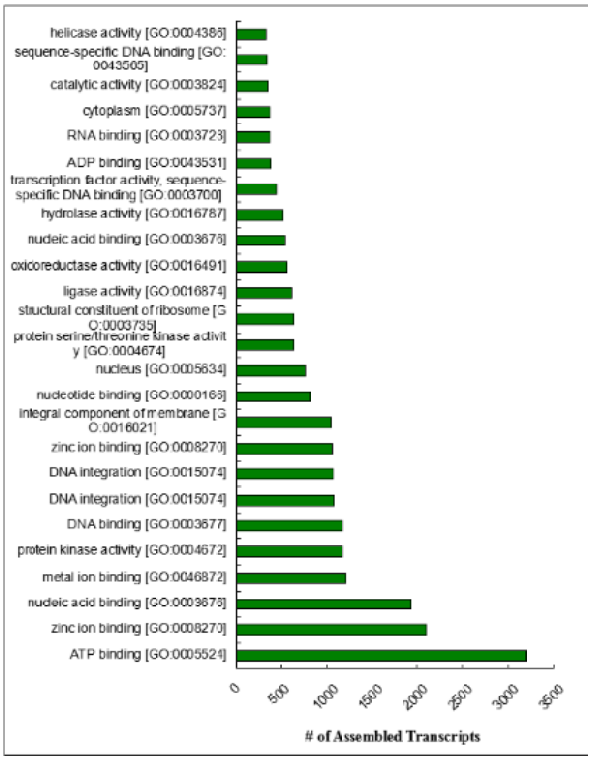


Fig.25 (b): Top 25 terms in molecular function category from GO annotation

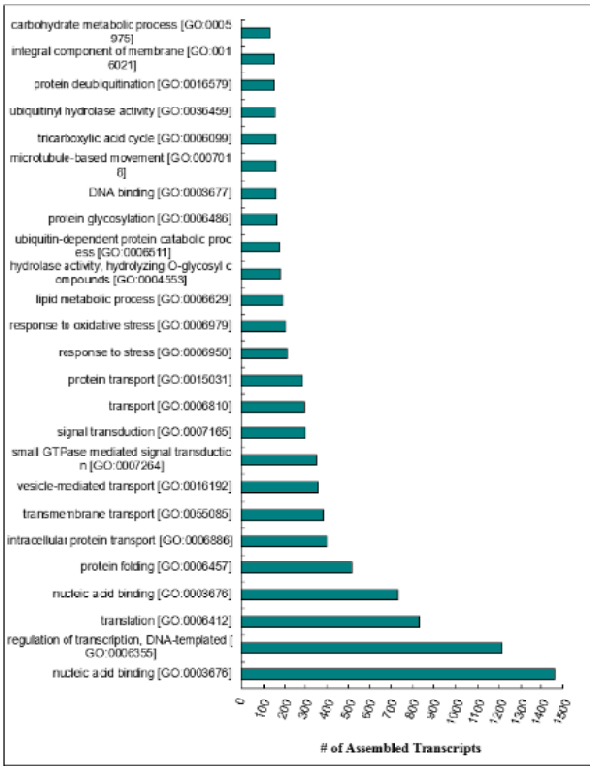


Fig. 25(a): Top 25 terms in biological process category from GO annotation

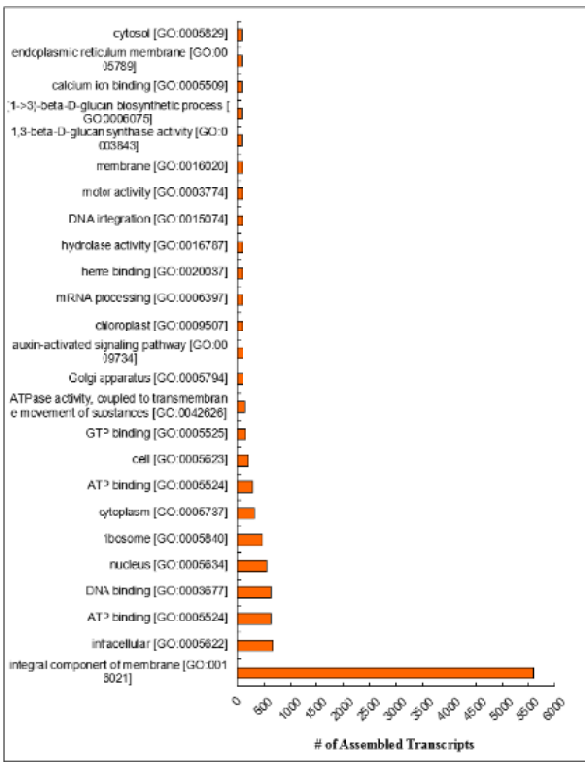


Fig. 25(c): Top 25 terms in cellular component category from GO annotation

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

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

The project has been concluded at the IINRG, Ranchi. Due to non-conducive environment insect showed severe mortality. The survived lac had been left for self-inoculation. The market survey has been carried out for the period to dispose of the available lac produce. The economic analysis of lac cultivation in farmer's field was carried out for the period.

Economics of Lac Cultivation

Eight farmers from Chatpur and Parasai village of Jhansi district were selected on the availability of trees in their on the basis of availability trees on their farms. A total of 123 trees were inoculated in both the villages. A total of 48 kg of brood lac was inoculated. The total stick lac harvested was 99.96 kg. The total cost of cultivation and value of processed lac was ₹ 9856 and ₹ 14300, respectively. The economic analysis of lac cultivation was carried out (Table 21) and benefit cost ratio was found at 1.5.

Table 21: Economics of Lac cultivation on *Butea monsperma* at farmer's field

Particular	Village/Farmers							
	Chatpur			Parasai				
	Sri Gulab	Sri Balbeer	Sri Balaram	Sri Rajveer	Sri Jagdeesh	Sri. Shiv Dayal	Kalyan Singh	Manoj Yadav
Number of trees inoculated	26	17	41	23	2	5	1	8
Quality of Broodlac inoculated (kg)	16	6	10	5	3	2	1	5
Sticklac harvested (kg)	40.26	12.5	18.2	11	5	4	2	7
Cost of cultivation (₹/Farmer)								
Pruning of host tree	360	270	270	270	36	36	36	90
Brood Lac bundling and tying	180	180	270	360	36	36	36	90
Removal of tied brood lac	360	270	270	270	36	36	36	90
Harvesting of stick lac	360	270	540	180	36	36	36	90
Scraping of stick lac	180	180	180	180	36	36	36	90
Cost of brood material	1280	480	800	400	240	96	80	90
Total cost of cultivation (₹ /Farmer)	**2720**	**1650**	**2330**	**1660**	**420**	**276**	**260**	**540**
Value of processed lac (₹)	4500	2000	3500	2000	750	500	300	750
B : C Ratio	1.7	1.2	1.5	1.2	1.8	1.8	1.2	1.4

AF04.10: Evaluation and Characterisation of Different Leucaena Germplasm at CAFRI

(A R Uthappa, A K Handa, S Vimala Devi, S B Chavan & Asha Ram)

The study was initiated in already established subabul plantations to evaluate and characterize the leucaena germplasm in the year 2015. Subabul accessions belonging to five different species *viz.*, *Leucaena diversifolia, L. shannoni, L. lanceolata, L. collinsii, L. leucocephala* and a hybrid (*L. shannoni* X *L. leucocephala*) were procured from IGFRI, Jhansi and planted at CAFRI, experimental field during August, 2006. The seedlings were planted at a spacing of 3m x 3m with three replication.

The maximum height was recorded in *L. leucocephala* S-18 and *L. leucocephala* S-22 (14.57m) and minimum height was recorded in *L. leucocephala* Silvi-4 (8 m). The maximum dbh was recorded in *L. shannoni*-22/83 (20.38 cm) and minimum dbh was recorded in *L. leucocephala* Silvi-4 (5.94 cm). The leaf, pod and seed characters were evaluated in order to study the variability in the germplasm. The different germplasm of leucaena exhibited wide range of morphological variability (Table 22). The leaf length ranged from 11.77 cm to 22.27 cm, with a mean of 16.51 cm. The pinna number, also, varied among the germplasm. The pod length showed wide variation among germplasm, with the range of 10.42 cm to 24.68 cm. The seed characters such as length, width and number of seeds/ pod also exhibited wide scale variation (Fig. 26).

The dendrogram obtained from the cluster analysis has resolved, *Leucaena* genetic resources into three clusters (Fig. 27). The genotypes from different locations grouped together to form a single major cluster as evident in cluster I and therefore the pattern of divergence was not depend on the geographic locations. The initial evaluation has shown wide scale variation among the germplasm, which can be further exploited for commercial use.

Table 22: Variability in different Leucaena germplasm

Characters	Minimum	Maximum	Average
Leaf length (cm)	11.77	22.47	16.51
Pinna number	8.00	18.00	12.14
Middle pinna length (cm)	4.73	10.08	6.49
Leaflet length (mm)	5.52	17.34	12.09
Leaflet width (mm)	1.39	5.16	3.45
Pod length (cm)	10.42	24.68	18.29
Pod width (cm)	1.61	2.32	1.97
Seed Length (mm)	6.59	9.51	7.82
Seed width (mm)	4.21	6.03	4.95
No. of seeds/pod	10.80	26.80	21.18

Fig. 26: Variation in leaf characters among Leucaena germplasm

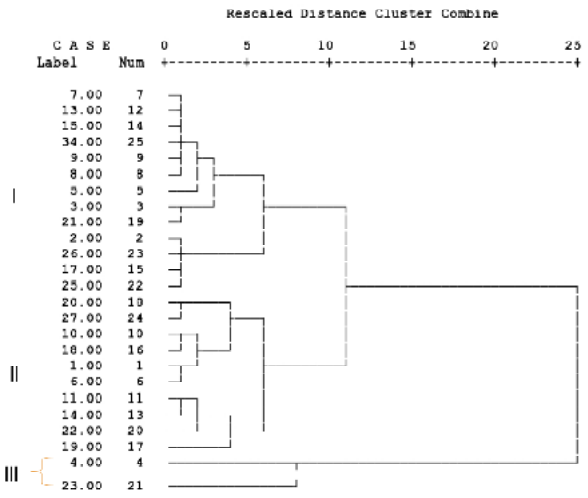


Fig. 27: Dendrogramof leucaena germplasm

2. RESEARCH ACHIEVEMENTS

2.4: HRD, Technology Transfer & Refinement Programme

The Institute organized a number of Farmers' activities for transfer of agroforestry technologies to increase the awareness and knowledge for speedy adoption of agroforestry.

Krishak Gosthi

A Krishak Gosthi was organized at village-Veerpura, Tehsil- Gauratha (Jhansi) on 12th February, 2015. Farmers have shown keen interest in various systems of agroforestry and tree plantation on bunds and boundaries. Farmers raised various queries related to agroforestry systems. About 145 farmers participated in Krishak Gosthi.

Vanmahotsava

Van mahotsava was organized during the 3rd week of July, 2015 at the institute. MPTS were planted at Campus of ICAR-CAFRI, Jhansi.

Training Programme

Organized three days' "ber pruning training programme" during 27th -29th May, 2015 at village Veerpura (Block- Bamour, Tehsil-Garoutha), Parasai, Chhatpur and Bachhauni (Block-Babina, Tehsil-Jhansi) in Jhansi district. In this training programme farmers learned the skills of ber pruning.

Organized three days' "ber budding training programme" during 12th-14th August, 2015 at village Veerpura (Block-Bamour, Tehsil-Garoutha), Parasai, Chhatpur and Bachhauni (Block-Babina, Tehsil-Jhansi) in Jhansi district. In this training programme farmers learned the skills of budding.

Training on Soil sample collection

ICAR-CAFRI organized a three days' soil sample collection training programme at Village Veerpura, Block Bamour, Tahsil Garautha in Jhansi district (U.P.) during 27th -29th May, 2015.

Animal Health Camp

A one day animal health camp was organized on 14th July, 2015 at village Parasai, Chhatpur and Bachchauni in Babina block of Jhansi district. During this camp, farmers' were made aware and motivated about the role of vaccination in animal health.

Awareness Campaigns

In light of consecutive droughts, awareness campaigns were launched by the institute to guide the farmers for economical use of available water resources for maximum crop production. Institute organized Kisan Gosthi at its campus and in different villages of Jhansi district during December, 2015. Farmers from villages, *viz*., Karari, Ambabai and Rundkararari (District Jhansi) had participated in the programme on 26th December, 2015 at ICAR-CAFRI, Jhansi. Scientists-Farmers interaction, showcasing of technical know-how & new tools and technologies of agroforestry, exposure visit of farmers to Institute research farm and Scientist visits to villages and gosthi with farmers were organized. The programme was chaired by Director, ICAR-CAFRI, Jhansi. Team of scientists from the institute visited Rajapur, Imiliya, Chhatpur villages to guide farmers on 28th & 29th December, 2015. A multidisciplinary team of Scientists from CAFRI, Jhansi visited these villages and interacted with farmers on problems related to agriculture and agroforestry and suggested the suitable technologies and management practices to get benefit in the cultivation. The farmers were, also, made aware of alternative systems which can provide maximum benefits in terms of production and livelihood during this drought situation as prevailing presently. During interaction and gosthi, farm women, rural youth, marginal and small farmers were actively participated in group discussion and question-answer session. Total 98 farmers were participated in the programme.

Jai Kisan Jai Vigyan Week

To commemorate the week (Jai Kisan Jai Vigyan Week-23rd to 29th December, 2015), different events, *viz*., farm gosthi, farm visit and eloquence on science and agriculture were organized on 23rd December, 2015. Farmers from Karari village participated in these events.

Farm Innovators Day

Institute organized Farm Innovators Day on 5th December, 2015 and facilitated two farmers on the occasion for willingly adopting agroforestry landuse.

Exhibitions

ICAR-Central Agroforestry Research Institute, Jhansi was participated in following different events during the year-2015 and showed the technology developed by the Institute through exhibitions:

Date	Programme	Places
12.02.2015	Krishak Gosthi	Village Veerpura (block-Bamour), Jhansi
20.03.2015	Kisan Mela	ICAR-IGFRI, Jhansi
21.05.2015	Khrarif productivity Gosthi-2015	Deen dayal Auditorium, Jhansi
05.06.2015	Jal Kranti Abhiyaan	Bundelkhand University, Jhansi
21.08. 2015	Agriculture Exhibition	Piprakothi, Motihari, Bihar
19.09.2015	Kissan Mela/Gosthi on the occasion of launch of Mera Gaon Mera Gaurav programme	ICAR-IGFRI, Jhansi
01.11.2015	Foundation Day	ICAR-IGFRI, Jhansi
28.12. 2015	Krishak Gosthi	Villages: Haibda, Rajapur and Kumharo Ka Purwa (block-Babina), Jhansi
29.12. 2015	Krishak Gosthi	Villages: Bachhauni, Parasai and Chhatpur (block-Babina) in Jhansi

Kharif Productivity Gosthi

Jal Kranti Abhiyan, Jhansi

Agriculture Exhibition

Visits

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

2. RESEARCH ACHIEVEMENTS

2.5: Externally Funded Projects

ICAR Network- NICRA Project

Assessment of Carbon Sequestration Potential of Agroforestry Systems

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

Mapping of Agroforestry Area through GIS and Remote Sensing

One districts each in Madhya Pradesh (Khandwa), Telangana (Nizamabad), Andhra Pradesh(Chittoor) and three district of Maharashtra (Nasik, Wardha & Latur) and two district of Karnataka (Bellary & Tumkur) were surveyed during 2015 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 to land uses and land covers. Work for two agro-climatic zones ACZ-10 & ACZ-12 is also under progress.

Agro-climatic Region-Wise Estimated Area under Agroforestry

During 2015, districts have been selected from two agro-climatic regions *viz.* Western Dry region and Western Plateau & hills region. Twenty per cent of total districts from each region *i.e.* 2 and 8 districts, respectively representing that region were selected. Land use and land cover analysis of the selected districts using RS2/ LISS- 3 data has been done (Fig. 28). Using this LULC, agriculture area has been masked and sub-pixel method was applied on this area to estimate agroforestry area. Area under agroforestry in the selected districts of these agro-climatic zones was estimated to be 430700.6 (2.41%), and 1555156.3 ha (4.75%), respectively. This was extrapolated for whole agro climatic region and area under agroforestry in Western Dry region (agro-climatic zone 14) and Western Plateau & hills region (Agro-climatic zone 9), come out to be 0.43, and 1.55M ha, respectively.

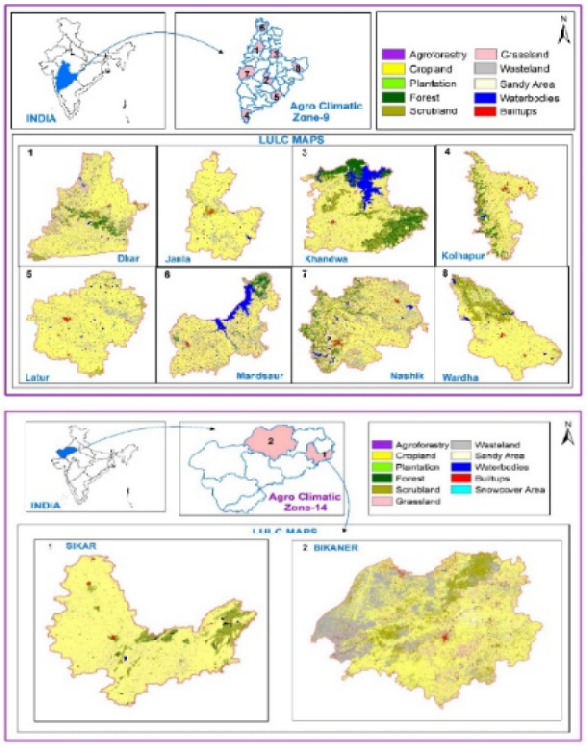


Fig. 28: Land use and land cover map of agro-climatic zone 14 and 9

Soil Carbon Stock in Agroforestry System Existing on farmer's Field in Selected Districts of Different States

During the 2015-16, two districts from Karnataka (Bellary and Tumkur) and one districts from Odisha (Kurdha), Bihar (Pusa), Andhra Pradesh (Chittoor), Maharashtra (Ahmad Nagar) and Himachal Pradesh (Solan) 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 90 cm soil profile. The soil organic carbon (SOC) under agroforestry in 0-90 cm soil depth varied from 40.97 to 62.57 t C ha^{-1} in surveyed district of different state.

Assessment of Carbon Sequestration Potential in Agroforestry System Existing on Farmer's Field in Selected Districts of Different States

During 2015-16, three districts of Karnataka (Bellary, Tumkur and Kolar), one district of Andhra Pradesh (Chittoor), five districts of Maharashtra (Latur, Wardha, Thane, Nasik, and Ahmed Nagar), one district of Odisha (Kurdha), Himachal Pradesh (Solan) and Bihar (Pusa) were taken for assessment of carbon sequestration potential (CSP) of agroforestry system existing on farmers field in these districts of different states. In Karnataka, *Areca catechu, Acacia nilotica, Azadirachta indica, Cocos nucifera, Mangifera indica* are the most common trees occurs on farmer's field and tree population in these district varied from 2.38 to 69.0 trees ha^{-1}. In Chittoor district of Andhra Pradesh, tree population is about 23.0 tree ha^{-1} and *Mangifera india, Tectona grandis, Azadirachta indiac, Cocos nucifera* and *Acacia nilotica* are dominant trees occurs on farmer's field. In different districts of Maharashtra, *Tectona grandis, Citrus sinesis, Azadirachta indica, Mangifera indica* and *Ziziphus mauritiana* are

Table 23: Biomass, soil carbon and carbon sequestered in agroforestry system existing on farmer's field

State			Himachal Pradesh (No. of tree ha^{-1})	Odisha (No. of tree ha^{-1})	Bihar (No. of tree ha^{-1})	Karnataka (No. of tree ha^{-1})		
District name and observed number of existing trees per hectare in the agroforestry at district level			Solan (22.47)	Kurdha (56)	Pusa (3.67)	Bellari (2.38)	Tumkur (33.08)	Kolar (69.0)
Tree Biomass (above and below ground) in Mg DM ha^{-1}	Baseline	Biomass	11.8	21.07	3.35	2.86	45.13	27.87
	Simulated		31.38	48.1	7.07	5.06	80.59	51.07
Total biomass (tree+ crop) in Mg DM ha^{-1}	Baseline		24.95	39.94	19.39	23.4	57.86	40.95
	Simulated		44.9	66.47	23.56	26.17	93.68	64.51
Soil carbon (Mg C ha^{-1})	Baseline	Carbon	14.0	14.78	4.31	19.24	17.03	6.17
	Simulated		15.26	16.47	6.58	20.11	19.63	12.14
Biomass carbon (Mg C ha^{-1})	Baseline		11.33	17.8	8.99	9.9	27.14	19.0
	Simulated		20.86	30.99	10.79	11.51	44.31	30.29
Total carbon (biomass + soil) (Mg C ha^{-1})	Baseline		25.33	32.58	13.3	29.14	44.17	25.17
	Simulated		36.12	47.46	17.37	31.62	63.94	42.43
Net carbon sequestered in agroforestry systems over the simulated period of thirty years (Mg C ha^{-1})		Carbon sequestered	10.97	14.88	4.07	2.48	19.77	17.26
Estimated annual carbon sequestration potential of agroforestry system (Mg C $ha^{-1}yr^{-1}$)			0.35	0.49	0.13	0.08	0.65	0.57

commonly found on farmer's field and tree population is varied from 2.11 to 11.98 trees ha^{-1} in surveyed districts (Table 23 & 24). In Kurdha district of Odisha, tree population is 56 trees ha^{-1} and *Bambusa vulgeris*, *Musa sapientam*, *Cocos nucifera* and *Acacia auriculiformis* are the most common tree species existing on farmer's field. In Solan district of Himachal Pradesh, *Grewia optiva*, *Leucaena lucocephala, Ficus palmate* and *Toona ciliate* are most dominant trees species existing on farmer's field. The population of tree in the districts is about 22.47 trees ha^{-1}. In Pusa districts of Bihar having 3.67 trees ha^{-1} on farmer's field and most common trees are *Lichi chinensis*, *Dalbergia sissoo*, *Mangifera indica* and *Wendlandia exserta*.

The tree biomass, biomass carbon, total carbon and net carbon sequestered in existing agroforestry system at district level in Karnataka, Andhra Pradesh, Maharashtra, Odisha, Himachal Pradesh and Bihar was estimated using CO_2 FIX model and extrapolated for next 30-years. The tree biomass, soil carbon and total carbon in baseline varied from 2.86 - 45.13 t DM ha^{-1}, 6.17-19.24 t C ha^{-1} and 29.14-44.17 t C ha^{-1}, respectively in Bellary, Tumkur and Kolar district of Karnataka. It is expected that corresponding value of these parameters would increase up to 5.06-80.59 t DM ha^{-1}, 26.17-93.68 t C ha^{-1} and 31.62-63.94 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 2.48, 19.77 and 17.26 t C ha^{-1},

Table 24: Biomass, soil carbon and carbon sequestered in agroforestry system existing on farmer's field

State			Maharashtra (No. of tree ha^{-1})					Andhra Pradesh (No. of tree ha^{-1})
District name and observed number of existing trees per hectare in the agroforestry at district level			Latur (2.11)	Wardha (13.53)	Thane (11.60)	Ahmed Nagar (6.73)	Nashik (11.98)	Chittoor (23.10)
Tree Biomass (above and below ground) in Mg DM ha^{-1}	Baseline	Biomass	1.36	9.01	11.11	3.1	10.37	21.1
	Simulated		3.85	29.06	22.74	7.34	25.27	49.26
Total biomass (tree+ crop) in Mg DM ha^{-1}	Baseline		14.69	23.92	26.91	9.02	28.22	41.21
	Simulated		17.69	45.18	39.89	13.42	44.44	69.93
Soil carbon (Mg C ha^{-1})	Baseline	Carbon	18.65	16.87	17.6	12.04	14.82	16.36
	Simulated		19.20	20.80	19.23	14.51	17.63	18.15
Biomass carbon (Mg C ha^{-1})	Baseline		0.66	4.32	5.34	4.03	4.99	18.77
	Simulated		7.80	20.88	18.28	6.14	20.37	32.53
Total carbon (biomass+soil) (Mg C ha^{-1})	Baseline		19.31	21.19	22.94	16.07	19.8	35.13
	Simulated		27.00	41.68	37.51	20.65	38.0	50.68
Net carbon sequestered in agroforestry systems over the simulated period of thirty years (Mg C ha^{-1})		Carbon	7.69	20.49	14.57	4.58	18.2	15.55
Estimated annual carbon sequestration potential of agroforestry system (Mg C ha^{-1} yr^{-1})		sequestered	0.25	0.68	0.48	0.15	0.60	0.51

respectively in three districts. In case of Solan (Himachal Pradesh), Kurdha (Odisha) and Pusa (Bihar), the total carbon stock available in baseline varied from 13.3 to 32.58 t C ha^{-1} and it is expected that over 30-years of simulated period the total carbon stock in agroforestry in these districts would be 17.37 to 47.46 t C ha^{-1}. Net carbon sequestered over the simulated period of 30-years would be 4.07 to 14.88 t C ha^{-1}. The tree biomass, soil carbon and total carbon available in existing agroforestry system in different districts of Maharashtra (Latur, Wardha, Thane, Ahmed Nagar and Nashik) are 1.36 to 11.11 t DM ha^{-1}, 12.04 to 18.65 t C ha^{-1} and 16.07 to 22.94 t C ha^{-1}, respectively and its corresponding values over the simulated period of 30-years would be 3.85 to 29.06 t DM ha^{-1}, 14.51 to 20.80 t C ha^{-1} and 27.00 to 41.68 t C ha^{-1}, respectively. The tree biomass, soil carbon and total carbon available in existing agroforestry system in Chittoor district of Andhra Pradesh are 21.10 t DM ha^{-1}, 16.36 t C ha^{-1} and 35.13 t C ha^{-1}, respectively and its corresponding values over the simulated period of 30-years would be 49.26 t DM ha^{-1}, 18.15 t C ha^{-1} and 50.68 t C ha^{-1}, respectively.

Agroforestry system existing on farmers field in Chittoor (A. P.)

Common agroforestry on farmers field in Bellary (Karnataka)

Studies on thermotolerance

There were clear trends in physiological traits associated with thermotolerance in temporal and seasonal scale in the multipurpose tree species (MPTS). Canopy temperature depression (CTD), rate of CO_2 assimilation and spectral indices were relatively more responsive towards temperature changes across the seasons. Various experiments related to thermotolerance and carbon assimilation have been conducted with select multi-purpose tree species namely *Albizia procera* and *Butea monosperma*. Some important photosynthetic traits such as rate of CO_2 assimilation were studied under three different temporal scales *viz*. pre-winter (in the month of September-October), winter (In the month of December-January) and post-winter (in the month of March-April). The trends clearly indicated that in post-winter season (at high temperature), rate of CO_2 assimilation was high and in winter season (at low atmospheric temperature) rate of CO_2 assimilation was low (Fig. 29). Similar pattern was observed in case of spectral reflectance of *A. procera* leaves, when studied at temporal scale (Fig. 30). Leaf area index of *A. procera* increased under high environmental temperature and positively correlated with canopy temperature depression (Fig. 31). Canopy temperature depression (CTD) was

high in pre winter and post winter season, whereas in winter season it was far low. These seasonal and temporal variations in temperature clearly indicated the adverse effect of elevated environmental temperature on physio-biochemical and spectral indices of MPTs.

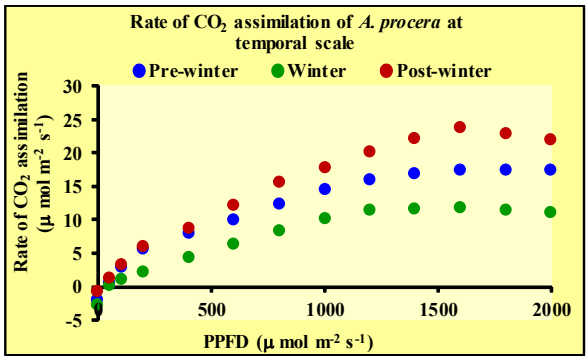


Fig.29: Rate of CO_2 assimilation of *A. procera* at temporal scale

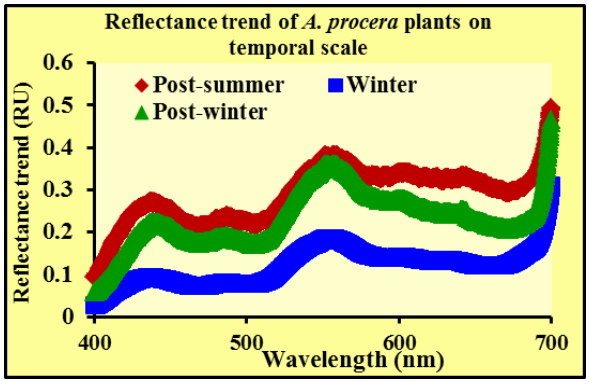


Fig. 30: Reflectance trend of *A. procera* plants on temporal scale

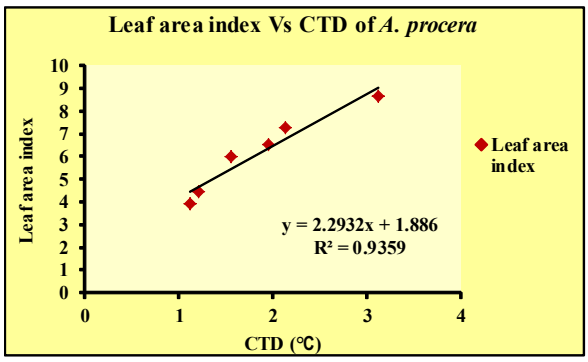


Fig. 31: Leaf Area Index Vs CTD of *A. procera*

MoRD, New Delhi

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

(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 has been 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 Annual 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:

Hydrological Monitoring

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 shallow dug wells (351 nos.) are being monitored for water table on monthly basis. During the month of October average water column was 3.21 m and supporting pump operation for 3-10 hours continuously.

Crop Productivity Enhancement

During the year no plantation works was taken up. In light of low rainfall forecast

during 2015 and mass awakening of farmers in this respect, farmers of the watershed devoted maximum area to sesame and blackgram in *kharif* season and barley during *rabi*. *Kharif* crop trial was carried out with 25 farmers while *rabi* trials with 30 farmers. Wheat trial of Lok-1 and HI 1479 were carried out with 20 farmers in 50 acre land. The response in terms of productivity was 10-15% higher as compared to local variety. Majority of the area during *rabi*, 2014-15 was under barley cultivation.

Strengthening of Livelihood through Women Self Help Groups (WSHGs)

After the capacity building of the farmers through trainings, orientations and meetings the women groups are coming in the mainstream and are talking of income generation. In Village *Dhikoli* three goatary and one vegetable group have been developed. One vegetable group in village *Domagor* is also developed.

The interactive session on WSHGs plan was held which was very interesting as the women groups shared their practical experiences in various fields e.g. SHG & bank linkages, role of federation, improved animal husbandry, other IGAs etc. They also exposed their experiences and views in several socio-economic aspects e.g. social problems they faced often, savings and bank related issues, health and sanitation issues, problems of lack of knowledge & access to govt. schemes & policies, deficit of livelihood opportunities etc. The Plan are enhancing livelihood through creating enterprises of WSHGs. The main livelihood running source are goatary and vegetable cultivation. In the model watershed area 51 Members from 5 SHGs have been benefitted through revolving fund (Table 25).

Capacity Building Programmes Organized

A number of capacity building training programmes were organized for developing knowledge, understanding and skills of the farmers. Such trainings aware the farmers and develops confidence in them. The capacity building programmes include trainings, orientation and exposure visits (Table 26).

Table 25: Strengthening of livelihood through Women Self Help Groups

S. No.	Village	Name of Group	No. of members	Name of Activity	Contribution by group	Loan from R. fund	Enterprise	Date
1	Dhikoli	Maa Ratangarh Wali	10	Goat rearing	10,000	40,000	1 unit of 10 goat	April 2015
2	Dhikoli	Jai Mata Di	11	Vegetable Farming	10,000	40,000	nil	April 2015
3	Dhikoli	Vindvashini	10	Goat rearing	10,000	20,000	1 unit of 10 goat	April 2015
4	Dhikoli	Shivshankar	10	Goat rearing	10,000	20,000	1 unit of 10 goat	April 2015
5	Domagor	Mahadevi	10	Vegetable Farming	10,000	20,000	nil	April 2015

Table 26: Capacity building programmes

Capacity Building Program	Nos
1. Training on Vermicomposting as Farm Yard Manure	1
2. Training on Fodder Cultivation & Vegetable Farming	3
3. Training & Capacity Building Pico Grids Operation and Management	1
4. Training on Farmer Producer Organization	1
5. Exposure visit of 35 farmers to CIRG, Makhdoom to learn & see goat rearing practices	1

Training on Vermicomposting as Farm Yard Manure- A training on vermicomposting at village Ganeshgarh on 28th Feb., 2015 was organized in which more than 30 women's participated, During the training women's knew why composting is necessary, How it can reduce chemical load & better returns can be added. Preparation process was demonstrated before them.

Training on Fodder Cultivation & Vegetable Farming- A training of fodder cultivation & Vegetable Farming was organized at DA, Pahuj Centre, Jhansi on 17th May, 2015, more than 70 farmers attended this training program. A detailed discussion of fodder cultivation and vegetable farming was discussed.

Training & Capacity Building Pico Grids Operation and Management of Renewal energy services- A training on Management of pico grids held at village dhikoli on 6th January, 2015. 30 Youth of Dhikoli & Domagor participated. During this training program youths got an on hand practical training on how to manage grids and solar irrigation system.

Training on Farmer Producer Organization- A training of FPO and its benefit was organized in village Dhikoli on 8th May, 2015, 30 peoples participated in the meeting.

Exposure visit to CIRG, Makhdoom, Mathura to Learn Goat rearing Practices- A two day Exposure visit was organized for women's on 30th-31st Jan., 2015 to learn about goat rearing practices. The Exposure visit made women learn various stall feeding

activities, Disease of goat and its prevention & Breed selection.

ICRISAT, Hyderabad

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

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

Background

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 23′ 56″ to 25 27′ 9.34″ N and 78 19′ 45.71″ to 78 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, development of 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, three checkdams (drop structure) were constructed on main drain of Chhatpur and Bachhauni village during 2015. Till now, three *nallah* plugs (small checkdam), nine checkdams, one haveli (traditional rainwater harvesting structure), one community pond and one farm pond were constructed. To measure runoff and soil loss, three gauging stations were also constructed. In totality, about one lakh fifteen thousand cubic meter surface water storage has been created in the watershed. To improve in-situ moisture condition, field /contour bunding was done in 50 ha.

Monitoring runoff and water table

To measure runoff, divers were installed at 12 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 M P 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. Total rainfall during the

year was 481.5 mm, about 45% less than the normal (877 mm), spread over in 46 rainy days. The one day rainfall amount was not sufficient large to generate runoff in any land use. The average water column during the year varied from 3.42 m in January to 2.04 m in December with 2.68 m in October. However, average water column in untreated watershed, Hatlab, was 1.44 m in October. The water table was about 86% higher in treated watershed as compared to untreated watershed during post monsoon. The effective groundwater recharge during the year was about 9 cm only as the rainfall was significantly lower than normal. Therefore, higher water column in treated watershed was due to residual effect of 2013. These water columns are indeed not sufficient to cater needs of irrigation but watershed dwellers will get drinking water.

Development of Agroforestry Interventions and Top Working of Desi Ber

To develop agroforestry interventions in the watershed, 5427 seedlings of teak were planted on 65 farmers' fields across the villages during 2015. Besides, 800 seedlings of *Acacia senegal* (kumat) provided by Gum & Resin project were also planted as live fence on farmers' fields.

Survival of different species was more than 80 % by the end of December, 2015. Apart from this, total 1700 desi ber were top worked and budded with improved varieties through convergence by Dept. of Horticulture, Govt. of Uttar Pradesh.

Productivity Enhancement

Crop productivity Assessment of Parasai Sindh Watershed

Due to delayed monsoon and long dry spell during rainy season, crops of *kharif* season affected badly. Sesame was almost failed due to moisture stress during flowering stage. During *rabi*, 2014-15, majority of the area was under wheat crop (var. Lok-1, HI 1544, HI-1479 and WH-147). Due to residual effect of ground water recharge during 2014, farmers were harvested *rabi* crops satisfactorily during 2014-15. Productivity of different crops sown in the watershed during *kharif*, 2015 and *rabi*, 2014-15 is given in Table 27.

Table 27: Productivity of different crops in Parasai-Sindh watershed

Rabi, 2014-15		*Kharif* 2015	
Crop	**Productivity (kg ha^{-1})**	**Crop**	**Productivity (kg ha^{-1})**
Wheat	2188.6	Groundnut	287.3
Chickpea	783.3	Blackgram	204.6
Mustard	1113.7	Greengram	132.7

The productivity of *rabi* season crops was significantly higher than productivity of untreated watershed.

Forage Resource Enhancement

About 1,37,000 rooted slips of Napier bajra hybrid, guinea grass and TSH were transplanted on bunds, near checkdams and around ponds during 2013-14 & 2014-15. Due to deficit in rainfall single cut could be obtained from the pasture established areas. On an average biomass yield of 3.5 DM t ha^{-1} could be obtained from the mixed pasture.

Self Help Groups and Capacity Building

Farmers of the villages Parasai, Chhatpur and Bachhauni were motivated to adopt agroforestry practices at their field. A one day animal health camp was organized on 14th July, 2015 at village Parasai, Chhatpur and Bachchauni in Babina block of Jhansi district in which livestock owners were made aware and motivated about the role of vaccination in animal health. Animals were given vaccination and medicines. Six

Self Help Groups (SHGs) were formed namely Shrihit 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. In November-December, 2015 the soil samples from watershed villages were collected and soil health cards were distributed to farmers on 5th December, 2015.

Drop structure and gauging station in Bachhauni village of Watershed

Field Day organized on 19th March, 2015 in Parasai watershed

Adoption of agroforestry interventions by small farmer in watershed

Visit of Advisor, MOWR, RD & GR, New Delhi and Chairman CWC, New Delhi along with CDO and other officers of line departments for scaling up of the models

NMOOP-MM-III Project

National Network on Integrated Development of Jatropha and Karanja

(S Vimala Devi, S B Chavan & A R Uthappa)

The National network on integrated development of Jatropha and Karanja was funded under NMOOP-MM-III, by Department of Agricultural Cooperation & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi for continuation of research on Tree Borne Oilseeds (TBOs) like Jatropha, Karanja and Mahua and also for development and promotion of these TBOs. Under this project, the evaluation of the germplasm lines under the National Multi-location trial II (2007), National Multilocation trial III (2008) and Progeny trial were continued for the current year.

A. National Multilocation trial II (2007)

The seeds of selected 17 superior genotypes of 14 different research centers (including NRCAF) of the network project were received in February, 2007 and their

nursery was raised. Their progeny was planted in field during August, 2007, following RBD in four replications. The morphological and yield parameters of the available genotypes were recorded and results are being presented here at the age of six years (Table 28).

The overall mean for tree height in this population was 2.93m, with mean bole diameter of 0.63m and canopy diameter of 2.73m. After pruning, in February, 2015, the maximum number of primary branches were observed in JA 9 followed by Pant J 03103. Similarly, the maximum number of secondary branches were recorded in JA9.

Table 28: Growth performance of *Jatropha curcas* under NMT II

Genotypes	TH (m)	BD (m)	# PB	# SB	CD (m)
Pant J 03103	2.90	0.66	6.00	13.00	3.45
PDKV Nov 3	3.20	0.62	3.00	8.00	2.50
JA9	3.15	0.82	6.50	21.50	2.50
Orissa 2	2.41	0.40	2.83	10.33	2.89
TNMC 19	3.08	0.68	4.50	13.00	2.28
TNMC 33	2.85	0.61	4.10	13.10	2.80
Mean	**2.93**	**0.63**	**4.48**	**13.15**	**2.73**

TH-Tree height, BD=Bole diameter, #PB- No. of Primary branches, #SB- No. of secondary branches and CD- Canopy diameter.

B. National Multilocation trial III (2008)

The seeds of selected 18 superior genotypes of 12 different centers (including NRCAF) 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 3x3m spacing. All the accessions were evaluated and data was recorded for different morphological and yield parameters (Table 29).

After pruning in February, 2015, the observations recorded in December, 2015, showed 1.76 m average tree height with 0.54m bole diameter and 0.32m canopy

Table 29: Growth performance of *Jatropha curcas* under NMT III

S. No.	Source centre	Genotype	TH (m)	BD (m)	# PB	# SB	CD (m)
1	PDKV, Akola	PDKV Nov19	1.86	0.51	3.93	33.14	0.71
2	NRCAF, Jhansi	NRC J 2	1.63	0.52	3.85	28.25	0.35
3	NRCAF, Jhansi	NRC J 18	1.58	0.45	4.50	21.25	0.29
4	NRCAF, Jhansi	NRC J 89	1.74	0.51	3.88	30.00	0.24
5	TFRI, Jabalpur	TFRI 07	1.85	0.60	4.13	43.13	0.38
6	JNKVV, Jabalpur	JJ 2	1.82	0.57	3.62	40.08	0.28
7	CRIDA, Hyderabad	CRJ 29	1.77	0.52	3.29	35.14	0.31
8	BAU, Ranchi	LBJJ 23	1.88	0.51	3.45	30.73	0.50
9	CSFER, Allahabad	CALD 14	1.76	0.52	4.13	37.00	0.35
10	TNAU, Mettupalaym	TNCJC 19	1.90	0.62	4.47	36.07	0.34
11	TNAU, Mettupalaym	TNCJC 20	1.79	0.50	3.86	37.36	0.50
12	TNAU, Mettupalaym	TNCJC 25	1.77	0.57	4.00	44.25	0.19
13	GBPAUT, Pantnagar	Pant JCP 1	1.76	0.56	3.50	38.50	0.24
14	GBPUAT, Pantnagar	Pant JCP 2	1.90	0.58	4.00	37.09	0.26
15	RCNEH, Tripura	TR 4	1.84	0.56	3.50	37.25	0.38
16	RCNEH, Manipur	MNJ 001	1.66	0.64	5.20	39.60	0.21
17	RCNEH, Manipur	MNJ 006	1.63	0.59	4.50	38.50	0.17
18	NDUAT, Faizabad	NDJC 1	1.54	0.43	4.50	29.50	0.14

TH-Tree height, BD=Bole diameter, #PB- No. of Primary branches, #SB- No. of secondary branches and CD- Canopy diameter.

diameter. The average primary and secondary branches were 4.02 and 35.38. PDKV Akola showed overall maximum morphological growth after pruning. None of the genotypes flowered this year, which may be due to moisture stress during the flowering period.

C. Progeny Trials

[I] Jatropha (*Jatropha curcas*)

Explorations were conducted during 2003-2005 in different eco-geographical regions of our country and seeds of *Jatropha curcas* were collected from various parts of Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Maharashtra, Andhra Pradesh and Chhattisgarh. The seeds, collected from different states, well sown in the nursery to raise the seedlings and these seedlings were planted in field for progeny evaluation. A total of 5 progeny trials with 27, 23, 9, 12 and 85 accessions in randomized block design in three replications were raised during 2004 to 06. In February, 2015, all accessions in each progeny trials were pruned

Table 30: Variability for morphological traits in *Jatropha curcas* germplasm accessions across five progeny trails

Progeny Trails	Average	Minimum	Maximum	SD	CV
PT-I					
TH (m)	2.09	1.90	2.45	0.20	9.75
BD (m)	0.73	0.54	0.83	0.10	13.76
#PB	5.47	3.67	7.00	1.11	20.22
#SB	28.58	23.50	33.00	3.41	11.94
CD (m)	1.44	1.35	1.53	0.08	5.55
PT-II					
TH (m)	1.85	1.10	2.10	0.31	16.69
BD (m)	0.83	0.70	0.92	0.08	9.20
#PB	5.37	3.00	7.00	1.34	25.05
#SB	22.63	6.00	35.67	8.78	38.82
CD (m)	1.31	0.53	9.00	0.36	27.37
PT-III					
TH (m)	2.17	1.93	2.48	0.11	5.08
BD (m)	0.66	0.59	0.75	0.04	5.73
#PB	4.20	3.67	5.83	0.50	11.91
#SB	24.67	15.75	34.17	4.37	17.72
CD (m)	1.24	0.95	1.59	0.14	11.13
PT-IV					
TH (m)	2.12	1.88	2.30	0.11	5.14
BD (m)	0.82	0.73	1.01	0.07	8.24
#PB	4.82	3.83	6.00	0.66	13.78
#SB	31.31	20.33	39.90	4.97	15.89
CD (m)	1.34	1.03	1.48	0.12	8.75
PT-V					
TH (m)	1.66	0.78	2.74	0.56	33.53
BD (m)	0.56	0.18	1.04	0.21	38.64
#PB	3.54	1.50	6.25	1.25	35.22
#SB	23.40	7.25	52.25	9.01	38.51
CD (m)	1.09	0.41	1.93	0.39	35.61

TH-Tree height, BD=Bole diameter, #PB- No. of Primary branches, #SB- No. of secondary branches and CD-Canopy diameter

to 50 % for management of canopy and in the reporting year, the morphological traits were evaluated and presented in the table 30.

In each of the progeny trial significant variation was observed for the traits under study. The average tree height varied between 1.66 m to 2.17 m, the mean bole diameter varied between 0.56 - 0.83 m. The primary and secondary branches ranged between 3.54 – 5.47 and 22.63 - 31.31, respectively. The average canopy diameter was 1.09-1.44 m across the progenies (Table 31). The fruit and seed yield was not recorded, as very minimal fruits were set in few accessions after pruning.

[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 plants were planted at the spacing of 5m x 5m by apart following randomized block design with three replications. The morphological data recorded during January, 2016 was analyzed using SYSTAT 11.

The traits like plant height, bole diameter at breast height (DBH), canopy diameter and number of primary branches showed significant differences among the genotypes. At the age of nine years, average tree height was 5.8 m, mean DBH was 0.66 m with mean canopy diameter of 5.87 m. The minimum and maximum tree height was 3.92m to 7.32 m, respectively, with DBH range of 0.38m to 0.92m. Canopy diameter ranged from 3.66 m to 7.90 m and number of primary branches

Table 31: Descriptive Statistics and correlation coefficients of morphological traits in *Pongamia pinnata* germplasm accessions

	TH (m)	BD (m)	# PB	CD (m)
Minimum	3.92	0.38	2.00	3.66
Maximum	7.32	0.92	3.17	7.90
Mean	5.80	0.66	2.43	5.87
Std. Error	0.14	0.02	0.06	0.18
Standard Deviation	0.81	0.13	0.31	1.03
C.V.	0.14	0.191	0.129	0.175
TH (m)	1.000			
BD (m)	0.713	1.000		
# PB	-0.105	0.131	1.000	
CD (m)	0.720	0.851	0.020	1.000

TH-Tree height, BD=Bole diameter, #PB- No. of Primary branches, #SB- No. of secondary branches and CD-Canopy diameter

varied from 2 to 3.17. The coefficient variation was low for all the traits (Table 31).

Correlation study revealed significant positive and high correlation between the morphological traits *viz*., tree height, DBH and canopy diameter in this population. The number of primary branches did not have significant correlation with any of the traits.

For the promotion of tree borne oilseeds under the NMOOP-MM-III project, Seedlings (Jatropha (1000 nos.) and Karanj (1000 nos.)) were raised from the high yielding genotypes identified from the germplasm accessions. A farmers and trainers training program was conducted to create awareness on TBOs. 35 farmers from 16 villages and 23 trainers from 8 districts participated in this training programme.

Quality planting material of Karanja

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, 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, the gum garden of *A. senegal* was extended and depth of notching or incision for tapping gum-butea standardized. The observations were recorded on survival of lac insect on butea trees in summer in relation to temperature and relative humidity.

1. AGROFORESTRY MODELS

Data on survival and plant growth in Agroforestry models (6 years old) raised on ICAR-CAFRI farm have been given in Table 32.

In agri-horti-silviculture model; maximum survival and plant height was recorded in *Acacia senegal*. Out of 24 citrus plants, 20 plants yielded fruits and during the year, 20 kg lemon fruits were harvested. The size of lemon fruit varied from 10g to 52g with average value of 28g. During *rabi* season wheat (HUW 234 Z-1) has been sown as an intercrop. After six years of planting natural oozing of gum has been observed in *A. senegal* first time.

In horti-silviculture-I model, the maximum survival was recorded in *T. arjuna* (100%). In horti-silviculture –II model, *Acacia*

Table 32: Growth and survival of trees in the agroforestry models at ICAR-CAFRI farm

Agroforestry Models	GBH (cm)	Height (cm)	Canopy (m^2)	Survival (%)	Pruned biomass (kg $tree^{-1}$)
Agri-horti-silviculture (Field No 25)					
Acacia senegal (Kumat)	28.8	462	16.8	86	5.83
Citrus limon (Lemon)	7.9 (CD)	320	9.0	83	1.94
Aegle marmelos (Bael)	23.8	396	10.7	71	2.71
Carrissa carandus (Karonda)	2.1 (CD)	146	1.3	75	--
Horti-Silviculture I (Field 20)					
Acacia nilotica (Babul)*	2.1 (CD)	196	1.2	86	--
Terminalia arjuna (Arjun)	18.0	316	5.4	100	--
Acacia senegal (Kumat) (boundary)	28.4	509	11.3	90	--
Horti-Silviculture II (Field 20)					
Acacia nilotica (Babul)	73.8	739	42.4	89	--
Terminalia arjuna (Arjun)	24.0	364	5.6	100	--
Acacia senegal (Kumat) (boundary)	19.2	340	6.2	80	--
Block plantation					
Acacia senegal (Kumat)	17.1	430	10.2	100	--
Agri- Silviculture (Field No. 40 & 41) (2012 planation)					
Acacia senegal (Kumat) (10x10m)	12.3	294	6.2	95	26.79
Acacia nilotica (Babul) (10x10m)	13.5	337	4.9	95	18.02
Acacia senegal (Kumat) (10x5m)	8.9	261	2.0	90	25.52
Acacia nilotica (Babul) (10x5m)	13.1	349	4.9	91	18.59
Acacia senegal (Kumat) (5x5m)	11.5	286	2.7	94	16.67
Acacia nilotica (Babul) (5x5m)	16.2	398	4.7	98	12.07

* Plantation in July 2014

nilotica has shown maximum growth (Table 33). Survival of *Acacia senegal* in block plantation on rocky site was 100 % and plants attained mean height of 430 cm with gbh of 17.10 cm. In general, survival and growth of *A. nilotica* was better than *A. senegal*.

Table 33: Descriptive statistics of gum yield from *A. senegal* (6 years old) tree (naturally oozing) in Agri-horti-silviculture model

Parameter	GBH (cm)	Height (cm)	Canopy (m^2)	Gum yield (g $tree^{-1}$)	Total no. of tears $tree^{-1}$
Count	4	4	4	4	4
Mean	32.75	558.75	25.29	58.70	4
Range	21.00	220.00	21.81	108.62	4
Minimum	18.00	445.00	15.03	26.10	4
Maximum	39.00	665.00	36.83	134.71	4
SD	9.88	97.93	09.83	50.99	4

In agri-silvi model (Field No. 40 and 41), maximum survival was recorded by *A. nilotica* at 5 x 5 m spacing while least by *A. senegal* at 10 x 5 m spacing. After 3 years of plantation, on an average, *A. nilotica* has shown better survival and growth than *A. senegal*.

During summer season (2015), natural oozing of gum in *A. senegal* and *A. nilotica* was observed in agri- horti- silviculture and horti- silviculture –II models. The gum yield of *A. senegal* ranged from 26.10 g $tree^{-1}$ to 134.71 g $tree^{-1}$ with an average value of 58.70 g $tree^{-1}$ (Table 33). In horti-silviculture-II model, the gum yield of *A. nilotica* ranged between 11.66 to 90.63 g $tree^{-1}$, with an average of 40.15 g $tree^{-1}$. The number of gum tear varied from 4 to 20 per tree with mean 9.67 tears $tree^{-1}$ (Table 34).

During *rabi* season, wheat (var. HUW 234 Z-1) was sown in agri-horti-silviculture model by following the recommended package of practices. Plant growth and yield attributes were measured at different

Table 34: Descriptive statistics of gum yield from *A. nilotica* (6 years old) tree (naturally oozing) in horti-silviculture model II

Parameter	GBH (cm)	Height (cm)	Canopy (m^2)	Gum yield (g $tree^{-1}$)	Total no. of tears $tree^{-1}$
Count	3	3	3	3	3
Mean	68.00	741.70	35.31	40.15	9.67
Range	20.20	115.00	32.96	78.97	16.00
Minimum	59.30	675.00	16.97	11.66	4.00
Maximum	79.00	790.00	49.93	90.63	20.00
SD	10.149	59.63	16.79	43.84	8.96

distances *viz.*, 1.0 m, 2.5 m and 4.5 m distances from each tree line (*Acacia senegal*, *Aegle marmelos* and *Citrus limon*) and control. Different tree species had significantly reduced grain yield up to 1.0m distance from tree trunk while yield at 2.5m and 4.5 m distance was not affected (Table 35). Maximum total biomass was recorded under *A. marmelos*. Lesser values for all the parameters were recorded nearer the tree line compared to farthest distance.

Data on survival and growth of various tree species planted in different agroforestry model at farmers' field in GKD watershed and Ambabai village have been given in Table 36.

After 6 years of planting, *Acacia senegal* recorded more survival (78%) than *A. nilotica* (53%) in GKD watershed. Out of planted horti-cultural species, guava had shown maximum survival (98%) while, karonda the least (12%). However, anola recorded maximum gbh and plant height.

In Ambabai village after 4 years of planting, survival of *A. senegal* was 54% with plant height of 255 cm and collar diameter of 6.9 cm. The survival percentage of average *A. senegal* on field bunds ranged from 50 to 83 % in GKD watershed (Table 37, 38 and 39).

Table 35: Growth and yield attributes of wheat (var. HUW 234 Z-1) under agri-horti-silviculture model including gum and resin yielding trees (2014-15)

Growth Parameters	Distance (m)	Tree Species				
		A. senegal	*C. limon*	*A. marmelos*	Control	Mean
Plant population m^{-2}	1.0	51	39	46	64	50
	2.5	58	50	48	64	55
	4.5	61	56	57	64	60
	Mean	57	49	50	64	
No. of tillers $plant^{-1}$	1.0	3.47	3.80	3.60	6.37	4.31
	2.5	4.87	5.47	5.33	6.37	5.51
	4.5	5.67	5.73	5.87	6.37	5.91
	Mean	4.67	5.00	4.93	6.37	
Plant height (cm)	1.0	92.07	94.03	95.47	104.93	96.63
	2.5	94.13	98.00	97.70	104.93	98.69
	4.5	98.50	101.30	104.10	104.93	102.21
	Mean	94.90	97.78	99.09	104.93	
Ear length (cm)	1.0	8.53	8.73	8.30	9.80	8.84
	2.5	8.87	8.80	8.80	9.80	9.10
	4.5	8.97	9.53	9.83	9.80	9.53
	Mean	8.79	9.02	8.98	9.80	
Total biomass ($g\ m^{-2}$)	1.0	781.67	578.33	775.00	1296.67	857.92
	2.5	868.33	830.00	846.67	1296.67	960.42
	4.5	1020.00	966.67	1150.00	1296.67	1108.33
	Mean	890.00	791.67	923.89	1296.67	
Grain yield ($g\ m^{-2}$)	1.0	289.83	230.21	301.83	439.98	315.47
	2.5	335.98	309.96	320.99	439.98	351.73
	4.5	418.49	399.59	426.34	439.98	421.10
	Mean	348.10	313.25	349.72	439.98	
Straw yield ($g\ m^{-2}$)	1.0	491.83	348.12	473.17	856.68	542.45
	2.5	532.35	520.04	525.68	856.68	608.69
	4.5	601.51	567.08	692.63	856.68	679.48
	Mean	541.90	478.41	563.82	856.68	

LSD (0.05)			
	Tree species	Distance	Tree species x Distance
Plant population m^{-2}	8.718	NS	NS
No. of tillers $plant^{-1}$	0.743	0.644	NS
Plant height (cm)	5.61	NS	NS
Ear length (cm)	0.475	0.412	NS
Total biomass ($g\ m^{-2}$)	181.887	157.519	NS
Grain yield ($g\ m^{-2}$)	63.899	55.339	NS
Straw yield ($g\ m^{-2}$)	120.659	104.525	NS

Gum Garden

Gum garden of *A. senegal* was developed in July, 2014 which further extended in 2015 at Central Research Farm of ICAR-CAFRI, Jhansi. In all total 353 plants of *A. senegal* and *B. monosperma* have been planted at 3 x 3 m spacing. The survival data is given in table 40.

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

Table 36: Growth parameters of trees in the agroforestry models at GKD Watershed (6 years old) and Village Ambabai (4 years old)

Plantation/Farmer	Collar diameter (cm)	Height (cm)	Canopy (m²)	Survival (%)
Thakur Das				
Acacia nilotica (Babul)	4.2	362	4.4	53
Psidium guajava (Guava)	5.2	306	5.9	98
Carrissa carandus (Karonda)	0.7	110	0.4	12
Himmat				
Acacia senegal (Kumat)	24.9 (GBH)	392	8.4	78
Emblica officinalis (Anola)	44.7 (GBH)	486	19.1	54
Carrissa carandus (Karonda)	0.9	72	0.3	18
Ghanshyam				
Acacia senegal (Kumat) (boundary) (Planted in 2012)	1.9	100		60
Mani Ram (Village Ambabai)				
Acacia senegal (Kumat)	6.9	255	4.6	54

Table 37: 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	80
3	**Gangadhar**	50	2.5 m apart	50
4	**Soni Pal**	50	2.5 m apart	70
5	**Saligram**	10	4 m apart	70
6	**Ghanshyam**	50	2.5 m apart	60
7	**Ram Swarup**	20	3 m apart	60
8	**Sumer**	20	3 m apart	50
9	**Manoj**	10	4 m apart	50
	Total	**310**		

Table 38: Survival of boundary plantation of *A. nilotica* on farmers' field at Shivrampur village in GKD watershed in July, 2015

S. No.	Farmer's Name	No. of tree planted	Spacing	Survival (%)
1	**Ramswarup**	20	5 m apart	50
2	**Soni Pal**	15	5 m apart	67
3	**Kashiram**	10	5 m apart	50
4	**Ramesh**	10	5 m apart	50
5	**Anandi**	20	5 m apart	75
6	**Dinesh**	5	10 m apart	60
7	**Devi Prasad**	10	5 m apart	70
	Total	**90**		

Table 39: Survival of boundary plantation of *A. senegal* on farmers' field at Shivrampur village in GKD watershed in July, 2015

S. No.	Farmer's Name	No. of tree planted	Spacing	Survival (%)
1	**Dadkole**	20	2.5 m apart	75
2	**Sumer**	05	5.0 m apart	60
3	**Ramswarup**	50	2.5 m apart	70
4	**Soni Pal**	30	3.0 m apart	67
5	**Saligram**	50	2.5 m apart	70
6	**Kashiram**	30	2.5 m apart	83
7	**Manoj**	20	3.0 m apart	75
8	**Ramesh**	10	5.0 m apart	70
9	**Roshan Pal**	20	5.0 m apart	75
10	**Anandi**	100	2.5 m apart	80
11	**Dinesh**	15	5.0 m apart	67
12	**Devi Prasad**	10	5.0 m apart	80
13	**Brajlal Pal**	17	5.0 m apart	65
	Total	**377**		

Table 40: Growth parameters of *A. senegal* and *B. monosperma* in Gum garden

Tree species	Collar diameter (cm)	Height (cm)	Canopy (m²)	Survival (%)
Gum garden Part- I (Planted July, 2014)				
A. senegal	3.14	144	--	88
B. monosperma	0.69	31	--	15
Gum garden Part- II (Planted July, 2015)				
A. senegal	0.73	51	--	85
B. monosperma	0.52	27	--	42

tissue culture raised progenies of 5 plus trees of *A. pendula* planted in randomised block design with four replications. Each progeny had 25 plants in a plot. Net plot size was 15 x 10m with the spacing of 3m x 3m. 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 30.24, 31.31, 29.19, 30.84 and 30.86 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 randomised block design in 4 replications having plot size of 15 x 10m with a spacing of 3 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 28.89, 35.18, 30.50, 33.47, 32.99, 29.09 and 27.36 cm, respectively. Maximum gbh was recorded by J-205 progeny, while minimum was recorded in NRC-5. Growth of another plantation of *A. pendula* and *A. latifolia* was also monitored. This plantation was established 1990 and now being used as agroforestry models for tapping gum and raising intercrops. The trees were planted at 5 x 5m spacing. After 25 years, the better survival (89%) was recorded in *A. pendula*, while better gbh, canopy spread and height was observed in *A. latifolia* (Table 41).

Table 41: Growth of *A. pendula* and *A. latifolia* after 25 years

Gum yielding tree species	GBH (cm)	Height (cm)	Canopy (m^2)	Survival (%)
***A. pendula* (Kardhai)**	38.56	718.83	21.98	89
***A. latifolia* (Dhau)**	42.84	738.58	23.22	85

Seed germination

Application of aqueous leaf extract of *Butea monosperma* had significant inhibitory effect on seed germination of all test crops (Table 42). However, irrespective extract concentration, the variation in average seed germination (86.6-90.3%) among crops was statistically non-significant. Generally, the inhibition in seed germination increased with increase in concentration of aqueous leaf extract from 0 to 15%. Among crops, green gram suffered with more inhibitory effect than the other two test crop, *viz.* black gram and guar. The interaction effect of crops and concentrations were found non-significant.

Table 42: Allelopathic effect of *B. monosperma* L. leaf extract on germination of summer pulses crops

Concentration (%)	Crop		
	Green gram	Blackgram	Guar
0	95.00	95.00	100
5	93.75	92.50	98.75
10	90.0	88.75	91.25
15	66.25	70.00	71.25
Mean	86.25	86.56	90.31
LSD (0.05%)	crop	concentration	crop x concentration
	NS	4.337	NS

1. Standardization of Gum Tapping Techniques

Depth of notching or incision on stem of *B. monosperma* L.

A repeat field trial was conducted on naturally occurring 15-20 years old trees of *B. monosperma* for assessing whether depth of notching 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. 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. Last year it was conducted in the month of February 2015, and repeated in February 2016; and exuded gum yield was evaluated. Findings revealed that maximum gum-butea was obtained when notching was done up to 1.0 cm depth on stem bark of the trees. The notching done up to depth of 0.5 cm yield minimum gum-butea (Fig. 32).

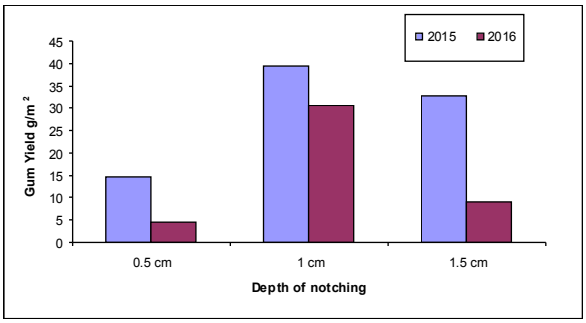


Fig. 32: Effect of different depths of incision on stem-bark on gum yield of *B. monosperma*

2. Factors of Survival of Lac Insect on *B. monosperma* in Summer

This 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. 33), about 48% lac insect survived during summer of 2015 which is better than the survival assessed in summer season of 2014.

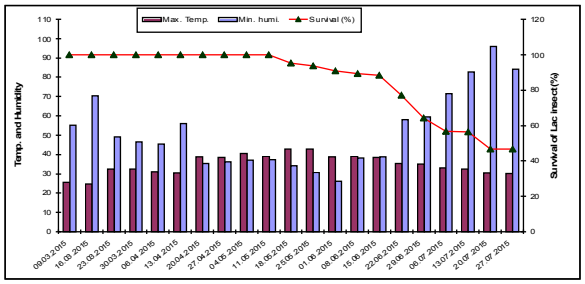


Fig. 33: Effect of temperature and RH on survival of lac insect on butea trees in summer

3. AICRP ON AGROFORESTRY

A. Research Achievements

The bioeconomic aspects of alley cropping have been worked out by integrating Ulmus with arable crops by Srinagar centre. Suitable agroforestry models for degraded and wastelands of Srinagar district have been developed. The centre also developed hortipasture model for almond orchards. In order to overcome cotton seed menace in the valley which has become environmental concern, male clones of poplar are being evaluated for further multiplication and distribution among interested groups so as to replace female clones of poplar with cotton free male clones.

At Palampur, eight seed sources of *Toona ciliata* are being evaluated after screening based on nursery condition under field conditions and out of these eight, HP 5(b) 48, HP 5(b) 71 and HP 1(c) 22 are promising ones. Similarly, *Sapindus mukorossi* germplasm has been collected from different seed sources across the state and is being screened and evaluated for better fruit yield. Three seed sources S3, S5 and S1 out of the earlier eight collections are best performing under field conditions. Being a continuous process, germplasm has also been collected from eight new seed sources and put under nursery evaluation this year. One day agroforestry training was organized by the centre under TSP for 50 farmers involving 23 were women farmers. Training covered various aspects of agroforestry with main emphasis on silvi-pastoral system for the reclamation of waste lands and also for improving the productivity of the natural grasslands. The centre, also, participated and contributed significantly in the training under TSP at Lahual Spiti along with Solan centre and PC Unit for Willow mortality and management.

The findings of studies conducted by Solan centre revealed that the cultivation of vegetable crops in combination with *Melia composita*, especially during winter season recommended for better economic return from the agroforestry systems. However, during summer season decrease in growth and yield parameters of tomato and capsicum within the agroforestry system probably indicates intense competition for critical resources like water, nutrients, photo synthetically active radiation. Soil chemical properties like soil organic carbon, pH, EC and nutrients availability were improved under agroforestry system than sole crop system. Another study by the centre revealed that among different soil working techniques, continuous contour recorded the highest plant survival percentage (100%) for both the tested tree species *Grewia optiva* and *Morus alba*. The pit planting recorded the lowest survival percentage. Similarly, different soil working techniques influenced the performance of grasses (*Panicum maximum* and *Setaria sphacelata)* under *Grewia optiva* and *Morus alba* and continuous contour resulted in higher (67.38%) survival percentage and number of tillers per plant of *Panicum maximum* and *Setaria sphacelata*. The runoff, soil and nutrient losses under different soil working techniques were computed on the basis of each rainfall event. Continuous contour recorded the less (33 ha m) runoff rates as compared to small ridge ditch (41 ha m) and highest (45 ha m) was recorded with pit planting. Similarly, soil and nutrient losses were recorded less in continuous contour (46 t ha^{-1}) as compared to small ridge ditch (51 t ha^{-1}) and highest (58 t ha^{-1}) was recorded in pit planting. However, potassium loss was slightly decreased in small ridge ditch, whereas all

other values against nutrient losses were favoured in continuous contour.

At Kahikuchi centre, it was observed that maximum plant height for *Acacia mangium* (12.55 m) was recorded in 5 m x 6 m spacing whereas the maximum dbh (25.10 cm) was observed in 5 m x 5 m spacing. However, the maximum timber volume (176.05 m^3 ha^{-1}) was recorded in 5 m x 4 m spacing. The sesamum and niger can be grown successfully as intercrop up to 4th year and thereafter only fodder crops *viz.*, hybrid napier and setaria can be grown as intercrops. The coconut yield in intercropped plot was 7.69 to 16.60 % higher in comparison to sole coconut plot (6943 nuts ha^{-1}). Whereas, intercrop yields of french bean, okra, cowpea and geen fodder yield of maize was less as intercrop than sole crops. The maximum buildup of organic matter (12.64%) was observed in vegetable as intercrop in coconut. Increase of available N (7.39%), available P_2O_5 (13.59%) and available K_2O (9.18 %) was observed in 5 years.

During last year, the Ludhiana centre supplied 1,95,000 No. of poplar plants, 11,000 No. of clonal plants of eucalyptus and 1500 No. of clonal plants of shisham to the farmers. Eucalyptus clones C-413, C-72 and C-2045 were released for commercial cultivation in Punjab. The productivity of these clones was 239, 223 and 214% higher than the seedlings (control), respectively. The fertilizer dose, timing and its method of application to poplar plantations during their different growth years were standardized and recommended to farmers for obtaining higher productivity from poplar based agroforestry system. Significant differences among the clones were noticed for growth parameters in the poplar zonal trial (clones from Pantnagar, Ludhiana and Hissar).

Significantly higher herb yield of lemon grass was observed under tree spacing of 8 m x 2.5 m (19.17 t ha^{-1}) and 7 m x 3 m paired at 2.5 m (19.21 t ha^{-1}) than 5 m x 3 m (17.45 t ha^{-1}) in 3 year old poplars. The yield of potato variety Kufri Badshah (12.47 t ha^{-1}), was significantly higher than the yields of Kufri Jyoti (10.89 t ha^{-1}) and Kufri Pukhraj (10.63 t ha^{-1}) under poplar. In weed control experiment in turmeric under poplar block plantations, pendimethalin @ 0.975 kg ha^{-1} and oxyfluorfen @ 0.235 kg ha^{-1} gave effective control of weeds, enhanced the crop yield and were safe to poplars. Soil samples were analyzed for soil organic carbon (SOC) as well as macro (N, P, K) and micronutrients (Fe, Mn, Zn and Cu) content after completion of one, two, three and four rotations of poplar based agroforestry system. The SOC stock in the surface layer was more than double after completion of four poplar rotations (20.3 t ha^{-1}) as compared to one rotation (9.9 t ha^{-1}). There was, also, a significant increase in available N, P and micronutrients after four cutting cycles over one cutting cycle.

Among the six clones of *Populus deltoides* planted on sodic soil at Faizabad centre, the highest annual growth increment in terms of plant height and dbh was recorded for L-49 clone (0.84 m yr^{-1} and 1.14 cm yr^{-1}), respectively. Among paddy and wheat varieties sown under different *Populus deltoides* clones, the maximum grain yield of rice was obtained in variety Sarjoo-52 (2.16 t ha^{-1}) and the maximum grain yield of wheat was obtained in variety PBW-502 (1.85 t ha^{-1}). The yield reduction in rice variety Sarjoo-52 (19.40%) and wheat variety PBW-502 (22.59%) was recorded as compared to open area.

Among mustard varieties sown, the maximum mustard yield was achieved in variety NDR-8501 (1.02 and 1.05 t ha^{-1}) under *Casuarina equisetifolia* and *Dalbergia sissoo* based agri-silviculture system, respectively. Under agri-silvi-horti system, the

highest fruit yield of guava (9.35 t $ha^{-1}yr^{-1}$) was recorded in treatment-50% NPK + 50% FYM as compared to other treatments and higher fresh corm yield of turmeric (5.87 t $ha^{-1}yr^{-1}$) was recorded in same treatment, which was found lower than open area (6.72 t $ha^{-1}yr^{-1}$). Data on leaf litter decomposition of poplar trees, showed that in annual cycle, there was 81.60-87.0% dry loss (G-48 vs L-49) in the leaf litter. The highest total green herbage yield (48.76 t ha^{-1}) of *Pennisetum purpureum* was recorded as compared to other grasses under *Dalbergia sissoo* based silvi-pastoral system.

Identification of new genotype (PBN selection 12-1) of *Bambusa nutans* for water logged conditions is under testing at Pantnagar. Five mortality resistant and straight bole elite genotypes (PS-20, PS-38, PS-52, PS-54 and PS-90) of *Dalbergia sissoo* were selected after II generation testing (20 years evaluation) for III generation testing and establishment of seed orchard. Endophytic *Fusarium equiseti* isolate (KP274872; 552bp) has been isolated from *Bambusa balcooa* and registered with NCBI. Gregarious flowering in certain genotypes of *Dendrocalamus giganteus* was observed. Early flowering in culm cuttings at nursery stage was recorded in *Bambusa nutans*. Two isolates (KT 6 and SE 6) were found to belong to the genus *Trichoderma,* while the other two isolates (ST 1 and BRT 11) were suspected to belong to *Penicillium* and *Aspergillus,* respectively. All the four fungal cultures were further identified by Indian Type Culture Collection (ITCC), IARI, New Delhi, India. Thus, the isolates were identified as *T. viride* (KT 6), *T. virens* (SE 6), *P. citrinum* (ST 1) and *Aspergillus flavus* var. *columnaris* (BRT 11). The potential fungal isolate BRT 11 identified as *A. flavus* var. *columnaris* (ITCC-6231) and ST 1 identified as *P. citrinum* (ITCC-6232) were deposited at ITCC gene bank. The centre organized a National Seminar on "Holistic Development of Agroforestry: Potential and Policy Issues" and one day training on "Clonal Propagation of Eucalyptus".

Ten-years-old clones of poplar at Pusa registered maximum height in L-52 (15.03 m) followed by L-49 and minimum in L-188 (12.50 m). Volume of the different poplar clones followed the order as: L-52 (0.384 m^3) >L-49 (0.359 m^3) > Uday (0.346 m^3) >PP-5 (0.333 m^3) >G-48 (0.249 m^3) >L-188 (0.198 m^3). The highest rate of decomposition in terms of percent weight loss was observed in the leaf litter of L-52 clone and minimum in L-188. The decomposition constant *k* for the leaf litter ranged from 0.00569 to 0.00653 gg^{-1} day^{-1}. Total above ground carbon stock in trees varied from 24.15 (L-188) to 47.44 t ha^{-1} (L-52). Thus, from the volume production and the C-sequestration point of view, L-52, L-49 and Uday emerged as the best clones. The three varieties of turmeric namely, Rajendra sonia, Rajendra sonali and NDH-92 grown as intercrop under 13-years-old *Emblica officinalis* indicated that the maximum reduction in yield of turmeric was 50.2 % for Rajendra sonali, 40.2 % for NDH-92, and 27.5 % for Rajendra sonia compared to the yield in open area. Soil organic carbon, available N and available P_2O_5 were built up under this orchard at the age of 13 years. Under *Simaruba glauca* based system turmeric, ginger, elephant foot yam and colocasia were grown as intercrops. The results indicated that the reduction in yield of intercrops was 15.2 % for turmeric, 27.8 % for colocassia, 31.6 % for elephant foot yam and 35.5 % for ginger, compared to the yield in open area.

Under mango based agri-horti-silvicultural system pineapple was the most profitable intercrop at Bhubaneshwar centre with net returns of ₹ 2,10,575, 1,89,410 and 1,67,210 ha^{-1} yr^{-1} with B:C ratios 3.21, 2.99 and 2.76 when intercropped with sole mango, mango + *Dalbergia sissoo* and mango + *Gmelina arborea* respectively, as against a net

return of ₹ 44,800 with B:C ratio 1.56 when grown as a sole crop. Arrowroot was the next best crop which recorded net returns of ₹70,454, 62,984 and 57,413 $ha^{-1}yr^{-1}$ with B:C ratios 2.28, 2.15 and 2.04 when intercropped with sole mango, mango + *Dalbergia sissoo* and mango + *Gmelina arborea,* respectively, as against a net return of ₹ 14,336 with B:C ratio 1.36 when grown as a sole crop. The highest guava fruit yield of 3.72 t ha^{-1} was recorded with no pruning and dry leaf mulch followed by no pruning and black polythene mulch (3.65 t ha^{-1}). However, the highest fresh arrowroot yield of 8.62 t ha^{-1} was recorded with heavy pruning (1m) during 3rd year of pruning with dry leaf much followed by heavy pruning with black polythene (8.27 t ha^{-1}). Similarly, highest net return of ₹76,368 and BCR of 2.27 was recorded with no pruning and dry leaf mulch followed by light pruning and dry leaf mulch.

Different agroforestry systems and cropping sequences have been verified at Jhargram centre for better productive utilization of unit area. The systems have been developed and demonstrated on farmers' field as well as at research stations. The *Eucalyptus tereticornis* + mango + lady's finger and *Eucalyptus tereticornis* + mango + bottle gourd followed by mustard agri-horti-silvi agroforestry model gave higher gross return ₹ 2.81 lakh and ₹ 2.69 lakh ha^{-1} $year^{-1}$, respectively during 7th year. Similarly, gamhar + mango + ladyfinger and gamhar + mango + bottle gourd followed by mustard agri-hort-silvi model is also very promising for the region. To achieve quantum jumps in the productivity levels, supply of better quality planting materials and for wider adoption of suitable model(s) along with refinement of appropriate package of practices, the centre has been sanctioned a project on "Transfer of innovative fruit based agroforestry models for crops production & poverty alleviation of farming community in Red & Laterite Zone of West Bengal", by NABARD for ₹ 821.53 lakh.

Under silvipasture system at Ranchi centre, it was observed that the growth performance of gamhar was better with hybrid napier and sudan grass after six years of plantation. The nitrogen content (231kg ha^{-1}) has increased with gamhar + sudan and it was significantly superior over control and gamhar (sole) treatments. Under Tribal Sub Plan programme, it was also observed that economic condition of tribal farmers and soil status of the farmers' field have improved after the cultivation/agroforestry practices.

In the evaluation 10 plus tree at SK Nagar centre, neem plus tree SKN-3 exhibited maximum plant height (12.53 m) and SKN-4 has highest CD (35.77 cm). Among 17 provenances of neem, the neem provenance from Bharuch recorded highest CD (33.23 cm). Out of 10 elite progenies of neem, No. 110 recorded higher plant height (6.99 m) after 11th year of plantation. In Ailanthus based silvipasture system, the highest dry biomass was recorded by *Cenchrus ciliaris* and maximum tree height (5.78 m) and CD (54.8 cm) was recorded in Ailanthus sole treatment. All the guinea grass varieties *viz;* PGG-664, JHGG-04, Riversdale and Makuni were found suitable in simarouba based agroforestry system.

A new block of Pomegranate *Sinduri* variety under agri-horti-culture model and another block of grafted Khejri at 6 m x 6 m distance under silvipasture model to study the economics, growth performance, production of fodder from leaves and Sangri from pods based on 4th QRT recommendations initiated by Fatehpur Shekhawati centre. The centre collected a total 24 CPT's of *P. cineraria* from Sikar, Jhujhunu, Churu, Nagore and Bikaner in Rajasthan. The centre selected 100 farmers in Banswara district under TSP component

during last year and currently a total of 180 farmers registered under TSP programme. Farm input such as quality planting material of mango and guava plants, seed of intercrop, insecticides, pesticides, fertilizer provided to them.

Under different spacing trial of poplar based agroforestry system, poplar has been found to attain significantly more girth at 5 m x 4 m and 10 m x 2 m spacing than paired row planting (18 m x 2 m x 2 m) after eight years of plantation at Hissar. After 8 years, the soil under poplar based agroforestry system showed 39.7 % more organic carbon than sole agriculture. Sorghum grown for fodder during the *kharif* season produced significantly higher yield in paired row planting than 5 m x 4 m and 10 m x 2 m spacing. Overall yield of sorghum under different spacing was poor due to shading effect and late occurrence of monsoon. Wheat and berseem grown during the winter season produced significantly higher yield in paired row planting and 10 m x 2 m than 5 m x 4 m spacing. A reduction in wheat yield from 30 (18 m x 2 m x 2 m) to 51 % (5 m x 4 m) was observed under different spacings over control in 8 years old age poplar based agroforestry system. However, protein content of wheat increased under agroforestry as compared to sole wheat crop (control). Also, the poplar based agroforestry system at 8 years age was found to sequester 113 % more carbon than sole agriculture. The rate of carbon storage was found to be 25.2 t ha^{-1} yr^{-1} in poplar based agroforestry system and 11.8 t ha^{-1} yr^{-1} in sole agriculture.

Eucalypts planted on a saline soil in February, 2007, attained significantly more girth at 3 m x 3 m spacing than 6 m x 1.5 m and 17 m x 1 m x1 m spacing. The grain yield of barley under eucalypts was significantly more (1.9 t ha^{-1}) under paired row plantation (17 m x 1m x 1 m) of Eucalypts than 3 m x 3 m (1.1 t ha^{-1}) and 6 m x 1.5 m (1.4 t ha^{-1}) spacings. In kinnow and Eucalypts based agri-silvi-horticulture system, a remarkable increase in dbh of clonal Eucalyptus recorded at the age of four years. The additional 10 % increase in recommended dose of nitrogen showed significant increase in grain and straw yield under both the kinnow + wheat (agri-horti) and kinnow + Eucalypts + wheat (agri-silvi-horti) systems. An increase of 14.9 and 36.3 % in grain yield over recommended dose of fertilizers under agri-horti and agri-silvi-horti, respectively was recorded. Seven years old poplar planted on field bunds has been found to 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 Nagpur centre in collaboration with social forestry department of Maharashtra compiled and published a book in Marathi for promotion of scientific agroforestry in the state covering complete scenario of forestry and agroforestry practices of the region. The centre also organised a six days "Capacity Building Training Programme" for field level officers (RFOs and others) for agroforestry practices developed of the region in which forty three forest officers attended training programme. The technology for propagation and cultivation of important bamboo species developed and the recommendation was approved in recently held meeting of four agricultural universities of the state.

In provenance trial of *Acacia nilotica* at Jabalpur centre, seeds of 30 provenances were collected from different places (*viz;* MP (17), Maharashtra (07), UP (02), Bihar (01), Chhattisgarh (02), and Punjab (1). At the age of 4½ years, Firojpur (Punjab) provenance recorded significantly higher plant height (3.38 m) and collar diameter (6.0 cm), MAI (75 cm), CAI (47 cm), whereas Shyampur, Sehore (MP) provenance recorded significantly lower plant height (1.11 m) and collar diameter (1.8 cm). Under 16 years old

agri-silvi-culture system (shisham + paddy-wheat) where 4 pruning treatments (*viz*; no pruning, 25%, 50% and 75% pruning) and one open were carried out in main plot and three levels of fertilizer and seed rate (*viz*; T1 recommended dose of fertilizer dose and seed rate, T2 (T1+ 25% more nitrogen than recommended dose, and T3 (T1 +25% more seed rate than recommended dose) in sub plot. Significantly higher grain yield of paddy (2.48 t ha^{-1}) and wheat (2.74 t ha^{-1}) was recorded under open conditions, whereas no pruning recorded significantly lowest grain yield of paddy (1.24 t ha^{-1}) and wheat (1.65 t ha^{-1}). Among different pruning treatments, 75% pruning recorded higher grain yield of both paddy (2.22 t ha^{-1}) and wheat (2.44 t ha^{-1}) and was significantly superior to other pruning treatments. In 17 years old hortipastoral system (guava + fodder oat) four pruning treatment i.e. levels of deheading *viz*; no deheading, deheading at 1.0 m, 1.5 m, 2 m height and one open (crop without tree) in main plot and four oat fodder varieties (*viz*; Kent, J0-2, J0-91 and J0-1) in sub plot, open condition recorded significantly higher green fodder yield (42.10 t ha^{-1}) in two cuttings. No pruning recorded significantly lowest yield (21.80 t ha^{-1}). Among levels of deheadings; deheadings at 1 m height recorded significantly higher fodder yield of oat (35.30 t ha^{-1}) and was significantly superior to other treatments. The percent reduction in green fodder yield under no deheading (pruning) deheading at 1.0 m, 1.5 m, and 2.0 m as compared to open was 52.29, 16.15, 26.6 and 31 %, respectively. Oat variety JO-2 recorded significantly higher green fodder yield in two cutting (38.00 t ha^{-1}) followed by JO-91 (31.90 t ha^{-1}).

Under germplasm evaluation of *Acacia nilotica var. cupressiformis* and *Acacia nilotica var. indica*, at Rahuri, the entry RHRANC-5 was found promising for all the growth parameters after 17th year of plantation. In provenance trial of *Acacia nilotica var. indica*, a progeny of RHRAN-1 recorded significantly highest plant height (11.83 m), collar diameter (31.53 cm), dbh (24.97 cm) and bole height (2.67 m) at the age of 14th years. In multi-location trial of neem, the line-117 recorded significantly highest plant height (5.45 m) and collar diameter (18.58 cm) whereas, local entry recorded highest bole height. The germplasm of *Acacia nilotica var. indica* collected from 61 different locations of Maharashtra and the entry RHRAN-36 recorded numerically highest plant height (5.36 m) and collar diameter (14.87 cm). In the experiment on evaluation of agri-horticultural system of different fruit tree species with inter crop under irrigated condition, it was observed that tamarind in treatment, (tamarind + custard apple) recorded maximum plant height (97.4 cm) and was followed by tamarind (91.8 cm) in tamarind + aonla treatment. Promising genotypes of P*ongamia pinnata* were collected and multi-location trial was planned for six locations from the coming *kharif* season.

In multi-location trial of neem (11 years age old) at Hyderabad centre, the line-117 recorded the highest tree height (7.65 m) followed by L-118 (7.36 m). In case of dbh, the highest was recorded by L-115 (72.0 cm) followed by L-117 (60 cm). In *Pongamia,* 29 germplasm lines were collected in collaboration with NBPGR, Hyderabad. Among 29 lines tested, SRJ-43 recorded the highest plant height 6.95 m followed by SRJ-39 (6.8m), SRJ-45 (6.56 m). Regarding dbh, the entry NGSR-27 recorded the highest (66 cm) followed by SRJ-39 (59 cm), SRJ-43 (51.8 cm) and SRJ-45 (51.6 cm). In *Simarouba* germplasm, a total of 50 segregating lines of Kali and Gouri were planed during 2011. This year some of the lines started flowering and observed less fruiting during April month (4th year). In mango + curry leaf + moringa based agri-horti system (3 years old), among the

different inter crops tested, cowpea (0.83 t ha^{-1}) + curry leaf (0.36 t ha^{-1}) + moringa (0.37 t ha^{-1}) in *kharif* and safflower in *rabi* performed better in terms of higher net returns (₹ 66,290 ha^{-1}) and B:C ratio 3.27. Regarding soil aspects, rainfed legume crops (cowpea, horse gram, black gram) performed better than non-legumes millets, castor and marigold. Higher OC (0.6%) and available N (0.17 t ha^{-1}) was found with cowpea > horse gram > black gram. In tamarind grafts plantation (14 years old trees) highest raw pod yield 3.06 t ha^{-1} was recorded. The growth performance of henna with double row produced significantly higher biomass (0.78 t ha^{-1}) with height (3.0 m) than in single row (0.64 t ha^{-1}) with height (2.6 m). Among the organic manures, application of neem cake @ 2 kg $plant^{-1}$ (2.00 t ha^{-1}) produced significantly higher biomass 0.67 t ha^{-1} with height (3.2 m).

The Custard apple trees in horti-pastoral system started flowering after 2½ years. Different fodder grasses, *Cenchrus ciliaris* (Anjan), *Panicum maximum* (Guinea) were established. In the first cutting, guinea grass has recorded higher herbage yield of 2078 kg ha^{-1}. The results of second consecutive year revealed that integrated use of 75% RD N + 25% poultry manure significantly influenced the grain and straw yield (1566 and 3288 kg ha^{-1}) of finger millet in agri-silviculture and at par with sole crop (without trees). The same nutrient management practice recorded the highest OC content (0.90%) and better available NPK (299, 42, 359 kg ha^{-1}). The combined treatments with bio-fertilizers also recorded more OC and NPK content than the famers' practice i.e. FYM 10 t ha^{-1}. The net returns and BC ratio was ₹ 12,462 and 1.57.

The results of first year revealed that there was no significant difference on fresh forage biomass by type of fodders i.e. maize and sorghum in *Melia dubia* (3 years old) based silvi-pastoral system. The highest fresh forage biomass was recorded in sub treatment (S-5) 75% RDN + 25% N through poultry manure (7.86 t ha^{-1}) and in interaction the fodder maize 50% RDN + 50% N FYM (M1 S4 84.19 q ha^{-1}), where as in fodder sorghum 75% RDN + 25% N poultry manure (M2 S5 7.54 t ha^{-1}). Regarding quality parameters, the crude protein (58%) and fiber were not significantly affected by different cereal fodders. But there was a significant effect by different nutrient management practices. The highest crude protein was registered in 50% RDN + 50 % N FYM in maize (M1 S4 8.04%) and in sorghum 75% RDN + 25% N poultry manure (M2 S3 9.37%). In case of crude fiber content, the significant effect was observed in type of fodder, nutrient combination and interaction treatments. The highest fiber content was found in maize (30.18%) followed by sorghum (23.78%). In interaction, the highest content was resulted in 100% RDF in maize (M1 S2, 32.84%) and in sorghum interaction 75% RDN + 25% N through poultry manure (M2 S5, 27.25%).

Tamarind is one of the mandate tree species on which the Dharwad centre is working and 14 clonal materials of the species are being evaluated. Of these 14 clones, the University has released two clones (NTI-14 & NTI-79). The performance of NTI-14 (34.12 kg fruits $plant^{-1}$) and SMG-13 (32.26 kg fruits $plant^{-1}$) and NTI-79 (30 kg fruits $plant^{-1}$) are superior and these three clones are being vegetatively propagated for demonstration under farmers' field. The vegetatively propagated clones of red tamarind and sweet tamarind were also, produced to meet the huge demand by the farmers. The centre is evaluating 20 provenances of neem for their growth under transitional tract of Dharwad. Among these collections, Bagalkot, Bijapur, Bailahongal and Raichur sources are identified as better sources and they are being used to develop agroforestry models. Neem seed yield was highest in Bijapur provenance

(3.25 kg plant^{-1}) and Bhimarayangudi provenance (3.12 kg plant^{-1}). Under *Pongamia pinnata* germplasm evaluation from different parts of the country, the maximum height and dbh was observed in RAK-89 (5.24 m and 13.51 cm, respectively) from Rahuri, MTP-II (5.06 m and 15.23 cm, respectively) and MTP-I (5.02 m and 13.86 cm, respectively) from Mettupalayam. The centre organized 18 training programmes during the year under capacity building objective.

Fourteen clonal progenies raised from candidate plus trees of *Ceiba pentandra* are being evaluated for the past seven years by TNAU centre, Mettupalayam. During last year, MTPCP 30 (Poonkodipallam) was found to perform well in terms of height, basal diameter and number of branches, while MTPCP 18 (Arachalur) recorded the maximum number of pods (208 pods tree^{-1}). The pod yield of MTPCP 18 worked out to be 57,616 No. ha^{-1} and the floss yield was 288 kg ha^{-1}. Growth and yield data observed during continuous drought in last three years was crucial in shortlisting eight moisture stress tolerant progenies (MTPCP 1, 2, 4, 11, 18, 30, 36 and 37) among the assembled fourteen clonal progenies through three physiological tests *viz.* Relative Water Content (RWC), Chlorophyll Stability Test and Proline estimation. Based on these tests, it was observed that MTPCP 18 ranked the highest in all the three tests followed by MTPCP 11 and MTPCP 30 which proved their tolerance to drought. Besides being the highest yielder, MTPCP 18 was also observed to be drought tolerant which indicated its suitability for cultivation by farmers in rainfed areas.

The centre also established an integrated tree fodder model using major tree fodder species like *Gliricidia sepium, Leucaena leucocephala, Sesbania grandiflora* and *Melia dubia* along with *Casuarina* as the main crop. The tree fodder species are being maintained as hedges and regular harvests cater to the green fodder need of the cattle component. Among the intercrops, *Gliricidia sepium* recorded the maximum green fodder yield (9.3 t ha^{-1}) while the nutritional values of *Melia dubia* were found to be superior in comparison with the other tree fodder species. It was also observed that three of the four intercrops and the main crop being leguminous in nature were found to contribute substantially to available nitrogen status.

The D & D survey by the Thrissur centre revealed that in the coastal regions of Kollam district, Kerala revealed that structural and functional diversity of the rural (Poothakulam gramma Panchayat) and semi-urban (Paravoor Municipality) home gardens were marginally variable. Interestingly the small sized home gardens in the semi-urban region showed highest standing stock of timber (321.56 m^3 ha^{-1}) followed by medium sized home gardens (220.31 m^3 ha^{-1}). Studies on the multitier silvopastoral systems suitable for tropical home gardens showed that, two- tier silvopastoral systems including hybrid napier + (mulberry / calliandra) is a better option for improving the productivity (31.5 t dry matter ha^{-1}) and quality (4.75 t of crude protein ha^{-1} on dry matter basis) of forage in comparison with hybrid napier monoculture (30.18 t of dry yield and 2.83 t of crude protein ha^{-1}), for profitable milk production.

The centre also standardized the planting density, cutting interval and cutting height for higher forage yields and forage quality for various selected fodder tree species. For Mulberry the annual fresh forage yield (79.15 t ha^{-1}yr^{-1}) and the crude protein content (5.415 t ha^{-1}yr^{-1}) was the highest at a density of 27777 plants ha^{-1} (60 cm x 60 cm spacing) at an interval of 12 weeks and at a pruning height of 100 cm. Similarly, forage yield (50.87 t ha^{-1}yr^{-1}) and crude protein content (3.52 Mg ha^{-1}yr^{-1}) was maximum for subabul at the highest tree density of 27777

plants ha^{-1} and harvesting at an interval of 12 weeks at a pruning height of 100 cm. The potting media of soil + coir pith compost + vermi compost in 2:1:1 ratio was found as a cheap alternative for production of quality planting stock of fodder tree species such as like calliandra and mulberry in humid tropics of Kerala. This media assured improved plant quality with low production cost.

The studies were conducted by Dapoli centre on the effect of different nitrogen fixing tree species on soil chemical properties and primary nutrients in lateritic soil. During the course of investigation the fresh soil samples were collected from root *rhizospheric* zone of nitrogen fixing tree species and these samples were taken for bacterial count and fungal count by serial dilution method. It is revealed from the study that use of nitrogen fixing trees species showed beneficial effect on bacterial count and fungal count. The highest bacterial count was observed in the *Acacia mangium* with the mean value of 150.67 CFU which was observed significantly superior over rest of species. In case of fungal count treatment, *Albizia lebbeck* was found to be significantly superior over rest of the species with the mean value of 69.33 CFU. The centre recommended to cultivate *Dendrocalamus stocksii* (Managa) which is more adaptable and more profitable followed by *Bambusa nutans* and *Bambusa arudinacea* in Konkan region of Maharashtra, as it showed higher B:C ratio and NPV compared to other bamboo species at the age of eleven years of plantation.

In hortipasture model developed by Kattupakkam centre the understorey area of coconut trees, napier bajra hybrid grass was cultivated and compared with napier bajra hybrid grass cultivated as sole crop. The biomass yield in sole crop (napier bajra hybrid grass) was higher by 14.7 % compared to yield under coconut tree. In another experiment in hortipasture model, in the understorey of guava trees, fodder cowpea was cultivated and compared to that of sole crop. Only 32% of biomass yield could be obtained in fodder cowpea cultivated under guava tree. The crude fibre content in cowpea understorey guava tree was higher (37.4%) compared to the sole crop. These hortipasture models could support 25 cows in maintenance, whereas it could support only 17 cows in lactation. Biomass yield of *Leucaena leucocephala* and *Gliricidia sepium* in silviculture was documented on pollarding. The total edible leaves biomass in *Leucaena leucocephala* and *Gliricidia sepium* was 9.20 t ha^{-1} and 18.54 t ha^{-1} respectively in rain fed condition. A feeding trial for ninety days with tree leaf meal based concentrate feed was carried out in buffalo calves (8-9 months old). *Gliricidia sepium* and *Leucaena leucocephala* leaves were included in concentrate mixture at 30% maintaining their ratio at 1:1. There was no significant difference in the body weight gain between control (no tree leaf meal) and tree leaf meal supplemented groups. Indicating that tree leaf meal could be added in concentrate mixture of buffalo calves without any adverse effect. The reduction in feed cost in tree leaf meal fed animals was to the tune of ₹ 4.70 Kg^{-1} feed. *Sesbania grandiflora* was integrated with brinjal and tomato. The biomass yield of *Sesbania grandiflora* at 75 days of pruning was 0.29 to 0.30 t ha^{-1}. No significant variation in yield was documented when *Sesbania grandiflora* was either integrated with brinjal or tomato. An experiment was initiated to assess the milking potential of milch cows on supplementation of *Sesbania grandiflora* fodder (2 kg daily) apart from grazing in farmers' field and it was found that *Sesbania grandiflora* supplementation increased milk yield by 270 ml day^{-1}.

The centre published a book on "Enhancing livestock productivity through agroforestry – TANUVAS experience" and released in April, 2015 during the Livestock

Production Council meeting of TANUVAS and another book compiled by the centre entitled "Handbook on Agroforestry Models in Tamil Nadu for Livestock Integration" released in the Workshop.

Tree survey in Chikkaballapur and Chamrajnagar districts conducted by Bangalore centre revealed that bund planting fallowed by boundary planting, block planting and interspaced in arable land are the main agroforestry systems. The main tree species observed were melia, tamarind, mango, silveroak, albizia and casurina in block plantation. The centre is in the process of establishing clonal seed orchard of mandated trees: simarouba and tamarind. In simarouba, 7 clones in each type namely Kaali and Gouri, 7 have been identified for clonal seed orchard. Similarly in tamarind 27 selections were collected and planted in tamarind clonal seed orchard. During 2014-15, three more clones have been identified in Mysore districts with better yield attributes and good yield. Finger millet grown in association with TBO's under rainfed ecosystem noticed considerable reduction in yield of intercrop which varied from 29-70 %, highest reduction was observed in melia based agroforestry system. The reduction in yield was attributed to competition for soil moisture and light. The results suggested that there is a need to develop suitable planting geometry for agroforestry trees. Agroforestry based Integrated Farming System, sesbania found to be good fodder tree during the lean period. IFS under rainfed and irrigated system recoded sustained production, improvement in soil health, increased man days on employment opportunity and finally enhanced farm income. Introduction of high yielding finger millet and red gram enhanced the yield (35 to 40 %) besides improving return net income and nutrition security in tribal sub area demonstrations.

Annual Group Meeting

The Annual Workshop of All India Coordinated Research Project on Agroforestry was organized by ICAR-CAFRI at SKUAST-(K), Srinagar from 25th to 27th July, 2015. The Annual Group meeting of All India Coordinated Research Project on Agroforestry was inaugurated by Dr. Javed Rizvi, Regional Director, South Asia Programme, World Agroforestry Center, on 25th of July, 2015 at Nund Reshi Convention center SKUAST-K, Shalimar, Srinager. Prof. K N Qaisar, Dean Faculty of Forestry welcomed the guests and highlighted the programme of AICRP-Agroforestry.

4. AWARDS AND RECOGNITIONS

Dr. K.G. Tejwani Award 2011-12

Dr. Rajendra Prasad, Principal Scientist (Soil Science) was awarded Dr. K G Tejwani Award 2011-12 for excellence in Agroforestry and Development.

Best Paper award

Dr. R P Dwivedi, Principal Scientist (Agricultural Extension) of ICAR-CAFRI, Jhansi was awarded Best Paper presentation award during National Seminar of Indian Society of Extension Education (ISEE) IARI, New Delhi during 26th -28th February, 2015 held at Rajmata Vijayaraje Scindhia Krishi Vishwavidyalaya, Gwalior (M.P.).

5. VISITS ABROAD

Dr. S K Dhyani, Director and Dr. A K Handa, Principal Scientist participated in Consultation Workshop on "Present Status and Future Prospects of Agroforestry in Nepal" Jointly Organized by Government of Nepal, Ministry of Agricultural Development, Ministry of Forests & Soil Conservation, World Agroforestry Centre and Asia Network for Sustainable Agriculture and Bio-resources (ANSAB) from 26th to 28th March, 2015 at Kathmandu, Nepal.

Dr. S Vimala Devi, Sr. Scientist participated in the Regional Workshop on Development of Communication Strategies for Adoption of Agri-Biotechnology in Asia on 28th to 29th September, 2015 held at Chiangrai, Thailand.

Dr. K B Sridhar, Scientist attended the workshop on "Systematic Review in Forest Science" at Forest Research Institute in Malaysia during 17th to 19th November, 2015. This visit was sponsored by IUFRO.

6. CONSULTANCY SERVICES

Impact Assessment of Soil and Water Conservation Measures in Forest Areas of Bundelkhand Region of Uttar Pradesh

The specific objectives of the consultancy project was to measure the impact of soil and water conservation measures under 'Special Bundelkhand Drought Mitigation Package' on floral and faunal biodiversity and on socio-economic benefits to the people in forests- fringe in study area. The field surveys were conducted during the November, 2014 to December, 2015. The study was based on primary data collected on structured schedule, applying stratified random sampling. From each forest division, three forest ranges have purposively been selected on the basis of maximum area covered under the project. Two sites, preferably separate forest block, from each forest range have been selected on the basis of highest soil and water conservation works done under the project. From each selected site, one nearest adjacent site was selected for comparison as control. Focus Group Discussions (FGDs) were conducted in the each selected site. The team covered 48 forest blocks covering 29 forest ranges and conducted 48 FGDs. The total budget was Rs. 10.5 lacs and the funding agency was Chief Conservator of Forest, Bundelkhand Zone, Jhansi, Uttar Pradesh.

Species such as *Anogeissus pendula*, *Diospyrous melanoxylon*, *Cassia fistula*, *Anogeissus latifolia*, *Butea monosperma* etc. showed natural regeneration. As the micro-climatic condition of the area improved, the population of birds, butterflies and insects increased. These areas have now become the breeding and nesting grounds. Beehives were found near the rain water harvesting structures and the population of herbivores, also, increased radically. Groundwater recharge enhanced significantly due to rainwater harvesting structures (RWHSs). RWHSs are now serving as permanent drinking water source for wildlife, livestock and villagers. These structures have now become major source of water for domestic chores of the villagers, pumping of water for irrigation of crops. It was observed that the water level of the open shallow dug wells located in and around the rainwater harvesting structures increased up to 0.5 to 2 m. The irrigation intensity and pumping hours increased due to water availability. Nomads used to camp near the structures with their sheep, ponies, donkeys and horses due to availability of water, pasture etc. Due to conservation of soil, water and natural vegetation, there has been higher productivity of crops, livestock and this in

turn improved livelihood of fringe population. Cropping pattern of the area shifted towards profitable crops and cropping intensity increased substantially. Crop diversification was also noticed to large extent. Two fold increment in crop yield was reported. The fallow lands lying vacant for decades came under cultivation due to water availability. Water conservation is widely believed to be the most cost-effective and environmentally sound way of reducing the demand for water. Gully and ravines got stabilized up to some extent due to introduction of trees and grasses. Runoff, soil loss and sedimentation was checked. The crop raiding incidences decreased due to regular forage availability in the forest for wild animals. The pressure of cattle grazing in forest area reduced due to availability of forage resources near the water harvesting structures.

Prior to interventions, the communities in the fringe areas were highly food insecure, a situation that caused regular outmigration of inhabitants to other areas in search of livelihood in times of even minor droughts. Soil and water conservation techniques not only improved and stabilized food production, but also reduced the impact of climate variability and rainfall irregularities, thereby improving household resilience. The conservation approach was successful in imparting a sense of ownership and responsibility among the stakeholders.

7. ON GOING PROECTS (2015-16)

SYSTEMS RESEARCH PROGRAMME

- **AF 02.14: Nutrient management in ber based agri-horti system**

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

- **AF 03.9: Initiation of pruning and its intensity on productivity of *Albizia procera***

  (Inder Dev, K B Sridhar & Asha Ram)

NATURAL RESOURCE & ENVIRONMENT MANAGEMENT PROGRAMME

- **AF 01.16: Evaluation of shade tolerance of crop species for agroforestry systems**

  (Badre Alam & Ram Newaj)

- **AF 01.24: Studies on arbuscular mycorrhizal fungi of important agroforestry plant species of Bundelkhand region**

  (Anil Kumar & Rajendra Prasad)

- **AF 05.6: Model watershed project on natural resource management through agroforestry interventions at Garhkundar, Tikamgarh, M. P.**

  (R K Tewari, Ramesh Singh, R P Dwivedi & 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**

  (R H Rizvi & A K Handa)

- **AF 05.12: Agroforestry based conservation agriculture for sustainable landuse and improved productivity**

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

- **AF 05.15: Management of sulphur and boron deficiency in mungbean-mustard cropping sequence under teak based agroforestry system**

  (Asha Ram, Inder Dev, Dhiraj Kumar & A R Uthappa)

TREE IMPROVEMENT, POST-HARVEST AND VALUE ADDITION PROGRAMME

- **AF 01.23: 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)

- **AF 04.1b: Exploration, evaluation and conservation of germplasm of *Acacia nilotica***

  (S Vimala Devi, Badre Alam & A R Uthappa)

- **AF 04.5: Genetics and breeding of *Jatropha* species**

  (S Vimala Devi, S B Chavan & A R Uthappa)

- **AF 04.9: Assessment of candidate genes for oil biosynthesis in *P. pinnata* using eco-tilling approach**

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

- **AF 05.10: Lac based agroforestry in Bundelkhand region: Introduction and evaluation**

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

- **AF 04.10: Evaluation and characterisation of different Leucaena germplasm at CAFRI**

  (A R Uthappa, A K Handa, S Vimala Devi, S B Chavan & Asha Ram)

HRD, TECHNOLOGY TRANSFER & REFINEMENT PROGRAMME

- **AF 05.13: Farmers' Perception and Attitude toward Agroforestry and Climate Change in Bundelkhand Region of Central India**

  (R P Dwivedi, Sudhir Kumar, R H Rizvi, Mahendra Singh, K B Sridhar & Asha Ram)

- **AF 05.14: Sustainability of agroforestry systems in India**

  (Mahendra Singh, R P Dwivedi, Inder Dev, K B Sridhar & A R Uthappa)

EXTERNALLY FUNDED PROJECTS

ICAR Net Work- NICRA Project- Lead Institute: CRIDA, Hyderabad

- **Assessment of carbon sequestration potential of agroforestry systems (National Initiative on Climate Resilient Agriculture)**

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

MoRD: New Delhi

- **Model watershed for sustaining agricultural productivity and improved livelihoods- Domagor Pahuj Watershed**

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

ICRISAT, Hyderabad

- **Enhancing groundwater recharge and water use efficiency in SAT Region through watershed interventions- Parasai-Sindh watershed, Jhansi**

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

NMOOP-MM-III Project

- **National network on integrated development of Jatropha and Karanj**

  (S Vimala Devi, S B Chavan & A R Uthappa)

Net Work Project: Lead Institute- ICAR-IINR&G, Ranchi

- **Harvest and post-harvest processing and value addition of natural resins, gums and gum resins**

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

Inter Institutional Project: Lead Institute: ICAR-IGFRI, Jhansi

- **Evaluation of aonla based horti-pasture system under different soil & water conservation practices in Central India**

  (Sunil Kumar, Ramesh Singh, Sunil Tiwari & A K Shukla)

CONCLUDED PROJECTS

- **AF 02.12: Effect of irrigation on performance of aonla under agroforestry systems**

  (R K Tewari, & Ramesh Singh)

- **AF 01.25: Development of soil quality index for assessing soil health of different agroforestry systems**

  (Rajendra Prasad, Ram Newaj & Ramesh Singh)

- **Observational Trial: Development of bamboo based agroforestry systems**

  (Inder Dev & K B Sridhar)

- **Observational Trial: Weed dynamics studies in different agroforestry systems**

  (Inder Dev)

8. PUBLICATIONS

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(C) Popular Articles

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9. IMPORTANT MEETINGS / ACTIVITIES

ICAR Industry Day and Agricultural Education Day

ICAR Industry Day and Agricultural Education Day were organized on 28th February, 2015. On this occasion, awareness programme on "Protection of Plant Varieties and Farmers Rights Act" was organized. The purpose of programme was to bring awareness about activities of PPVFRA to the notice of breeders, development workers, farming communities, tribal communities in and around the area of domain of SAUs and ICAR institutions.

Lectures on Agricultural Education Scenario in India and status of agri-based industries in Jhansi were delivered. CAFRI, Jhansi can contribute for 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, NGOs and Societies. Students were taken to laboratory and farm visit. Almost 100 participants including sixty students along with faculty member from different Colleges, SRFs, RAs, M.Sc. dissertation students and Ph.D. Scholars participated in the function.

National Agroforestry Day

"National Agroforestry Day" was celebrated on 8th May, 2014 at ICAR-CAFRI, Jhansi. On this occasion, Van Mahotsava was organized by the staff members in the Institute campus by the planting of various tree species.

SAARC Regional Expert Consultation Workshop

A three days SAARC Regional Expert Consultation Workshop on "Technological

Advancement in Agroforestry Systems: Strategy for Climate Smart Agriculture Technologies" in SAARC Countries was organized during 16th -18th June, 2015. The workshop was organized by SAARC Agriculture Centre, Dhaka, SAARC, Forestry Centre, Thimpu and ICAR- CAFRI, Jhansi. The objective of the workshop was to document the innovative agroforestry practices under the influence of changes (climate, socio-economic, governance) in SAARC countries; to assess the productive and environmental functions of trees in agriculture landscape and its contribution to food security and poverty alleviation and to identify emerging issues and propose strategies to develop agroforestry.

Institute Research Council

Institute Research Council (IRC) meeting was held on 26th -27th & 30th June, 2015. All the Scientists of the Institute participated in the meeting and presented the progress and significant findings of their projects. Five new projects were approved in the IRC-2015.

National Workshop on "TBOs: Way Ahead"

A two-days' National Workshop on "TBOs: Way Ahead" was jointly organized by ICAR-Central Agroforestry Research Institute (ICAR-CAFRI), Jhansi, and Department of Agriculture Cooperation & Farmers' Welfare (DAC&FW), Ministry of Agriculture, Cooperation & Farmers' Welfare, Government of India at ICAR-CAFRI Jhansi during 15th -16th October, 2015. The objective of the workshop was to promote the tree borne oilseed production to increase the oil productivity in the country, creating increasing awareness to the state departments about the TBOs and, also, to know the constraints and challenges faced in the research and development of tree borne oilseeds. 102 members including official representation of state departments from six different states *viz*., Rajasthan, U.P., Tamil Nadu, Mizoram, Madhya Pradesh, Uttarakhand and Maharashtra participated in the two days' National Workshop. In the interaction session of the participants, issues such as non-availability of quality planting material in required quantities, lack of storage facilities, lack of assured market, utilization of bunds for TBOs plantation, lack of standard package of practices, inadequate collection and processing centers and necessity for involvement of community plantation in TBOs were brought out.

SAARC Regional Training on Smart Practices for Climate Resilient Agriculture

SAARC Regional Training on "Smart Practices for Climate Resilient Agriculture" was jointly organized by ICAR-CAFRI, Jhansi, NRM Division, New Delhi; SAARC

Agriculture Centre, Dhaka; SAARC Forestry Centre, Thimpu and International Food Policy Research Institute, South Asia Office, New Delhi during 16th to 20th November, 2015 at National Agricultural Science Complex, New Delhi. The training focussed on capacity building on Climate Smart Resilient Agriculture Technologies in SAARC countries. Delegates from Bangladesh, Bhutan, India, Nepal, Maldives, Pakistan, Sri Lanka, and Cambodia participated in this training programme.

World Soil Day and Farm Innovators Day

A function was organized on 5th December, 2015 at the Institute to mark the International Year of Soils-2015 and celebrate the World Soil Day along with Farm Innovators Day. The hon' ble Member of Legislative Assembly, Uttar Pradesh Shri Ravi Sharma, Sadar, Jhansi graced the occasion as chief guest. About 100 farmers from nearby selected villages attended the function and of these 44 selected farmers received the soil health cards from the Chief

Guest and rest distributed afterwards. While distributing soil health cards to the farmers, the chief guest emphasized on soil health by saying "Swasth Dhara, Khet Hara".

Republic Day and Independence Day

Republic Day (26th January, 2015) and Independence Day (15th August, 2015), respectively were celebrated at ICAR-CAFRI, Jhansi. Flag hoisting ceremony was observed on both the occasions. Cultural programmes and sport events were organized for the staff along with their family members on the occasions.

10. PARTICIPATION IN WORKSHOP/COORDINATION/ MEETINGS/SYMPOSIA

Event	Duration	Venue	Participants
Standing Technical Committee Meeting for NMSA	09th January, 2015	Krishi Bhawan, New Delhi	Dr. S K Dhyani
Workshop on "Quality Planting Material Production & Supply System"	16th & 17th January, 2015	RVSKVV, Gwalior (M P)	Dr. S K Dhyani, Dr. R K Tewari, Dr. A K Handa & Dr. S Vimala Devi
Interactive Meeting in Connection with Indo-French Workshop	04th February, 2015	New Delhi	Dr. S K Dhyani
5th International Conference on "Climate Change & Sustainable Management of Natural Resources"	9th-11th February, 2015	ITM Universe, Sithouli, Gwalior (M P)	Dr. Badre Alam
National Symposium on Agroforestry	13th & 14th February, 2015	GBPUA&T, Pantnagar (Uttrakhand)	Dr. S K Dhyani
Workshop of the Nodal Officers (HRD) for "Training Needs Analysis"	26th February, 2015	NAARM, Hyderabad (A P)	Dr. Badre Alam
Indo-French Workshop on Scientific Cooperation for Agricultural Research	9th - 11th March, 2015	NASC Complex, New Delhi	Dr. S K Dhyani, Dr. Inder Dev, Dr. K B Sridhar, Dr. Asha Ram, Sh. S B Chavan & Sh. A R Uthappa
Meeting with DDG (ICRAF) regarding ICAR-ICRAF work plan	12th March, 2015	New Delhi	Dr. S K Dhyani
Launch Workshop of Task Force-6 on Himalayan Agriculture under the National Mission on Sustaining Himalayan Ecosystems	13th May, 2015	NASC Complex, New Delhi	Dr. S K Dhyani & Dr. Inder Dev
Workshop on National Mission on Sustaining Himalayan Ecosystem (NMSHE) for lower Himalayas	04th June, 2015	Directorate of Cold Water Fisheries, Bhimtal (U K)	Dr. Mahendra Singh & Sh. A R Uthappa
Lecture delivered in Workshop of "Jal Krainti Abhiyan" Organized by Ministry of Water Resources, River Development & Ganga Rejuvenation (MOWER, R D & G R), Govt. of India, New Delhi	5 June, 2015	Bundelkhand University, Jhansi (U P)	Dr. Ramesh Singh
Delivered talk on "Cost –effective Checkdam and maintenance of Rainwater harvesting Structure"	10th & 11th June, 2015	Vikas Bhavan, Jhansi (U P)	Dr. Ramesh Singh

Event	Duration	Venue	Participants
Lecture delivered on "Agroforestry Country Report India"	16th - 18th June, 2015	SAARC Regional Expert Consultation Workshop, ICAR-CAFRI, Jhansi (UP)	Dr. A K Handa
Lecture delivered on "Agroforestry Interventions in Watershed Management in Semi-Arid Region of Central India"			Dr. Ramesh Singh
Refresher course on Agriculture Research Management	13th - 25th July, 2015	NAARM, Hyderabad (A P)	Dr. Mahendra Singh
Annual Workshop of All India Coordinated Research Project on Agroforestry	25th - 27th July, 2015	SKUAST(K), Srinagar (J & K)	Dr. R K Tewari, Dr. Sudhir Kumar, Dr. R P Dwivedi, Dr. Inder Dev, Dr. K B Sridhar, Dr. Asha Ram, Sh. S B Chavan & Sh. A R Utthappa
Workshop on KRISHI Portal	4th - 5th August, 2015	NASC, New Delhi	Dr. Asha Ram
4th NICRA Review Meeting	12th - 14th August, 2015	Central Marine Fisheries Institute, Cochin	Dr. Ram Newaj, Dr. R H Rizvi & Sh. S B Chavan
Lecture delivered in training programme for District Technical Resource Team (DTRT) of Jhansi, Lalitpur and Jalaun districts under MANREGA Scheme	19th August, 2015	Vikas Bhawan, Jhansi (UP)	Dr. Ramesh Singh
International Training Programme on "Conservation Agriculture: (CA): Developing Resilient Systems"	2nd - 11th September, 2015	CSSRI, Karnal (Haryana)	Dr. Inder Dev
Regional Consultation on "Agroforestry: the Way Forward"	8th -10th October, 2015	NASC Complex, New Delhi	Dr. R K Tewari, Dr. A K Handa, Dr. Inder Dev, Dr. Ramesh Singh & Dr. Asha Ram
25th Asian Pacific Weed Science Society Conference on Weed Science for Sustainable Agriculture, Environment and Biodiversity	13th - 16th October, 2015	Hyderabad (A P).	Dr. Inder Dev
National Workshop on "TBOs: Way Ahead"	15th - 16th October, 2015	ICAR-CAFRI, Jhansi (U P)	Dr. Sudhir Kumar, Dr. Badre Alam & Dr. Dhiraj Kumar
Inter-Ministerial Committee Meeting for implementation of National Agroforestry Policy	2nd November, 2015	Krishi Bhawan, New Delhi	Dr. A K Handa
One day Workshop on Hindi Rajbhasha	7th November, 2015	NASC Complex, New Delhi	Dr. Asha Ram

Event	Duration	Venue	Participants
Delivered invited lecture on "Carbon sequestration and agroforestry practices"	17th November, 2015	SAARC Regional Training, NASC, New Delhi	Dr. A K Handa
Delivered a lecture on "Use of GIS & Remote Sensing for Agroforestry R&D"	20th November, 2015	SAARC Regional Training, NASC, New Delhi	Dr. R H Rizvi
Delivered a lecture on "Rainwater Harvesting and Watershed Management for Climate Resilient Agriculture			Dr. Ramesh Singh
Delivered invited lecture on "National Agroforestry Policy and Current Status of Agroforestry R & D in India"	16th November, 2015	AMITY University, Noida (U P)	Dr. A K Handa
XXII International Grassland Congress	21st - 24th November, 2015	New Delhi	Dr. Sudhir Kumar, Dr. R P Dwivedi, Dr. Inder Dev, Dr. S Vimala Devi, Dr. Ramesh Singh, Dr. Mahendra Singh, Dr. Asha Ram, Sh. S B Chavan & Sh. A R Uthappa
Delivered a lecture on "Carbon sequestration potential Carbon Sequestration and Agroforestry Practices of various forest trees"	30th November, 2015	Winter School, SHIATS, Allahabad (UP)	Dr. R H Rizvi
Delivered a lecture on "National Resource Management through Integrated Watershed Development Interventions in Semi- Arid Region of Central India"			Dr. Ramesh Singh

11. TRAININGS AND CAPACITY BUILDING

a. Participation in Trainings

Event	Duration	Venue	Participants
Winter School on "Livestock based Integrated Farming Systems for Enhancing Resource use Efficiency and Improving Livelihood of Small and Marginal Farmers"	28th January-17th February 2015	ICAR-IGFRI, Jhansi (U P)	Dr. Asha Ram
Training on "Role of Scientists in Natural Resource and Environment Management"	16th - 20th February, 2015	IIFM, Bhopal (M P)	Dr. R K Tewari & Dr. K B Sridhar
MID Infrared Spectroscopy Training	9th - 13th March, 2015	ICAR-IISS, Bhopal (M P)	Dr. Asha Ram
Training cum Workshop on Right to Information Act, 2005 for Central Public Information Officers	27th - 28th April, 2015	ISTM, New Delhi	Dr. Sudhir Kumar
Three months' attachment training on "Estimation of Some Soil Properties through Alpha- MIR Spectroscopy"	11th May - 10th August, 2015	ICAR-IISS, Bhopal (M P)	Dr. Dhiraj Kumar
Refresher Course on Agriculture Research Management	13th - 25th July, 2015	NAARM, Hyderabad (A P)	Dr. Mahendra Singh
Training on "Hyperspectral Remote Sensing"	27th - 31st July, 2015	National Remote Sensing Centre, Hyderabad (A P)	Dr. R H Rizvi
Summer School on "Conservation agriculture for Enhancing Resource use Efficiency and Arresting Land Degradation"	19th August - 8th September, 2015	ICAR RC NEH, Umiam	Sh. A R Uthappa
International Training Programme on "Conservation Agriculture: (CA): Developing Resilient Systems"	2nd - 11th September, 2015	ICAR-CSSRI, Karnal (Haryana)	Dr. Inder Dev
Training on "Gender Sensitization and Training Workshop: Concepts and Tools for Gender Analysis"	12th - 13th October, 2015	ICRAF, New Delhi	Dr. R P Dwivedi
SAARC Regional Training programme on "Smart Practices for Climate Resilient Agriculture"	16th - 20th November, 2015	NASC complex, New Delhi	Dr. Asha Ram & Dr. Dhiraj Kumar

Event	Duration	Venue	Participants
IUFRO-SPDC Training workshop "Systematic Review in Forest Science"	17th - 19th November, 2015	Forest Research Institute of Malaysia (FRIM), Selangor, Malaysia	Dr. K B Sridhar
Training on p- XRP Spectroscopy	14th - 17th December, 2015	ICAR-IISS, Bhopal (M P)	Dr. Dhiraj Kumar
Training on Application of Computer Algorithms and Statistical Software	18th December, 2015 – 7th January, 2016	ICAR – IASRI, New Delhi	Dr. S Vimala Devi

b. Trainings organized for Various Categories of Employees

Event	Duration	Venue	Participants
Scientific			
SAARC Regional Training programme on "Smart Practices for Climate Resilient Agriculture"	16th - 20th November, 2015	NASC complex, New Delhi	Dr. Asha Ram & Dr. Dhiraj Kumar

c. HRD funds Allocation and Utilization

(₹ in Lakh)

Year	Allocation	Utilization
2015-2016	1.60	1.60

12. राजभाषा गतिविधियाँ

हिन्दी पखवाड़ा

दिनाँक 14 सितम्बर, 2015 को निदेशक (कार्यवाहक) की अध्यक्षता में हिन्दी पखवाड़ा (14-28 सितम्बर, 2015) का शुभारम्भ किया गया। हिन्दी पखवाड़ा की शुरूआत आई. सी.ए.आर. कुलगीत से हुई। प्रभारी अधिकारी, राजभाषा ने हिन्दी पखवाड़े की रूप-रेखा एवं कार्यक्रमों की विस्तारपूर्वक जानकारी प्रस्तुत की। कार्यक्रम में मानूनीय कृषि मंत्री, भारत सरकार का हिन्दी दिवस पर संदेश तथा भारतीय कृषि अनुसंधान परिषद, के महानिदेशक महोदय की अपील पढ़कर सभी को उनके बहुमूल्य विचारों से अवगत कराया। कार्यक्रम की अध्यक्षता करते हुए निदेशक ने अपने उद्‌बोधन में कहा कि भारत सरकार के गजट में इस संस्थान का नाम "क" क्षेत्र में है, इसलिए सभी को अपना प्रशासनिक कार्य शत-प्रतिशत हिन्दी में करना है। निदेशक (कार्यवाहक) ने सभी वैज्ञानिकों एवं अधिकारियों से अपील की कि हिन्दी में अधिक से अधिक पुस्तकें, तकनीकी बुलेटिनों तथा प्रसार बुलेटिनों का प्रकाशन किया जाए जिससे किसान भाई अनुसंधान को पढ़कर उसका भरपूर लाभ उठा सकें। उन्होनें समस्त वैज्ञानिकों, अधिकारियों से अपील की कि हिन्दी में पत्राचार को बढ़ाने में अपना सहयोग प्रदान करें जिससे राजभाषा विभाग द्वारा दिये गये लक्ष्यों को पूरा किया जा सके।

संस्थान में हिन्दी पखवाड़े के दौरान हिन्दी को बढ़ावा देने के लिए विभिन्न प्रतियोगिताओं का आयोजन किया गया। प्रतियोगिताओं को सफल बनाने हेतु निदेशक महोदय द्वारा प्रत्येक प्रतियोगिता के लिए अलग-अलग निर्णायक मण्डल का गठन किया गया था। प्रतिभागियों को प्रोत्साहित करने हेतु प्रत्येक प्रतियोगिता के लिए प्रथम, द्वितीय एवं तृतीय पुरस्कारों का भी प्रावधान रखा गया था। इसके साथ ही साथ सरकारी कामकाज में राजभाषा को बढ़ावा देने हेतु प्रशासनिक अधिकारियों एवं कर्मचारियों के लिये पिछले एक साल के कार्यकाल में 20,000 या उससे अधिक शब्द हिन्दी में लिखनें के लिये प्रथम, द्वितीय तथा तृतीय पुरस्कार रखे गये थे।

दिनाँक 28-09-2015 को हिन्दी सप्ताह का समापन प्रभारी निदेशक की अध्यक्षता में सम्पन्न हुआ। इस अवसर पर मुख्य अतिथि महोदय द्वारा प्रतियोगिता में विजयी प्रतिभागियों को पुरस्कार वितरित किये गये। कार्यक्रम में वार्षिक राजभाषा पत्रिका "कृषिवानिकी आलोक-2015" नवम् अंक का विमोचन भी मुख्य अतिथि महोदय द्वारा किया गया। मुख्य अतिथि ने राजभाषा अधिनियम 1963 की धारा 3 (3) एवं राजभाषा नियमों, 1976 का उल्लेख करते हुए सभी से अपने दैनिक कार्यों में इसकी अनुपालना करने की अपील की।

हिन्दी कार्यशालायें

संस्थान पर वर्ष 2015 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 2015 के दौरान आयोजित कार्यशालाओं का विवरण निम्नवत है :

दिनांक	विषय	वक्ता
20 मार्च, 2015	"कंरज के पेड़ की जैव ईधन के रूप में उपयोगिता	श्री विशाल, वरिष्ठ शोध अध्येता
12 जून, 2015	गुणवत्ता युक्त पौध की उपलब्धता सुनिश्चित कराना	डॉ. रमाकान्त तिवारी, प्रधान वैज्ञानिक
14 सितम्बर, 2015	विज्ञान एवं मानव जीवन	डा. राजेन्द्र प्रसाद, प्रधान वैज्ञानिक
19 दिसम्बर, 2015	जलवायु परिवर्तन एवं कृषि : अतीत, वर्तमान एवं भविष्य	डा. राजेन्द्र प्रसाद, प्रधान वैज्ञानिक

राजभाषा कार्यान्वयन समिति की बैठकें

संस्थान में वर्ष 2015 के दौरान राजभाषा कार्यान्वयन समिति की कुल चार बैठकें सम्पन्न हुई जिसमें सरकारी कामकाज में राजभाषा को बढ़ावा देने हेतु 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 टिप्पणीयां हिन्दी में लिखने के लिए अपील की गयी।

13. WOMEN IN AGRICULTURE

As per the ICAR guidelines, ICAR-CAFRI continued to emphasize on harnessing women power in agriculture to encourage gender equity. Even at the Institute, regular meetings of Women Cell were 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 the Domagor Pahuj watershed total 26 women self-help groups (WSHGs) were formed and their accounts were opened in the bank. The interactive session on WSHGs was held in which women groups shared their practical experiences in various fields e.g. SHG & bank linkages, role of federation, improved animal husbandry, other IGAs etc. They also exposed their experiences and views in several socio-economic aspects e.g. social problems they faced often, savings and bank related issues, health and sanitation issues, problems of lack of knowledge & access to govt. schemes & policies, deficit of livelihood opportunities etc.

Two days exposure visit to ICAR-CIRG, Makhdoom, Mathura was organized for women SHGs during 30th-31st January, 2015 to learn about goat rearing practices. The Exposure visit made women learn various stall feeding techniques, disease of goat and its prevention and breed selection.

In Parasai-Sindh watershed, 16% households have guava homestead agroforestry due to active participation and attitude of women. Women were also helping in dairying through fodder management.

Exposure visit of WSHGs to ICAR-CIRG, Makhdoom, Mathura, U. P.

Homestead agroforestry and fodder management at Parasai-Sindh watershed

14. DISTINGUISH VISITORS

- Dr. A K Sikka, DDG (NRM), ICAR, New Delhi.
- Dr. Arvind Kumar, Vice Chancellar, RLB CAU, Jhansi (U. P.).
- Dr. A K Singh, Vice Chancellor, RVSKV, Gwalior (M. P.).
- Dr. Shaikh Mohammad Bokhtiar, Director, SAC, SAARC, Dhaka (Bangladesh).
- Mr. Sangay, Director, SFC, SAARC, Thimpu (Bhutan).
- Dr. S K Dhyani, NRM Division, ICAR, New Delhi.
- Dr. Javed Rizvi, Regional Director, South Asia Progarmme, ICRAF, New Delhi.
- Dr. P K Ghosh, Director, ICAR-IGFRI, Jhansi (U. P.).
- Sh. Ravi Sharma, Hon'ble MLA Sadar, Jhansi (U. P.).
- Dr. Rajendra Choudhary, Sr. Liaison & Monitoring Officer, South Asia Programme, ICRAF, New Delhi.
- Sh. B N Navlawala, Chief Advisor, Water Resources, River Development and Ganga Conservation Ministry, Govt. of India, New Delhi.
- Dr. Tayan Raj Gurung, Senior Program Specialist (NRM), SAC, Dhaka.
- Mr. Karma Jigme Themphel, Participatory Forest Management Specialist, SFC, Thimpu.
- Dr. Anupam Barik, Addl. Commissioner, DAC & FW, New Delhi.
- Sh. A B Pandya, Chairman, Central Water Commission, New Delhi.
- Dr. Jitendra Chauhan, Scientific advisor of Hon'ble Union Minister of Agriculture, New Delhi.
- Sh. Satyapal Singh Verma (Progressive Farmer), Sharanpur (U.P.)

15. PERSONNEL

Dr. O P Chaturvedi, Director

Scientific

1. Dr. Anil Kumar, Pr. Scientist (Plant Pathology)
2. Dr. R K Tewari, Pr. Scientist (Horticulture/ Fruit Science)
3. Dr. Ram Newaj, Pr. Scientist (Agronomy)
4. Dr. Rajendra Prasad, Pr. Scientist (Soil Science)
5. Dr. Sudhir Kumar, Pr. Scientist (Horticulture/ Fruit Science)
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 (SWC Engs.)
11. Dr. R H Rizvi, Sr. Scientist (Computer Application)
12. Dr. S Vimala Devi, Sr. Scientist (Genetics & Plant Breeding)
13. Dr. Mahendra Singh, Sr. Scientist (Agriculture Economics)
14. Dr. Naresh Kumar, Sr. Scientist (Agroforestry)
15. Dr. K B Sridhar, Scientist (Forestry)
16. Sh. K Rajarajan, Scientist (Genetics & Plant Breeding) (on Study Leave)
17. Sh. S B Chavan, Scientist (Forestry) (on Study Leave)
18. Dr. Asha Ram, Scientist (Agronomy)
19. Sh. A R Uthappa, Scientist (Forestry)
20. Dr. Dhiraj Kumar, Scientist (Soil Science)
21. Dr. Veeresh Kumar, Scientist (Entomology)

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. Sh. Rajesh Srivastava, Sr. Technical Officer (Art & Photo)
8. Sh. R K Singh, Sr. Technical Officer
9. Sh. S P Singh, Sr. Technical Officer
10. Sh. Prabhu Dayal, Technical Officer
11. Sh. Ram Bahadur, Technical Officer
12. Sh. Ajay Kumar Pandey, Sr. Technical Assistant
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

Administration

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, Private 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

16. MISCELLANEOUS

New Staff Members Joined

- Dr. Naresh Kumar, Sr. Scientist (Agroforestry)
- Dr. Dhiraj Kumar Scientist (Soil Science)
- Dr. Veeresh Kumar, Scientist (Entomology)
- Sh. Ajay Kumar Pandey, Sr. Tech. Assistant

ICAR Inter Zonal Sports Meet at ICAR-NDRI, Karnal

Mr. Rajesh Srivastava (Sr. T.O.) and Mr. Attar Singh (SSS) from ICAR-CAFRI participated in ICAR Inter Zonal Sports Meet held during 11th -14th March, 2015 at ICAR-NDRI Karnal. Mr. Rajesh Srivastava won the ICAR Championship in chess and Mr. Attar Singh got 3rd position in cycle race.

Promotion

- Dr. A Datta, ACTO promoted to the grade of CTO w. e. f. 30th December, 2013.
- Sh. K P Sharma, Assistant promoted to the post of AAO w. e. f. 6th February, 2015.
- Sh. S P Singh, Tech. Officer promoted to Sr. Technical Officer w. e. f. 21st March, 2015.

Institute Joint Staff Council

New IJSC has been constituted for the period of 01/03/2016 to 28/02/2019.

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 2014-15 of the Institute.

Zonal Sports Meet

A contingent of 19 players from ICAR-CAFRI, Jhansi participated in ICAR Zonal Tournament-2015 held at ICAR-CSWRI, Avikanagar, Rajesthan during 2nd to 6th November, 2015 organized by ICAR- Central Sheep and Wool Research Institute. ICAR-CAFRI secured 2nd position in cycle race (Sh. Attar Singh) and in badminton (Sh. A R Utthappa, Sh. S B Chavan, Dr. Asha Ram and Sh. Birendra Singh).

Transfer

Smt. Uma, Assit. Chief Technical Officer has been transferred to ICAR-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/ Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80

S. No	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target/Criteria Value				
							Excellent	V. Good	Good	Fair	Poor
							100%	90%	80%	70%	60%
*	Administrative 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 updation 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
A.	Agroforestry models/ systems identified /refined/developed	False	False	True	False	False	False
B.	Improved agronomic practices developed for agroforestry systems	True	False	False	False	False	False
C.	Characterization /selection of improved germplasm/ strains	True	False	False	False	False	True
D.	Kisanmela/gosthi /demonstrations	False	False	False	True	False	True
E.	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

Name	Name
Dr. Tej Pratap (Chairman) Former Vice-Chancellor Sher-E-Kashmir University of Agricultural Sciences and Technology of Kashmir **Kashmir (J &K)**	**Dr. J C Dagar** Emeritus Scientist, Central Soil Salinity Research Institute, Zarifa Farm, Kachawa Road, **Karnal (H R)**
Dr. M A Shankar Former Director of Research University of Agricultural Science, GKVK, **Bengaluru (K R)**	**Dr. P Kaushal** Regional Coordinator, National Afforestation and Eco-Development Board, Y. S. Parmar University of Horticulture & Forestry, Nauni, **Solan (H.P.)**
Dr. V K Mishra Ex-Dean, College of Horticulture & Forestry, Mishra Bhawan, Palace Road, **Solan (H.P.)**	**Dr. O P Chaturvedi** Director ICAR- CAFRI, **Jhansi (U.P.)**
Assistant Director General (Agron./AF & CC) NRM Division, Indian Council of Agricultural Research, Krishi Anushandhan Bhawan-II, **New Delhi**	**Dr. Anil Kumar** Pr. Scientist & Member Secretary, ICAR-CAFRI, **Jhansi (U.P.)**

Annexure-III

Institute Management Committee

Name	Name
Dr. O P Chaturvedi (Chairman) Director ICAR-CAFRI, **Jhansi (U. P.)**	**Dr. (Mrs.) S Vimala Devi** Sr. Scientist ICAR-CAFRI, **Jhansi (U. P.)**
Dr. Pankaj Kaushal Head (C I Div.) ICAR-IGFRI, **Jhansi (U. P.)**	**Dr. M J Kaledhokar** Pr. Scientist, NIASM, **Baramati (M. H.)**
Dr. Prem Singh Principal Scientist, IIFSR, **Modipuram (U. P.)**	**Sh. Satyapal Singh Verma** (Progressive Farmer) **Saharanpur (U.P.)**
Assistant Director General (Agron./AF & CC) Indian Council of Agricultural Research, Krishi Anushandhan Bhawan-II, **New Delhi**	**Dr. R C Dhiman,** **General Manager,** R&D Centre, WIMCO Ltd., WIMCO Seedling Division, Kashipur Road, Bagwala, Rudrapur, **US Nagar (Uttrakhand) - 263153**
Wg. Cdr. Pramode Sahney (Retd.), Senior Advisor Development Alternatives, Taragram, Orchha – 472 246, **Distt. Tikamgarh (M. P.)**	**Sh. J L Sharma** H.O. & Member Secretary ICAR- CAFRI, **Jhansi (U. P.)**

Annexure-IV

Institute Joint Staff Council
(01/03/2016 to 28/02/2019)

Chairman : O P Chaturvedi (Director)				
Category	**Staff Side**		**Office Side**	
Technical	Sh. Prabhu Dayal, Technical Officer	Member	Dr. Ram Newaj Pr. Scientist	Member
	Sh. Kashi Ram Driver, Tech. Asstt.	Member	Dr. A K Handa Pr. Scientist	Member
Administration	Sh. Tridev Chaturvedi, Stenographer (Gr.III)	**Secretary**	Dr. R H Rizvi Sr. Scientist	Member
	Sh. Birendra Singh, Assistant	**Member, CJSC**	Sh. Rajendra Singh, ACTO	Member
Supporting	Sh. Attar Singh SSS	Member	Sh. J L Sharma A.O. & H.O.	**Member Secretary**
	Sh. Ram Singh SSS	Member	Sh. S B Sharma AF&AO	Member

Annexure–V

Women Cell

Name	Name
Dr. S Vimala Devi, Sr. Scientist – **Chair Person**	**Smt. Kaushalya Devi**, Jr. Clerk - Member
Km. Shelja Tamrkar, Tech. Assistant - Member	**Smt. Sadhna Pandey**, Sr. Scientist, IGFRI, Jhansi (U. P.) - Member
Sh. Tridev Chaturvedi, Stenographer (Gr.III) IJSC- Secretary	**Sh. J L Sharma**, A.O. & H.O. Member Secretary

Note

Swachh Bharat Abhiyan

स्वच्छ भारत

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