भाकृअनुप
ICAR

कृषिवानिकी
Agroforestry

वार्षिक प्रतिवेदन
ANNUAL REPORT
2012-13



राकृवाअनुके
NRCAF

राष्ट्रीय कृषिवानिकी अनुसंधान केन्द्र, झाँसी
National Research Centre for Agroforestry, Jhansi

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COVER PHOTOGRAPHS

(1) Guava based Agroforestry System; (2) Union Agriculture Minister Hon'ble Sharad Pawar visits NRCAF stall during exhibition in 2nd ASEAN-India Ministerial Meeting on Agriculture & Forestry and Agriculture Expo & Symposium during October, 2012 held at NASC Complex, New Delhi; (3) A Farmer's fair and Innovative farmer's day.

2013

PREFACE

I am happy to present the Annual Report of National Research Centre for Agroforestry, Jhansi for the period 2012-13. The report presents the findings and significant achievements of agroforestry research undertaken through the in-house and external funded projects, network and inter-institutional collaboration, technology demonstrations, capacity building and various other activities during the year.

The Centre continued its research endeavours by strengthening and updating the data collection, analysis, interpretation and reporting the results for all the ongoing projects. In addition it demonstrated agroforestry technologies through watershed programmes, FPARP and a series of sponsored training programmes. The demonstrations clearly indicated that the risk partitioning feature of the agroforestry systems comprising of diversified components encouraged the farmers in their adoption. Implementation of agroforestry based integrated soil and water conservation measures at Garhkundar-Dabar enhanced ET to 62 per cent as compared to 53 per cent in untreated (control) watershed receiving 815 mm annual average rainfall. Reduced runoff (22% vs. 39%) along with increased base flow (4.5% vs. 1.2%) and groundwater recharge (11% vs. 7%) of total rainfall received as compared to untreated watershed. Economic Water productivity and total income increased from ₹ 3.7 to 5.9 m^{-3} and ₹ 17000 to 33000 $ha^{-1}y^{-1}$ within six years, respectively. Moreover the interventions helped in reducing soil loss and nitrogen transport by 50 per cent. Scaling-up of these technologies in drought prone rainfed areas with enabling policy and institutional support would promote equity and livelihood along with strengthening various ecosystem services, while reducing poverty and building resilience in semi-arid tropics. As a replication of the model watershed, two more watershed projects have been initiated in consortium mode in the Bundelkhand region in Jhansi district, Uttar Pradesh to test the agroforestry based integrated technologies in the medium rainfall (700–1100 mm) areas of the country.

During the year 28 trainings for farmers, office bearers of watershed committee, self-help groups, users groups, watershed development team members, field functionaries and BSAs were conducted for IWMP on natural resource management and agroforestry, production system and micro-enterprises, livelihood support activities and accounting. These trainings were organized in response to request from Land Development and Water Resources and Department of Agriculture (PIAs of IWMP), from Jhansi, Lalitpur, Jalaun, Mahoba, Hamirpur and Banda districts of Bundelkhand region. Centre also organized four Field Days under the FPARP programme.

I express my gratitude to Hon'ble Dr. S Ayyappan, Secretary, DARE and Director General, ICAR, New Delhi and Dr. A K Singh, Ex. DDG (NRM) as well as present Dr. A K Sikka, DDG (NRM), ICAR, New Delhi for their constant guidance, encouragement and support. My appreciation is also due to Dr. J C Dagar, Ex. ADG (Agronomy/AF) & Dr. B Mohan Kumar, ADG (Agronomy/AF), ICAR, New Delhi for cooperation and support. The help of the PME Cell and Editorial Committee in compiling and timely publication of the report is highly appreciated. I am thankful to Director, IGFRI, Jhansi for sharing the infrastructure from time to time.

(SK Dhyani)

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EXECUTIVE SUMMARY

NRCAF was established during 1988 to initiate organized research in Agroforestry. Since last 25 years interdisciplinary research efforts are in progress to meet the needs of farmers, farmwomen and other stakeholders. Executive summary of continuing projects is given below.

- The studies continued during the year on growth parameters of coppice shoots of four different clones of Eucalyptus namely C-3, C-6, C-7 and C-10. The monthly increments in dbh ranged from 0.246 to 0.584 cm. The dbh increment in summer varied from 0.275 to 0.584 cm, whereas in winter season it ranged from 0.246 to 0.568 cm. The variations in rainy season increments were almost constant with values ranging from 0.418 to 0.475 cm. Growth performance of black gram crop was better under wider row spacing as compared to closer row spacing, while the tree geometry was same.
- In aonla based agroforestry system grain yield of wheat (var. WH147) reduced by 19.2 to 26.2% while straw yield by 21.4 to 27.6% under different treatments. Sole wheat crop recorded 3.86 t ha^{-1} yield, while yield under rainfed aonla treatment was 3.12 t ha^{-1}.Wheat crop in treatment of aonla irrigated in summer recorded 2.85 t ha^{-1} grain yield. Reduction in crop yield under agrihorticulture system is obviously due to competition for nutrients and moisture.
- *Albizia procera* was pruned (25, 50 and 75%) as per treatments (2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} year pruning initiation plots) during December. By and large most of the growth parameters of the tree and pasture components were not affected significantly due to age of pruning initiation and its intensity, however canopy spread was significantly affected by initiation of pruning. Initiation of pruning, intensity of pruning and their interaction affected the fuelwood biomass production significantly. Total fodder and total biomass production were significantly affected by intensity of pruning.
- Performance of *Ailanthus excelsa* and *Grewia optiva* in Rakar soil showed that average height, and dbh of *Ailanthus* were 5.02 m and 31.37 cm, respectively and for *Grewia optiva* were 4.76 m and 23.87 cm. Biomass produced from under storey *Stylo* was 4.49 D.W t ha^{-1} (*Ailanthus excelsa*) and 4.82 D.W t ha^{-1} (*Grewia optiva*).
- The mature culms of *Dendrocalamus strictus*, *Bambosa vulgaris* were harvested during Nov./December. In total 4532 (*D. strictus*) and 1166 (*B. vulgaris*) mature culms were harvested from a total of 5163 (*D. strictus*) and 1495 (*B. vulgaris*) clumps. Average culms/clump, internodes/culm, internodal length and dbh were observed to be 32, 10.5, 19.14 cm and 3.75 cm (*D. strictus*) and 20, 14.9, 24.6 cm and 4.66 cm (*B. vulgaris*), respectively. Height gained ranged from 2.04 to 3.24 m (*D. strictus*) and 2.64 to 5.64 m (*B. vulgaris*), while fresh weight gained by individual culm varied from 1-3 kg $culm^{-1}$ (*D. strictus*) and 3-8 kg $culm^{-1}$ (*B. vulgaris*) in different classes. Total yield of 17.29 t (*D. strictus*) and 8.3 t (*B. vulgaris*) on fresh weight basis was obtained from an area of 1.3 ha and 0.8 ha, respectively.

- Comparative studies under varying regimes of shade and without shade confirmed that more than 33% shade of incident light would be highly detrimental to the crops. Several physiological and biochemical characteristics studied in pea (*Pisum sativum*) have differentially responded with increasing the intensity of shade. Maximum reduction in yield in comparison to open was noted in 75% shade followed by 50 and 33% shade. Effects of varying shade on photosynthetic and photochemical efficiency traits have also been conducted on pea plants. During *kharif* season, although, germination of pigeon pea (*Cajanus cajan*) was successful across all the three regimes of shade, subsequently the untimely excess rain severely affected the crop phenology and performance of the crops and it matured very late for harvesting.
- Effect of AM inoculants on growth, yield, phosphorus uptake and arbuscular colonization index of three popular varieties of wheat (Kathiya, LOK-1 and WH- 147) in two common soil types (red and black) showed that all AM inoculants significantly increased shoot length, dry shoot weight, dry root weight, number of ears per plant, thousand seed weight and yield per plant. Number of tillers per plant was increased by five inoculants (*A. mellea, G. aggregatum, G. cerebriforme, G. diaphanum, G. etunicatum, G. fasciculatum*). Shoot length, dry shoot weight, dry root weight and thousand seed weight were significantly more in red soil as compared to black soil.
- Soil quality indicators *viz.* porosity, water holding capacity (WHC), available P, cation exchange capacity (CEC) and potential nitrogen mineralization (PNM) of soil from 22 years old *E. officinalis* based AF system had brought improvement in soil health in comparison to normal planting, soil moisture conservation (SMC) techniques (stone mulch, deep basin and deep basin+ ploughing). Soil health indicator values were more in surface soil than sub-surface soil layers. The PNM was directly related to C/N ratio of soil and it decreased with increase in C/N ratio. In 20 years old *H. binata* based AF systems (black soil), tree density of 400 tree ha^{-1} had shown highest values of soil quality indicators while the least by control (pure crop). Increasing tree density from 200 to 400 tree ha^{-1} had improved value of soil quality indicators and further increase in tree density upto 800 tree ha^{-1} did not yield any additional influence. Similarly, in 18 years *H. binata* based AF system (red soil) involving four levels of pruning *viz.* control, 25, 50 and 75% canopy pruning indicated that soil quality indicators values were more in surface than sub-surface soil layers. Highest soil quality indicator values were observed in 50% pruning. Physical, chemical and biological characteristics of six other ongoing agroforestry trials had more B.D., SOC and dehydrogenase activity indicating in comparison to open field indicating beneficial effects on soil health.
- A total of 24 published equations on stem volume of *Eucalyptus* spp. could be traced for the states of Uttar Pradesh, Uttarakhand, Rajasthan, Punjab, Bihar and Tamilnadu. These equations pertain to Jhansi, Ranchi, Dehradun, Pantnagar, Jodhpur, Ludhiana, Firozpur, Patiala, Ranchi and Nillgiris Hill. The simulated data points (dbh and Stem Volume) for these equations were clubbed into one data set for country level as a whole and

allometric equation (Stem Volume=A*(dbh)^{B} was fitted on this country level data set. The equation Stem Volume = 0.00060*(dbh)$^{2.07699}$ with (R^2=0.86981) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbh values. This equation can be used to predict the stem volume for the dbh range of 2 to 52 cm at country level. A total of eight published equations on AGB (above ground biomass) could be traced for the states of Uttar Pradesh, Uttarakhand, Bihar, Tamilnadu and some raw data pertaining to Haryana and Karnataka. These equations pertain to Jhansi, Samastipur, Dehradun, Pantnagar and Nillgiris Hill. The simulated data points (dbh and above ground biomass) for these equations were clubbed into one data set for country level as a whole and allometric equation (AGB=A*(dbh)^{B} was fitted on this country level data set. The equation AGB=0.74*(dbh)$^{1.81}$ with (R^2=0.91) is proposed to be used for predicting the Above Ground Biomass of the standing tree on the basis of their observed dbh values. This equation can be used to predict the AGB for the dbh range of 1 to 42 cm at country level.

- During second year of the NICRA project major focus was to assess carbon sequestration potential of agroforestry practices adopted by the farmers in Bulandsahar, Gorakhpur (Uttar Pradesh), Mandi (Himachal Pradesh) and Faridkot and Nawashahar (Punjab), mapping agroforestry area in Punjab using remote sensing and GIS technique and to study thermo-tolerance of crops and MPTs for agroforestry importance under Temperature Gradient Tunnel. Agroforestry area in Punjab was estimated to be 272504.51 ha, which is 5.44 % of total geographic area (5004912.21ha). Area under agroforestry was highest in Bhatinda district (7.02 %) and lowest in Fatehgarh Saheb district (2.97 %). The total carbon stock in baseline varied from 13.76 to 41.62 t C ha^{-1} in the districts Bulandshar, Gorakhpur (U.P.), Mandi (H.P.), Faridkot and Nawashahar (Punjab). It is also projected that after 30-years, the total carbon stock would be 17.37 to 69.98 t C ha^{-1} in these districts. A collective effect of elevated temperature was found on per plant yield, which indicated that the grain yield of black gram under ambient (open) condition was higher than yield achieved under TGT. However, the grain yield of crop was higher in sector -1 and decreased with increasing in temperature with 1^{0}C in sector 2, 3, 4 and 5. In case of til, the grain yield was higher under TGT than ambient condition.
- In Domagor-Pahuj watershed a total 27 women SHG have been formed and 16 of them have started livelihood support activity with financial assistance from revolving fund. Cultivation of barley has spread to 165 ha area by 160 farmers. 30 Farmers from nearby villages purchased barley seed from this watershed. Demonstrations on wheat, micro-nutrients, PSB and vegetables were conducted through convergence by State Department. Thus, convergence has been successfully demonstrated in the watershed.
- Three gully plugs, one field drainage structure, one *haveli* outlet and two check dams have been constructed in the Parasai-Sindh watershed. Additional 14000 m^3 rain water storage capacity has been created in the watershed. Process has been streamlined for procurement of input, record upkeep,

site selection, supervision of construction through watershed committee. Boundary plantation and agri-horticulture system has been developed in the watershed. Seven groundnut varieties were introduced on farmer's field. TAG-37A has shown highest pod yield. Lac insect was introduced to develop alternate source of income. Water availability against check dams constructed in 2011 was observed upto December as against upto September prior to project work.

- Analysis of runoff from treated and untreated watershed showed that soil profile in treated watershed saturated with 700-800 mm rainfall while that of untreated watershed required 1500 mm rainfall for saturation. This indicates that watershed treatments augmented ground water recharge. Out of 112 open dug wells, 90% wells were wet throughout the year with average 3.6 m water column in treated watershed as against 90% dry wells in pre management period.
- Weed dynamics study was initiated during *kharif*, 2012 in the agroforestry systems. *Celosia argentea, Commelina benghalensis, Commelina diffusa, Cyperus rotundus, Digitaria sanguinalis, Physalis minima* were some of the most dominant weeds. Heavy weed infestation coupled with high rainfall during *kharif* season has by and large caused heavy losses to different crops grown under different agroforestry systems. Under wasteland conditions *Ageratum conyzoides, Alternanthera sessilis, Bulbostylis barbata, Commelina benghalensis, Cyperus iria, Dactyloctenium aegyptium, Echinochloa crusgalli, Euphorbia hirta, Parthenium hysterophorus, Physalis minima* were some of the dominant weeds.
- Positive effects towards increasing number of flowers in the inflorescence and fruits were observed subsequent after spraying of differentially responding growth chemicals. Both á-NAA and Gibberellic acid have shown tangible results followed by Salicyclic acid towards increasing the number of female flowers.
- Consistent trend in annual increment of collar diameter and plant height were observed higher in clonal (stem cutting) than seedling plants of *Pongamia pinnata*. Clonal plants maintained better physio-biochemical efficiency than seedling plants in dry hot summer. Better physio-biochemical efficiency in clonal plants has been reflected in its efficiency of early flowering, profuse flowering, and pod yield. Differential rate of CO_2 assimilation ($A_{maxPPFD}$) was higher in clonal plants than seedling plants during stressful dry season. Similarly photochemical efficiency mainly thylakoid electron transport rate was higher in stem cutting than seedling plants. Such trend was also reflected in enzyme activity like peroxidase, nitrate reductase, protein profiling, anthocyanin and total soluble sugar etc.
- *Acacia nilotica* germplasm accessions (33 plus trees planted in 2004 and 2006 & 20 provenance selection) showed that progenies of 10 plus trees (PT 2, 3, 12, 13, 14, 15, 16, 25, 27 & 28) from Sagar, Damoh, Buldhana, Khadwa, Indore, Shajaur, Dabra, Bansi and Balajee, respectively, belonging to Madhya Pradesh and Maharashtra showed superior performance for all the four characters than their population means. Among the Provenance selections, PR 1, 4, 15 and 20 from Sagar, Mandla, Shajapur and Coimbatore showed better

performance by recording the higher than population mean value for all the four characters.

- Growth data of *Acacia nilotica* showed that families 14 and 12 were performing well at the age of 7-years. Trees of family 14 attained maximum height and dbh of 6.98 m and 8.21 cm, respectively. Mean annual increment in height was maximum (0.64 m) for family 12 and in dbh (0.77 cm) for family 14. Significantly high correlations were found between ages 5&6 and 5&7 for height and dbh, indicating that selection at an age of 5 years may be suitable. Mean calorific value and specific gravity of *A. nilotica* wood was estimated to be 4549.9 cal gm^{-1} and 0.615 gm cm^{-3}, respectively.
- A total of 60 individual nucleotide sequences belonging to different gene families responsible for fatty acid biosynthesis in oil rich plants were retrieved from the public domain, NCBI data base. Clustal W-analysis revealed that the conserved regions of the same gene across the plant species were used for primer designing which will be further used in the generating the molecular information in *Pongamia pinnata*.
- In lac based agroforestry system in Bundelkhand region, for Baisakhi crop the settlement of lac insect ranged from 19.8 (GKD WS) to 20.4 no. cm^{-2} (NRCAF site) and lac input: output ratio was recorded as 1:3.6 at NRCAF, 1:2.02 at GKD WS.
- All the 27 accessions (3 years old) of *Jatropha curcas* differed significantly from each other for plant height, collar girth, number of secondary branches, branch length and canopy diameter. Accessions NRCJ-9, 25, 2, 1, 13 and 23 showed their superiority among all the accessions based on fruit and seed yield. Fruit and seed yield had significantly positive correlations ($p>0.01$ and 0.05 levels) with each other.
- Similarly, in another evaluation trial, out of 45 crosses 44 and their 10 parents were evaluated for their growth, fruits and seed yield traits. At the age of 6 years, all the crosses differed significantly from each other for these parameters. Parents differed significantly for canopy diameter and seed yield. Crosses NRCJ 34, 12, 38, 20 & 13 and parents NRCJ 51, 50, 54, 46 & 50 showed their superiority on the basis of seed yield.
- In candidate plus tree progeny trial-I with 23 progenies (seven years old) NRCJ-33 recorded highest seed yield of 460 kg $plant^{-1}$. This was followed by NRCJ34 (450g $plant^{-1}$), NRCJ31 (355g $plant^{-1}$), NRCJ42 (328g $plant^{-1}$) and NRCJ49 (325g $plant^{-1}$). In candidate plus tree progeny trial-II with 9 progenies, NRCJ-70 (227.5g $plant^{-1}$) was recorded for highest seed yield per plant at the age of seven years. This was followed by NRCJ68 (225g $plant^{-1}$) & NRCJ64 (225g $plant^{-1}$) and NRCJ65 (210g $plant^{-1}$).
- In candidate plus tree progeny trial-III (seven year old plantation) with 12 progenies, NRCJ-91 was found superior on the basis of morphological traits. In provenance trial-I (seven year old plantation), 18 provenances were evaluated and NRCJ-75 & NRCJ79 were recorded for high seed yield per plant. In candidate plus tree progeny trial (six year old plantation), 85 progenies were evaluated. Progeny of NRCJ-126 recorded highest seed yield (760g). This was followed by NRCJ124, NRCJ127, NRCJ116 and NRCJ159. The National Trial-II (five year old plantation) is

having 17 selected genotypes of 14 different centers. In this trial, maximum seed yield was obtained in Orissa-2 & TNMC8 (150g). This was followed by PDKVNov3 (147.50g) MPJ55 (138.75g), Bawal Sel (135.0gm) and Pant J03103 (133.75g). National Trial-III planted in Aug.2008 is having 18 selected genotypes of 12 different centers. In this trial, maximum seed yield was obtained in NRCJ89 (145g). This was followed by CRJ29 (130g), CALD14 (127.50g), TNMC19, TFRI07, Pant JCP2 & TR4 (125g) and TNMC20 (123m).

- In candidate plus tree progeny trial of Karanja (07 year old plantation) with 18 progenies, a large variation was observed in number of pods between and within genotypes. At the age of seven years 18 genotypes bear pods. High bearing of pods per tree was recorded in NRCP-21 (1616) followed by NRCP-13 (985), NRCP-17 (432) and NRCP-6 (415). Though, maximum number of pods (6654 & 2025) were recorded in NRCP-21 followed by NRCP-7(155 plant^{-1}) and 1565 &1355 in NRCP13 (1565 & 1355 plant^{-1} in two trees). Highly significant trait differences were observed among the 18 accessions for the pod, seed and growth characters.
- In agri-horti-silviculture model, maximum survival was recorded in *Aegle marmelos* and plant height in *Acacia senegal.* In horti-silviculture models *Acacia nilotica* out performed *A senegal* in growth and survival. In newly planted agri-silvi model (NRCAF farm), on an average, *A. senegal* had shown better survival (81%) than *A. nilotica* (77%). On farmers' fields, after 42 months of planting *A. senegal* recorded 78% survival and *A. nilotica* (53%) in GKD watershed. Among horti-cultural species, guava had shown maximum survival (98%), while karonda the least (18%). In terms of plant height *A. senegal* was better than *A. nilotica.* Newly planted *A. senegal* recorded 70 to 96% survival in GKD watershed.
- Standardization of gum tapping techniques from *Butea monosperma* revealed that among four types of cuts *viz.* knotching (control), vertical, slant and horizontal cuts on bark of the stem, maximum gum-butea was obtained by knotching followed by vertical cuts. The slant cuts yielded minimum gum-butea. The trial to assess effect of gum inducer (Ethephon) on yield of gum-butea revealed that yield of gum butea was significantly influenced by application of Ethephon, however, dose did not affect the yield. Maximum gum-butea was obtained when Ethephon was sprayed on tree surface before knotching. The study on effect of fire on yield of gum-butea revealed that yield of gum-butea (g m^{-2}) was higher in trees subjected to accidental fire than the trees not affected by fire. Preliminary results from a separate trial conducted to study effect of lac production on gum yield and *vice versa* revealed that inoculation of lac insect increases gum exudation in butea trees. Trees inoculated with lac insect yielded more gum (76.0 g m^{-2}) than un-inoculated trees. Yield of gum-butea was positively correlated with tree height, basal girth, bole surface area, and bark thickness. However, sugar content in bark was negatively correlated with all tree parameters and gum yield.

1. INTRODUCTION

Agroforestry as a land use practice owe its origin from beginning of human civilization. Trees and other woody perennials invariably were important component of the farming system practices of all agrarian communities world over. In most of the situations these were exploited to meet the subsistence requirement for tree produce such as fuel, fodder, fruit, wood for agricultural implements and household needs etc. However, as the demographic pressure increased and there was greater emphasis on agriculture and industrialization for meeting the growing demand of the society, exploitation of natural resources including vegetation took an alarming proportion. Gradually it was realized that for sustaining agriculture growth and environment protection, there has to be emphasis on natural resource conservation and improvement of vegetation cover. Afforestation, reforestation and planting trees on agriculture landscape were considered as one of the best option to achieve the twin objectives. This led to the concept with a new term of 'agroforestry' in the last quarter of the 20th century. At the same time it was also firmly realized that the concept will not succeed without scientific input. This was how organized research on agroforestry was initiated world over.

In India, the organized research on agroforestry was initiated with launching of an All India Coordinated Research Project on Agroforestry since April, 1983 and transferred to NRCAF in 1997 with empowerment of Director, NRCAF as Coordinator of the programme. At present, AICRPAF is running at 25 SAUs and 11 ICAR Institutes and one ICFRE institute. To further strengthen the agroforestry research and development, National Research Centre for Agroforestry (NRCAF) was established at Jhansi, Uttar Pradesh on 8th May, 1988.Centre research programmes were reoriented under System Research,Natural Resource & Environment Management,Tree Improvement, Post-Harvest & Value Addition and HRD, Technology Transfer & Refinementprogrammesafter detailed discussion from this year.

Vision

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

Mission

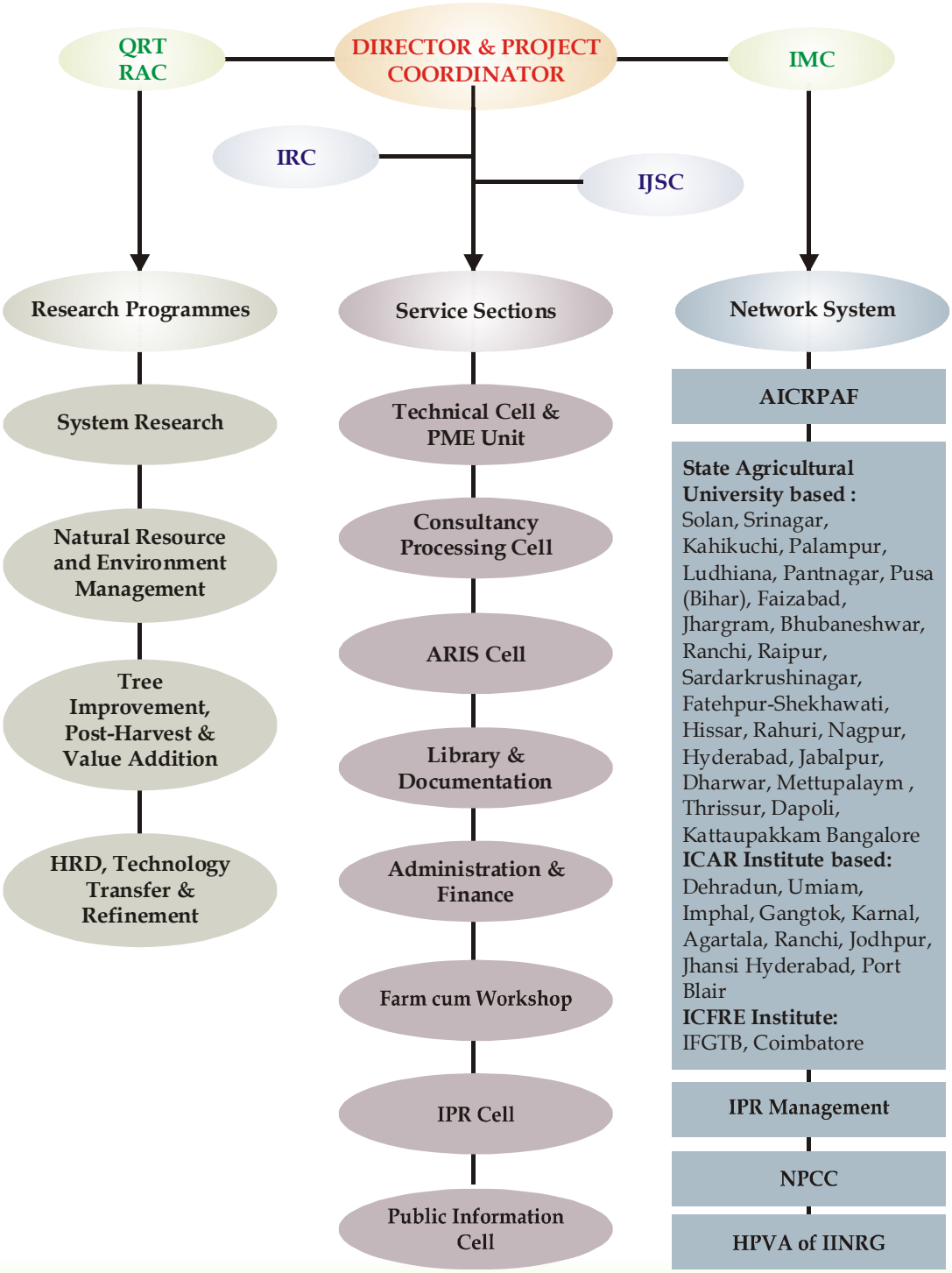
To improve quality of life of rural people through integration of perennials on agriculture landscape for economic, environmental and social benefits.

Mandate

- To undertake basic and applied research for developing and delivering technologies based on sustainable agroforestry practices for farms, marginal land and wastelands in different agroclimatic zones in India.
- To coordinate network research with the State Agricultural Universities/ICAR Institutes/other related research Institutes for identifying technologies which can be transferred from one region to another.
- To provide training in (a) research methodologies and (b) use and application of technologies developed, at various levels.

- To develop technological packages of different agroforestry practices for various agroclimatic zones for transfer to farm, field and wastelands.
- To act as repository of information on the subject.
- To collaborate with relevant national and international agencies for achieving the mandate.
- To provide consultancy.

Organizational Setup of NRCAF



Laboratory, Library and ARIS Cell

Centre has six very well equipped laboratories for all the disciplines as well as GIS and Computers labto take up agroforestry research in India.

Centre's library is well furnished and equipped with LAN facilities. The library has 4179 books including Hindi books, bounded back volumes of research journals (2178) and subscribes 16 Indian Journals. References were supplied to the researchers on individual basis as well as through CERA (Consortium for e-Resources in agriculture).

Centre has well developed Agricultural Research Information Service (ARIS) Cell comprising of computers, server, LAN and Internet facility. The Centre's Web Site *i.e.***www.nrcaf.ernet.in** has been developed and is hosted on the Web server to provide information about the Centre. The websitecontains complete information on its organizational setup, scientific staff, ongoing research projects, research achievements and facilities available in the field of agroforestry. The website is regularly updated with the latest information.

Research Farm

NRCAF research farm possess about 86 ha land. Major area is rocky and degraded land which was gradually developed. About 15%area has been occupied for office infrastructures, residential complex, roads etc. and arable land have been utilized for various agroforestry experiments and block plantations and crop cultivation. Research farm possess seven shallow dug wells but their recharge is very poor due hard pan (3-5 m below ground).

Cultivation is totally dependent on rainfall. Due to continuous rainfall and water logging condition crops sown during *kharif* were badly affected. *Rabi* crops were sown in maximum available fields on account of availability of irrigation water from Pahuj canal as well as from shallow wells. Corp wise area and production during *rabi* 2011-12 and *kharif* 2012 and area sown during *rabi* 2012-13 are given below:

Season/crop and variety	Area (ha)	Production (Qtls)	Season/crop and variety	Area (ha)	Production (Qtls)
***Rabi* 2011-12**			***Kharif* 2012-13**		
Wheat (WH-147/ PBW502/ PBW343)	10.45	225.50	Black gram (T-9/Azad-2)	7.85	13.15
Barley (Jagrati)	1.30	26.00	Green gram (PDM-139/SML668)	2.20	1.08
Gram (Samrat/ Vaibhav/JG-16)	2.50	14.85	Arhar (UPAS-120)	0.14	0.06
Peas (Sapana)	0.40	2.55	Til(T-78/Shekhar)	8.42	0.09
Mustard (Varuna)	0.50	3.35	Soybean (PS1042)	0.80	Crop failed due to continuous rainfall
Lentil (K-75)	1.10	1.04	Cowpea fodder (BL-1/EC4216)	2.00	
Taramira (Karan)	2.40	2.85	Groundnut (TG37A)	1.00	

During *Rabi* 2012-13 about 20.32 ha area was sown which include 2.97 ha experimental and 17.35 ha general cropped area. Crop wise area sown in *Rabi* season is given below:

Crop	Sown area (ha)		Total area (ha)
***Rabi* 2012-13**	**Experimental**	**General**	
Wheat (WH147/PBW550/PBW)	1.75	10.00	11.75
Gram (Samrat/KGD1168)	-	2.50	2.50
Mustard (Varuna)	0.50	-	0.50
Lentil (K-75)	0.5184	-	0.5184
Taramira (Karan)	-	3.65	3.65
Barley (Jagrati)	-	0.90	0.90
Pea (Sapana)	0.20	0.30	0.50
Total area (ha)	**2.9684**	**17.35**	**20.3184**

During the year revenue of ₹ 5.90 lakh has been generated from Central Farm and details thereof is as under:

S. No.	Farm Produce	Total (₹)
1.	Grains	4,17,616=00
2.	Straw	87,200=00
3.	Fruits (aonla/bael)	16,460=00
4.	Timber/Fuel wood	65,800=00
5.	Others (leasing pond for fish rearing)	3000=00
	Grand Total	**5,90,076=00**

Photography, Meetings and Training

A well-equipped photography unit meets the day-to-day photographic and reprographic needs of the scientists. Provision also exists for the preparation of charts and posters. Photography unit is also equipped with digital cameras for still & video photography with audio recording options. Conference Hall/Committee/Training Room with modern facilities are available for scientific meetings and group discussions.

Budget (2012-13)

(₹ in Lakh)

S.N.	Head of Account	NON- PLAN		PLAN	
		Allocation	Expenditure	Allocation	Expenditure
A.	**Main Institute**				
1.	Establishment charges including LSP & PF	372.00	371.00	0.00	0.00
2.	Wages	9.00	8.95	0.00	0.00
3	Overtime allowance	0.05	0.04	0.00	0.00
4.	Traveling expenses	2.70	2.63	3.50	3.49

S.N.	Head of Account	NON- PLAN		PLAN	
		Allocation	Expenditure	Allocation	Expenditure
5.	Other charges including equipments & HRD	63.31	63.26	115.20	114.89
6.	Works	0.00	0.00	0.00	0.00
	Major (Original)	0.00	0.00	60.20	60.18
	Miner incl. R & M	6.85	6.83	21.10	21.10
	Total	**453.99**	**452.71**	**200.00**	**199.66**
1	Pension	41.50	41.49	0.00	0.00
2	P-Loans & Advances	1.80	1.80	0.00	0.00
B.	**Plan Scheme**				
1.	AICRP on Agroforestry, Coordinating Unit: NRCAF, Jhansi				1184.59
2.	Harvest and post-harvest processing and value addition of natural resins, gums and gum resins (ICAR, New Delhi)				6.48
3.	IPR Management in agroforestry (ICAR, New Delhi)				3.98
4.	National Initiative on Climate Resilient Agriculture (NICRA; ICAR, New Delhi)				33.19
5.	Studies on Mitigation Potential of Different Agroforestry Systems on Climate Change (NPCC, DST, New Delhi)				3.04
C.	**Externally Funded Projects**				
4.	National network on integrated development of Jatropha and Karanj (NOVOD Board Project)				7.68
D	**Revenue Receipt**			**Target**	**Achievement**
				13.50	**24.19**

**100% budget utilization under Plan and Non-Plan, higher revenue generation.*

2. RESEARCH ACHIEVEMENTS

2.1. System Research Programme

AF01.17: Analysis of Eucalyptus based Agroforestry for Crop- lands in Jhansi

(A K Handa, Ram Newaj, Badre Alam, Anil Kumar, Ajit & Ramesh Singh)

The studies continued during the year on growth parameters of coppice shoots of four different clones of Eucalyptus namely C-3, C-6, C-7 and C-10. The monthly increments in dbh values ranged from 0.246 to 0.584 cm. The increment values in summer varied from 0.275 to 0.584 cm, whereas in winter season it ranged from 0.246 to 0.568 cm. The variations in rainy season increments were almost constant with values ranging from 0.418 to 0.475 cm. Maximum value of average monthly increment in dbh was recorded in rainy season (0.45 cm) followed by summer (0.43 cm) and winter season(0.38 cm), supporting the hypothesis that increased moisture and optimum temperature promotes tree growth.

Blackgram was taken as intercrop during *kharif* season. Growth, yield attributes and yield of blackgram are given in Table 1.Growth performance of crop was better under wider row spacing (10 x 2 m) as compared to closer row spacing, although the tree geometry is same. The grain and straw yield also varied between the spacing but differences are very less. In boundary plantation growth, yield attributes and yield of crop was better than agrisilviculture. The influence of trees on intercrop could not be drawn due to very high mortality in coppices after first harvest. However, the pure crop produced higher grain than agrisilviculture and boundary plantation.

Table 1: Growth, yield attributes and yield of blackgram

Spacing	Character	Clone of Eucalyptus				Mean
		C3	C6	C7	C10	
Agrisilviculture						
5 x 4 m	Plant height (cm)	56.20	57.40	54.50	61.90	57.50 (56.20)
	No. of podsplant^{-1}	35.30	38.90	39.30	36.70	37.55 (46.40)
	No. of seedpod^{-1}	6.10	6.40	6.40	6.30	6.30 (6.30)
	Grain yield (q ha^{-1})	30.50	40.30	40.50	34.20	36.37 (97.50)
	Straw yield (q ha^{-1})	119.3	147.2	169.50	108.30	136.07 (202.50)
10 x 2 m	Plant height (cm)	63.00	62.00	64.40	56.60	61.50
	No. of podsplant^{-1}	42.60	41.40	40.20	39.60	40.95
	No. of seedpod^{-1}	6.33	6.00	6.10	6.10	6.13
	Grain yield (q ha^{-1})	30.50	29.30	43.80	38.70	35.57
	Straw yield (q ha^{-1})	119.50	104.80	121.20	147.20	123.17
Boundary Plantation						
3.0 m	Plant height (cm)	61.00	61.00	60.30	66.60	62.22
	No. of podsplant^{-1}	39.90	45.20	40.70	38.90	41.17
	No. of seedpod^{-1}	6.53	6.53	6.40	6.33	6.44
	Grain yield (q ha^{-1})	87.00	70.00	33.30	63.50	63.45
	Straw yield(q ha^{-1})	265.5	252.5	120.83	185.66	206.12

Note: Figures in parentheses are growth, yield attributes and yield of pure crop

Due to young canopy of coppice trees of *Eucalyptus*, difference in photosynthetic photon flux density (PPFD) was not very prominent over the understory crops studied during *rabi*season. The PPFD was observed in the range of 1250 to 1400 micromole m^{-2} s^{-1} during the forenoon hours and it was in the range of 500to750 micromole m^{-2} s^{-1} during the afternoon hours. CCM index was found to be at par along with the distance of tree line indicating the impact of incident PPFD over crops. CCM index was found to be in the range of 18.7 to 26.1 for documenting the impact of canopy of the *Eucalyptus*. Various canopy variables as captured and analyzed varied depending upon the trees and the LAI (leaf area index) and were in the range of 0.84 to 2.1. Microclimatic effects have been reflected in canopy temperature depression (CTD)(Fig.1).

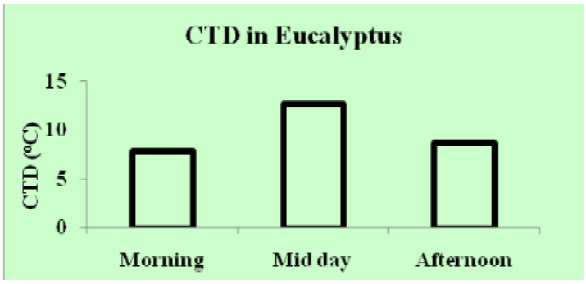


Fig.1: Diurnal canopy temperature depression (CTD) in Eucalyptus trees in agroforestry system

AF02.12: Effect of Irrigation on Performance of Aonla under Agroforestry Systems

(R K Tewari & Ramesh Singh)

In aonla based agroforestry system grain yield of wheat (var. WH147) reduced by 19.2 to 26.2% while straw yield by 21.4 to 27.6% under different treatments. Sole wheat crop recorded 3.86 t ha^{-1}yield, while yield under rainfedaonla treatment was 3.12 t ha^{-1}.Wheat crop in treatment of aonla irrigated in summer recorded 2.85 t ha^{-1} grain yield. Reduction in crop yield under agrihorticulture system is obviously due to competition for nutrientsand moisture. Maximum reduction in crop yield was recorded in vicinity of tree *i.e.*within 2.0 m distance from tree (Table 2).

Effect of irrigation now is being monitored in another 16 year old. Initial growth of trees under different treatments

Table 2: Crop yield at different distances from tree under aonla based Agrihorticulture system (wheat var. WH 147)

Treatments	Grain yield (t ha^{-1})				Straw yield (t ha^{-1})				Average	
	1m	2m	3m	4m	1m	2m	3m	4m	Grain	Straw
Aonlarainfed + Crop (T4)	1.63	2.84	3.49	4.36	2.1	3.5	4.2	5.6	3.12	3.85
Aonla Summer irrigated + Crop (T5)	1.72	2.55	3.50	3.65	2.2	3.2	4.3	4.5	2.85	3.55
Sole crop (T6)	4.18	3.22	3.61	4.43	5.3	4.0	4.6	5.7	3.86	4.90

Table 3: Plant growth and fruit yield of aonla (16 years old)

Treatment	Tree height (m)	Collar girth (cm)	Canopy spread (m)	Fruit yield (kg $plant^{-1}$)
T1 Aonlarainfed	5.74	56.6	5.76	38.3
T2 Aonla summer irrigated	5.33	61.4	5.87	28.1
T3 Aonla irrigated	6.20	77.2	6.37	42.0
T4 (T1 + Crop)	5.14	57.4	6.01	35.0
T5 (T2 + Crop)	6.15	76.4	7.15	50.1

and fruit yield was recorded. Irrigation treatments as per technical programme are being imposed. Fruit yield varied in the range of 28.1 to 50.1 kg plant^{-1} in different treatments (Table 3).

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

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

Nutrient management in ber based agrihorticulture system was laid out during August 2010 with nine treatments.However, during 2012, as per the recommendation of RAC and with the approval of IRC 2012, the technical programmewas modified and 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 with three replications and each treatment with six plants were suggested. The treatments were imposed as per the modified programme for the reporting period. Cent per cent plant survival was observed. The observations on growth parameters (collar diameter and canopy spread) were found non- significant as the treatments were imposed during ensuing season.

The sesame (*kharif)* and lentil (*rabi)* were grown as intercrops. Sesame variety T-78 was sown on July 20, 2012 using 4.5 kgha^{-1} seed rate and was supplied with recommended dose of nutrients (30 Kg N, 15 Kg P_2O_5 ha^{-1}). The crop was taken as rainfed without any irrigation. Continuous rainfall and heavy infestation of weeks did not allow weeding and resulted into failure of crop.Lentil variety K-75 (Mallikamasoor) was sown on 1stOctober, 2012 using 40 kgha^{-1} seed rate on residual fertility under rainfed condition. Data presented in Table 4 revealed that plant population varied from 25.6 to 28.2 plantsm^{-2} at 30 days after sowing. Data ranged for different parameters as 9.75 to 11.95 cm (plant height); 6.58 to 8.41 cm (root length); 0.24 to 0.39 g plant^{-1} (shoot + root fresh biomass) and 0.06 to 0.10 gplant^{-1} (Dry weight) at 30 days after sowing. By and large similar trend was recorded at 60 days after sowing; however there was substantial increase root and shoot length as well as total plant biomass.

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

(Inder Dev)

Initiation of pruning and its intensity on productivity of *Albizia procera* based silvipastoral system was initiated during August, 2006. *A. procera* plants were established during 2006 and the pasture component (*Chrysopogon fulvus* and *Stylosanthes seabrana*) was established during July-August, 2007. This year *procera* was pruned (25, 50 ad 75%) as per treatments (2nd, 3rd, 4th, 5th and 6th year pruning initiation plots) during December. The data on various parameters *viz.*, survival (%), growth and biomass production were recorded and are presented in Table 4, 5 and 6. Data reveals that by and large most of the growth parameters of the tree and pasture components were not affected significantly due to age of pruning initiation and its intensity, however canopy spread was significantly affected by initiation of pruning (Table 5 and 6). Initiation of pruning, intensity of pruning and their interaction affected the fuelwood biomass production significantly. Total fodder and total biomass production were significantly affected by

Table 4: Plant population and growth parameters of lentil at 30 and 60 days after sowing (DAS)

Treat	Plant population m^{-2}	Plant ht. (cm)		Root length (cm)		Total fresh biomass (root+ shoot) ($gplant^{-1}$)		Total dry biomass (root+ shoot) ($gplant^{-1}$)	
		30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T2	26.4	9.75	14.14	7.22	7.28	0.24	0.98	0.06	0.32
T4	28.2	11.95	14.91	7.92	7.76	0.39	1.03	0.08	0.34
T6	25.6	10.76	15.72	8.41	8.49	0.27	1.26	0.07	0.39
T8	26.0	11.84	16.46	6.75	7.14	0.33	1.17	0.10	0.40
T9	27.8	10.00	14.79	6.58	7.49	0.33	1.24	0.09	0.40
T10	26.8	11.06	16.01	7.46	8.25	0.29	1.31	0.08	0.40

Table 5: Survival and growth of *A. procera* influenced by age and intensity of pruning

Treatments	Survival (%)	Height (m)	GBH (cm)	Canopy spread (m)
Initiation of pruning				
2nd year	66.92	12.90	39.18	2.04
3rd year	60.19	13.67	41.13	2.01
4th year	47.81	12.25	34.72	2.63
5th year	55.28	12.53	41.32	2.83
6th year	48.37	10.98	37.52	3.72
Significance (p value)	0.3211	0.3015	0.3443	0.0024
Intensity of pruning				
25%	53.01	11.88	37.91	2.37
50%	55.33	12.66	40.017	2.77
75%	58.81	12.86	38.39	2.79
Significance (p value)	0.7687	0.5651	0.7339	0.3947
Initiation of pruning x Intensity of pruning				
Significance (p value)	0.9964	0.7892	0.4894	0.8657

Table 6: Growth of pasture component influenced by age and intensity of pruning in *A. procera* based silvipastoral system

	Chrysopogon fulvus			*Stylosanthes seabrana*	
Treatment	**Height (cm)**	**Tussock diameter (cm)**	**Tillers/ tussock**	**Height (cm)**	**Branches per plant**
Initiation of pruning					
2nd year	155.44	33.11	65.67	134.69	64.53
3rd year	155.51	31.44	66.92	133.96	61.96
4th year	152.69	34.76	64.13	128.58	67.89
5th year	160.27	30.64	60.42	132.00	64.49
6th year	161.22	31.84	63.23	128.89	64.27
Significance (p value)	0.5896	0.1402	0.1334	0.2853	0.7241
Intensity of pruning					
25%	155.31	32.40	64.03	130.81	62.10
50%	156.21	32.71	64.65	132.85	65.87
75%	159.56	33.17	63.54	131.21	65.91
Significance (p value)	0.6349	0.7053	0.8520	0.7290	0.4115
Initiation of pruning x Intensity of pruning					
Significance (p value)	0.1202	0.2501	0.7046	0.6417	0.8578

Table 7: Fuelwood and forage production (D.W. t ha^{-1}) influenced by age and intensity of pruning in *A. procera* based silvipastoral system

	Tree		Pasture			Total fodder	Total biomass
	1	2	3	4	5 (3+4)	6 (2+3+4)	7 (1+6)
Treatments	**Fuel wood**	**Leaf fodder**	**Grass fodder**	**Legume fodder**	**Total pasture**		
Initiation of pruning							
2nd year	1.278	0.729	3.33	2.63	5.96	6.689	7.973
3rd year	1.274	0.753	3.27	2.71	5.98	6.733	8.008
4th year	1.344	0.726	3.47	2.66	6.13	6.856	8.201
5th year	1.371	0.673	3.63	2.65	6.28	6.953	8.326
6th year	1.617	0.788	3.56	2.84	6.40	7.188	8.807
Significance (p value)	<0.0001	0.2970	0.8533	0.9837	0.9053	0.9540	0.7516
Intensity of pruning							
25%	1.162	0.579	3.16	2.55	5.71	6.289	7.450
50%	1.383	0.723	3.38	2.5	5.88	6.603	7.987
75%	1.586	0.921	3.8	3.04	6.84	7.761	9.352
Significance (p value)	<0.0001	<0.0001	0.1023	0.1629	0.1614	0.0231	0.0037
Initiation of pruning x Intensity of pruning							
Significance (p value)	0.8144	0.9510	0.8433	0.5018	0.8764	0.8158	0.7938

intensity of pruning. Rest of the parameters were not significantly affected (Table 7).

Observational Trial

Development of Bamboo Based Agroforestry Systems in Six Agroclimatic Zones

(Inder Dev)

Development of bamboo based agroforestry systems in six agroclimatic zones of India was a part of the National Bamboo Mission project till 2012. Presently the same project is continuing as an observational trial at NRCAF. Plantation of *Dendrocalamus strictus*, *Bambusa vulgaris* and *B. tulda* was done during 2007 (rainy season). The mature culms of *D. strictus*, *B. vulgaris* were harvested during 2012 (Nov./December). Data presented in table 8 reveals that 4532 (*D.*

Table 8: Growth parameters and yield in bamboo based agroforestry systems

Parameters	*Dendrocalamus strictus*	*Bambusa vulgaris*
Total # of Clumps	100	37
Total # of Culms	5163	1495
Average # culms per clump	32	20
Average inter node per culm	10.5	14.9
Inter nodal length	19.14	24.6
Total # of matured culms/felled	4532	1166
Total # of culms retained	633	329
Avg. Fresh weight (kg)	Class I – 2-3; Class II- 1-2	Class I – 7-8; Class II- 6-7; Class III- 3-6
Av. dbh	37.52 mm	46.62 mm
Average height	Class I – 2-4; Class II- 1.5-2	Class I – 6-8; Class II- 4-6; Class III- 2-4
Total yield (tonnes on F.W. basis)*	17.29	8.3

*Total area under *Dendrocalamus strictus* (1.3 ha); *Bambusa vulgaris* (0.8 ha)

strictus) and 1166 (*B. vulgaris*) mature culms were harvested from a total of 5163 (*D. strictus*) and 1495 (*B. vulgaris*) culms. Average culms/clump, internodes/culm, intermodal length and dbh were observed to be 32.0, 10.5, 19.1 cm and 3.75 cm (*D. strictus*) and 20, 14.9, 24.6 cm and 4.66 cm (*B. vulgaris*), respectively. Height gained ranged from 2.04 to 3.24 m (*D. strictus*) and 2.64 to 5.64 m (*B. vulgaris*), while fresh weight gained by individual culm varied from 1-3 kgculm^{-1} (*D. strictus*) and 3-8 kgculm^{-1} (*B. vulgaris*) in different classes. Total yield of 17.29 t (*D. strictus*) and 8.3 t (*B. vulgaris*) on fresh weight basis was obtained from an area of 1.3 ha and 0.8 ha, respectively.

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)

The experiments were conducted under varying regimes of shade *viz.* 33, 50 and 75% shades of incident sun light under simulated shade-net house conditions and open (as a control) with pea (*Pisum sativum* variety-Sapna) during *rabi* 2012. A typical trend of PPFD (Photosynthetic photon flux density) inside net house and open grown crop is given (Fig. 2). Remarkable differences in all the phenological events were observed from germination to crop harvest. There was differential response in germination phenology across all the shade and open field (Fig. 3). Biomass index of open grown plants was higher in comparison to 33% shade followed by 50 and 75% shade grown crop (Fig. 4). Yield of open grown pea plants was higher and gradually decreased as the shade intensity increased. Maximum reduction in yield in comparison to open was found in 75% shade followed by 50 and 33% shade (Fig. 5).

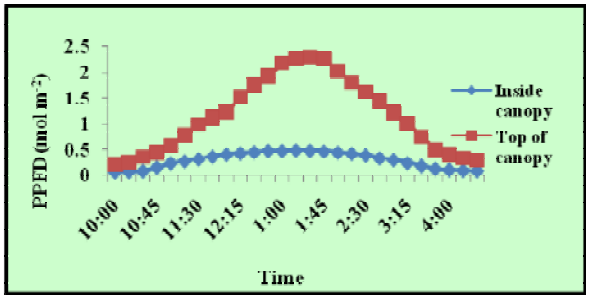


Fig. 2: A typical diurnal PPFD trend in pea experimental plants (open grown)

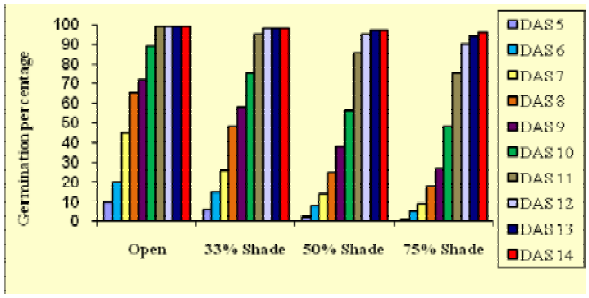


Fig. 3: Germination phenology of pea under different shade (DAS= Days after sowing)

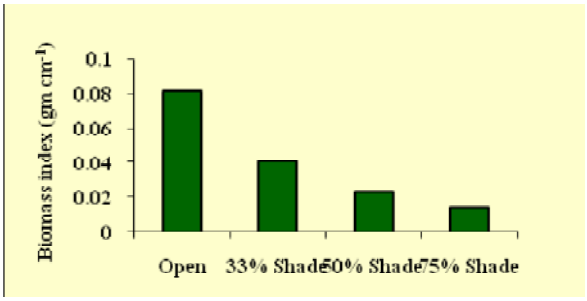


Fig.4: Biomass index of pea plants grown under different shade after 45 DAS

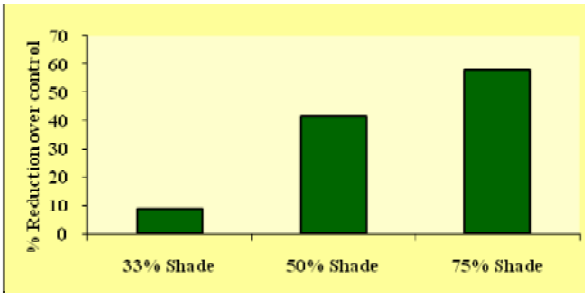


Fig. 5: Percentage reduction over control in pea crop under different shade

Anthocyanin, decreased as the light intensity decreased or shade increased (Fig. 6). Comparative studies of pigment profile of

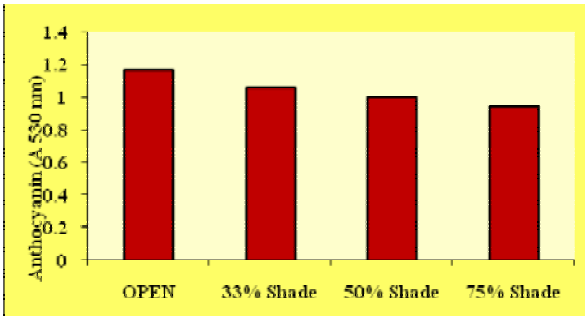


Fig. 6: Anthocyanin concentration in pea leaves under different shade

pea leaves have shown a certain trend in chlorophyll a, chlorophyll b and total chlorophyll along with increasing shade (Fig.7).

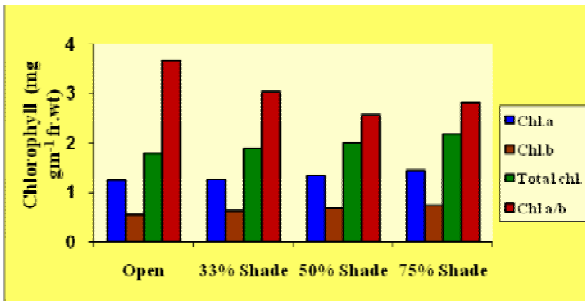


Fig. 7: Pigment profiles of pea plants under different shade

The number of root nodules decreased as the shade increased indicating the low nitrogen fixing capacity of deep shade grown plants. Nitrate reductase enzyme played an important role asunder shade its activity decreased (Fig. 8). Some important enzymes like Peroxidase (POD), Catalase (CAT), Ascorbic acid oxidase (AAO) and Phenylalanine ammonia lyase (PAL) were also studied. AAO activity showed an increasing trend with increase shade intensity

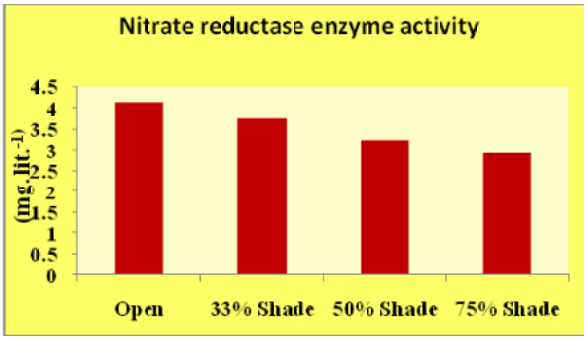


Fig. 8: Nitrate reductase enzyme activity in pea leaves under different shade

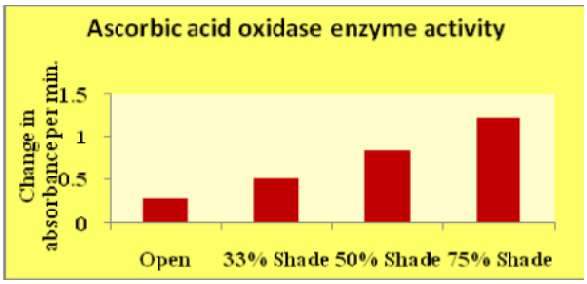


Fig. 9: Ascorbic acid oxidase enzyme activity in pea leaves under different shade

(Fig. 9) whereas, other enzymes like POD, CAT and PAL showed decreasing trends with increase in shade intensity (Fig. 10, 11, 12). SDS protein profiling of pea plants in various shade regimes was also noted (Plate 1).

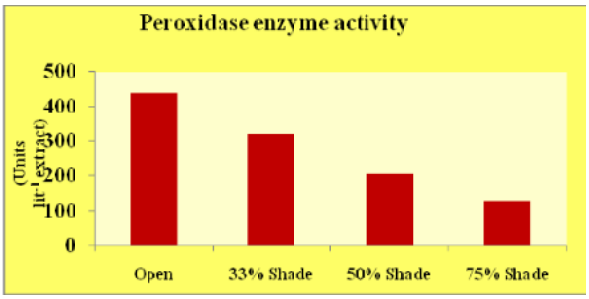


Fig.10: Peroxidase enzyme activity in pea leaves under different shade

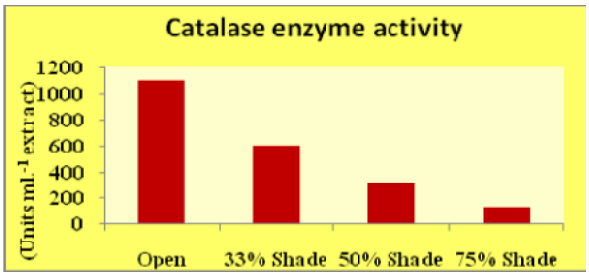


Fig. 11: Catalase enzyme activity in pea leaves under different shade

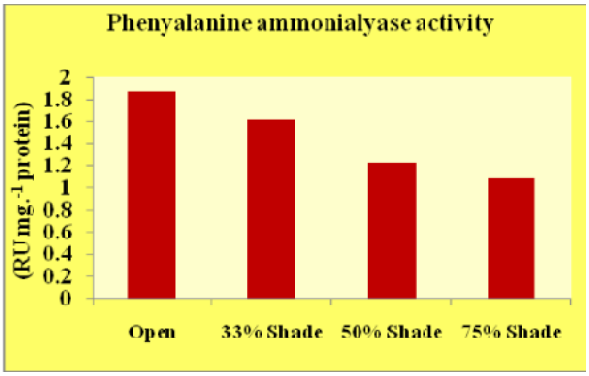


Fig.12: Phenylalanine ammonia lyase activity in pea leaves under different shade

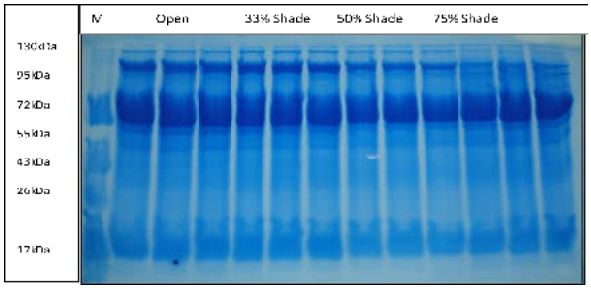


Plate-1: SDS-PAGE of pea leaves protein grown under different shade (M-mol. Wt. marker)

Rate of CO_2 Assimilation (A) versus PPFD relationship under varying regimes of shade and open (as control)in pea crop were also studied systematically through advanced portable photosynthesis system. Response curve of A versus PPFD were generated by step changing of light intensity through in-built led fixed in the Leaf Fluorescence Chamber (LCF-6400-40). Differential responses for the quantity of light required to saturate CO_2 assimilation (A) were noted in the crops grown under varying regimes of light (Fig.13). Photosystem-2 electron transport rate (ETR) in open grown crop was higher than shade grown crop and gradually decreased with increase in shade intensity (Fig. 14). Comprehensive physiological and biochemical studies in pigeon pea (*Cajanus cajan*) under varying shade in *kharif* 2012 were conducted for assessing shade adaptability. Due to excess and untimely rain fall, the crop phenology and performance of the *kharif*crop (pigeon pea) was affected which led to late maturity and growth of the crop. It was observed that excess water lodging in open field led to the inferior growth and productivity of the crops. The germination trend of pigeon pea has been observed (Fig. 15). Biomass index of pigeon pea decreased with increasing shade intensity (Fig. 16). A trend of pigment profile was also studied (Fig. 17). Leaf area of pigeon pea has also been monitored (Fig. 18).Various physiological and biochemical studies in greater details including rate of CO_2 Assimilation (A) versus PPFD and photochemical efficiency relationship under varying regimes of shade and open (as control)in pigeon pea crop have also been studied.

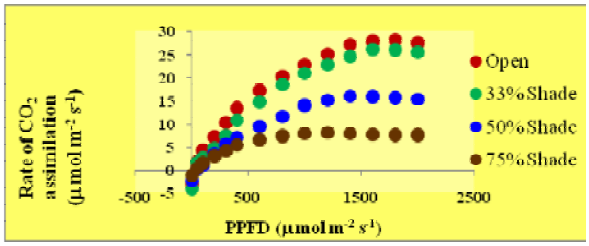


Fig. 13: Rate of CO_2 assimilation at various PPFD and under different shade of pea plants

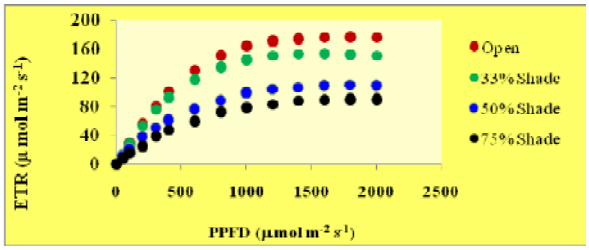


Fig.14: Electron transport rate (ETR) of pea under different shade

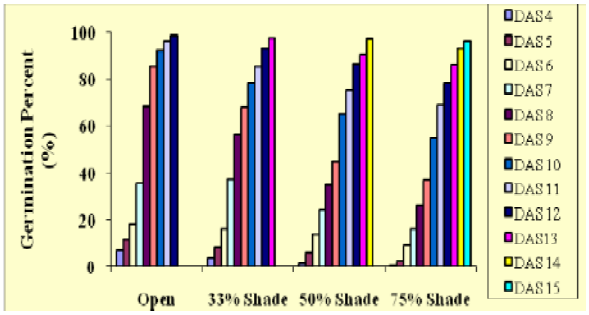


Fig. 15: Germination phenology of pigeon pea under different shade(DAS= Days after sowing)

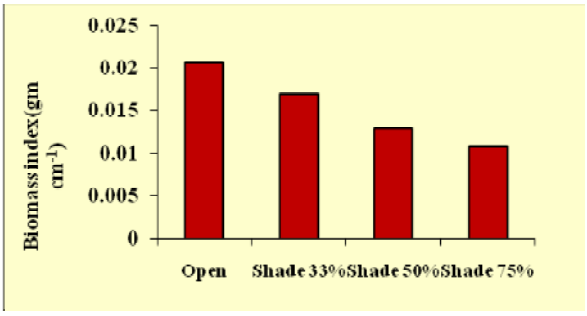


Fig. 16: Biomass index pigeon pea plants grown under different shade

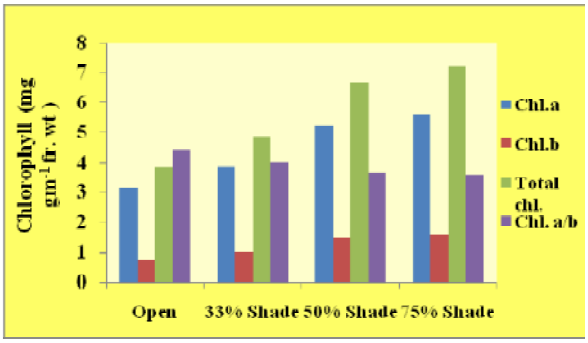


Fig.17: Pigment profile of pigeon pea under different shade

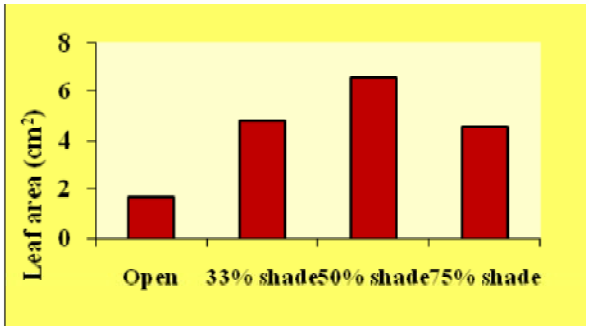


Fig. 18: Leaf area of 45 DAS old plants of pigeon peaunder different shade

AF01.24: Studies on Arbuscular Mycorrhizal Fungi of Important MPT's

(Anil Kumar & Rajendra Prasad)

The present study was initiated during 2007-08 to identify suitable arbuscular mycorrhizal (AM) species for inoculation of important agroforestry tree species and intercrops. A series of experiments on field surveys, identification of common AM fungi in rhizosphere of selected tree species and intercrops, culturing, purification and characterization of AM fungi, screening of the fungi for improved growth, response to AM inoculation in local soil types, and integration of chemical fertilizers with bio-fertilizers are being conducted. The results obtained during last year are summarized below:

Results on effect of AM inoculants on growth, yield, phosphorus uptake and arbuscular colonization index of three popular varieties of wheat in two common soil types showed that all AM inoculants significantly increased shoot length, dry shoot weight, dry root weight, number of ears per plant, thousand seed weight and yield per plant. Number of tillers per plant was increased by five inoculants (*A. mellea, G. aggregatum, G. cerebriforme, G. diaphanum, G. etunicatum, G. fasciculatum*). Shoot length, dry shoot weight, dry root weight and thousand seed weight were significantly higher in red soil as compared to black soil. Differences in other parameters in two soil types were found non-significant. Growth parameters exhibited variable trends in three wheat varieties. Maximum shoot lengths and Number of yearplant^{-1} were recorded in WH-147, numbers of tillers, dry shoot weights and grain yield plant^{-1} in LOK-1 and dry root weight and average year length in Kathiya (Table 9 and 10).

Table 9: Effect of AM inoculants on vegetative growth of three popular varieties of wheat in two common soil types of Central India

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
Shoot length (cm)												
A. mellea	83.33	90.00	80.00	84.44	80.67	78.00	66.00	74.89	82.00	84.00	73.00	79.7
A.scrobiculata	81.67	85.33	68.00	78.33	82.00	68.00	82.00	77.33	81.33	76.67	75.00	77.8
G. aggregatum	84.00	85.00	72.00	80.33	86.00	72.67	72.67	77.11	85.00	78.33	72.33	78.7
G. arborense	87.67	81.33	78.00	82.33	80.67	75.33	70.67	75.56	84.17	78.33	74.33	78.9
G. cerebriforme	86.00	88.00	72.00	82.00	81.33	82.00	69.33	77.56	83.67	85.00	70.67	79.8
G. diaphanum	96.33	88.00	72.00	85.44	84.00	80.67	75.33	80.11	90.17	84.33	73.67	82.7
G. eutunicatum	81.33	88.67	61.33	76.44	83.33	78.00	78.00	79.78	82.33	82.33	69.67	78.1
G. fascicutatum	82.67	84.67	74.00	80.44	78.00	80.00	69.33	75.78	80.33	82.33	71.67	78.1
G. hoi	92.00	89.67	57.33	79.67	84.00	76.67	63.33	74.67	88.00	83.17	60.33	77.7
G. intraradices	88.67	84.00	77.33	83.33	77.33	74.00	70.00	73.78	83.00	79.00	73.67	78.6
Control	81.67	76.00	57.33	71.67	71.33	73.17	57.33	67.27	76.5	74.58	57.33	69.7
Mean	85.94	85.33	69.94	80.40	80.79	76.23	70.36	75.79				
Pooled mean	83.36	80.78	70.15									
$LSD_{0.05}$	V@=1.2	S=1.0	A=2.4	S*V=1.8		V*A=4.1		S*A=3.4		S*V*A=5.8		

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
Number of tillers per plant												
A. mellea	9.3	13.0	10.0	10.8	12.7	12.3	10.7	11.9	11.0	12.7	12.7	10.3
A.scrobiculata	11.7	12.3	9.0	11.0	12.7	13.3	10.3	12.1	12.7	12.8	12.8	9.7
G. aggregatum	10.7	13.0	9.7	11.1	12.0	16.0	9.7	12.6	11.3	14.5	14.5	9.7
G. arborense	9.3	14.0	10.7	11.3	10.0	13.0	10.7	11.2	9.7	13.5	13.5	10.7
G. cerebriforme	8.3	13.0	10.0	10.4	11.0	12.7	10.0	11.2	9.7	12.8	12.8	10.0
G. diaphanum	10.3	13.3	9.3	11.0	9.7	13.0	10.0	10.9	10.0	13.7	13.7	9.7
G. eutunicatum	11.3	12.3	11.3	11.7	11.3	12.3	9.3	11.0	11.3	12.3	12.3	10.3
G. fascicutatum	10.7	12.0	10.3	11.0	11.0	12.0	10.0	11.0	10.8	12.0	12.0	10.7
G. hoi	9.3	11.7	9.0	10.0	10.3	10.0	9.3	9.9	9.8	10.8	10.8	9.7
G. intraradices	9.3	11.3	12.0	10.9	10.7	11.3	7.3	9.8	10.0	11.3	11.3	9.7
Control	7.0	9.3	9.3	8.6	8.0	8.3	8.0	8.1	7.5	8.83	8.83	8.7
Mean	9.76	12.30	10.10	10.71	10.85	12.21	8.58	10.88				
Pooled mean	10.30	12.26	9.82									
$LSD_{0.05}$	V@=0.6	S=NS	A=1.1	S*V=0.8		V*A=NS		S*A=NS		S*V*A=NS		
Dry shoot weight (g)												
A. mellea	35.35	32.24	30.81	35.14	34.90	34.10	30.72	33.23	35.13	36.65	30.76	34.18
A. scrobiculata	34.19	35.46	33.99	34.55	36.61	36.72	32.97	35.43	35.40	36.10	33.48	34.99
G. aggregatum	35.99	33.21	29.19	32.80	31.61	32.03	30.75	31.46	33.80	32.62	29.97	32.13
G. arborense	33.99	37.21	29.81	33.67	34.15	37.27	31.42	34.28	34.10	37.24	30.61	33.97
G. cerebriforme	34.33	35.60	33.29	34.41	32.57	31.97	29.24	31.26	33.45	33.78	31.26	32.83
G. diaphanum	34.96	33.38	30.73	33.02	30.97	32.83	30.63	31.47	32.96	33.11	30.68	32.25
G. etunicatum	34.67	35.21	34.45	34.78	32.10	37.38	30.58	33.35	33.38	36.30	32.52	34.10
G. fasciculatum	36.26	36.71	33.03	35.34	35.13	33.42	31.46	33.34	35.70	35.10	32.25	34.34
G. hoi	34.45	40.12	32.30	35.62	32.57	31.69	30.56	31.61	33.51	35.91	31.43	33.62
G. intraraces	34.42	37.45	29.94	33.94	34.90	33.73	31.86	33.50	34.66	35.59	30.90	33.72
Control	18.84	18.27	19.16	18.76	18.35	17.11	18.44	17.97	18.60	17.69	18.80	18.36
Mean	33.41	34.72	30.61	32.91	32.17	32.57	29.87	31.54				
Pooled mean	32.79	33.64	30.24									
$LSD_{0.05}$	V*=0.77	S=0.6	A=1.5	S*V=NS		V*A=2.55		S*A=NS		S*V*A=NS		
Dry root weight (g)												
A. mellea	10.31	10.14	23.78	14.74	7.47	9.42	21.69	12.86	8.89	9.78	22.74	13.80
A. scrobiculata	8.94	8.65	24.15	13.92	7.93	8.77	21.93	13.21	8.44	8.71	23.54	13.56
G. aggregatum	9.71	8.30	25.49	14.50	9.46	8.44	27.46	15.12	9.58	8.37	26.48	14.81
G. arborense	8.11	9.52	22.39	13.34	9.17	12.33	22.78	14.76	8.64	10.92	22.89	14.05
G. cerebriforme	9.99	13.10	29.04	17.37	9.75	10.55	24.23	14.85	9.87	11.82	26.64	16.11
G. diaphanum	9.85	9.31	25.16	14.77	8.89	9.78	18.69	12.45	9.37	9.55	21.93	13.61
G. etunicatum	8.83	10.57	22.96	14.12	9.74	10.24	24.19	14.72	9.29	10.41	23.58	14.42
G. fasciculatum	8.58	12.78	28.18	16.52	9.40	9.00	22.98	13.79	8.99	10.89	25.58	15.16
G. hoi	9.54	10.20	23.90	14.55	9.33	8.10	27.30	14.91	9.44	9.15	25.61	14.73
G. intraraces	9.78	9.98	24.01	14.57	9.65	10.49	19.33	13.16	9.72	10.20	21.67	13.86
Control	4.58	5.10	10.95	6.86	6.10	4.49	10.72	7.10	5.32	4.78	10.84	6.98
Mean	8.30	9.78	23.64	14.11	8.81	9.24	22.03	13.36				
Pooled mean	8.87	9.51	22.84									
$LSD_{0.05}$	V*=0.58	S=0.5	A=1.11	S*V=0.82		V*A=1.93		S*A=1.57		S*V*A=2.72		

Table 10: Effect of AM inoculants on yield related parameters of three popular varieties of wheat in two common soil types of Central India

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
Number of ears												
A. mellea	9.3	9.0	5.0	7.8	10.7	9.3	4.7	8.2	10.0	4.8	8.0	8.0
A. scrobiculata	11.3	9.6	4.7	8.6	10.3	9.3	4.3	8.3	10.8	5.0	8.4	8.4
G. aggregatum	10.7	11.3	3.7	8.6	9.0	7.7	5.3	7.0	9.8	4.0	7.8	7.8
G. arborense	9.0	8.3	4.0	7.1	9.3	9.0	3.7	7.3	9.7	9.8	7.2	7.2
G. cerebriforme	8.3	8.6	4.0	7.0	10.0	9.3	5.0	8.1	9.7	4.5	7.6	7.6
G. diaphanum	10.3	10.7	4.7	8.6	6.7	9.3	4.7	6.9	8.5	4.7	7.8	7.7
G. etunicatum	11.0	7.0	4.3	7.4	11.0	10.0	4.3	8.4	11.0	4.3	7.9	7.9
G. fasciculatum	10.0	9.0	4.3	7.8	10.0	7.7	4.3	7.3	10.0	4.3	7.6	7.6
G. hoi	9.0	10.3	4.7	8.0	9.7	7.7	4.3	7.2	9.3	4.5	7.6	7.6
G. intraradices	9.3	9.6	4.0	7.7	9.0	9.3	4.3	7.6	9.70	4.17	7.61	7.61
Control	5.3	6.0	3.3	4.89	5.67	6.67	3.30	6.22	5.50	3.33	5.10	5.10
Mean	9.42	9.10	4.24	7.58	9.21	8.67	4.39	7.42				
Pooled mean	9.32	8.86	4.32									
$LSD_{0.05}$	V*=0.77	S=0.63	A=1.47	S*V=NS		V*A=2.55		S*A=NS		S*V*A=NS		
Average ear length (cm)												
A. mellea	10.0	9.4	10.7	10.0	9.4	10.7	10.0	9.9	9.8	9.4	10.7	10.0
A. scrobiculata	9.8	9.4	10.8	10.0	9.9	10.8	10.0	10.0	9.6	9.6	10.8	10.0
G. aggregatum	9.8	9.3	10.7	10.0	10.1	10.9	10.1	10.3	9.8	9.7	10.8	10.1
G. arborense	10.1	9.5	10.8	10.1	9.6	10.9	10.1	10.1	10.0	9.5	10.8	10.1
G. cerebriforme	10.2	9.3	10.7	10.1	9.6	11.0	10.1	10.2	10.1	9.4	10.9	10.1
G. diaphanum	10.0	9.4	11.7	10.4	9.6	10.8	10.2	10.0	9.9	9.5	11.3	10.2
G. etunicatum	9.8	9.9	11.7	10.5	9.6	10.6	10.3	10.0	9.8	9.8	11.2	10.3
G. fasciculatum	9.8	9.4	11.0	10.1	9.8	10.8	10.1	10.1	9.8	9.6	10.9	10.1
G. hoi	9.8	9.8	10.7	10.1	9.8	11.0	10.1	10.2	9.7	9.8	10.9	10.1
G. intraradices	10.2	9.5	10.8	10.1	9.5	10.9	10.1	10.1	10.0	9.5	10.8	10.1
Control	9.8	9.7	10.8	10.03	9.97	11.00	10.25	10.43	9.97	9.85	10.93	10.3
Mean	9.95	9.49	10.94	10.12	9.77	9.72	10.85	10.12				
Pooled mean	9.86	9.61	10.89									
$LSD_{0.05}$	V*=0.77	S=0.63	A=1.47	S*V=NS		V*A=2.55		S*A=NS		S*V*A=NS		
Thousand seed weight (g)												
A. mellea	46.65	49.16	45.67	47.16	44.22	44.73	45.44	44.80	45.43	46.94	45.55	45.98
A. scrobiculata	43.83	50.84	4316	45.95	43.94	48.64	45.96	46.18	43.89	47.74	44.56	46.10
G. aggregatum	49.88	49.68	54.11	51.22	46.43	46.82	57.96	50.40	48.15	48.25	56.03	50.81
G. arborense	47.29	46.82	42.66	45.59	40.46	42.67	45.29	42.81	13.88	44.75	43.98	44.20
G. cerebriforme	49.77	42.97	46.52	46.21	34.66	38.58	50.78	41.34	42.22	40.78	48.65	43.88
G. diaphanum	50.71	51.42	53.04	41.72	47.19	44.77	52.40	48.12	48.95	48.10	52.72	49.92
G. etunicatum	42.78	47.26	48.86	46.30	39.76	44.10	46.19	43.35	41.27	45.68	47.58	44.82
G. fasciculatum	42.24	47.73	54.82	48.26	44.14	45.17	50.23	46.51	43.19	46.45	52.53	47.39
G. hoi	47.73	44.60	42.63	44.99	46.27	45.92	56.69	49.63	47.00	45.26	49.66	47.31
G. intraradices	47.83	41.29	46.89	45.34	47.00	40.16	49.83	45.66	47.42	40.72	48.36	45.50
Control	37.63	36.19	37.24	37.00	36.48	37.01	37.54	37.10	37.10	36.60	37.44	37.04
Mean	46.03	46.18	47.17	46.45	42.78	43.51	48.60	45.00				
Pooled mean	44.40	44.84	47.91									
$LSD_{0.05}$	V*=1.34	S=1.10	A=2.56	S*V=1.89		V*A=4.43		S*A=3.62		S*V*A=NS		

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
Yield per plant (g)												
A. mellea	17.35	19.83	12.90	16.69	16.60	16.49	12.69	15.26	16.98	18.16	12.79	15.98
A. scrobiculata	16.88	17.35	13.81	16.01	16.58	17.45	14.74	16.26	16.73	17.40	14.28	16.13
G. aggregatum	17.76	18.64	11.32	15.91	14.69	20.38	14.87	16.65	16.23	19.51	13.10	16.28
G. arborense	16.58	16.43	13.55	15.52	15.23	19.33	13.97	16.18	15.90	17.88	13.76	15.85
G. cerebriforme	17.35	17.85	16.29	17.16	14.10	15.30	11.15	13.50	15.70	16.57	13.72	15.33
G. diaphanum	18.14	18.18	13.25	16.52	15.42	16.10	14.31	15.26	16.78	17.12	13.78	15.89
G. etunicatum	15.10	16.04	14.75	15.30	14.56	17.64	12.97	15.10	14.83	16.84	13.86	15.18
G. fasciculatum	17.10	15.26	13.33	15.23	16.96	15.18	12.57	14.90	17.03	15.22	12.95	15.10
G. hoi	16.45	15.01	13.71	15.10	15.80	17.38	12.44	15.21	16.13	16.20	13.10	15.13
G. intraradices	17.31	17.52	12.64	15.82	18.95	15.35	12.75	15.68	18.13	16.43	12.69	15.75
Control	8.17	7.49	7.13	7.66	8.74	8.69	7.54	8.25	8.46	8.10	7.40	7.98
Mean	16.20	16.33	13.15	15.25	15.24	16.29	12.58	14.68				
Pooled mean	15.72	16.31	12.86									
$LSD_{0.05}$	V*=0.53	S=NS	A=1.02	S*V=0.76		V*A=1.77		S*A=NS		S*V*A=2.5		

Maximum root:shoot ratio was recorded in Kathiya, followed by LOK-1 and WH- 147. The differences in its two soil types were found non-significant. Eight AM inoculants (*G. aggregatum, G. arborense, G. cerebriforme, G. diaphanum, G. etunicatum, G. fasciculatum, G. hoi* and *G. intraraces*) significantly increased root:shoot ratio. Maximum mycorrhizal dependency was recorded for Lok-1, followed by Kathiya and WH-147 which was significantly higher in red soil than in black soil. Mycorrhizal dependency of different AM inoculants varied in narrow range of 45.4-50.4% (Table 11).

Phosphorus uptake per plant was at par in Kathiya and LOK-1 and significantly more than respective value in WH147. P uptake was more in red soil than black soil and inoculations with AM significantly increased its value (Table 12).

Colonization index was at par in WH-147 and LOK-1 and significantly more than colonization index in kathiya. Colonization index values were significantly more in red soil than black soil and ranged from 32.4 to 47.3% in plants treated with different AM inoculants (Table 13).

Effect of tree shade on nodulation, arbuscular colonization and growth of pea was studied. The results showed that number of nodules and arbuscularmycorrhizal colonization were significantly more in open as compared to their respective values in tree shade. Dry shoot weight of pea plants was more in open and differences in their shoot length, root length and dry root weight were found non-significant (Table 14).

Results on occurrence of AMF and rhizobium in chickpea, pea and wheat at NRCAF and nearby farmers' fields showed thatboth AMF and rhizobium was recorded present in chickpea, pea and wheat, except rhizobium on wheat. Maximum colonization both AMF and rhizobium were recorded in chickpea followed by pea and wheat and intensity of colonization was more outside NRCAF research farm (Table 15). Inoculations with bio-fertilizers (AMF, rhizobium and PSB) have given good results in fields at NRCAF. It will be interesting to test their response in farmer's field where these are present in abundance.

Table 11: Root-shoot ratio and mycorrhizal dependency of three popular varieties of wheat in two common soil types of Central India

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
Root-Shoot ratio												
A. mellea	0.29	0.26	0.77	0.44	0.21	0.28	0.71	0.40	0.25	0.27	0.74	0.42
A. scrobiculata	0.26	0.25	0.72	0.41	0.22	0.24	0.70	0.38	0.24	0.24	0.71	0.40
G. aggregatum	0.27	0.25	0.88	0.47	0.30	0.26	0.89	0.49	0.29	0.26	0.89	0.48
G. arborense	0.24	0.26	0.75	0.41	0.27	0.33	0.73	0.44	0.25	0.29	0.74	0.43
G. cerebriforme	0.29	0.37	0.88	0.51	0.30	0.33	0.83	0.49	0.30	0.35	0.86	0.50
G. diaphanum	0.28	0.28	0.82	0.46	0.29	0.30	0.61	0.40	0.29	0.29	0.72	0.43
G. etunicatum	0.25	0.30	0.67	0.41	0.30	0.28	0.79	0.46	0.28	0.29	0.73	0.43
G. fasciculatum	0.24	0.35	0.86	0.48	0.27		0.73	0.42	0.25	0.31	0.80	0.45
G. hoi	0.28	0.25	0.74	0.43	0.29	0.26	0.90	0.48	0.28	0.26	0.82	0.45
G. intraraces	0.29	0.27	0.80	0.45	0.28	0.31	0.61	0.40	0.28	0.29	0.71	0.43
Control	0.25	0.28	0.57	0.36	0.33	0.26	0.58	0.39	0.29	0.27	0.58	0.38
Mean	0.27	0.28	0.77	0.44	0.28	0.28	0.73	0.43				
Pooled mean	0.27	0.28	0.75									
$LSD_{0.05}$	V*=0.022	S=NS	A=0.041	S*V=NS	V*A=0.072		S*A=0.058		S*V*A=0.101			
Mycorrhizal dependency												
A. mellea	48.69	52.34	44.69	48.57	42.10	50.10	44.17	45.45	45.39	51.21	44.43	47.01
A. scrobiculata	45.66	46.87	48.12	46.88	44.99	52.39	47.69	48.36	45.32	49.63	47.91	46.88
G. aggregatum	48.65	43.47	44.81	45.64	40.54	46.54	49.69	45.64	44.59	45.00	47.32	45.64
G. arborense	44.36	49.79	42.10	45.40	43.63	56.20	46.15	48.66	44.00	53.00	44.10	45.40
G. cerebriforme	47.00	51.70	51.64	50.11	42.20	48.98	45.37	45.52	44.60	50.34	48.51	50.11
G. diaphanum	47.63	45.31	46.11	46.35	38.73	49.20	40.80	42.91	43.18	47.25	43.46	46.35
G. etunicatum	45.80	48.99	47.26	47.35	41.55	54.56	46.50	47.53	43.67	51.78	46.88	47.35
G. fasciculatum	47.70	52.80	50.80	50.43	45.12	49.10	46.36	46.85	46.41	50.93	48.58	50.43
G. hoi	46.63	53.37	46.29	48.76	41.65	45.23	49.53	45.47	44.14	49.30	47.91	48.76
G. intraraces	46.91	50.73	43.92	47.18	45.16	50.78	43.03	46.32	46.03	50.75	43.47	47.18
Mean	46.90	49.54	46.57	47.67	42.57	50.30	45.94	46.27				
Pooled mean	44.73	49.92	46.26									
LSD (0.05)	V@=1.22	S=1.00	A=2.23	S*V=1.72	V*A=3.85		S*A=3.15		S*V*A=5.45			

@V: Variety, S: Soil order, A: Arbuscular mycorrhiza

Table 12: Phosphorus uptake per plant in three popular varieties of wheat in two common soil types of Central India

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
P uptake per plant *A. mellea*	17.30	26.18	38.14	26.21	8.60	9.25	16.46	11.44	12.90	16.21	27.30	18.82
A. scrobiculata	12.38	17.83	45.88	25.36	10.93	10.08	21.66	14.23	11.66	13.95	33.77	19.79
G. aggregatum	25.33	34.78	28.64	29.59	12.34	11.54	14.31	12.73	18.84	23.16	21.48	21.16
G. arborense	15.37	46.84	44.49	35.57	12.80	17.43	16.36	15.53	14.10	32.14	30.42	25.54
G. cerebriforme	19.60	27.53	40.33	29.15	9.39	11.32	15.00	11.91	14.50	19.43	27.67	20.53
G. diaphanum	8.68	24.36	20.13	17.72	8.21	10.64	7.22	8.69	8.44	17.50	13.67	13.21
G. etunicatum	16.08	47.17	23.78	29.01	12.21	13.12	14.62	13.31	14.14	30.15	19.20	21.16
G. fasciculatum	16.64	47.15	54.99	39.53	10.92	13.15	17.80	13.96	13.68	30.15	36.40	26.74
G. hoi	19.27	52.60	28.56	33.48	11.47	7.99	14.91	11.46	15.37	30.31	21.73	22.47
G. intraraces	18.97	40.53	31.29	30.26	9.58	15.34	11.43	12.10	14.24	27.94	21.36	21.18
Control	4.54	7.62	4.34	5.50	3.59	3.79	4.56	3.98	4.06	5.71	4.45	4.74
Mean	15.82	33.60	32.78	27.40	9.99	11.24	14.03	11.76				
Pooled mean	12.91	22.42	23.41									
$LSD_{0.05}$	V@=1.26	S=1.03	A=2.41	S*V=1.78		V*A=4.18		S*A=3.41		S*V*A=5.91		

@V: Variety, S: Soil order, A: Arbuscular mycorrhiza

Table 13: Colonization index of three varieties of wheat in two common soil types of Central India

AM species	Alfisol				Vertisol				Varietal means			Pooled mean
	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	Mean	WH 147	LOK 1	Kathiya	
<u>Colonization index</u>												
A. mellea	38.14	40.45	31.97	36.85	36.41	32.65	21.61	30.22	37.28	36.55	26.79	33.54
A. scrobiculata	42.49	38.60	16.58	32.56	35.90	37.28	23.37	32.19	39.20	37.94	19.97	32.37
G. aggregatum	43.22	50.27	19.69	37.73	36.53	37.01	27.46	33.67	39.88	43.64	23.58	35.70
G. arborense	58.70	51.56	21.84	44.03	48.89	33.11	36.96	36.32	53.80	42.33	24.40	40.18
G. cerebriforme	45.04	56.15	38.76	46.65	46.17	47.68	37.59	40.48	45.61	51.91	33.18	43.56
G. diaphanum	48.05	42.36	33.28	41.23	41.61	33.74	33.93	36.43	44.83	38.10	33.60	38.83
G. etunicatum	40.45	57.23	26.97	41.55	44.31	39.86	34.84	39.67	42.38	48.55	30.91	40.61
G. fasciculatum	53.00	41.42	35.10	43.17	48.41	39.73	32.62	40.26	50.17	40.58	33.85	41.71
G. hoi	46.80	38.25	35.38	40.14	55.30	40.39	40.11	45.26	51.05	39.32	37.74	42.70
G. intraraces	56.50	49.64	33.00	46.38	48.91	56.81	39.00	48.24	52.71	53.23	36.00	47.31
Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	42.95	42.36	27.43	37.68	40.22	36.21	21.13	34.45				
Pooled mean	41.58	39.28	27.27									
$LSD_{0.05}$	V@=2.77	S=2.26	A=5.30	S*V=NS		V*A=9.17		S*A=7.49		S*V*A=NS		

*V: Variety, S: Soil order, A: Arbuscular mycorrhiza

Table 14: Effect of tree shade on nodulation, arbuscular mycorrhizal colonization and growth of pea

Light conditions	Sampling date			Mean
	18.01.13	31.01.13	19.02.13	
Number of nodules per plant				
In open	27	13	14	18
In tree shade	1	3	7	3
Mean	14	8	10	
Colonization index(%)				
In open	19.8	10.0	8.0	12.6
In tree shade	1.7	1.9	3.9	2.5
Mean	10.7	6.0	6.0	
Shoot Length (cm)				
In open	31.4	36.2	47.6	38.4
In tree shade	23.6	29.9	44.9	32.8
Mean	27.5	33.0	46.2	
Root length (cm)				
In open	16.0	15.9	15.8	15.9
In tree shade	17.3	16.4	15.9	16.5
Mean	16.6	16.2	15.9	
Dry Shoot Weight (g)				
In open	1.346	2.126	4.456	2.641
In tree shade	0.544	1.387	2.736	1.556
Mean	0.945	1.757	3.594	
Dry Root Weight (g)				
In open	0.152	0.107	0.132	0.130
In tree shade	0.056	0.115	0.078	0.083
Mean	0.104	0.111	0.105	
Total Dry Weight (g)				
In open	1.498	2.233	4.584	2.771
In tree shade	0.600	1.502	2.814	1.639
Mean	1.049	1.867	3.699	
	LSD 0.05			
	Sampling date	Light conditions		Interaction
Number of nodules per plant	NS	4		8
Colonization index	NS	4.1		7.0
Shoot length	7.1	NS		NS
Root length	NS	NS		NS
Dry shoot weight	0.744	0.607		NS
Dry root weight	NS	0.139		NS
Total dry weight	0.756	0.617		NS

Table 15: Presence of arbuscular mycorrhizae and rhizobium in rhizosphere of wheat, pea and chickpea at NRCAF and nearby farmer's field

S. No.	Location	Soil type	Date of sampling	Number of nodules per plant	Arbuscularmycorrhizal colonization index
Wheat					
1.	Simardha block (Aonla experiment)	Black	02.02.13	-	40.0
2.	Simardha block (Guava experiment)	Yellow	02.02.13	-	63.6
3.	*Albizia* experiment	Red	06.02.13	-	27.4
4.	Bamboo experiment	Red	06.02.13	-	23.4
5.	Near bio-diesel plant	Red	04.01.13	-	4.8
6.	Mango plot	Black	11.01.13	-	29.4
7.	Near eucalyptus experiment	Black	09.01.13	-	1.3
8.	Village: Simardha (Sh Karamsingh Yadav)	Red (DAP, Urea)	06.02.13	-	77.8
9.	Village: Simardha (Sh BabuLal Kushwaha)	Red	06.02.13	-	77.1
10.	Bada Gaon (Sh Raja Ram)	Black	11.02.13	-	39.4
11.	Village: Raksha (Sh Papu Kushwaha)	Black	11.02.13	-	55.3
12.	Village: Raksha (Sh Amar Singh)	Black	11.02.13	-	43.5
13.	Village: Bhojala (Sh Jai Ram Kushwaha)	Red	12.02.13	-	31.5
14.	Village: Bhojala (Sh Lashman)	Red	11.02.13	-	
15.	CASU, Jhansi	Red	11.02.13	-	
Pea					
1.	Custard apple field	Red	06.02.13	4	0.7
2.	Village: Bada Gaon (Ram Prasad)	Black	11.02.13	36	67.5
3.	Village: Raksha (Sh Amar Singh)	Black	11.02.13	22	75.0
4.	CASU, Jhansi	Red	12.02.13	37	57.5
Bengal-gram					
1.	Bamboo field	Red	06.02.13	29	17.6
2.	Near pond	Black	07.02.13	32	59.4
3.	Village: Simardha (Sh Karamsingh Yadav)	Red	06.02.13	81	93.3
4.	Village: Simardha (Sh BabuLal Kushwaha)	Red	06.02.13	81	91.9
5.	Village: Raksha (Sh Papu Kushwaha)	Black	11.02.13	37	71.5
6.	Village: Bhojala (Sh Sunil Yadav)	Red	12.02.13	36	81.3
7.	CASU, Jhansi	Red	12.02.13	40	83.2
8.	Village: Raksha (Sh Amar Singh)	Black	12.02.13	33	

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

(Rajendra Prasad & Ram Newaj)

Soil Health indicators values

During the year soil samples were collected from different agroforestry systems (AF) for assessing soil health indicator values in surface (0-15 cm) and sub-surface (15-30 cm) soil layers. The detailed data on porosity, water holding capacity (WHC), available P, cation exchange capacity (CEC) and potential nitrogen mineralization (PNM) for *E. officinalis* based AF system involving four soil moisture conservation (SMC) techniques *viz.* normal planting, stone mulch, deep basin and deep basin+ ploughing have been presented in Table 16.

Table16: Soil health indicators values of Aonla (*E. officinalis*) based AF system

Moisture conservation Treatments	Tree-Rhizosphere zone		Non-Rhizosphere zone	
	0-15cm	15-30cm	0-15cm	15-30cm
Porosity (%)				
Normal Planting	42.89	36.83	37.83	35.41
Stone mulch	43.83	36.65	38.01	36.36
Deep basin	40.85	38.70	38.23	35.81
Deep basin+ Deep plowing	42.29	41.21	37.93	37.52
Water holding capacity (%)				
Normal Planting	12.79	11.70	11.40	12.43
Stone mulch	11.79	9.99	10.38	10.10
Deep basin	13.68	14.98	13.18	12.97
Deep basin+ Deep plowing	13.78	12.39	12.80	12.20
Available phosphorus ($kgha^{-1}$)				
Normal Planting	9.72	8.43	9.07	7.17
Stone mulch	9.69	9.99	9.84	7.81
Deep basin	11.11	12.61	11.86	9.20
Deep basin+ Deep plowing	11.60	11.70	11.65	7.60
Cation exchange capacity (C mol+ kg^{-1} soil)				
Normal Planting	11.02	9.58	7.59	9.61
Stone mulch	10.89	8.06	8.66	8.76
Deep basin	17.79	13.04	12.03	10.74
Deep basin+ Deep ploughing	14.90	11.20	10.96	9.14
Potential N mineralization rate ($mgkg^{-1}$ $soild^{-1}$)				
Normal Planting	8.82	7.36	10.88	7.91
Stone mulch	8.08	7.36	8.54	7.51
Deep basin	12.85	11.31	13.81	11.60
Deep basin+ Deep ploughing	11.79	10.47	12.31	12.59

In general, deep basin technique of SMC had highest values of WHC, CEC, available P and PNM while deep basin+ ploughing had highest porosity. As compared to normal planting, SMC techniques had brought improvement in observed soil health indicator values (Fig.19). Irrespective of soil depth and SMC techniques, on an average tree-rhizosphere soil had higher values of all studied indicator except PNM than non-rhizosphere soil. In case of PNM reverse was true (Fig. 20). Keeping rhizosphere zone aside, values of all soil health indicators were more in surface soil than sub-surface soil layers (Fig. 21). The PNM was directly related to C/N ratio of soil and it decreased with increase in C/N ratio (Fig. 22).

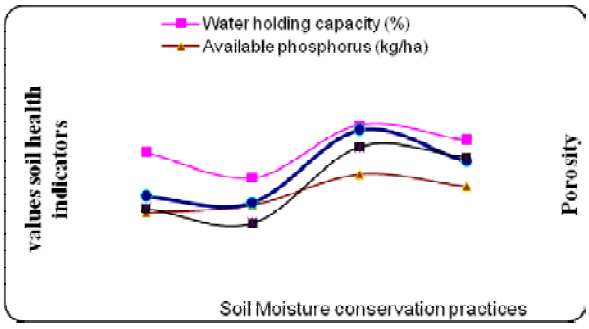


Fig.19: Effect different soil moisture conservation practices on soil health indicators values (0-30 cm) of Aonla (*E. officinalis*) based agroforestry system

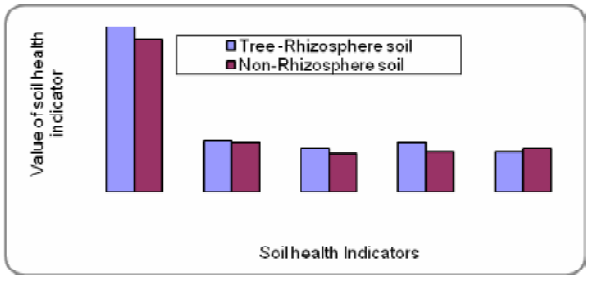


Fig. 20: Effect of tree rhizosphere on soil health indicators in Aonla *(E. officinalis)* based agroforestry system

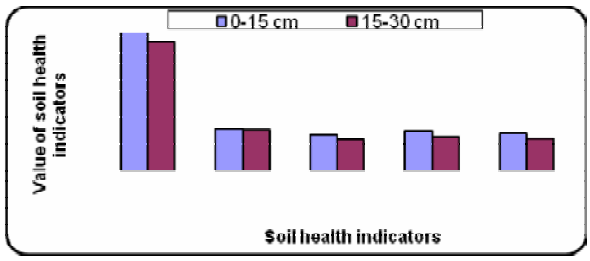


Fig.21: Effect of sampling depth on soil health indicators in Aonla (*E. officinalis*) based agroforestry system

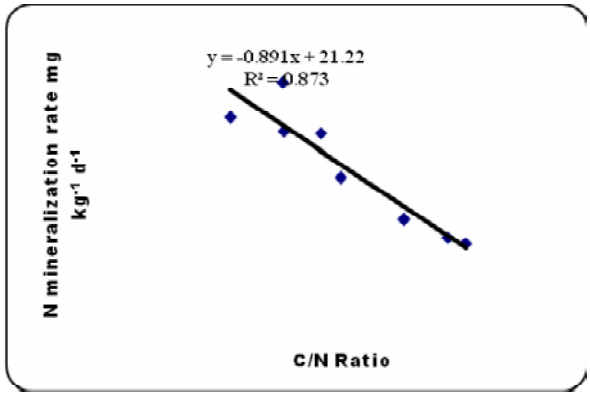


Fig.22: Effect of C/N ratio on Potential N mineralization in soil in Aonla *(E. officinalis)* based agroforestry system

The data on soil health indicator values (WHC, available P and CEC) from *H. binata* based AF systems (black soil) involving different tree densities (Table 17) indicated that on an average, surface soil had more values than sub-surface soil. As indicated from observed values of indicators, tree density of 400 treeha^{-1} had shown highest values while the least by control (pure crop).

Table 17: Soil health indicators values of 20 year old Anjan-I *(H. binata-I)* based agroforestry system (black soil)

Soil quality indicator	Indicator values							
	D1: 220 treesha^{-1}		D2: 400 treesha^{-1}		D3: 800 treesha^{-1}		Control	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Water holding capacity (%)	22.8	16.3	25.2	21.3	24.9	22.6	20.5	19.7
Available P (kgha^{-1})	16.9	16.5	20.4	17.9	19.5	16.8	13.2	14.2
CEC (C mol+ kg^{-1} soil)	24.0	15.8	27.6	19.7	27.7	19.7	22.3	16.5

Increasing tree density from 200 to 400 treeha^{-1} had improved value of soil quality indicator and further increase in tree density to 800 tree ha^{-1} did not yield any additional influence on soil quality indicators (Fig 23).

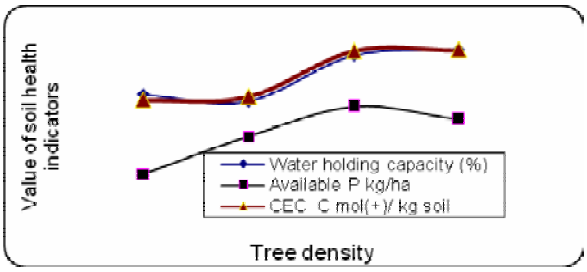


Fig. 23: Effect of tree density on Soil health indicators (0-30 cm) of 20 year old *H. binata* based agroforestry system (black soil)

Data on WHC, available P and CEC from *H. binata* based AF system (red soil) involving four levels of pruning *viz.* control 25, 50 and 75% canopy pruning has been given in Table 18. In all pruning levels, values of indicators were more in surface than sub-surface soil. Irrespective of soil depths, highest indicator values were observed in 50% pruning while least in control (Fig. 24).

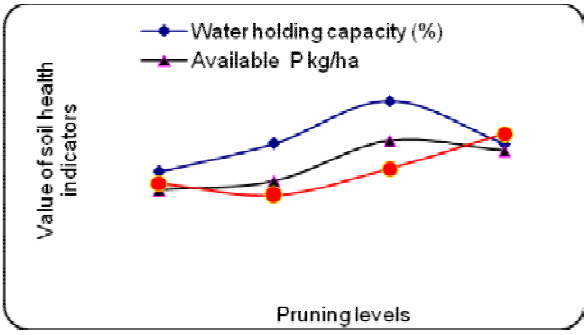


Fig.24: Effect of Pruning levels on soil quality indicators (0-30 cm) of Anjan-II (*H. binata*-II) based agroforestry system (red soil)

Increasing pruning level from 25 to 50% canopy had positive effect on values of soil health indicators. Further increasing in pruning level to 75% pruning did not yield respect to soil health.

In addition to above said AF systems, physical, chemical and biological characteristics of six other ongoing agroforestry trials were also estimated (Table 19). The textural class of soil varied from loam to silt loam and clay loam. Wide variation in physical, chemical and biological properties was observed in different agroforestry trails. The WHC varied from 11.4 to 26.6%, B. D. from 1.43 to 1.52 gcm^{-3}, Soil pH from 6.75 to 8.34, EC from 66.9 to 416 ìSm^{-1}, SOC from 0.26 to 0.57%, available N from 308.3 to 492.3 kgha^{-1}, available P from 7.3 to 12.4 kgha^{-1} and dehydrogenase activity from 34.4 to 117.2 ìg TPFg^{-1}day^{-1}. In-comparison to open field, all AF trials have recorded more values of B.D., SOC and dehydrogenase activity indicating thereby beneficial effects on soil health.

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

(S K Dhyani, R K Tewari, Ramesh Singh, R P Dwivedi, D R Palsaniya & Dr. R H Rizvi)

National Research Centre for Agroforestry, Jhansi has selected Garhkundar-Dabar watershed in 2005-06 to improve rural livelihood through

Table 18: Soil health indicators values of Anjan-II *(H. binata-II)* based agroforestry system (red soil)

Soil quality indicator	Indicator values							
	Control		25% Pruning		50% Pruning		75% Pruning	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Water holding capacity (%)	14.2	12.7	15.5	14.3	18.9	15.1	16.3	13.5
Available P (kgha^{-1})	13.9	11.2	15.0	11.0	17.3	12.8	16.1	13.0
CEC (C mol+kg^{-1} soil)	13.8	11.9	13.8	10.7	14.6	12.7	17.3	13.5

Table19: Physical, Chemical and Biological Characteristics of soils under different Agroforestry Systems

Characters	Agroforestry Systems						
	P. pinnata	*A. nilotica*	*A. senegal-I*	*A. senegal-II*	*E. officinalis*	*D. sissoo*	Open field
Description of Agroforestry Systems							
Age (years)	5	3	3	3	7	16	-
Height (m)	3.6	4.8	3.0	3.0	4.2	14.8	-
dbh / CD (cm)	8.8	14.7 (CD)	7.0 (CD)	7.0 (CD)	11.8 (CD)	21.6	-
Associated crops	-	-	Mustard	Mustard	Mustard	Wheat	Wheat
Physical Characteristics of soil (0-30 cm depth)							
Sand (%)	39.5	34.0	30.0	23.5	34.0	31.5	21
Silt (%)	34.1	38.6	46.6	55.0	39.6	41.0	55.8
Clay (%)	26.4	27.4	23.4	21.5	26.4	27.5	23.2
Soil texture Class	Loam	Clay loam	Loam	Silt loam	Loam	Clay loam	Silt loam
WHC (%)	11.4	18.0	20.3	20.6	26.6	20.1	19.3
B.D. (gcm^{-3})	1.43	1.46	1.45	1.47	1.46	1.46	1.52
Chemical and biological characteristics of soil (0-30 cm depth)							
Soil pH (1:2)	6.75	7.22	7.60	8.34	8.33	6.79	7.44
Soil EC (μSm^{-1})	83.02	88.6	134.9	416.5	350.8	66.9	72.7
SOC (%)	0.44	0.55	0.55	0.57	0.48	0.36	0.26
Available N (kg ha-)	308.3	340.8	431.7	492.3	399.3	380.5	414
Available P(kg ha^{-1})	8.2	12.4	11.0	7.3	8.0	8.5	8.9
Dehydrogenase activity (μg TPF g^{-1} day^{-1})	113.6	117.2	46.7	67.0	38. 6	87.6	34.4

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. Progress made during the year 2012 under different heads is as follow:

Hydrological Monitoring

Several *in-situ* and *ex-situ* interventions were implemented in the watershed which had been described in the previous reports.Datalogger based automatic stage level recorders were installed at six sites, including control watershed, to measure runoff during rainy season. Besides this, manual and self-recording rain gauges were also installed in the watershed to measure the rainfall. Total 821.3 mm rainfall was received and it was spread over in 41 rainy days (Fig. 25).

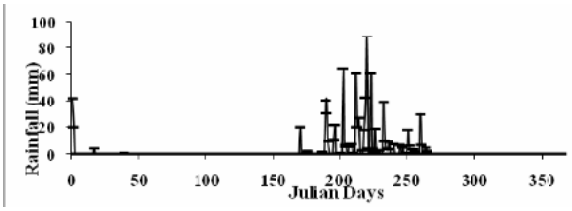


Fig. 25: Rainfall recorded at Garhkundar-Dabar watershed during 2012

Groundwater recharge increased linearly in control watershed, whereas groundwater recharge in treated watershed reached to its maximum capacity (70-75 mm)

after receiving of 700-800 mm rainfall. Storage capacity of groundwater aquifer is limited therefore additional rainfall could not help in further groundwater recharge. Results indicated that integrated watershed development interventions reduced surface runoff and enhanced groundwater recharge and ET.

All open shallow dug wells (112 nos.) in the watershed were monitored fortnightly for water level. The average depth of the wells are 8.54 m. Due to conservation measures (series of gabions and checkdams, field bunding and vegetative measures) taken in the watershed, 96 per cent wells were wet with 3.96 average water column during December 2012. It is found that the number of Diesel pump set increased to 78 as compared to 46 in the beginning of the project. *Rabi* sowing was done in entire cultivable land of the watershed (Fig. 26).

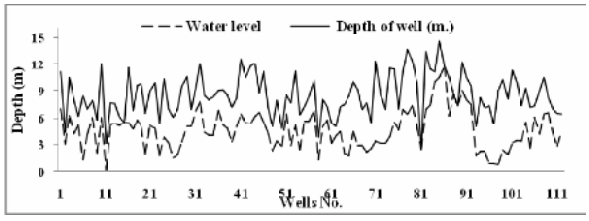


Fig. 26: Water level in open wells during December 2012

Crop and Agroforestry Demonstration

During the year, growth, fruit yield and crop yield from agrihorticulture system on farmers' field were recorded in Garhkundar-Dabar watershed (Table 20a & 20b). These plantations were raised in 2007.

The growth of plants on different farmers field ranged between 3.02 to 4.04 (height), 9.11 to 12.0 cm (collar diameter) and 3.2 to 4.6 m canopy spread. Still, the canopy is open even after 5 years of plantation. Fruit yield of guava was recorded 15-18.4 kgtree^{-1} on two farmers field while that of citrus 5.1 kg and aonla 5.6 kgtree^{-1}. This has added to their income and helping in risk partitioning. Crop yields under agrihorticulture system on farmers' field are comparable with average crop yields of the area. Wheat yielded 2.85 to 3.06, gram 1.28 to 1.37 and groundnut 1.18 to 1.35 tha^{-1} under different agroforestry systems.

Crop yield of wheat, gram, groundnut, sesame and black gram under sole cropping

Table 20a: Growth of fruit plants under agrihorticulture system on farmer's field in Garhkundar-Dabar watershed

Farmer Name	Fruit crop	Height (m)	Collar Diameter (cm)	Spread (m)
Sh.Dhani Ram	Guava	3.02	9.30	3.2
	Citrus	3.66	9.11	4.1
Sh. M. Salim Khan	Guava	4.04	11.06	4.6
Sh.Himmat	Aonla	3.90	12.0	4.3

Table 20b: Fruit and crop yield under Agri horticulture system on farmer's field

Farmer Name	Fruit crop	Yield (kg tree^{-1})	Crop	Yield (tha^{-1})
Sh. Dhani Ram	Guava	18.4	Wheat* Groundnut	2.85 1.26
	Citrus	5.1	Gram* Groundnut	1.37 1.18
Sh. M. Salim Khan	Guava	15.0	Wheat* Groundnut	3.06 1.35
Sh.Himmat	Aonla	5.6	Gram*	1.28

*Recorded during 2011-12

was recorded 3.45, 1.72, 1.27, 0.67 and 0.72 tha^{-1}, respectively. Further, during the year, 1335 saplings of 7 species were planted on field bunds mostly as replacement. The survival of plants as recorded in December, 2012 is given in Table 21.

Average survival of plants was recorded 86.7%.*A.senegal* and teak recorded maximum (about 94%) survival while bamboo recorded only 41% survival. Other species recorded survival above 72%. Low survival of bamboo plants was due to naked root planting of sapling raised by cutting in nursery bed. This can further be improved by planting containerized sapling. Based on farmers demand for planting material in Garhkundar-Dabar watershed, it is concluded that farmers prefer species which can withstand high biotic pressure. Teak, Kumat and Bamboo have proved their superiority, hence in great demand. MaaShitala Shelf Help Group of Village Kundar became self-reliant as they have accrued assets plus cash of about '94,000 while Shiv Shakti Shelf Help Group of Shivrampur village has assets of ₹25,000.

Table 21: Plantation and survival of plants in Garhkundar-Dabar watershed during 2012

Species	Planted	Survival	% Survival
Teak	600	563	93.8
Bamboo (*B. vulgaris*)	200	82	41.0
A. senegal	410	387	94.4
Aonla (NA-7)	50	36	72.0
Guava (L-49)	40	31	77.5
Custard apple	25	18	72.0
Pomegranate	50	41	82.0
Total	1335	1158	86.7

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

(Ajit, A K Handa & R H Rizvi)

Generalized models for predicting stem volume of Eucalyptus spp.

A total of five published equations on volume could be traced for the state of Uttar Pradesh. These equations pertain to Jhansi and Muzaffarnager. The observed range of DBH values for the harvested trees varied from 8 to 39 cm and the observed range for the stem volume varied from 0.002658 to 1.844566 (m^3tree^{-1}). The equation Stem Volume = $0.00006^* (dbh)^{2.649141}$with ($R^2$=0.89181) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbhvalues in UP.

A total of three published equations on volume could be traced for the state of Uttrakhand. These equations pertain to Dehradun and Pantnagar. The observed range of values dbh for the harvested trees varied from 6 to 40 cm and the observed range for the stem volume varied from 0.005661 to 0.847136 (m^3tree^{-1}). The equation Stem Volume = $0.00159^*(dbh)^{1.72411}$with (R^2=0.87775) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbh values in Uttrakhand.

A total of five published equations on volume could be traced for the state of Rajsthan. These equations pertain to Jodhpur. The observed range of dbh values for the harvested trees varied from 5 to 52 cm and

the observed dbh for the stem volume varied from 0.007763 to 2.203535 (m^3tree^{-1}). The equation Stem Volume = $0.00057*(dbh)^{2.08136}$ with (R^2=0.95055) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbh values in Rajasthan.

A total of eight published equations on volume could be traced for the state of Punjab. These equations pertain to Ludhiana, Firozepur and Patiala. The observed range of dbh values for the harvested trees varied from 7 to 32 cm and the observed range for the stem volume varied from 0.008666 to 0.893252 (m^3tree^{-1}). The equation Stem Volume=$0.00005*(dbh)^{2.80441}$ with (R^2= 0.97852) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbh values in Punjab.

Only one published equations on volume could be traced for the state of Bihar. This equation pertains to Ranchi. The observed range dbhrange for the harvested trees varied from 2 to 14 cm and the observed range of values for the stem volume varied from 0.000908 to 0.096032 (m^3tree^{-1}). The equation Stem Volume= $0.00006*(dbh)^{2.82030}$ with (R^2=0.99867) is proposed to be used for predicting or estimating the stem volume of the standing tree on the basis of their observed dbh values in Bihar.

A total of two published equations on volume could be traced for the state of Tamilnadu. These equations pertain to Nillgiris Hill. The observed range of values dbh for the harvested trees varied from 5 to 30 cm and the observed range for the stem volume varied from 0.136 to 0.9286 (m^3tree^{-1}). The equation Stem Volume = $0.01863*(dbh)^{1.14922}$ with (R^2=0.98740) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbh values in Tamilnadu.

Country level Stem Volume Generalized Equation: A total of 24 published equations on volume could be traced for the states of Uttar Pradesh, Uttarakhand, Rajasthan, Punjab, Bihar and Tamilnadu. These equations pertain to Jhansi, Ranchi, Dehradun, Pantnager, Jodhpur, Ludhiana, Firozepur, Patiala and Nillgiris Hill. The observed range of dbh values for the harvested trees varied from 2 to 52 cm and the observed range for the stem volume varied from 0.000908 to 2.203535 (m^3tree^{-1}). The simulated data points (dbh and stem volume) for these equations were clubbed into one data set for country level as a whole and allometric equation (Stem Volume=$A*(dbh)^B$ was fitted on this country level data set. The parameter estimates (A and B) along with their asymptotic standard error and wald confidence interval were computer using non-linear regression. The equation Stem Volume=$0.00060*(dbh)^{2.07699}$ with (R^2=0.86981) is proposed to be used for predicting the stem volume of the standing tree on the basis of their observed dbh values. This equation can be used to predict the stem volume for the dbh range of 2 to 52 cm at country level.

Country level Above Ground Biomass Generalized Equation: A total of eight published equations on AGB (above ground biomass) could be traced for the states of Uttar Pradesh, Uttrakhand, Bihar, Tamilnadu and some raw data pertaining to Haryana and Karnataka. These equations pertain to Jhansi, Samastipur, Dehradun, Pantnager and Nillgiris Hill. The observed range of values dbh for the harvested trees varied from 1 to 42 cm and the observed range for the AGB varied from 2.43 to 1707.35 ($Kgtree^{-1}$). The simulated data points (dbh and Above Ground Biomass) for these equations were clubbed into one data set for country level as a whole and allometric

equation ($AGB=A*(dbh)^B$ was fitted on this country level data set. The parameter estimates (A and B) along with their asymptotic standard error and wald confidence interval were computer using non-linear regression. The equation $AGB=0.74*(dbh)^{1.81}$ with ($R^2=0.91$) is proposed to be used for predicting the Above Ground Biomass of the standing tree on the basis of their observed dbh values. This equation can be used to predict the AGB for the dbh range of 1 to 42 cm at country level.

ICAR Net Work Project

National Initiative on Climate Resilient Agriculture

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

In the second year of the project the major focus was to assess carbon sequestration potential of agroforestry practices adopted by the farmers in Bulandsahar, Gorakhpur (Uttar Pradesh), Mandi (Himachal Pradesh) and Faridkot and Nawahsahar (Punjab), mapping agroforestry area in Punjab using remote sensing and GIS technique and to study thermotolerance of crops and MPTs for agroforestry importance under Temperature Gradient Tunnel (TGT).

The area statistics obtained for different land uses and land covers for Punjab is presented in Table 22 and Fig. 27 & 28. According to this classification, agroforestry area was estimated to be 272504.51 ha, which is 5.43 per cent of total geographic area. Cropland has an estimated area of 80.13 per cent; forest, plantation, grassland and wasteland have 3.14, 1.31, 2.47 and 1.34 per cent, respectively area under them. As far as area under agroforestry at district level is concerned, highest area was found in Bhatinda district (7.02%) and lowest in FatehgarhSaheb district (2.97%). Ground truth verification was done in two districts namely, Bhatinda and Patiala and GPS points

Table 22: Land use/land covers statistics for Punjab state

Sl. No.	Land use/ land cover	Area (ha)	Area (%)
1	Agroforestry	2,72,504.51	5.43
2	Cropland	40,22,670.82	80.13
3	Plantation	65,902.87	1.31
4	Forest (dense + open)	1,57,818.13	3.14
5	Grassland	1,23,955.89	2.47
6	Wasteland	67,502.07	1.34
7	River sand	16,220.33	0.32
8	Water/ water bodies	32,224.43	0.64
9	Builtups	2,61,183.74	5.20
Total		**5019982.79**	**100.00**

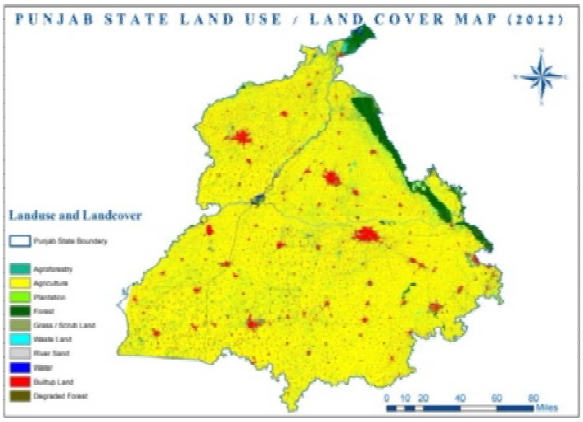


Fig. 27: Land uses and land covers in Punjab

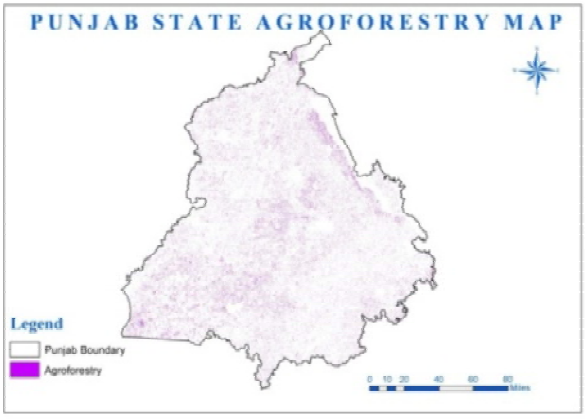


Fig. 28: Agroforestry area in Punjab

for agroforestry were collected. The accuracy in agroforestry class in these two districts came out to be 81.25 and 78.75 percent, respectively. Thus, on this basis, overall accuracy in agroforestry class is about 80 percent for Punjab state.

During the year, 13 districts spreading over Uttrakhand, Himachal Pradesh, Haryana, Punjab and Uttar Pradesh were surveyed for existing agroforestry systems. Soil samples from 61 villages representing different AF systems were collected from surface (0-15 cm) and sub-surface (15-30cm) soil layers. After processing soil samples were analysed for soil organic carbon (SOC). Wide variation in SOC was noticed among different districts across various states. In general, SOC content was more in surface soil layers (0-15 cm) than sub-surface soil layers (15-30 cm). In surface soil, maximum SOC was observed in Mandi district (8.89 gkg^{-1}) of Himachal Pradesh while, minimum in Nawansahar district (3.25 gkg^{-1}) of Punjab. In sub-surface soils, maximum amount (7.62 gkg^{-1}) of SOC was observed in Dehradun district of Uttrakhand while, in Faridkot district of Punjab the least (2.12 gkg^{-1}). On an average, highest amount of SOC in 0-30 cm soil depth was observed in Dehradun district (34.3 $Mgha^{-1}$) of Uttrakhand whereas, minimum in Nawansahar (12.7 $Mgha^{-1}$) in Punjab.

Irrespective of districts, soil samples collected from Uttrakhand were found to have maximum SOC followed by Himachal Pradesh. Minimum amount of SOC was found in soils collected from Punjab. The SOC content also varied among different agroforestry systems. Among all the AF systems from which soils were collected, maximum amount of SOC was found in silvipasture, which was at par with pure horticultural orchards in surface layers. The minimum amount of SOC was found in agricultural field. Sub-surface layers had lower SOC than surface soil layers. All the AF systems were found to have more SOC than pure agricultural crop field.

The carbon sequestration potential of agroforestry practices in two districts of Uttar Pradesh (Bulandsahar and Gorakhpur), two districts of Punjab (Faridkot and Nawahsahar) and one district of Himachal Pradesh (Mandi) was studied during the year of report. The dominant tree species recorded in Bulandshahar and Gorakhpur are *Eucalyptus tereticornis* and *Populus deltoids* under fast growing, *Dalbergia sissoo, Syzygium cumini, Tectona grandis*, *Azadirachta indica, Mangifera indica, Acacia nilotica* under medium growing and *Psidium guajava*, *Zizyphus mauritiana*, *Artocarpus heretophylus* under slowgrowing. The total number of trees per hectare recorded in these districts was 7.01 and 15.78 trees ha^{-1}, respectively. The tree biomass and soil carbon in baseline under Bulandshahar was 2.71 and 10.65 t ha^{-1}, respectively and in Gorakhpur, these were 18.20 and 9.89 t ha^{-1} respectively. The tree biomass and total carbon stock after 30-year would be 8.65and 17.37 t ha^{-1} in Bulandsahar. Similarly in Gorakhpur, tree biomass and total carbon stock after 30-year would be 31.66 and 27.42 t ha^{-1}.

In Faridkot and Nawahsahar of Punjab, the common tree species are *Eucalyptus tereticornis*, *Melia azedarach, Populus* spp. and *D. strictus*. The tree density in Faridkot was 1.94 trees ha^{-1} in Nawahasar there were 13.85 trees ha^{-1}. The tree biomass in baseline was 0.58 and 6.70 t ha^{-1} in Fridkot and Nawahsahar, respectively and after 30-year it will be increased slightly. The total carbon available in agroforestry practices as baseline in Faridkot was 22.91 t C ha^{-1} and it will be 26.25 t C ha^{-1} after 30-year. Similarly, in Nawahsahar, total carbon in baseline was 17.25 t C ha^{-1} and after 30-year it would increase up to 22.21 t C ha^{-1}. In district Mandi (Himachal Pradesh) the most common tree

species are *Pinus roxburghii*, *Morus alba*, *Cedrus deodara*, *Delonix regia* and *Eucalyptus tereticornis*. Tree density in this districts was 50.91 tree ha^{-1} and tree biomass in baseline was 29.40 t ha^{-1} and it will be increased up to 69.82 t ha^{-1} after 30-year. The total carbon stock in baseline was 41.62 t C ha^{-1} and it would be 69.98 t C ha^{-1} after 30-year.

In connection with the studies on thermotolerance of crops and MPTs for agroforestry importance for climate resilient agriculture, various experiments have been conducted under newly fabricated Temperature Gradient Tunnel (TGT) at the Centre with a target temperature of 5°C above ambient temperature with a step gradient of 1°C through Sector 1 to Sector 5 inside the TGT. Most emphasis in the initial experiment was to study and monitor the environmental variables as obtained inside the TGT along with the experiments conducted with the select crops and tree saplings. A collective effect of elevated temperature was found on per plant yield as well (Fig.29&30), which indicated that the grain yield of blackgram under ambient (open) condition was higher than yield achieved under TGT. However, the grain yield of crop was higher in sector -1 and decreased with increasing in temperature with 1°C in sector 2, 3, 4 and 5. In case of til, the grain yield was higher under TGT than ambient condition. For greater details studies, on protein profiling through SDS-PAGE was also done (Plate-2). Several other important studies at cellular and molecular level through different assay and isolation techniques, enzyme kinetics, plants and soil analysis are in progress. Similar experiments with rabi crops like mustard and wheat have also been conducted and data analysis is in progress.

Similar experiments are also being conducted on MPTs like *Pongamia pinnata* and *Dalbergia sissoo* plants inside TGT and under ambient conditions. From preliminary studies with the young saplings of these two MPTs, it has been noted that there is some initial increment in plant height but at advanced stage it may be affected otherwise

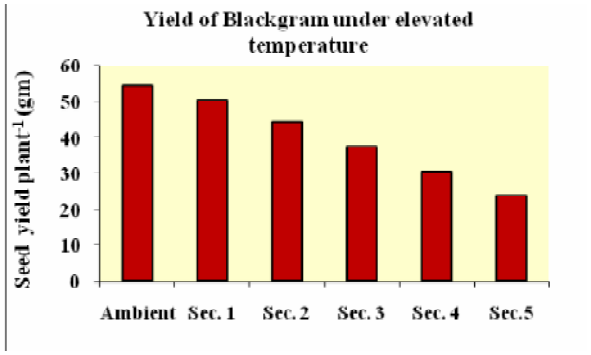


Fig. 29: Grain yield of black gram under elevated temperature

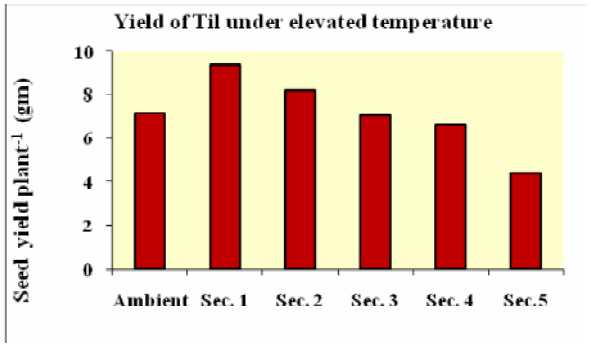


Fig. 30: Grain yield of til under elevated temperature

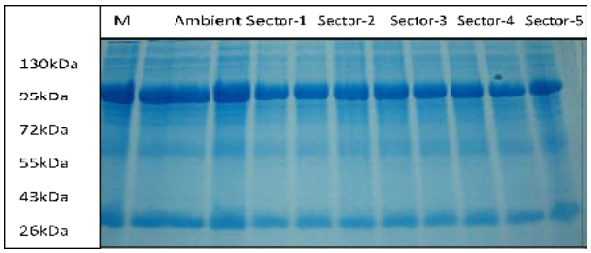


Plate 2: SDS-PAGE of blackgram grown under elevated temperature and ambient as control. At 72kDa RUBISCO protein shows major difference

and monitoring of plant growth and other relevant physiological studies are in progress under elevated temperature (Fig. 31).

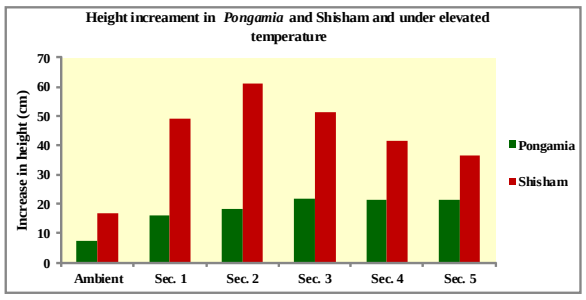


Fig. 31: Height increment of *Pongamia* and Shisham under elevated temperature

MoRD, New Delhi

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

(S K Dhyani, Ramesh Singh, R K Tewari, D R Palsaniya, R H Rizvi & K B Sreedhar)

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 activities through participatory watershed development programme through cost-effective integrated natural resource management 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 socio-economic and livelihood analysis, water resource development, top working of ber, crop and agroforestry demonstration was taken up. The brief report under different heads is as follows:

Socio-economy of watershed

In the watershed total 26 women self-help groups (WSHGs) were formed and their accounts were opened in the bank. The total members in WSHGs are 270. Sixteen WSHGs have started different activities with the assistance from the revolving fund. The list of WSHGs started activities during the year is given in Table 23.

Water resource development

During the year 2012, total rainfall of 670.25 mm was received which was spread over in 32 rainy days (Fig. 32) In the watershed, open shallow dug wells are the only means of irrigation to the crops. These wells are situated in weathered zone (unconfined aquifer) above granite rock and have slow rate of recharge due to low water column. Due to integrated watershed development interventions, higher water table were recorded in open wells (Fig. 33).

Table 23: WSHGs, activities and financial details

Sl. No.	Village	Name of group	No. of Members	Name of activity	Assistance from revolving fund (₹)
1	Domagor	Thakur Baba WSHG	10	Vegetable Cultivation	20000
2	Domagor	Karodi Baba WSHG	10	Goat rearing	20000
3	Domagor	Ma Gauri WSHG	10	Goat rearing	20000
4	Nayakheda	Bishnu WSHG	10	Goat rearing	20000
5	Nayakheda	Jagdamba WSHG	12	Vegetable Cultivation	20000
6	Nayakheda	Jai Bhole Baba WSHG	10	Vegetable Cultivation	20000

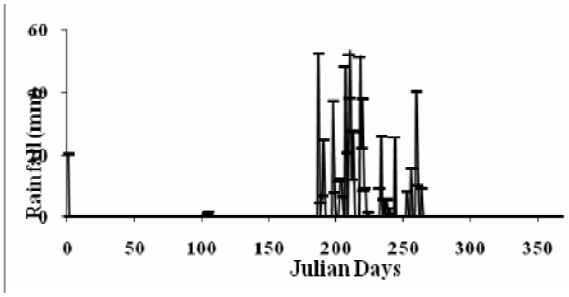


Fig. 32: Daily rainfall in the watershed during 2012

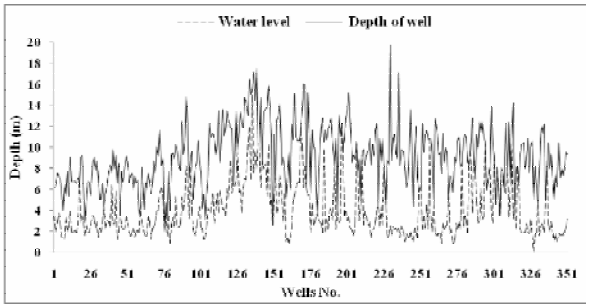


Fig. 33: Water level in open wells at DomagorPahuj watershed during Dec. 2012

Crop demonstration

Participatory groundnut trials

Ninety participatory trials were conducted during *Kharif* - 2012 to promote use of micro nutrients (MN) and PSB in groundnut (varieties- TAG-24 and TAG-37A). Micro-nutrient and PSB were provided by Dept. of Ag., Jhansi. Observation was taken from 18 participatory trials and compared with local variety *Jhumuku*. Average production (pod yield) of TAG-37A with MN and PSB was observed to have highest yield (1736 kgha^{-1}) followed by TAG-24 (1483 kg ha^{-1}) and Jhumuku (1135 kgha^{-1}). It was observed that application of MN and PSB increased the groundnut yield by 16 to 18 % irrespective of varieties (Table 24).

To promote vegetable, fifty participatory trials (each in 0.5 acre, brinjal, tomato and chili grown together) were conducted in the watershed during *Kharif*-2012. Barley variety Narendra-2 was introduced in watershed during *Rabi* –2011-12. Now, it has been grown by 165 farmers in 168 ha in Domagor-Pahuj watershed during *Rabi* 2012-13. The seed was also purchased by 100 farmers of 30 villages from Jhansi and Tikamgarh districts. This variety was supplied 1–2 irrigations.

Convergence of different schemes

Hundred trials, each in one ha, of wheat in Dhikauli were conducted by Dept. of Agriculture, Jhansi, Govt. of U.P. Fifty households were started poultry with assistance from the Dept. of Agriculture.

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

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

Background

In recent times Bundelkhand region has been in a grip of severe drought continuously

Table 24: Performance of groundnut with micro nutrients and PSB in participatory trials at Domagor-Pahuj watershed during *Kharif* – 2012

Crop	Pod yield (kg ha^{-1})
Groundnut (TAG-24) + MN + PSB+RDF	1262
Groundnut (TAG-24) + RDF	1483
Groundnut (TAG-37A) + MN + PSB+RDF	1496
Groundnut (TAG-37A) + RDF	1736
Jhumuku + MN + PSB+RDF	962
Jhumuku + RDF	1135

RDF : Recommended Dose of Fertilizers; Groundnut variety: local

from 2004 to 2007. In the region, more than 831 per cent of open wells were dried up due to deficit rainfall. Cattle were abandoned due to shortage of water and fodder. Most part of the region was dependent on drinking water supply through tanker. In view of this Babina block of Jhansi district in Uttar Pradesh was selected as target block for the initiation of the project related to Enhancing groundwater recharge and water use efficiency. A watershed namely, Parasai-Sindh watershed has been selected in Jhansi district of Uttar Pradesh in 2011 with a view to develop through consortia mode of International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad and National Research Centre for Agroforestry (NRCAF), Jhansi. The general characteristics of watershed are presented in Table 25. The villages are located about 25 km west of the district headquarter. Theproject villages– Parasai, Chataarpurn and Bachauni lie beteen 25^0 23‘ 56’’ to 25^0 27‘ 9.34’’ N and 78^0 19‘ 45.71’’ to 78^0 22‘ 42.57’’ E (Fig. 34).

The overall objectives of this initiative is to improve the livelihoods of rural poor in fragile dryland areas on a sustainable basis by enhancing the impact of watershed interventions thru integrated watershed management approach in drought affected region of Bundelkhand.

The specific objectives of this initiative are aimed as follows:

- To enhance water availability in target villages through rainwater harvesting and recharging of the wells
- To enhance water use efficiency and agricultural productivity through agroforestry based improved

Table 25: General characteristics of Parasai-Sindh watershed

Morphometric characteristics	
Location	25^0 24’ to 25^0 27’ N Latitude, 78^0 20’ to 78^0 22’ E longitude
Area	1246 ha
Altitude	270 to 315 m above MSL
Relief (m)	45
Length (m)	6263
Width (m)	3994
Perimeter (km)	27.83
Drainage density ($kmkm^{-2}$)	2.11
Landuse	**ha (%)**
Agricultural land	785.86 (63.07)
Barren land	322.96 (25.92)
Forest	5.64 (0.45)
Scrub land	111.29 (8.93)
Road (kachha and pucca)	11.16 (0.90)
Habitation	9.04 (0.73)
Resources	
Rabi crops	Wheat, gram, pea, etc.
Kharif crops	Groundnut, black gram, sesame, etc.
Means of irrigation	388 open shallow dug wells existing in unconfined aquifer
Vegetation resource Life fence	Neem along road side, scattered desiber on field bunds , *Butea*along the drains Few farmers have *L. camera* along road side as live fence

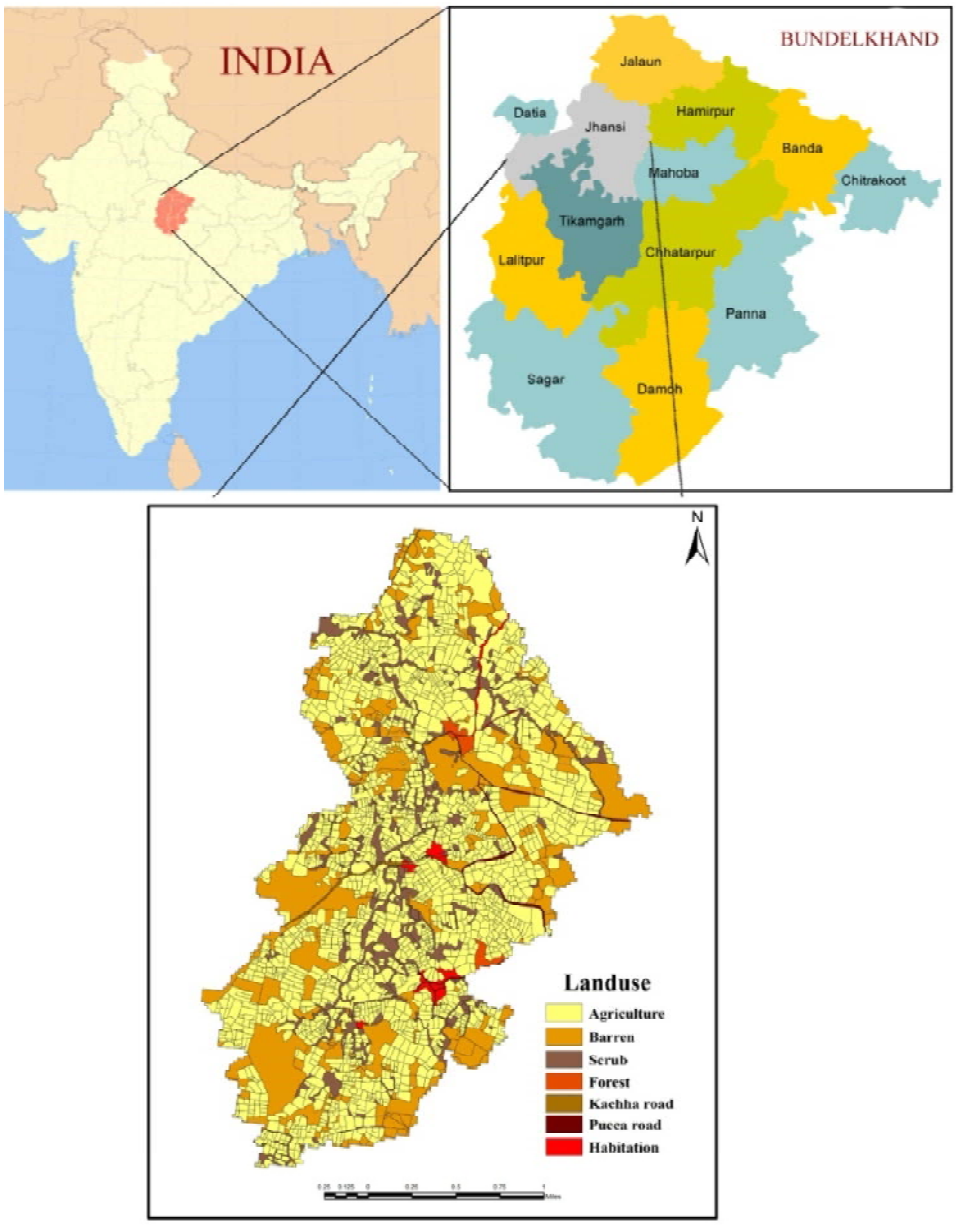


Fig. 34: Location and land use of Parasai-Sindh watershed

management of land and water resources

- To establish a site for learning.
- Water resources development, new process of participatory watershed development, development of agroforestry interventions, top working of ber and lac cultivation, crop demonstration and capacity building are discussed in subsequent section:

Water Resources Development

Construction of rainwater harvesting structures

Open shallow dug well are the only means of irrigation in the watershed and recharge rate of these wells are very slow due to low water column. To augment groundwater recharge, two cost effective checkdams were constructed at Chhatpur

village during 2011. During the year 2012, threenallah plugs, one field drainage structures, one outlet of *haveli* at Parasai and one checkdam in main ephemeral stream of Parasai-Sindh watershed were constructed. Design of all structures was cost effective. In toto, surface storage of about 25,000 m^3 was created for rainwater. One gauging station was also constructed in Bachhauni village of the watershed. Construction of other checkdams in Parasai-Sindh watershed is in progress.

Monitoring groundwater table

All the open shallow dug wells (388 nos.) are situated in unconfined aquifer and these are only means of irrigation in the watershed. These wells are monitored for water table on monthly interval. The average depth and water column during December, 2012 of open wells are 9.66 and 3.12 m, respectively (Fig. 35).

Process of Participatory watershed development

Transparency in execution of works results into higher people's participation and quality interventions. In Parasai-Sindh watershed, villagers and watershed committee members were fully involved in the process of execution of different watershed development interventions. The committee was constituted in open meeting and working was briefed. The committee does procurement of all material, enters in record book, verifies all the bills and submits for payment to the project implementing agency. The site selection for construction of structures is done by the committee in presence of the experts. Designing and assessment of materials is done by the team and committee is entrusted the execution. Similarly for enhancing productivity, decision on procurement of quality seeds, planting materials and other inputs is also taken by the committee in open meeting. The onus of execution lies with the villagers which is driving force for speedy sailing of the project works. This led to the speedy execution and quality product at competitive cost besides huge people's participation.

Development of Agroforestry Interventions, Top Working of Ber and Lac Cultivation

To develop agroforestry interventions in

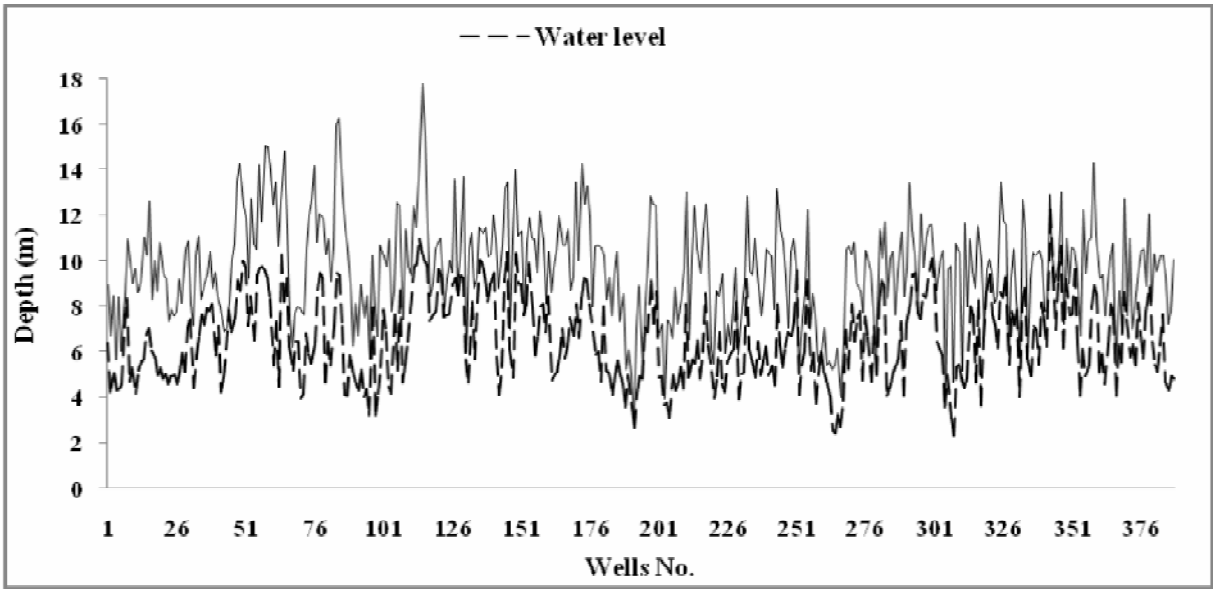


Fig. 35: Water level in open wells during December 2012

the watershed, 3101 seedlings of different species were planted on farmers' fields during 2012. Brief account of seedling of different species planted in watershed is given in Table 26.

Table 26: Details of seedlings planted in watershed during 2011

Village/Plants	Parasai	Chhatpur	Bachhauni
Guava	70	172	8
Papaya	100	0	0
Teak	400	960	140
Lemon	210	0	40
Mango	37	103	0
Bamboo	54	341	5
Jackfruit	81	120	24
Pomegranate	5	54	2
Karonda	12	13	0
Aonla	6	144	0
Total	975	1907	219

Survival of different species varied from 60 to 96 per cent by the end of December, 2012. Highest survival was recorded in case of citrus and lowest forkaronda. Apart from this, total 143 desiber were budded with improved varieties and survival was about 43 per cent by December, 2012. To strengthen rural livelihoods cultivation of lac was introduced on farmers' fields. During the year 2012, lac inoculated on 5 trees in the watershed.

Participatory Demonstration Trials and Weed Study

Varietal evaluation of groundnut at farmer's field

Groundnut varietal evaluation trials were laid out in the farmer's field in Parasai and Chhatpur villages of Parasai Sindh Watershed during *Kharif*, 2012. Seven varieties *viz.*, ICGS-5, ICGV-350, ICGV-86015, ICGV-8784, ICGV-91114, ICGV-9346, and TAG -24 as well as two local varieties *viz.*, Shivpuri and Kaushal were evaluated for yield potential in participation with the farmers. The data presented in Table 27 indicated that the pod weight was highest (45g 100 pods^{-1}) in ICGV-86015, ICGV-91114 and Shivpuri. Lowest pod weight was observed in ICGV-8784 (75g100 pods^{-1}). Weight of kernels varied in range of 0.55 to 0.7 g100kernels^{-1}. Pod yield of different varieties was recorded as 1.23 to 1.88 tha^{-1}. ICGV- 91114 produced highest pod yield (1.88 tha^{-1}) followed by ICGV-9346 (1.62 tha^{-1}), whereas Kaushal (1.23tha^{-1}), ICGS-5 (1.26 tha^{-1}) and TAG-24 (1.37 tha^{-1}) had lowest pod yield. However, the biomass potential was highest in Shivpuri (4.30 DM tha^{-1}) followed by ICGV-8784 (3.84 DM tha^{-1}) and ICGV- 86015(3.67 DMtha^{-1}). Total

Table 27: Participatory varietal evaluation of groundnut at farmer's field

S. No.	Variety	Pod weight (g 100 pod^{-1})	*Kernel-spod^{-1}	Kernel wt. (g pod^{-1})	100 kernal weight (g)	Pod yield (t ha^{-1})	Kernel yield (t ha^{-1})	Straw yield (t ha^{-1})
1	ICGS -5	85	1.61	0.55	35	1.26	0.59	2.31
2	ICGV - 350	85	1.75	0.6	35	1.43	0.73	2.68
3	ICGV -86015	95	1.77	0.7	40	1.32	0.87	3.65
4	ICGV – 8784	75	1.72	0.55	30	1.51	0.62	3.83
5	ICGV - 91114	95	2.00	0.6	30	1.88	1.07	2.99
6	ICGV – 9346	85	1.66	0.55	40	1.62	0.76	2.27
7	SHIVPURI	95	1.70	0.65	40	1.41	0.87	4.31
8	KAUSHAL	85	1.74	0.6	40	1.23	0.62	3.32
9	TAG - 24	85	1.84	0.55	35	1.37	0.63	2.42

*Average of 100

kernel yield of different varieties were recorded in the range of 0.59 to 1.07 t ha^{-1}.

Participatory groundnut trials

Out of 29 varietal demonstrations of groundnut during *kharif*, 2012; observation were taken from 10 participatory trials respectively for Control (Jhumku), TAG-24 and TAG-37A. Number of $tillersplant^{-1}$ varied in range of 4.6 to 11.6 tillers $plant^{-1}$ under varied plant population and management practices adopted by the farmers(Table 28). Jhumku was observed to have more tillering as compared to other varieties. Profuse tillering was reflected in higher biomass in this variety. Nodulation varied in the range of 38 to 76 ($nodulesplant^{-1}$). TAG-24 was observed to have highest pods (19.2 $podsplant^{-1}$) and correspondingly this variety had highest 1.68 tha^{-1}(kernel yield) and 2.42 t ha^{-1} (pod yield) followed by TAG 37A. Analysis of the data clearly indicated that variety TAG-24 performed better as compared to other varieties.

Weeds Study

Weed density and biomass in different participatory groundnut varietal evaluation trials in Parasai-Sindh Watershed are presented in Table 29. A perusal of the data revealed that *Ageratum conyzoides, Commelina benghalensis, Digitaria sanguinalis, Eragrostis* spp. among many others were some of the dominant weeds present in different groundnut varieties. Under overall conditions the density of weeds was 65.88 $weedsm^{-2}$ (ICGS-5); 61.4 $weedsm^{-2}$(Shivpuri); 52.56 $weedsm^{-2}$ (ICGV-86015); 43.48 $weedsm^{-2}$ (ICGV-8784); 37.6 $weedsm^{-2}$ (ICGV-9346); 36.92 $weedsm^{-2}$ (ICGV-350); 39.28 $weedsm^{-2}$ (ICGV-91114); 33.36 $weedsm^{-2}$ (TAG-24) and 30.32 $weedsm^{-2}$ (Kaushal). Maximum biomass gained by weeds on dry weight basis was 99.4 g m^{-2} (ICGV-9346); 81.76 g m^{-2} (Kaushal) and 47.2 g m^{-2} (TAG-24) among different groundnut varieties sown, however lowest biomass of 18.08 g m^{-2} on dry weight basis was gained by weeds in groundnut variety ICGV-8784.

Table 28: Participatory groundnut demonstration at different farmer's fields in Parasai Sindh watershed

S. No.	Name of farmer	Village	Variety	Tillers $plant^{-1}$	Nodules $plant^{-1}$	Pods $plant^{-1}$	Kernel wt. (g100 $kernels^{-1}$)	Pod yield (tha^{-1})	Kernel yield (tha^{-1})
1	Thakurdas	Parasai	Control*	5.8	40	13	40	0.86	0.57
	Phool Singh	Chhatpur	Control*	10.2	38	7	45	0.91	0.63
3	Ramesh	Parasai	Control*	6.8	76	15.2	45	0.99	0.66
4	Ramesh	Parasai	TAG-24	5.2	31.4	9.6	35	1.22	0.79
5	Ramesh	Parasai	TAG-24	5.4	30.6	7.8	40	1.58	1.03
6	Devi Singh	Chhatpur	TG-37A	4.6	47	12	40	1.39	0.98
7	Sunil	Chhatpur	TAG-24	5.8	47.8	19.2	40	2.42	1.68
8	Puran Singh	Chhatpur	Control*	11.6	48.6	6.6	45	1.09	0.72
9	Neeraj	Parasai	TAG-24	5.6	28	13.6	35	0.95	0.65
10	Maniram	Parasai	TG-37A	4.6	59.4	15	45	2.05	1.47
11	Nathuram	Parasai	TG-37A	5	56	13.6	40	2.10	1.49

*Control- variety Jhumku

Table 29: Infestation of weeds in different ground evaluation trials at Parasai-Sindh watershed

Species	Weeds density (Av. Countm^{-2}) at harvest stage								
	1	**2**	**3**	**4**	**5**	**6**	**9**	**7**	**8**
	ICGS-5	ICGV-350	ICGV-86015	ICGV-8784	ICGV-91114	ICGV-9346	TAG-24	Shivpuri	Kaushal
Ageratum conyzoides	30 (45.54)	13.32 (36.08)	18 (34.25)	1.32 (3.04)	12.68 (32.28)	8.68 (23.09)	10 (39.09)	24 (39.09)	1.32 (4.35)
Celosia argentea	2 (3.04)	2 (5.42)	1.32 (2.51)	1.2 (2.76)	0.68 (1.73)	1.2 (3.19)	0.68 1.11	0.68 1.11	1.32 (4.35)
Commelina benghalensis	7.32 (11.11)	1.32 (3.58)	0.68 (1.29)	2.4 (5.52)	3.2 (8.15)	2 (5.32)	1.6 (2.15)	1.32 (2.15)	4 (13.19)
Cynadon dactylon	0.88 (1.34)	0.8 (2.17)	0.68 (1.29)	0.88 (2.02)	0.96 (2.44)	0.68 (1.81)	1.12 (2.15)	1.32 (2.15)	0.4 (1.32)
Cyperus iria	0.8 (1.21)	0.68 (1.84)	0.96 (1.83)	2 (4.60)	0	0	0	0.96 (1.56)	0.48 (1.58)
Cyperus rotundus	0	2.68 (7.26)	1.32 (2.51)	0.68 (1.56)	2.08 (5.30)	1.2 (3.19)	(5.32) (2.15)	1.32 (2.15)	0
Dactyloctenium aegyptium	2.68 (4.07)	0.68 (1.84)	0.48 (0.91)	2.68 (6.16)	1 (2.55)	1.12 (2.98)	0.68 (4.36)	2.68 (4.36)	1.32 (4.35)
Digitaria sangunalis	4 (6.07)	0	6 (11.42)	16.68 (38.36)	9.32 (23.73)	3.2 (8.51)	4 (8.66)	5.32 (8.66)	4.68 (15.44)
Echinochloa crusgalli	0.8 (1.21)	1(2.71)	1.32 (2.51)	1.32 (3.04)	1.12 (2.85)	1.04 (2.70)	1.32 (6.51)	4 (6.51)	1.16 (3.83)
Elusine indica	1.6 (2.43)	1.4 (3.79)	1.6 (3.04)	2 (4.60)	1.6 (4.07)	1.32 (3.51)	1.32 (5.41)	3.32 (5.41)	4 (13.19)
Euphorbia hirta	1.2 (1.82)	1.4 (3.79)	0	0	1 (2.55)	1.52 (4.04)	0	0.88 (1.43)	1.08 (3.56)
Eragrostis spp.	12.68 (19.25)	9.32 (25.24)	4 (7.61)	2.68 (6.16)	2.68 (6.82)	11.32 (30.11)	4 (10.88)	6.68 (10.88)	6.68 (22.03)
Lueca saspera	0.8 (1.21)	0.68 (1.84)	0.88 (1.67)	0.96 (2.21)	0.96 (2..44)	0.96 (2.55)	0.68 (2.61)	1.6 (2.61)	1.2 (3.96)
Mollugopentaphylla	0	0	8 (15.22)	0	0	0	0	3.32 (5.41)	0
Oldenlandia diffusa	1.12 (1.70)	0.96 (2.60)	0	0	0	0.68 (1.81)	0	0.68 (1.11)	0
Phyllanthu ssp	0	0	0	0	0	0	1.32 (0.33)	0	0
Hyptissu aveolens	0	0	0	0	0	0	1.32 (0.33)	0	0
Unidentified broad leaf	0 (0.00)	0.68 (1.84)	7.32 (13.93)	8.68 (19.96)	2 (5.09)	2.68 (7.13)	0	3.32 (5.41)	2.68 (8.84)
Av. weed count m^{-2}	65.88	36.92	52.56	43.48	39.28	37.6	33.36	61.4	30.32
Av. weight (F.W. g m^{-2})	67.52	77.16	91.12	54.84	178.36	224.68	141.08	128.96	277.24
Av. weight (D.W. gm^{-2})	31.48	21.32	29.76	18.08	67.72	99.4	47.2	46.4	81.76

Plate 3: Boundary plantation of teak in Parasai-Sindh watershed

Plate 4: Participatory field day varietal evaluation of groundnut

Observational trial

Weed Dynamics Studies in Different Agroforestry Systems

(Inder Dev)

Agroforestry has been viewed as an example of tree species competition in which a secondary species (e.g. tree species) controls the weeds and releases the main crop from a strong competition that may be offered by weeds. Weeds grow on soil along with the crop and deplete the nutrients; water and space allotted for the intended crop and finally cause huge reduction in crop yield. Weeds in crop field reduce input efficiency, interfere with agricultural operations, impair quality and act as alternate hosts for several insect pests and diseases.

A weeds identification and infestations study in different agroforestry systems was initiated during *kharif*, 2012. Weed infestation and weed biomass in different agroforestry system is presented hereunder.

Weeds in Aonla + blackgram agroforestry system during *kharif*-2012

The data presented in Table 30 reveals that at 60 DAS, *Echinochloa crusgalli* (35.2 plants m^{-2}), *Dactyloctenium aegyptium* (8.0 plants m^{-2}), *Commelina benghalensis* (7.2 plants m^{-2}), *Cyperus iria, Cyperus rotundus* and *Panicum* spp. (3.2 plants m^{-2}) were some of the most dominant weed flora. At harvest stage *Digitaria sanguinalis* (56.68 plants m^{-2}) was most dominant weed followed by *Echinochloa crusgalli* (30 plants m^{-2}). Weed biomass was 397.6 gm^{-2} (FW), 55.2 gm^{-2} (DW) at 60 DAS and 318.36 gm^{-2} (FW) and 48.16 gm^{-2} (DW) at harvest stage.

Weeds in *Anogeissus* + cowpea agroforestry system during *kharif*-2012

Data presented in Table 31 reveals that *Cyperus rotundus* (128 plants m^{-2}) followed by *Commelina benghalensis* (54 plants m^{-2}) and *Echinochloa crusgalli* (25.2 plants m^{-2}) were some of the most dominant weeds at 30 DAS. Similarly *Cyperus rotundus* was the most dominant weed at 60 DAS. Average weed count was 225.6 weeds m^{-2} (30 DAS) and 228.04 weeds m^{-2} at 60 DAS. Weed biomass was 101.6 g m^{-2} (FW) and 22.8g m^{-2} (DW) on first observation and 115.8 F.W g m^{-2} (FW) and 26.6 D.W g m^{-2}.

Weeds in Bamboo + blackgram agroforestry system during *kharif*-2012

Data presented in Table 32 reveals that at 60 DAS *Cyperus rotundus* (137.6 plants m^{-2}), *Echinochloa crusgalli* (74.8 plants m^{-2}), *Commelina benghalensis* (74.8 plants m^{-2}) and *Digitaria sanguinalis* (50.8 plants m^{-2}) were

Table 30: Weed density and biomass in Aonla + blackgram Agroforestry system

Weed species	Av. Density m^{-2}	
	60 DAS	At harvest
Commelina benghalensis	7.2 (9.52)	4.68 (4.55)
Cynadon dactylon	0 *(0.00)*	2 *(1.94)*
Cyperus iria	3.2 *(4.23)*	1.2 *(1.17)*
Cyperus rotundus	3.2*(4.23)*	0 *(0.00)*
Dactylocteniu maegyptium	8 *(10.58)*	4 *(3.89)*
Digitaria sanguinalis	12 *(15.87)*	56.68 *(55.11)*
Echinochloa crusgalli	35.2 *(46.56)*	30 *(29.17)*
Eragrostis spp.	0 (0.00)	0.68 (0.66)
Luecasaspera	0 (0.00)	0.28 *(0.27)*
Panicum spp.	3.2 *(4.23)*	0 (0.00)
Tridex procumbens	0.8 *(1.06)*	0(0.00)
Unidentified broad leaf	2.8 *(3.70)*	3.32 *(3.23)*
Av. weed countm^{-2}	75.6 (100)	102.84 (100)
Av. weight (F.W. gm^{-2})	397.6	318.36
Av. D.W (F.W gm^{-2})	55.2	48.16

Figures in the parenthesis indicate the % density

most dominant weeds species. At harvest stage also *Cyperu srotundus* (104.8 plants m^{-2}) was the most dominant weed. Total weed population was 390 weeds m^{-2} (60 DAS) and 342.8 weeds m^{-2} (at harvest stage). Weed biomass was 423.6 g m^{-2} (FW), 85.72 gm^2 (DW) at 60 DAS and 571.2 gm^{-2} (FW) and 112.42 gm^{-2} (DW) at harvest stage.

Table 31: Weed density and biomass in *Anogeissus* + Cowpea agroforestry system

Weed species	Av. Density m^{-2}	
	30 DAS	60 DAS
Achyranthes aspera	0 *(0.00)*	4 *(1.75)*
Ageratum conyzoides	0 (0.00)	4.68 (2.05)
Bulbostylis barbata	2 (0.89)	0 *(0.00)*
Celosia argentea	0.4 *(0.18)*	42.68 *(18.72)*
Commelina benghalensis	54 (23.94)	0 (0.00)
Cyperus rotundus	128 (56.74)	84 *(36.84)*
Dactyloctenium aegyptium	4 (1.77)	0 (0.00)
Digitaria sanguinalis	8 (3.55)	14 (6.14)
Echinochloa crusgalli	25.2 (11.17)	0 (0.00)
Eragrostis spp.	0.8 (0.35)	60 (26.31)
Physalis minima	0 (0.00)	2.00 (0.88)
Hyptissua veolens	0 (0.00)	2 (0.88)
Sid aacuta	3.2 (1.42)	0.68 (0.3)
Unidentified broad leaf	0 (0.00)	14 (6.14)
Av. weed count m^{-2}	**225.6**	**228.04**
Av. weight (F.W. gm^{-2})	101.6	115.8
Av. weight (D.W. gm^{-2})	22.8	26.6

Table 32: Weed density and biomass in Bamboo+ black gram agroforestry system

Weed species	Av. Density m^{-2}	
	60 DAS	At harvest
Celosia argentea	36 (*9.23*)	23.2 (*6.77*)
Commelina benghalensis	74.8 (*19.18*)	39.2 (*11.44*)
Commelina diffusa	0 (0.00)	4 (*1.17*)
Cyperus rotundus	137.6 (*35.28*)	104.8 (*30.57*)
Dactyloctenium aegyptium	0 (0.00)	6 (*1.75*)
Digitaria sanguinalis	50.8 (*13.03*)	100.8 (*29.40*)
Echinochloac rusgalli	74.8 (*19.18*)	50 (*14.59*)
Oldenlandia diffusa	0 (0.00)	14.8 (*4.32*)
Unidentified broad leaves	16 (*4.10*)	0 (0.00)
Av. weed count m^{-2}	**390**	**342.8**
Av. weight (F.W. gm^{-2})	423.6	571.2
Av. weight (D.W. gm^{-2})	85.72	112.42

Weeds in Ber + til agroforestry system during *kharif*-2012

The crop was heavily infested with the weeds and due to heavy infestation of weeds; the crop was virtually wiped out from the field. Among the various weeds present in the system at 60 DAS were *Echinochlo acrusgalli* (98 plants m^{-2}) and *Cyperus rotundus* (55.2 plants m^{-2}) and biomass attained by weeds was 268.4 gm^{-2} (FW) and 67.52 gm^{-2} (DW) (Table 33). Observations taken during last week of September revealed that *Jussia easuffruticosa* (56.68 plants m^{-2}) was the most dominant weed.

Weeds in *Eucalyptus* + black gram agroforestry system during *kharif*-2012

Data presented in Table 34 reveals that *Echinochloa crusgalli* (63.6 plants m^{-2}) and *Cyperus rotundus* (29.2 plants m^{-2}) were the most dominant weeds at 60 DAS. The infestation of *Echinochloa crusgalli* has increased to the level of 71.41% at harvest stage. Biomass attained by weeds was 237.6

Table 33: Weed density and biomass in ber + til agroforestry system

Weed species	Av. Density m^{-2}	
	60 DAS	Sept. (last week)
Bulbostylisbarbata	1.2 (0.69)	0(0.00)
Celosia argentea	1.2 (0.69)	0 (0.00)
Commelina benghalensis	2.8 (1.60)	12 (9.27)
Commelina diffusa	0 (0.00)	18 (13.91)
Cyperus rotundus	55.2 (31.58)	18.68 (14.44)
Dactyloctenium aegyptium	0.8 (0.46)	0 (0.00)
Digitaria sanguinalis	14.8 (8.47)	10.68 (5.16)
Echinochloac rusgalli	98 (56.06)	4 (3.09)
Eragrostis spp.	0 (0.00)	6.68 (5.16)
Jussiaea suffruticosa	0 (0.00)	56.68 (43.80)
Panicum spp.	0.8 (0.46)	0 (0.00)
Phyllanthus spp.	0 (0.00)	2.68 (2.07)
Av. weed count m^{-2}	174.8 (100.0)	129.4 (100.0)
Av. weight (F.W. gm^{-2})	268.4	364.52
Av. weight (D.W. g m^{-2})	67.52	86.26

Table 34: Weed density and biomass in Eucalyptus + blackgram agroforestry system

Weed species	Av. Density m^{-2}	
	60 DAS	At harvest
Celosia argentea	2.8 (2.44)	8.4 (5.36)
Commelina benghalensis	6.4 (5.57)	6.4 (4.08)
Commelina diffusa	2.8 (2.44)	14.68 (9.36)
Cyperus rotundus	29.2 (25.44)	8.04 (5.13)
Echinochloa crusgalli	63.6 (55.40)	112 (71.41)
Phyllanthus spp.	2.8 (2.44)	2 (1.28)
Polygonum spp.	1.2 (1.05)	2 (1.28)
Unidentified broad leaf	5.6 (4.88)	3.32 (2.12)
Unidentified narrow leaf	0.4 (0.35)	0 (0.00)
Av. weed count m^{-2}	**114.8**	**156.84**
Av. weight (F.W. gm^{-2})	237.6	386.8
Av. weight (D.W. gm^{-2})	54.20	77.36

gm^{-2} (FW) and 54.20 gm^{-2} (DW) at 60 DAS and 386.8 gm^{-2} (FW) and 77.36 gm^{-2} (DW) at harvest stage.

Weeds in Neem+blackgram agroforestry system during *kharif*-2012

Data presented in Table 35 reveals that *Echinochloa crusgalli* (200.68 plants m^{-2}) and *Cyperus rotundus* (55.32 plants m^{-2}) were the most dominant weeds at 60 DAS. Similarly, at harvest stage *Echinochloa crusgalli* and *Cyperus rotundus* were the most dominant weeds. Biomass attained by weeds was 515.24 gm^{-2} (FW) and 77.56 gm^{-2} (DW) at 60 DAS and 378.88 gm^{-2} (FW) and 58.32 gm^{-2} (DW) at harvest stage.

Weeds in Shisham + Green gram agroforestry system during *kharif*-2012:

Data presented in Table 36 reveals that *Echinochloa crusgalli* (37.50 plants m^{-2}), *Digitaria sanguinalis* (20.8 plants m^{-2}) and *Cyperus rotundus* (18.4 plants m^{-2}) were the most dominant weeds at 60 DAS. By and large similar trend was observed at harvest stage, however, infestation of *Celosia argentea* has increased from 7.2 plants m^{-2} (60 DAS) to 10.8 plants m^{-2} (harvest stage). Biomass attained by weeds was 504.4 gm^{-2} (FW) and 112 gm^{-2} (DW) at 60 DAS and 380.88 gm^{-2} (FW) and 87.28 gm^{-2} (DW) at harvest stage.

Weeds infestation under wasteland conditions during *kharif*-2012

Data presented in Table 37 revealed that *Euphorbia hirta* was the most dominant weeds of the upland (wasteland) conditions of Bundelkhand region. Some of the other

Table 35: Weed density and biomass in Neem + blackgram agroforestry system

Weed species	Av. Density m^{-2}	
	60 DAS	At harvest
Celosia argentea	4.80 (1.80)	13.84 (7.95)
Commelina benghalensis	4.68 (1.76)	4.68 (2.69)
Cyperus rotundus	55.32 (20.78)	34.56 (19.85)
Echinochloa crusgalli	200.68 (75.40)	114.56 (65.79)
Digitaria sanguinalis	0.68 (0.26)	114.56 (65.79)
Av. weed count m^{-2}	266.16	174.12
Av. weight (F.W. gm^{-2})	515.24	378.88
Av. weight (D.W. gm^{-2})	77.56	58.32

dominant weeds infesting wasteland were *Dactylocteniuma egyptium* (8 plants m^{-2}), *Sida acuta* (3.96 plants m^{-2}) among many others. Weed density at maximum growth stage was 151.36 weeds m^{-2}. Biomass attained by weeds was 258.36 gm^{-2} (FW) and 78.8 gm^{-2} (DW) at maximum growth stage during *kharif* season.

Table 36: Weed density and biomass in Shisham+ green gram agroforestry system

Weed species	Av. Density m^{-2}	
	60 DAS	At harvest
Commelina benghalensis	3.2 (3.85)	1.6 (1.49)
Celosia argentea	7.2 (8.65)	10.8 (10.05)
Cyperus rotundus	18.4 (22.12)	8.8 (8.19)
Dactyloctenium aegyptium	0.8 (0.96)	8 (7.44)
Digitaria sanguinalis	20.8 (25.00)	16 (14.89)
Echinochloa crusgalli	31.2 (37.50)	58 (53.96)
Hyptissua veolens	0 (0.00)	2 (1.86)
Physalis minima	0.8 (0.96)	1.6 (1.49)
Unidentified broad leaf	0.8 (0.96)	0.68 (0.63)
Av. weed count m^{-2}	83.2	107.48
Av. weight (F.W. gm^{-2})	504.4	380.88
Av. weight (D.W. gm^{-2})	112	87.28

Table 37: Weed density and biomass under wasteland conditions

Species	Av. Count m^{-2}
	At maximum growth stage
Ageratum conyzoides	1.32 (0.87)
Alternanthera sessilis	3.68 (2.43)
Bulbostylisbarbata	0.68 (0.45)
Commelina benghalensis	1.32 (0.87)
Cyperusiria	0.32 (0.21)
Dactylocteniuma egyptium	8(5.29)
Echinochloa crusgalli	1.08 (0.71)
Eragrostis spp.	2.68 (1.77)
Euphorbia hirta	10 (6.61)
Heteropogon contortus	3.32 (2.19)
Luecasa spera	1 (0.66)
Mollugo pentaphylla	0.68 (0.45)
Parthenium hysterophorus	3.32 (2.19)
Phyllanthus spp.	2 (1.32)
Physalis minima	1.68 (1.11)
Sida acuta	6 (3.96)
Sonchus spp.	4 (2.64)
Medicago spp.	1 (0.66)
Unidentified broad leaf	6.32 (4.18)
Unidentified narrow leaf	13.32(8.80)
Av. weed count m^{-2}	151.36
Av. weight (F.W. gm^{-2})	258.36
Av. weight (D.W. gm^{-2})	78.8

2. RESEARCH ACHIEVEMENTS

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

AF01.22: Studies for Augmenting Pistillate Flowers with Exogenous Application of Growth Regulators and Chemicals in *Jatropha curcas*

(Badre Alam & Sudhir Kumar)

Concentrations of the growth chemicals/ regulators for exogenous spraying were continued as in the last year. For example, Ethephon was used in the range of 500, 1000 and 2000 ppm; á-NAA 50, 100 and 200 ppm, Salicylic acid 1, 2.5 and 5 mM and Gibberellic acid 10, 30 and 60 ppm. As per the schedule spraying was done three times in a month till the main flowering time. Number of flowers in the inflorescence and fruits continued to apparently increase consequent upon spraying of differentially responding growth chemicals. It was noted that both á-NAA and Gibberellic acid have shown tangible results followed by salicylic acid towards increasing female flowers and fruits (Fig.36&37). However, this year flowering in *Jatropha curcus* was observed relatively less than the previous year probably due to excess rain and prolonged moist climate during post-monsoon season. Flower drop at the terminal stages was also observed as it affects fruit formation. Visual monitoring and scoring were also done.

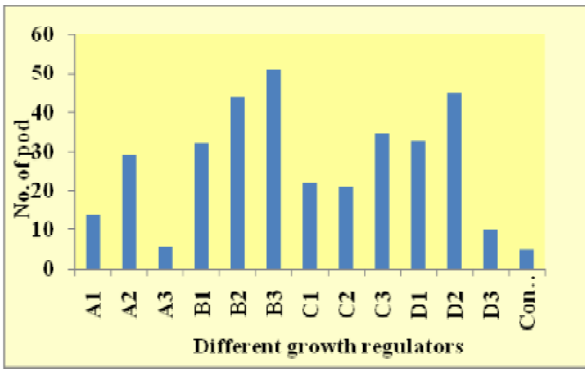


Fig. 37: Effect of exogenous spraying of growth regulators on fruit formation in *Jatropha curcas*

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

(Badre Alam & A K Handa)

The annual height and collar diameter increment was higher in stem cutting (clonal) than seedling of *Pongamia pinnata*plants (Fig. 38 and 39). Canopy diameter of stem cutting *Pongamia pinnata* plants was observed relatively higher than seedling trees. The average canopy diameters of clonal plant were 4.15m (EW) and 3.78m (NS) and that

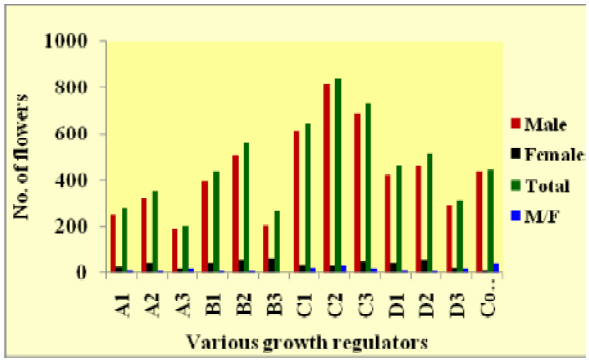


Fig. 36: Effect of exogenous spraying of growth regulators on flowering in *Jatropha curcas*

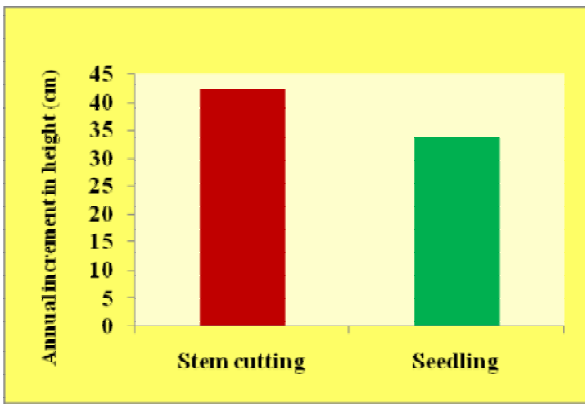


Fig. 38: Annual height increment in clonal and seedling plants of *P. pinnata*

of seedling plants 3.25m (EW) and 3.18m (NS) (Fig. 40). Phenology revealed that number of flowering plants was relatively less than in the previous year (Fig. 41). However, the number of plants flowered remained higher in clonal plants than the seedling plants indicating the consistent higher adaptability of clonal plants to dry rainfed climate. Flower retention capacity, comparative flowering efficacy (Fig. 42 & 43) and number pods per plant were higher in clonal plants than seedling plants of *Pongamia pinnata* (Fig. 44). Average fresh and dry weights of pods were much less in seedling in comparison to stem cutting plants (Fig. 45).

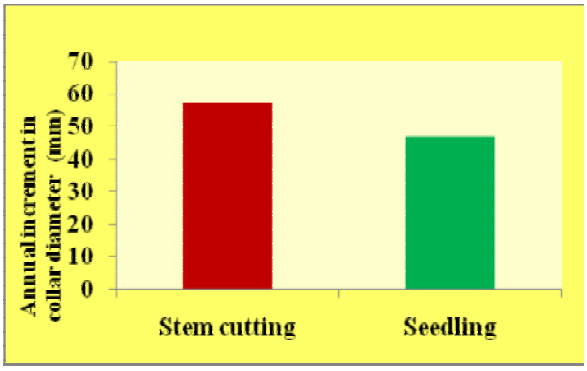


Fig. 39: Annual girth increase in clonal and seedling plant of *P. pinnata*

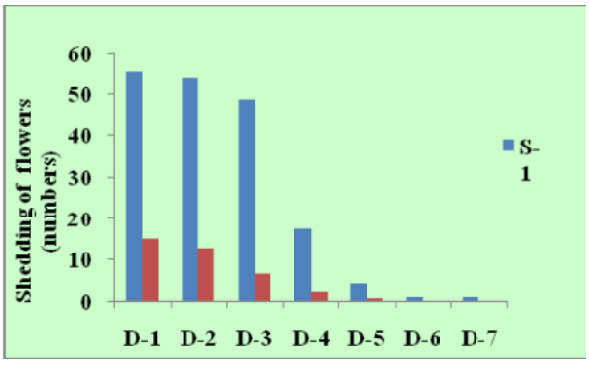


Fig. 42: Shedding of flower numbers of seedling plants (S-1 and S-2= sample trees and D-1 to D-7= Days for Shedding in flowers number)

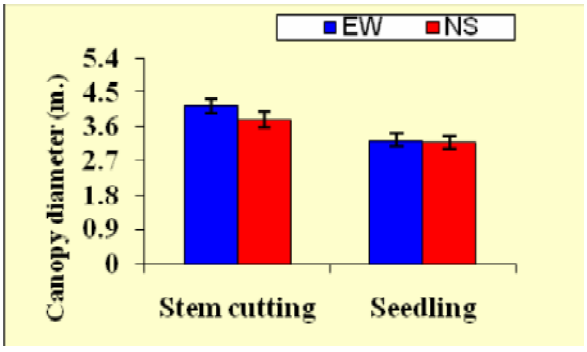


Fig. 40: Canopy diameter of stem cutting and seedling plants

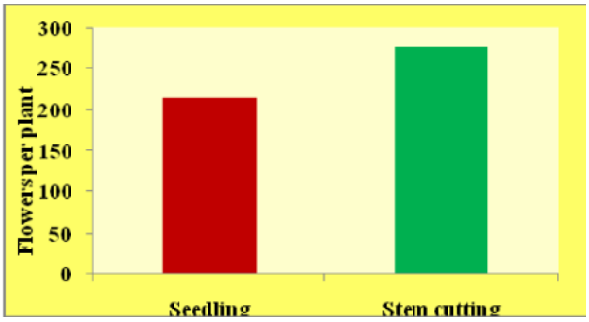


Fig. 43: No. of Flowers per plant in seedling and stem cutting plants

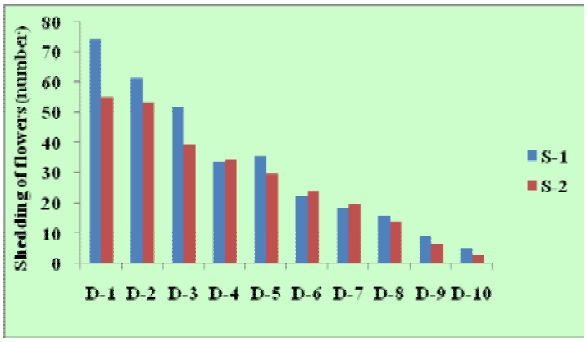


Fig. 41: Shedding flower numbers of stem cutting plants (S-1 and S-2= sample trees and D-1 to D-10 = Days for Shedding in flowers number)

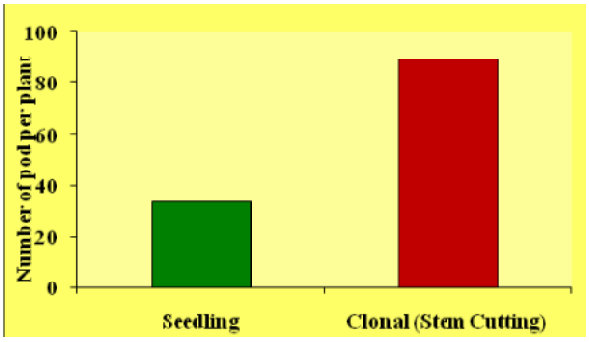


Fig. 44: Pod yield per plant in seedling and stem cutting plants

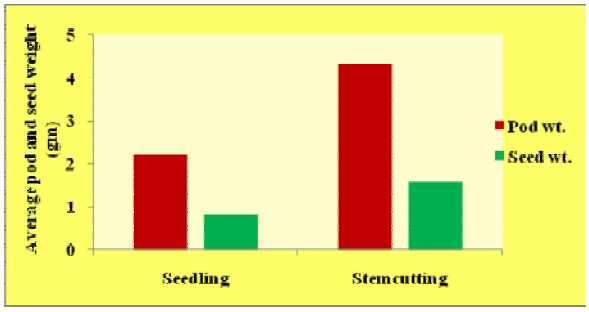


Fig. 45: Average pod and seed weight of seedling and stem cutting plants

Monitoring the plant stand, there are eighty plants surviving under the experiment at present. As better photosynthetic and photochemical efficiency in clonal plants, higher rate of CO_2 assimilation and PS-2 electron transport were observed (Fig. 46 & 47). Both these parameters clearly indicated the differences of internal physio-biochemical properties of clonal and seedling plants. Besides, many biochemical determinants were studied namely anthocyanin, proteins, soluble sugar content, enzyme activities for comparing clonal and seedling plants. Study of relative intrinsic trend in leaf senescence of clonal and seedling plants for their response indicated differentialresponse towards leaf senescence related ageing processes and it has been reflected in biochemical events (Fig. 48-51 and Plate 5).

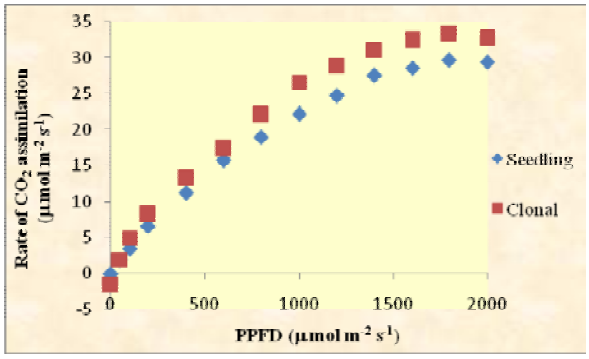


Fig. 46: Rate of CO_2 assimilation versus photosynthetic photon flux density (PPFD) in seedling and stem cutting plants of *P. pinnata*

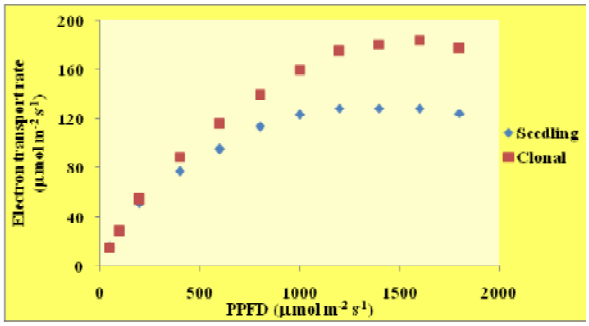


Fig. 47: Electron transport rate at different PPFD in Clonal and seedling plants of *P. pinnata*

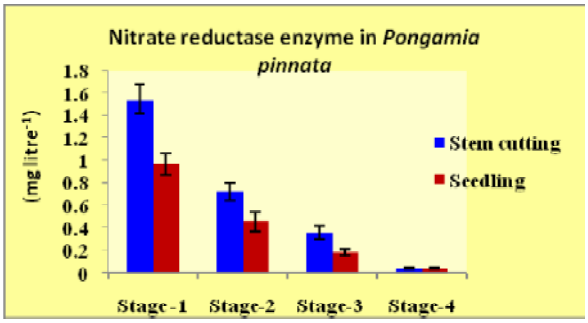


Fig. 48: Nitrate reductase enzyme activity during senescence in Clonal and stem cutting plants of *P. pinnata*

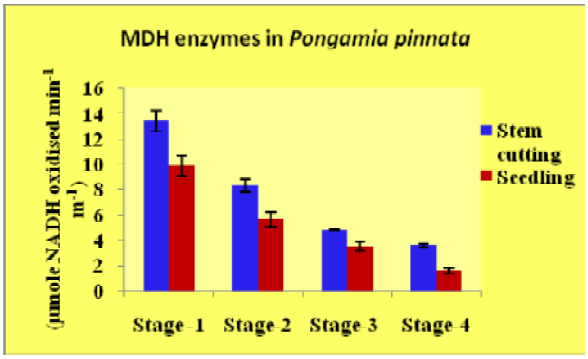


Fig. 49: Malate dehydrogenase activity during senescence in Clonal and stem cutting plants of *P. pinnata*

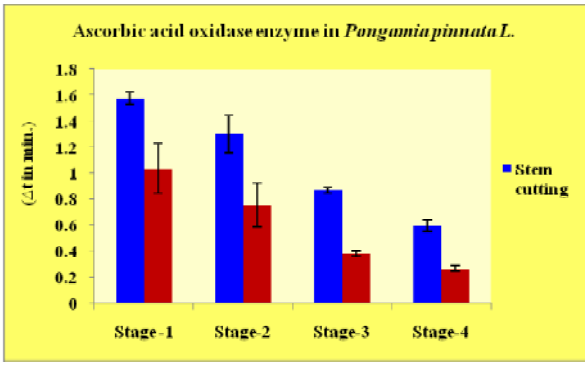


Fig. 50: Ascorbic acid oxidase activity during various stages of senescence in *P. pinnata* plants

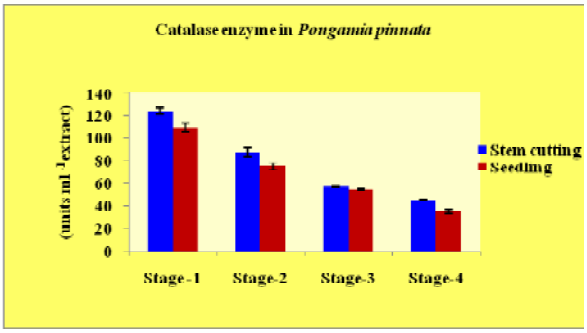


Fig. 51: Catalase enzyme activity during various stages of senescence in *P. pinnata* plants

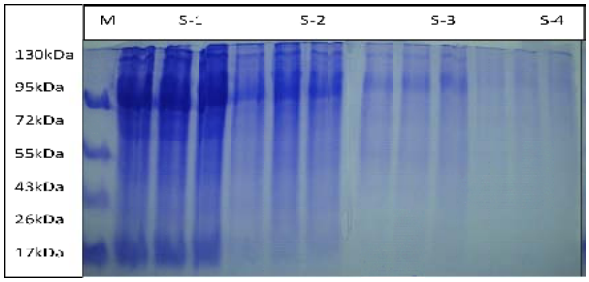


Plate-5: SDS-PAGE of various stages of senescence in *Pongamiapinnata* clonal plant.
M = mol. wt. marker; S 1 to S4 indicates from green to senescence stage

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

(S Vimala Devi & Badre Alam)

Plus tree progeny trial (Established in 2004)

Data on growth parameters *viz.*, tree height, clean bole height, dbh, canopy diameter and number of primary branches were recorded for collected germplasmfrom Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Maharashtra. Significant differences were observed for all the major traits (Table 38). Average tree height of the progenies was 6.47m ranging from 5.58m (PT 9) to 7.22m (PT 14). Average clean bole height was 1.14 m, ranging from 0.94m (PT 19) to 1.40m (PT 2). Average dbhof the plus tree progenies was 16.5 cm, ranging from 12.1cm (PT 15) to 21.9 cm (PT 4) and average canopy diameter was 4.46m ranging from 3.64 m (PT 10) to 5.41m (PT 12).

A comparative study of growth performance of individual plus tree progeny with the population mean of tree height, dbh, Canopy diameter and Number of primary branches revealed that the progenies of 7 plus trees *viz.*, PT 2, 3, 12, 13, 14, 15 & 16 from Sagar, Damoh, Buldhana, Khadwa, Indore and Shajaur respectively showed superiority for all the four characters than population mean

Plus tree Progeny trial (Established in 2006)

The trial consisting of 11 Plus tree progenies collected from Madhya Pradesh and Rajasthan were planted in Randomized block design in 2006. Significant differences

Table 38: Growth performance of promising plus tree progenies at the age of 8.5 years

Plus tree Progeny	Location of collection	State	Tree height (m)	dbh (cm)	Canopy diameter (mm)	No. of Branches
PT 2	Sagar	MP	6.96	18.8	4.90	4.7
PT 3	Damoh	MP	6.72	16.5	4.89	4.7
PT 12	Buldhana	Maharashtra	6.93	17.3	**5.41**	4.6
PT 13	Khandwa	MP	6.64	17.4	-	4.5
PT 14	Indore	MP	**7.22**	21.8	4.89	**5.1**
PT 15	Indore	MP	7.03	-	4.76	4.3
PT 16	Shajapur	MP	7.18	18.2	5.17	4.3
Over all Mean (22 PTs)			**6.47**	**16.5**	**4.46**	**4.2**

were observed for tree height, clean bole height, Diameter at breast height and canopy diameter(Table 39). Average tree height was 5.83m ranging from 5.32m (PT 24) to 6.64m (PT 32), average clean bole height 1.86m ranging from 1.52m (PT29) to 2.19m (PT 27) and average dbhwas 7.7 cm ranging from 5.6cm (PT 31) to 9.4 cm (PT 28). A comparative analysis of plus tree means over the population mean for all the four traits revealed that the performance of PT 25, 27 & 28 were superior.

Provenance Progeny Trial (Established in 2004)

Data on growth parameters *viz.* Tree height, Diameter at Breast Height (dbh), Canopy Diameter and Clean bole height of 20 provenance progenies were recorded during the reporting period 2012. Significant differences between all the progenies for all the four traits were observed (Fig. 52). The average tree height was 6.01m and 11 progenies recorded higher mean height than the population. The average dbh was 13.2cm and 6 provenance progenies showed above the population mean diameter. Of the 20 Provenance progenies, PR 1, 4, 15 and 20 from Sagar, Mandla, Shajapur and Coimbatore showed better performance and recorded higher mean value for all the four characterstha n population.

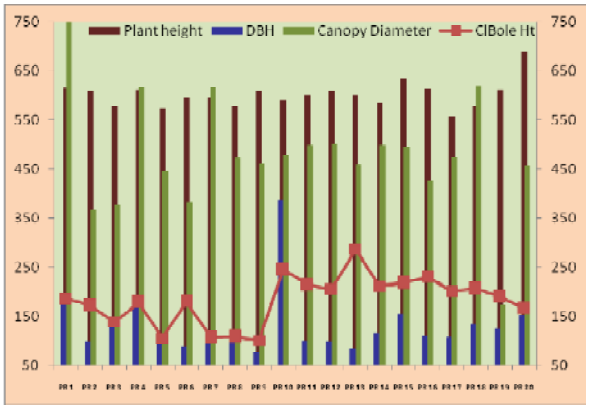


Fig. 52: Growth performance of promising provenance progenies at the age of 8.5 years

AF 04.5: Genetics and Breeding of *Jatropha* species

(Sudhir Kumar, R V Kumar and D R Palsaniya)

A. Plus tree progeny trial I (Aug. 2004)

Seeds of twenty seven accessions of *Jatropha curcas* were collected from various parts of Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Maharashtra, Andhra Pradesh and Chhattisgarh in November 2003 and planted in the field during August, 2004 following randomized block design with three replications for evaluation of different morphological traits as well as seed yield and oil content. Initially, the spacing between plant to plant and row to row was kept 2m, but due to overcrowding plants was uprooted alternatively in the month of February, 2008 after harvesting of fruits to create space for optimum growth and hence line to line distance increasedupto 4m. In the month of Feb.-March, 2008 plants were pruned at the height of 80cm from the ground level.At the age of eight years all these accessions were recorded for different morphological as well as yield parameters. The results obtained are reported here (Table 40).

Morphological Characters

Average plant height was 3.35m and

Table 39: Growth performances of promising plus tree progenies at the age of 6.5 years

Plus tree Progeny	Location of collection	State	Tree height (m)	Clean Bole height (cm)	dbh (cm)	Canopy diameter (m)
PT 25	Dabra	MP	5.90	0.91	19.4	3.71
PT 27	Bansi	Rajasthan	5.46	0.81	21.9	3.62
PT 28	Balajee	Rajasthan	5.98	0.95	18.8	3.31

ranged from 2.99m (NRCJ-21) to 3.74m (NRCJ-9). Ten accessions recorded height above the population mean. Significant variations in collar girth of all accessions were recorded. Mean collar girth was 64.26cm which ranged from 56.86cm (NRCJ-22) to 75.40cm (NRCJ-2). Out of 27 accessions, eleven were recorded above the population mean. Number of primary branches per plant showed significant variation. Mean number of primary branches was 6.48 and ranged from 5.12 (NRCJ-24) to 7.80 (NRCJ-2). Out of 27 accessions, fourteen were recorded above the population mean. Number of secondary branches per plant varied from 32.11 (NRCJ-26) to 77.10 (NRCJ-2) with a mean of 46.39 per plant. Out of 27 accessions, twelve were recorded above the population mean.Branch length differed significantly with each other. Average branch length was 2.71m and ranged from a 2.30m (NRCJ-20) to 3.08m (NRCJ-19). A total of fourteen

Table 40: Growth performance of CPT progenies of *J. curcas*

Accession	Plant height (m)	Collar girth (cm)	No. of primary branches	Branch length (m)	No. of secondary branches	Canopy diameter (m)
NRCJ 1	3.12	61.45	6.64	2.57	55.82	2.76
NRCJ 2	3.60	75.40	7.80	2.98	77.10	3.01
NRCJ 3	3.22	66.20	7.20	2.65	66.60	2.56
NRCJ 4	3.00	60.40	6.60	2.51	57.00	2.88
NRCJ 5	3.28	66.67	6.53	2.76	56.33	2.73
NRCJ 6	3.08	57.63	6.38	2.49	47.25	2.55
NRCJ 7	3.53	69.36	6.64	2.89	50.79	2.84
NRCJ 8	3.31	66.31	7.38	2.76	56.08	2.82
NRCJ 9	3.74	59.43	6.86	3.05	49.14	2.41
NRCJ 10	3.41	65.18	7.00	2.81	41.45	2.80
NRCJ 11	3.50	64.23	6.23	2.85	45.31	2.69
NRCJ 12	3.27	64.00	6.46	2.70	39.85	2.84
NRCJ 13	3.32	64.20	6.60	2.74	47.47	2.56
NRCJ 14	3.21	62.00	5.75	2.58	39.50	2.60
NRCJ 15	3.07	60.44	6.89	2.50	52.78	2.70
NRCJ 16	3.08	59.33	5.92	2.52	36.92	2.72
NRCJ 17	3.26	60.00	6.73	2.65	44.45	2.69
NRCJ 18	3.42	66.57	6.21	2.78	49.14	2.64
NRCJ 19	3.73	70.70	6.50	3.08	39.80	2.71
NRCJ 20	3.53	62.92	6.31	2.30	43.77	2.53
NRCJ 21	2.99	60.14	5.86	2.47	38.71	2.54
NRCJ 22	3.33	56.86	5.14	2.73	33.86	2.46
NRCJ 23	3.49	63.31	6.31	2.75	37.23	2.58
NRCJ 24	3.33	70.13	5.13	2.75	33.50	2.69
NRCJ 25	3.64	66.36	7.09	2.90	37.09	2.54
NRCJ 26	3.31	59.33	5.78	2.49	32.11	2.44
NRCJ 27	3.19	70.00	6.00	2.66	46.00	2.60
Mean	**3.35**	**64.26**	**6.47**	**2.71**	**46.39**	**2.67**
Max	**3.74**	**75.4**	**7.80**	**3.08**	**77.10**	**3.01**
Min	**2.99**	**56.85**	**5.12**	**2.30**	**32.11**	**2.41**
SEM±	**0.02**	**0.64**	**0.09**	**0.03**	**1.07**	**0.02**

accessions were recorded above the population mean. Canopy diameter was also found significant. Mean canopy diameter was recorded 2.67m and ranged from 2.41m (NRCJ-9) to 3.01m (NRCJ-2).

Yield Characters

All the accessions were evaluated for the yield attributing characters (Table 41) except accession NRCJ-3, NRCJ-4, NRCJ-8 and NRCJ-22 did not bear even single fruit. Fruit length was non-significant. Average fruit length was recorded 25.97mm and ranged from 24.16mm (NRCJ-21) to 27.52mm (NRCJ-26). Ten accessions recorded fruit length above the population mean. Fruit width was also found non-significant, however average width was recorded 20.81mm and ranged from 19.21mm (NRCJ-21) to 23.53mm (NRCJ-9) and eleven accessions recorded above the population mean. Average fruit weight was recorded 224.93g that ranged from 200.00g (NRCJ-27) to 290.00g (NRCJ-26) and a total of ten accessions recorded above the population mean. However, the differences among accessions were non-significant. As such, fruit yield differed non-significantly for all the accessions and recorded 271.32g plant^{-1}. Yield ranged from 150.00g (NRCJ-27 & NRCJ-21) to 470.00g (NRCJ-6) and nine accessions were recorded above the population mean. Average seed length was recorded 18.27mm that ranged from 17.65mm (NRCJ-21) to 19.08mm (NRCJ-6) and nine accessions were recorded above the population mean. The seed width for all the accessions differed non-significantly. Average seed width was recorded 11.10mm and ranged from 10.13mm (NRCJ-21) to 11.52mm (NRCJ-19). Out of 27 accessions, 14 were found above the population mean.The seed thickness ranged from 8.17mm (NRCJ-6) to 10.27mm (NRCJ-15) with an average of 8.85mm and nine accessions recorded above the population mean. Seed weight ranged from 48.47g (NRCJ-27) to 64.70g (NRCJ-9) with an average of 57.94g hundred^{-1} seeds. A total of thirteen accessions. Seed weight ranged from 48.47g (NRCJ-27) to 64.70g (NRCJ-9) with an average of 57.94g hundred seeds and a total of 13 accessions were recorded above the population mean. The seed yield ranged 75.00g (NRCJ-27) to 260.00g (NRCJ-9) and a total of 10 accessions were recorded above the population mean.

Character Association

All parameters of 27 accessions were assessed for correlation coefficient (r = 0.135-0.973, p>0.01 & 0.05 level). Seed and fruit yield had significantly positive correlations with each other. All the morphological traits had positive correlation with each other, except canopy diameter, which had no positive correlation with plant height and branch length. In case of yield traits, fruit width and fruit weight had positive correlation with plant height. Collar girth and number of primary & secondary branches had significantly positive correlation with all the growth traits. The canopy diameter had significantly positive correlation with collar girth and number of primary & secondary branches.

B. Evaluation of Intra-specific Hybrids and their parents

In hybrid evaluation trial, 45 intraspecific crosses of *J. 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 with 5 plants as unit. Interspaces were used for growing crops at the age of six years and they were evaluated for morphological, fruit and seed yield

Table 41: Yield attributes of CPT progenies of *J. curcas*

Accession	Fruit length (mm)	Fruit width (mm)	100 fruit wt (g)	Fruit yield (g)	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	100 seed wt (g)	Seed yield (g)
NRCJ 1	26.49	20.35	231.67	326.67	17.74	11.19	8.68	61.95	190.00
NRCJ 2	26.86	21.03	231.67	341.67	18.45	11.16	9.07	55.92	191.67
NRCJ 3	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
NRCJ 4	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
NRCJ 5	25.29	20.89	207.50	175.00	18.08	11.30	8.81	59.44	115.00
NRCJ 6	26.66	20.28	220.00	470.00	19.08	10.13	8.17	58.17	260.00
NRCJ 7	26.57	20.61	216.00	271.00	18.12	10.78	8.57	51.50	147.00
NRCJ 8	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
NRCJ 9	25.95	23.53	241.67	246.67	18.25	11.18	9.18	64.70	135.00
NRCJ 10	25.37	20.08	210.00	176.00	18.16	11.20	8.53	56.08	93.00
NRCJ 11	25.94	20.96	221.67	255.00	18.30	11.16	9.05	58.55	146.67
NRCJ 12	24.72	20.65	214.29	259.29	18.06	11.22	8.95	57.62	144.29
NRCJ 13	27.05	21.00	226.67	315.83	18.55	11.31	8.81	57.89	181.67
NRCJ 14	25.16	19.22	220.00	175.00	18.42	11.50	9.32	54.06	90.00
NRCJ 15	24.21	21.26	215.00	250.00	18.19	11.49	10.27	58.48	150.00
NRCJ 16	24.96	20.34	233.33	293.33	17.88	11.09	8.77	59.09	168.33
NRCJ 17	25.46	20.25	216.67	303.33	18.25	11.26	8.54	55.18	173.33
NRCJ 18	26.63	20.86	224.17	242.50	18.63	11.12	8.80	56.24	140.83
NRCJ 19	25.86	20.72	233.33	226.67	17.69	11.52	9.23	58.11	126.67
NRCJ 20	26.15	20.85	255.00	230.00	18.06	11.13	8.90	62.22	170.00
NRCJ 21	24.16	19.21	205.00	150.00	17.65	10.13	8.32	51.37	110.00
NRCJ 22	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
NRCJ 23	25.83	21.35	241.25	312.50	18.65	10.99	9.06	62.12	180.00
NRCJ 24	26.13	20.69	207.00	259.00	18.60	10.98	8.53	59.81	138.00
NRCJ 25	26.12	21.10	240.00	338.75	18.24	10.83	9.06	61.26	193.75
NRCJ 26	27.52	21.14	290.00	310.00	18.67	11.01	8.68	62.80	175.00
NRCJ 27	24.66	20.19	200.00	150.00	17.96	10.37	8.71	48.47	75.00
Mean	**25.97**	**20.81**	**224.93**	**271.32**	**18.27**	**11.10**	**8.85**	**57.94**	**154.34**
Max	**27.52**	**23.53**	**290.00**	**470.00**	**19.08**	**11.52**	**10.27**	**64.70**	**260.00**
Min	**24.16**	**19.21**	**200.00**	**150.00**	**17.65**	**10.13**	**8.17**	**48.47**	**75.00**
SEM±	**0.15**	**0.16**	**3.11**	**11.78**	**0.09**	**0.06**	**0.08**	**0.69**	**6.68**

parameters. During reporting period Plants were affected due to continuous heavy downpour of rain water at the time of flowering and fruit setting and as a result, one cross *i.e.* NRCJ-45 completely died.

I. **Performance of Hybrids:** Hybrids performance has been given in Table 42. In some cases values are less than previous year as the plants suffered due to stagnation of water.

All the crosses branches. At the age of six years, average plant height was 3.01m. Plant height ranged from 2.37m (NRCJ-39) to 3.43m (NRCJ-42). A total of 23 crosses were recorded above the population mean. Collar girth showed wide range of variation and differences were significant. Average collar girth was 82.22cm and ranged from 45.00cm (NRCJ-40) to 96.89cm (NRCJ-6).

There was variation in number of

primary branches at individual plant level but they were found non-significant. Number of primary branches ranged from 6.00 (NRCJ-20) to 11.88 (NRCJ-38). Twenty five crosses were recorded above the population mean (9.63). Average number of secondary branches was 81.05 per plant and ranged from 49.13 (NRCJ-39) to 101.38 (NRCJ-29). Average branch length was 2.89m. The length ranged from 2.32m (NRCJ-39) to 3.38m (NRCJ-42). Canopy diameter differed significantly. Average canopy diameter was recorded as 3.34m and ranged from 1.95m (NRCJ-40) to 4.05m (NRCJ-42). A total of 21 crosses were recorded above the population mean.

Yield and yield attributing Characters

Fruit length differed non- significantly with each other. Fruit length ranged from 22.38mm (NRCJ-21) to 26.14mm (NRCJ-34) with the mean of 24.62mm. Average fruit width was 20.44mm. It ranged from 18.32mm (NRCJ-1) to 21.72mm (NRCJ-39). Average fruit weight was 208.21 g. Fruit weight ranged from 167.50 g (NRCJ-35) to 235.00g (NRCJ-43). Nineteen crosses had fruit weight above the population mean. The average fruit yield was obtained 375.60g and ranged from 227.50g (NRCJ-21) to 563.57g (NRCJ-12). Eighteen crosses had fruit yield above the population mean. Seed length ranged from 16.58mm (NRCJ-35) to 18.84mm (NRCJ-15) with a population mean of 17.84mm. Seed width ranged from 10.23mm (NRCJ-20) to 11.59mm (NRCJ-33) with the population mean of 11.09mm. Average seed thickness was 8.75mm and ranged from 8.11mm (NRCJ-21) to 9.56mm (NRCJ-34). Seventeen crosses were recorded above the population mean. The crosses were also evaluated for seed weight. The average seed weight was recorded as 53.24g and ranged from 38.66g (NRCJ-1) to 70.41g (NRCJ-29). Seventeen crosses had seed weight above the population mean. All crosses differed significantly among themselves in seed yield. Average seed yield was 196.14g and ranged from 100.0g (NRCJ-1) to 302.50g (NRCJ-34). Seventeen crosses had seed yield above the population mean.

Character Association

Fruit and seed yield had positive and significant correlations with fruit length, fruit weight, and seed weight. Morphological traits had high positive correlation with each other. Branch length also had positive correlation with fruit length. Fruit length had positive correlation with fruit width, fruit weight, fruit yield seed length, seed weight and seed yield. Likewise, other traits also had positive correlation with one or more characters.

II. Performance of Parents: Parents performance has been given in Table 43. A wide range of variation was observed in the plant height of parents but statistically they were *at par*. Average plant height was 3.07m and ranged from 2.61m (NRCJ-52) to 3.48m (NRCJ-47). Five parents were recorded above the population mean. Mean girth was recorded 74.67 cm, which ranged from 57.33cm (NRCJ-52) to 89.33cm (NRCJ-47). Mean number of primary branches were 9.18 per plant and ranged from 7.33 (NRCJ-52) to 10.89 (NRCJ-47). Mean number of secondary branches was 71.00 per plant and ranged from 57.00 (NRCJ-51) to 84.89 (NRCJ-47). Average branch length was 3.27m and it ranged from 2.54m (NRCJ-52) to 5.42m (NRCJ-48). Only two parents were recorded above the population mean. Mean canopy diameter was recorded 3.36m and ranged from 2.83m (NRCJ-52) to 3.97m (NRCJ-47).

Table 42: Growth performance and seed yield of hybrid *J. curcas*

Hybrid	Plant height (m)	Collar girth (cm)	No. of primary branches	No. of secondary branches	Branch length (m)	Canopy diameter (m)	Seed yield (g)
NRCJ-1	2.98	76.93	9.93	79.50	2.85	3.26	100.00
NRCJ-2	3.03	85.71	9.21	82.43	2.89	3.37	218.33
NRCJ-3	3.24	81.86	10.14	82.93	3.10	3.30	221.25
NRCJ-4	3.07	82.83	9.25	74.33	2.94	3.19	166.00
NRCJ-5	3.04	79.10	8.60	67.70	2.94	3.36	151.67
NRCJ-6	2.86	96.89	10.00	79.44	2.76	3.39	134.17
NRCJ-7	3.00	82.36	10.36	80.18	2.92	3.65	181.25
NRCJ-8	3.06	75.83	10.17	78.58	2.95	3.51	166.25
NRCJ-9	2.93	80.45	9.18	72.55	2.75	3.45	169.00
NRCJ-10	2.47	57.20	6.20	52.20	2.37	2.53	000.00
NRCJ-11	3.00	85.58	8.75	82.25	2.87	3.19	169.00
NRCJ-12	3.05	89.45	10.00	85.27	2.92	3.42	291.43
NRCJ-13	3.19	91.73	11.07	98.40	3.06	3.76	260.00
NRCJ-14	3.05	68.67	9.78	94.56	2.91	3.32	136.00
NRCJ-15	3.14	86.10	9.50	90.00	3.05	3.82	203.33
NRCJ-16	3.09	83.93	9.20	79.07	2.97	3.28	208.57
NRCJ-17	3.21	92.00	10.07	89.14	3.13	3.76	230.00
NRCJ-18	3.07	88.07	10.50	87.43	2.91	3.66	163.57
NRCJ-19	2.82	81.83	8.17	71.17	2.65	2.83	000.00
NRCJ-20	2.51	58.40	6.00	65.00	2.37	2.38	275.00
NRCJ-21	2.90	91.83	8.33	78.33	2.78	3.18	105.00
NRCJ-22	2.90	91.50	9.79	79.64	2.79	3.23	249.17
NRCJ-23	3.12	87.17	9.75	85.83	2.98	3.13	147.86
NRCJ-24	3.22	90.75	10.17	93.00	3.09	3.51	142.00
NRCJ-25	2.96	70.00	10.11	72.67	2.87	3.38	210.00
NRCJ-26	2.88	78.50	9.90	71.70	2.77	3.25	166.67
NRCJ-27	3.06	85.64	9.57	89.07	2.94	3.49	196.88
NRCJ-28	2.90	80.20	9.10	86.20	2.78	3.15	215.00
NRCJ-29	2.85	79.38	10.13	101.38	2.73	3.04	240.00
NRCJ-30	2.80	91.00	9.57	84.00	2.77	2.93	247.50
NRCJ-31	2.99	69.86	9.86	89.71	2.83	3.24	248.75
NRCJ-32	3.18	91.29	10.29	91.14	3.11	3.60	220.00
NRCJ-33	3.00	85.60	9.40	78.20	2.88	3.27	302.50
NRCJ-34	2.66	62.25	8.13	69.00	2.69	3.03	132.50
NRCJ-35	3.16	90.75	11.00	84.25	3.04	3.57	193.75
NRCJ-36	3.05	81.71	11.00	85.00	2.96	3.58	175.00
NRCJ-37	3.12	85.25	10.25	80.88	3.00	3.32	286.67
NRCJ-38	3.05	78.50	11.88	81.25	2.97	3.52	175.00
NRCJ-39	2.37	51.50	6.75	49.13	2.32	2.41	275.00
NRCJ-40	2.75	45.00	8.00	59.00	2.46	1.95	000.00
NRCJ-41	3.15	75.17	10.00	62.17	3.10	3.79	167.50
NRCJ-42	3.43	93.75	11.00	77.75	3.38	4.05	130.00
NRCJ-43	3.18	79.80	10.60	84.20	3.11	3.73	187.50
NRCJ-44	2.68	70.67	9.00	65.33	2.58	3.26	000.00
NRCJ-45	0.00	0.00	0.00	0.00	0.00	0.00	000.00
Mean	**3.01**	**82.22**	**9.63**	**81.05**	**2.89**	**3.34**	**196.14**
Max	**3.43**	**96.89**	**11.88**	**101.38**	**3.38**	**4.05**	**302.50**
Min	**2.37**	**45.00**	**6.00**	**49.13**	**2.32**	**1.95**	**100.00**
SEM±	**0.02**	**1.21**	**0.13**	**1.25**	**0.02**	**0.03**	**6.34**

Yield and yield attributing Characters

Average fruit length was 24.98mm and ranged from 24.08mm (NRCJ-49) to 26.91mm (NRCJ-51). Average fruit width was 20.90mm and ranged from 19.97mm (NRCJ-48) to 22.87mm (NRCJ-51). Five parents were recorded above the population mean. Average fruit weight was 203.09g which ranged from 188.60g (NRCJ-47) to 215.00g (NRCJ-53). Six parents were recorded above the population mean. Average fruit yield was 372.43g and ranged from 282.50g (NRCJ-49) to 650.00g (NRCJ-51). Six parents were recorded above the population mean. Average seed length was recorded as 17.73mm and ranged from 16.66mm (NRCJ-50) to 18.21mm (NRCJ-54). Average seed width was 11.17mm and ranged from 10.96mm (NRCJ-50) to 11.52mm (NRCJ-48). Average seed thickness was 8.66mm ranging from 8.27mm (NRCJ-48 & 51) to 9.06mm (NRCJ-47). Five parents were recorded above the population mean. Average seed weight was recorded 52.29g ranging from 45.65g (NRCJ-49) to 58.06g (NRCJ-55). Average seed yield was found significant and recorded 197.86g and ranged from 137.00g (NRCJ-47) to 370.00g (NRCJ-51). A total of five parents had seed yield above the population mean.

Character Association

All parameters of parents were assessed for correlation coefficient (r =0.343 to 0.996, p>0.01 and 0.05 level). Fruit and seed yield had significantly high positive correlations (p>0.01 level) with each other. Morphological traits had significantly high positive correlations with each other. Fruit length with fruit width, fruit weight with fruit yield, seed width, seed weight & seed yield and fruit yield with fruit weight & seed yield also had positive correlation with each other.

III. Comparative Performance of Parents and Hybrids

A comparison of the average seed yield of both population revealed that though the seed yield of hybrids was slightly less than the parents but fruit yield was more. Seed yield was quite high in case of selected hybrids than their parents. However, much difference was not recorded in other traits (Table 44).

Table 43: Growth performance and seed yield of parents *J. curcas*

Parents	Plant height (m)	Collar girth (cm)	No. of primary branches	No. of secondary branches	Branch length (m)	Canopy diameter (m)	Seed yield (g)
NRCJ-46	3.14	69.69	9.00	81.77	3.07	3.29	226.67
NRCJ-47	3.48	89.33	10.89	84.89	3.40	3.97	137.00
NRCJ-48	3.12	82.55	9.55	71.36	5.42	3.73	148.75
NRCJ-49	3.07	77.45	9.91	60.64	2.98	3.03	142.50
NRCJ-50	3.04	72.00	8.83	65.83	2.97	3.30	267.50
NRCJ-51	3.13	76.43	9.00	57.00	3.05	3.38	370.00
NRCJ-52	2.61	57.33	7.33	65.44	2.54	2.83	000.00
NRCJ-53	2.99	68.30	8.80	64.20	2.90	3.19	191.67
NRCJ-54	3.11	81.33	10.00	79.22	3.05	3.71	262.00
NRCJ-55	3.02	72.73	8.36	72.64	2.95	3.19	213.33
Mean	**3.07**	**74.67**	**9.18**	**71.00**	**3.27**	**3.36**	**197.86**
Min	**3.48**	**89.33**	**10.89**	**84.89**	**5.42**	**3.97**	**370.00**
Max	**2.61**	**57.33**	**7.33**	**57.00**	**2.54**	**2.83**	**137.00**
SEM±	**0.05**	**2.50**	**0.30**	**2.45**	**0.28**	**0.08**	**14.84**

Table 44: Average comparative performance of hybrids and parents

	Seed yield (g)	Plant height (m)	Collar girth (cm)	No. of primary branches	No. of secondary branches	Branch length (m)	Canopy diameter (m)
Hybrids	196.14	3.01	82.22	9.63	81.05	2.89	3.34
Parents	197.86	3.07	74.67	9.18	71.00	3.27	3.36

	Fruit yield (g)	Fruit length (mm)	Fruit width (mm)	Seed length (mm)	Seed width (mm)	100 Fruit weight (g)	100 Seed weight (g)
Hybrids	375.60	24.62	20.44	17.84	11.09	208.21	53.24
Parents	372.43	24.98	20.90	17.73	11.17	203.09	52.29

AF 04.6: Age- Age Correlation Model for Juvenile Selection of Trees in Agroforestry

(R H Rizvi, Ajit & K B Sreedhar)

Growth Performance of *Acacia nilotica*

Growth data for 15 families of *Acacia nilotica* recorded at the age of seven years (Table 45) indicated that highest mean height was attained by trees of family 14 (6.98 m) followed by family 12 (6.82 m). DBH height was also maximum for family 14 (8.21 cm) followed by family 12 (7.97 cm). This showed that families 14 & 12 were performing well at the age of 7 years as compared to other families.

Mean annual increment (MAI) in height showed that highest MAI was 63.8 cm for family 12 followed by 62.8 cm for family 3 and 61.3 cm for family 14 (Fig. 53). In case of 'dbh' the MAI was highest (0.77 cm) for family 14 followed by family 12 (0.76 cm) and family 5 (0.75 cm).

Age-Age Correlation Analysis

Age to age correlations for tree traits *viz.* height, dbh and canopy diameter were computed between different ages *i.e.* 4, 5, 6

Table 45: Tree height and diameter at breast height of *A. nilotica* families

Family No.	Plant height (m)		Diameter at breast height (cm)	
	6-years	7-years	6-years	7-years
1	6.06	6.48	7.16	7.87
2	4.78	5.30	5.48	5.82
3	5.80	6.32	7.07	7.59
4	5.69	6.33	7.44	7.90
5	5.86	6.53	7.43	7.95
6	4.67	5.31	5.37	5.83
7	4.82	5.54	5.42	5.81
8	5.24	5.90	6.37	6.85
9	5.65	6.38	6.32	6.89
10	4.73	5.35	5.97	6.46
11	5.82	6.67	7.30	7.95
12	5.81	6.82	7.13	7.97
13	4.65	5.42	5.62	6.23
14	6.12	6.98	7.54	8.21
15	4.78	5.64	5.48	6.19

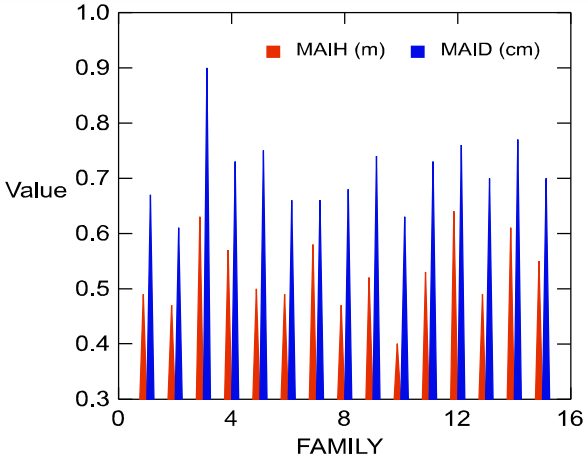


Fig. 53: Mean annual increment in height and dbh of *A. nilotica*

and 7 years (Table 46). The age-age correlations were significantly high (>0.90) between 5&6, 5&7 for all three traits. This indicated that performance of *A. nilotica* trees at 5 years age is highly correlated with the performance at 6 and 7 years. Thus, selection of trees at an age of 5 years may be suitable rather than selection at later age *i.e.* 6 or 7 years. This will be further verified by developing age-age correlation models for these traits.

Empirical models developed for traits height and DBH are given below:

Height: $r_{age:age}$ = 1 + 0.187 LAR (R^2=0.875), and

dbh: $r_{age:age}$ = 1.023 + 0.297 LAR (R^2=0.824);

Where, LAR – log (younger age/ older age) &$r_{age:age}$ – age-age correlations.

These models will be improved by adding 8th year data that may be used for determining the age of early selection on the basis of these traits.

Wood density & calorific value of *A. nilotica*

Ten samples of *A. nilotica* wood were sent to Institute of Wood Science & Technology, Bangalore for estimation of wood density and calorific value. According to their estimation, calorific value of these samples ranged from 4542.8 to 4557.7 cal g^{-1}. Specific gravity of these samples ranged between 0.596 to 0.651 g cm^{-3} (Table 47).

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

(S Vimala Devi, AK Handa, K Rajarajan & Sudhir Kumar)

Association mapping has been used to identify genes of interest in many plant species with varying degrees of success.

Table 46: Age-age Correlations for three traits of *A. nilotica*

	Height			Diameter at breast height			Canopy diameter		
	5 yrs	6 yrs	7 yrs	5 yrs	6 yrs	7 yrs	5 yrs	6 yrs	7 yrs
4 yrs	0.945	0.917	0.911	0.953	0.923	0.916	0.707	0.712	0.679
5 yrs		0.966	0.961		0.964	0.953		0.958	0.917
6 yrs			0.992			0.987			0.949

Table 47: Calorific value and wood density of *A. nilotica*

Calorific value (cal g^{-1})			Specific gravity (gm cm^{-3})	
1	WS1	4555.2	WS1	0.651
2	WS2	4549.1	WS2	0.596
3	WS3	4557.7	WS3	0.629
4	WS4	4544.7	WS4	0.599
5	WS5	4542.8	WS5	0.601
Mean		**4549.9**	**Mean**	**0.615**

Significant associations between candidate genes and traits of interest have been reported.

Database search was performed for identification of fatty acid biosynthesis gene sequences from Castor, Soybean, Brassica and Jatropha collection available in the Genbank. The nucleotide sequences of Brassica were used as query sequence in the different public data base like NCBI, Castor bean genome database, etc. The genome counting sequence showing identity to the fatty acid biosynthesis genes were downloaded. The critical genes involved in the oil biosynthesis were identified by comparing candidate genes with critical genes in castor, soybean and Jatropha.

Simple sequence repeat (SSR) motifs were identified in thecandidate genes using SSR identification tool. Primer pairs were designed using Primer 3.0 from the conserved sequences of fatty acidbiosynthesis genes. This will be used for amplification and detection of polymorphisms between high versus low oil content genotypes of *Pongamia pinnata.*

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

(Sudhir Kumar, Rajendra Singh, S Ghosal & Md. Monobrullah, IINRG)

An experiment is being conducted since July 2008 for the introduction and evaluation of lac in Bundelkhand region at three different site; NRCAF, GKD WS and JFM. Both the crops were sprayed twice to protect the crop from predator- white moth and black moth. The first spray was carried out after one month of inoculation and second after male emergence or one month of first spray with Endosulfan @ 0.05% along with 0.01% Carbendazim.

Baisakhi or summer season crop

For the Baisakhi crop, lac inoculation was done in different quantity (based on shoot availability) at all the sites during second week of November, 2011 on *Butea monosperma* on selected plants which were pruned during April, 2011 for getting new shoots.The settlement of lac insect ranged from 19.8 (GKD WS) to 20.4 No. cm^{-2} (NRCAF site). After one month of inoculation, the survival of the lac insect on *B. monosperma* varied from 86.3 (NRCAF) to 85.1 per cent (GKD WS site). The sex ratio (male: female) varied from 1:4 at GKD WS to 1:4.6 at NRCAF site (Table 48).

The crop was harvested during August 08-16, 2012 and recorded lac input: output ratio as 1:3.6 at NRCAF, 1:2.02 at GKD WS and nil at JFM site. At JFM site the crop was damaged (Table 49).

Table 48: Performance of Lac (Basakhi crop: 2011-12) in *B. monosperma*

Location	NRCAF, Jhansi	JFM site, Talbehat, M.P.	GKD WS, Tikamgargh, M.P.
Inoculation time	11.11.2011	12.11.2011	12.11.2011
No. of inoculated trees	29	15 (small trees)	10
Inoculated brood lac (kgs)	33.5	3.25	5
Settlement (No. cm^{-2})			
Minimum	13	13	13
Maximum	35	33	29
Mean	20.4	20.3	19.8
Survival (%) (Dec. 2011)	86.3	85.3	85.1
Sex ratio (Male: Female)	1:4.6	1:4.4	1:4

Table 49: Lac production (*Baisakhi crop*: 2011-12) on *B. monosperma* at different site of inoculation

Season : *Baisakhi crop* (2011-12)						
Location	Mode of inoculation and quantity (kg)		Harvested Lac (kg)		Total	Input/ output ratio
			Brood lac	Stick lac		
NRCAF, Jhansi	Inoculated Brood lac	33.500	55.650	64.700	120.350	1:3.60
GKD site	Inoculated Brood lac	5.000	4.100	6.000	10.100	1:2.02
JFM site, Talbehat*	Inoculated Brood lac	3.250	-	-	-	-

* The crop was damaged as mostly trees were pruned by JFM officials.

Katki or rainy season crop

Brood lac of Rangeeni strain was inoculated during second week of August, 2012 on *B. monosperma* (NRCAF, JFM site and GKD WS) on selected plants which, were pruned during February/ March, 2012 for new shoots.The brood lac was inoculated 34.5kg at NRCAF, 5kg at GKD WS and 4.5kg at JFM site. Further observations could not be recorded as crop was washed out due to continuous rain fall after inoculation.

NOVOD Board Project

NOVOD Board Funded Project: National Network on Integrated Development of Jatropha and Karanja

(Sudhir Kumar & RV Kumar)

[I] Jatropha (*Jatropha curcas* L.)

(1) Candidate Plus Tree Progeny Trial-I (Aug., 2005)

Seeds of twenty three progenies of the candidate plus trees (CPT) collected from different parts of Rajasthan during November, 2004 were planted in field during August, 2005 at 3m spacing in randomized block design with three replications. All accessions are being studied (Table 50).

Non-significant differences ($p>0.05$ level) among 23 Genotypes were observed. Significantly positive correlations ($r = 0.188$ to 0.942, $p>0.01$ level) were observed between all the traits with each other (plant height, collar diameter, number of primary and secondary branches, branch length and canopy diameter).

Average seed yield was 243.41g plant^{-1} and varied from 113.33g plant^{-1} in NRCJ52 to 460g plant^{-1} in NRCJ33. This was followed by 450g in NRCJ34, 355g in NRCJ31, 328g in NRCJ42 and 325g in NRCJ49.

Morphological Characters

Average plant height was recorded 292.85cm that ranged from 275.17cm (NRCJ44) to 314.69cm (NRCJ55). Ten accessions were recorded above the population mean. Average collar girth was 65.04cm with the range of 57.16cm (NRCJ51) to 73.5cm (NRCJ56). Ten were recorded above the population mean. Average number of primary branches plant^{-1} was 6.62 and ranged from 5.42 in NRCJ44 to 7.9 in NRCJ56 & NRCJ38. Thirteen were recorded above the population mean. Average number of secondary branches plant^{-1} was recorded 65.81 with the range of 47.67 in NRCJ44 to 77.10 in NRCJ56. Twelve accessions were recorded above the population mean. Average primary branch length was 288.01cm and ranged from 270.25cm (NRCJ44) to 310.80cm (NRCJ38). Eleven accessions were recorded above the population mean. Average canopy diameter was 263.16cm and it ranged from 232.50cm

in NRCJ39 to 286.25cm in NRCJ51. Eleven accessions were recorded above the population mean.

(2) Candidate Plus Tree Progeny Trial-II (August, 2005)

The seeds of candidate plus tree collected during November, 2004 from different parts of Rajasthan and Uttar Pradesh were planted in the field during August, 2005. In this trial, nine candidate plus tree progenies were planted in randomized block design in three replications at the spacing of 3m apart. At the age of seven years, all these accessions were recorded for different morphological and seed yield parameters and results are presented in Table 51.

Non-significant differences ($p>0.05$ level) among the nine genotypes for all the growth parameters except number of primary branches plant^{-1} were observed. Significantly positive correlations ($r = 0.602$ to 0.956, $p>0.01$ level) were observed between all the traits with each other.

Table 50: Growth performance of different CPT progenies of *J. curcas*

Genotype	Plant height (cm)	Collar girth (cm)	No. of primary branches	Branch length (cm)	No. of secondary branches	Canopy diameter (cm)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})
NRCJ31	286.67	63.08	6.33	282.63	68.33	284.58	355.00	394.05
NRCJ32	288.85	66.92	6.69	284.54	65.31	268.27	177.50	197.03
NRCJ33	305.83	67.17	6.17	302.08	70.42	260.21	460.00	510.00
NRCJ34	286.67	64.22	7.22	276.56	64.22	247.17	450.00	499.50
NRCJ35	283.67	67.40	6.93	279.87	71.60	253.17	155.00	172.05
NRCJ36	311.25	66.75	6.50	307.13	60.00	266.25	202.50	224.78
NRCJ37	282.50	63.62	6.50	278.19	65.25	271.88	305.00	338.55
NRCJ38	314.50	72.10	7.90	310.80	77.00	284.25	208.33	231.25
NRCJ39	292.78	66.00	6.44	289.28	57.67	232.50	268.75	297.20
NRCJ42	295.38	66.46	6.77	285.15	67.92	260.39	328.00	364.08
NRCJ43	294.33	63.40	6.67	289.97	68.27	272.50	191.67	212.75
NRCJ44	275.17	62.92	5.42	270.25	47.67	261.67	215.00	238.65
NRCJ45	280.83	65.00	6.50	275.33	68.00	255.42	317.50	352.43
NRCJ48	276.36	58.09	6.18	272.18	63.09	242.09	275.00	305.25
NRCJ49	296.00	64.50	5.60	291.80	62.40	259.00	325.00	360.75
NRCJ51	294.17	57.17	6.67	290.17	66.33	286.25	161.25	178.99
NRCJ52	296.92	61.00	6.31	289.77	55.08	271.35	113.33	125.80
NRCJ53	290.83	66.67	6.92	287.08	74.42	281.88	259.17	287.68
NRCJ54	285.00	62.50	6.75	292.88	57.00	253.75	250.00	277.50
NRCJ55	314.69	63.50	6.63	302.72	61.44	246.56	242.00	268.62
NRCJ56	278.00	73.50	7.90	276.55	77.10	255.75	216.25	240.04
NRCJ57	287.50	64.08	6.83	283.08	72.33	269.79	206.67	229.40
NRCJ58	300.00	67.09	6.73	295.59	72.18	268.86	196.00	217.56
Mean	**292.85**	**65.04**	**6.62**	**288.01**	**65.81**	**263.16**	**243.41**	**270.19**
SEM±	**15.87**	**3.94**	**0.66**	**16.13**	**8.55**	**13.31**		
CD@5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**		
C.V	**9.55**	**10.59**	**17.79**	**23.30**	**9.88**	**8.77**		

Table 51: Growth performance and seed yield of nine CPT progenies of *J. curcas*

Genotype	plant height (cm)	Collar girth (cm)	No of primary branches	Branch length (cm)	No of secondary branches	Canopy diameter (cm)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})
NRCJ59	271.67	65.33	6.33	251.67	61.42	262.92	185.00	205.35
NRCJ60	258.70	64.40	5.70	234.25	43.70	232.25	135.00	149.85
NRCJ61	261.88	68.75	7.13	237.50	56.50	242.50	155.00	172.05
NRCJ62	246.67	56.33	5.50	218.75	43.50	230.42	205.00	227.55
NRCJ63	262.08	61.00	5.92	240.63	49.33	260.83	155.00	172.05
NRCJ64	262.92	66.75	6.00	243.29	53.75	265.21	225.00	249.75
NRCJ65	256.00	73.00	6.20	234.10	53.80	269.10	210.00	233.10
NRCJ68	248.33	47.67	6.00	230.00	40.67	242.50	225.00	249.75
NRCJ70	283.33	75.00	6.83	260.83	51.00	279.58	227.50	252.53
Mean	**262.80**	**64.96**	**6.16**	**240.64**	**51.64**	**254.91**	**192.69**	**213.89**
SEM±	**14.54**	**5.15**	**0.76**	**13.82**	**6.93**	**21.98**		
CD@5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

Seed yield

Fruiting and seed yield was very low due to continuous rain during flowering period. Average seed yield was 192.69g plant^{-1}. The seed yield varied from 135g plant^{-1} in NRCJ60 to 227g plant^{-1} in NRCJ70. This was followed by 225g in NRCJ68 & NRCJ64, 210g in NRCJ65 and 205g in NRCJ62.

Plant height

At the age of seven years average plant height was 262.80cm and ranged from 246.67cm (NRCJ62) to 283.33cm (NRCJ70). Other progeny that showed their superiority for plant height was NRCJ59 (271.67cm). Two accessions *viz.* NRCJ59, and NRCJ70 were recorded above the population mean. Rest of the progenies were either equal or below the population mean.

Collar girth

Average collar girth was 64.96cm and it ranged from 47.67cm (NRCJ68) to 75.0cm (NRCJ70). Out of nine accessions, five NRCJ65, NRCJ61, NRCJ64, NRCJ59 and NRCJ70 were recorded above the population mean.

Number of primary and secondary branches

Average number of primary Branches plant^{-1} was 6.16 and it ranged from a minimum of 5.5 (NRCJ62) to a maximum of 7.13 (NRCJ61). Out of 9 accessions, four NRCJ65 (6.20), NRCJ70 (6.83) NRCJ59 (6.33), and NRCJ61 (7.13) were recorded above the population mean. Average number of secondary branches plant^{-1} was 51.64 and it ranged from a minimum of 40.67 (NRCJ68) to a maximum of 61.42 (NRCJ59). Other accessions having high number of secondary branches were NRCJ61 (56.50), NRCJ65 (53.80) and NRCJ64 (53.75). Out of 9, four accessions were recorded above the populations mean.

Branch length

Average primary branch length was recorded 240.64cm with the range from minimum of 218.75cm (NRCJ62) to a maximum of 260.83cm (NRCJ70). Other accessions recorded for more length were NRCJ59 (251.67cm), NRCJ64 (243.29cm) and NRCJ63 (240.63cm). Out of 9, three accessions were recorded above the population mean.

Canopy diameter

At the age of seven years, average canopy diameter was 254.91cm and ranged from a minimum of 230.42cm (NRCJ62) to a maximum of 279.58cm (NRCJ70). Five accessions NRCJ70, NRCJ63, NRCJ64, NRCJ65 and NRCJ59 were recorded above population mean for this trait.

(3) Candidate Plus Tree Progeny Trial-III (Aug., 2005)

The seeds of twelve candidate plus trees collected during November, 2004 from different parts of Uttar Pradesh, Madhya Pradesh and Rajasthan were planted in the field at the spacing of 3x4m during August, 2005, for progeny evaluation based on growth and yield traits. Three accessions *viz.* NRCJ66, 67 and 69 died during 2011 due to heavy and continuous downpour of water; hence data are not available for reporting. For rest of the accessions data were recorded for different morphological traits and results are being presented in Table 52.

Non-significant differences ($p>0.05$ level) among the nine genotypes for all the characters studied were observed. Significantly positive correlations ($r=0.450$ to 0.858, $p>0.01$ & $p>0.05$ level) were observed between all the characters with each other except girth and number of primary branches.

Plant height

At the age of seven years, average plant height was 280.68cm and it ranged from minimum of 242.0 cm (NRCJ90) to 320.0 cm (NRCJ91). Out of nine genotypes, five were recorded above the population mean. The other genotypes for highest plant height were NRCJ40 (308.33cm), NRCJ41 (303.33cm) and NRCJ92 (297.0cm) and NRCJ89 (287.5 cm).

Collar girth

Average collar girth recorded was 69.48cm with the range from 55.75cm (NRCJ47) to 90.0cm (NRCJ91). Other genotypes having more collar girth were NRCJ89 (86.50cm), NRCJ50 (72.50cm) and NRCJ90 (72.0cm). Out of nine genotypes, six were recorded above the population mean.

Number of primary and secondary branches per plant

Average number of primary branches was 7.92 and it ranged from 6 (NRCJ90) to 11 (NRCJ91). Out of 9 genotypes, five were recorded above the population mean. The other genotypes with high number of primary branches were NRCJ41, NRCJ89, NRCJ40 and NRCJ46. Average number of secondary branches per plant was 55.68 and ranged from a minimum of 33.50 (NRCJ47) to a maximum of 84.0 (NRCJ91). Other genotypes having branches were NRCJ89, 41 and 40. Five genotypes were recorded above the population mean.

Branch length

Average branch length per plant was recorded 260.34cm and it ranged from a minimum of 210.63cm (NRCJ47) to a maximum of 307.50cm (NRCJ91). The other genotypes with more branch length were NRCJ40 (289.17cm), NRCJ92 (282.0cm) and NRCJ41 (279.17cm).

Canopy diameter

At the age of seven years, average canopy diameter was 278.40cm and ranged from a minimum of 205.63cm (NRCJ47) to a maximum of 350.0cm (NRCJ91). Other genotypes having high canopy diameter were NRCJ40 (320.83cm), NRCJ92 (313.50cm) and NRCJ41 (310.0cm). Out of 9 genotypes, five were recorded above the population mean.

Table 52: Growth performance of different CPT progenies of *J. curcas*

Genotypes	Plant height (cm)	Collar girth (cm)	Primary branches	Primary branch length (cm)	No. of secondary branches	Canopy diameter (cm)
NRCJ40	308.33	69.67	8.67	289.17	66.33	320.83
NRCJ 41	303.33	63.33	9.67	279.17	66.67	310.00
NRCJ 46	262.50	69.00	8.50	246.25	59.25	263.13
NRCJ 47	250.00	55.75	6.25	210.63	33.50	205.63
NRCJ 50	255.00	72.50	6.50	246.25	53.00	236.25
NRCJ 89	287.50	86.50	9.50	275.00	67.50	293.75
NRCJ 90	242.00	72.00	6.00	216.00	36.00	215.00
NRCJ 91	320.00	90.00	11.00	307.50	84.00	350.00
NRCJ 92	297.00	71.80	7.00	282.00	52.20	313.50
Mean	**280.68**	**69.48**	**7.92**	**260.34**	**55.68**	**278.40**
SEM±	**6.94**	**2.48**	**0.43**	**8.49**	**4.11**	**12.65**
C.D.	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

(4) Provenance Trial I (Aug., 2005)

The seeds of 18 different provenances collected from Rajasthan, Uttar Pradesh, Madhya Pradesh, Uttarakhand and Tamilnadu during October-November 2004 were planted in the field for evaluation of their growth and yield. The trial was planted in the field during August, 2005, following randomized block design in three replications. Each provenance had six plants under each replication. The plants were planted at the spacing of 5 m apart. Data on growth and yield parameters recorded are being presented in Table 53.

Significant differences (p>0.05 level) among the 18 provenances for plant height, and number of secondary Branches were observed. Rest characters were found non-significant. Significantly high positive correlations (r =0.42 to 0.943, p>0.01 level) were observed between all the growth traits with each other.

Fruit and Seed yield

The seed yield varied from 48 kgha^{-1} in NRCJ87 to 66kg ha^{-1} in NRCJ75. Among other provenances NRCJ79 also gave 64kg ha^{-1} seed yield. The 100 fruit weight varied from 170.50g to 260.52g. Similarly, 100 seed weight varied from 41.50g to 46.50g. Fruit length varied from 24.58mm to the 27.12mm. Fruit width varied from 20.62mm to 21.98mm.

Plant height

At the age of seven years the average plant height was 234.66cm and ranged from a minimum of 170.0cm (NRCJ80) to a maximum of 268.56cm (NRCJ88). Other provenances recorded for high plant height were NRCJ84 (254.25cm), NRCJ82 (252.50cm), NRCJ87 (245.00cm), and NRCJ79 (242.50cm). A total of eight provenances were recorded above the population mean.

Collar girth

Average collar girth was recorded 61.24cm with the range from a minimum of 42.0cm (NRCJ80) to a maximum of 77.25cm (NRCJ82). Other accessions having high collar girth were NRCJ87 (76.60cm), NRCJ83 (66.60cm), NRCJ81 (65.33cm) and NRCJ77 (62.60cm). Out of 18 provenances, seven were recorded above the population mean.

Number of primary and secondary branches per plant

Number of primary branches ranged from a minimum of 4.60 (NRCJ85) to a maximum of 8.40 (NRCJ87) with the population mean of 6.08. Other provenances with high number of primary branches were NRCJ83 (8.0), NRCJ88 & NRCJ74 (7.00) and NRCJ82 (6.75). Out of 18 provenances, five were recorded above the population mean. Secondary branches per plant were increased and significant. The population mean for this trait was recorded 58.90 with the range from a minimum of 31.40 (NRCJ85) to a maximum of 78.22 (NRCJ88). Other provenances recorded with high number of secondary branches were NRCJ83 (75.20), NRCJ75 (73.00) and NRCJ87 (72.80). Seven accessions were recorded above the population mean.

Primary branch length

Average primary branch length was 224.64cm and ranged from a minimum of 164.50cm (NRCJ80) to a maximum of 245.88cm (NRCJ82). The other accessions with high branch length were NRCJ88 (241.61cm), NRCJ87 (239.10cm) and NRCJ84 (234.19cm).

Canopy diameter

At the age of seven years, average canopy diameter was recorded 267.40cm with the range from 176.50cm (NRCJ85) to 337.50cm (NRCJ82). Other accessions having high canopy diameter were NRCJ88 (321.67cm), NRCJ79 (313.13cm), NRCJ83 (295.5cm) and NRCJ87 (287.20cm). Out of

Table 53: Growth performance of different provenances of *J. curcas*

Genotypes	Plant height (cm)	Collar girth (cm)	No. of primary branches	Primary branch length (cm)	No. of sec. branches	Canopy diameter (cm)	Seed yield (g)	Seed yield (kg ha^{-1})
NRCJ71	215.00	56.00	5.00	208.00	42.00	196.00	000.0	00.0
NRCJ72	206.67	50.33	5.33	200.33	56.33	227.17	000.0	00.0
NRCJ73	223.75	54.75	5.00	219.25	71.50	268.75	000.0	00.0
NRCJ74	222.33	56.33	7.00	223.33	62.33	236.67	000.0	00.0
NRCJ75	232.50	62.50	5.50	225.75	73.00	280.00	165.0	66.0
NRCJ76	236.25	60.50	5.00	229.63	44.00	285.63	000.0	00.0
NRCJ77	238.00	62.60	4.80	232.00	36.60	240.50	000.0	00.0
NRCJ78	232.50	51.00	5.00	226.50	48.00	243.75	000.0	00.0
NRCJ79	242.50	58.00	6.00	233.88	57.75	313.13	160.0	64.0
NRCJ80	170.00	42.00	5.00	164.50	33.00	177.50	000.0	00.0
NRCJ81	226.67	65.33	6.00	221.00	55.67	247.17	000.0	00.0
NRCJ82	252.50	77.25	6.75	245.88	50.50	337.50	140.0	56.0
NRCJ83	238.00	66.60	8.00	232.30	75.20	295.50	000.0	00.0
NRCJ84	254.25	58.63	6.00	234.19	69.63	273.12	125.0	50.0
NRCJ85	181.60	61.60	4.60	175.60	31.40	176.50	000.0	00.0
NRCJ86	212.50	54.50	5.00	208.25	36.50	177.75	000.0	00.0
NRCJ87	245.00	76.60	8.40	239.10	72.80	287.20	120.0	48.0
NRCJ88	268.56	60.89	7.00	241.61	78.22	321.67	130.0	52.0
Mean	**234.66**	**61.24**	**6.08**	**224.64**	**58.90**	**267.40**	**140.0**	**56.0**
SEM±	**9.99**	**5.83**	**0.63**	**10.65**	**8.00**	**20.38**		
CD@5%	**29.04**	**NS**	**NS**	**NS**	**23.26**	**NS**		
C.V	**7.69**	**-**	**-**	**-**	**25.97**	**-**		

18, nine provenances were recorded above the population mean.

(5) Candidate Plus Tree Progeny Trial (August, 2006)

Progeny seeds of candidate plus trees collected during November, 2005 from different parts of Uttar Pradesh, Uttaranchal, Madhya Pradesh and Maharashtra, were planted in the field during August, 2006 in the form of evaluation trial. In this trial, 84 CPT progenies were planted in randomized block design in three replications. The spacing between plant to plant and row to row was 3m apart. At the age of six years all the accessions were recorded for seed yield (Table 54) and different morphological traits.

Table 54: Fruit and seed yield parameters of selected genotypes of *J. curcas*

Genotype	Fruit length (mm)	Fruit width (mm)	100 fruit weight (g)	fruit yield (g plant^{-1})	Seed length (mm)	Seed width (mm)	Seed thick-ness (mm)	100 seed weight (g)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})
NRCJ 81	27.01	19.17	200.00	220.00	16.39	10.42	7.35	43.53	125.00	138.75
NRCJ 84	26.82	19.81	225.00	880.00	18.41	11.42	9.16	55.37	510.00	566.1
NRCJ 93	26.05	21.15	250.00	705.00	17.91	11.48	8.29	59.80	410.00	455.1
NRCJ 94	27.42	20.79	240.00	280.00	18.24	11.91	8.92	55.26	150.00	166.5
NRCJ 96	28.70	21.15	215.00	510.00	18.21	10.80	9.32	50.50	295.00	327.45
NRCJ 104	26.36	20.27	205.00	535.00	17.21	11.38	8.16	54.37	315.00	349.65
NRCJ 106	24.86	21.77	220.00	525.00	19.29	10.24	9.97	58.05	305.00	338.55
NRCJ 111	25.52	20.87	240.00	780.00	17.42	10.81	8.32	52.93	450.00	499.5
NRCJ 114	24.96	18.10	220.00	745.00	15.28	10.36	8.16	52.78	440.00	488.4
NRCJ 115	27.22	21.52	225.00	605.00	17.50	10.57	11.39	54.72	358.33	397.75
NRCJ 116	25.34	21.54	215.00	995.00	17.20	10.94	8.20	50.44	585.00	649.35
NRCJ 124	29.26	20.74	255.00	1165.00	18.36	10.32	8.21	61.07	680.00	754.80
NRCJ 125	25.92	20.29	250.00	840.00	18.28	11.39	8.94	49.41	497.50	552.23
NRCJ 126	28.66	20.41	265.00	1295.00	15.91	10.98	7.80	46.85	760.00	843.6
NRCJ 127	25.60	20.43	205.00	1135.00	16.23	10.14	8.73	49.67	670.00	743.7
NRCJ 128	26.45	22.19	245.00	250.00	18.69	11.92	8.42	51.68	285.00	316.35
NRCJ 129	27.88	21.13	245.00	765.00	17.91	10.39	8.32	45.63	445.00	493.95
NRCJ 137	26.64	19.20	230.00	480.00	17.32	10.51	7.29	55.44	280.00	310.8
NRCJ 139	25.63	19.71	190.00	510.00	18.41	10.24	9.31	42.98	300.00	333.0
NRCJ 140	26.63	19.62	220.00	305.00	18.81	11.32	8.19	50.20	175.00	194.25
NRCJ 142	26.53	20.03	222.50	617.50	17.83	11.22	8.20	50.17	362.50	402.38
NRCJ 143	28.17	25.45	220.00	745.00	17.34	12.36	8.68	47.34	440.00	488.4
NRCJ 145	28.08	21.44	235.00	600.00	17.48	10.74	8.18	34.67	352.50	391.28
NRCJ 150	25.73	19.67	220.00	235.00	17.24	10.80	8.41	43.34	135.00	149.85
NRCJ 152	24.62	21.27	165.00	112.50	17.08	10.47	8.63	46.27	117.50	130.45
NRCJ 154	26.12	18.92	220.00	445.00	16.86	10.40	7.81	52.85	255.00	283.05
NRCJ 158	28.45	21.78	270.00	465.00	18.41	10.32	8.16	56.81	265.00	294.15
NRCJ 159	25.31	20.34	242.50	910.00	17.92	10.87	8.20	56.59	537.50	596.63
NRCJ 164	26.41	19.34	225.00	485.00	16.31	10.39	7.26	48.67	285.00	316.35
Mean	26.58	20.63	226.08	618.24	17.56	10.85	8.61	50.72	368.24	408.75
SEM±	0.24	0.22	4.20	50.40	0.15	0.09	0.27	1.12	28.70	

ANOVA revealed significant differences (p> 0.01& 0.05 levels) among the 84 genotypes for all the growth, characters except number of primary and secondary branch. Significantly positive correlations (r =0.092 to 0.973, p>0.01& 0.05 level) were observed between all with each other except number of primary branches, branch length and plant height.

Fruit and Seed yield

A large variation was recorded in the fruit and seed yield among the genotypes. Besides it, there was variation in seed yield over the years and selected genotypes were not showing consistency in the seed yield. Average seed yield was 368.24g per plant. Maximum seed yield of 760.0g was recorded in NRCJ126. It was followed by NRCJ124 (680.0g), NRCJ127 (670.00g), NRCJ116 (585.00g), NRCJ159 (537.5g) and NRCJ84 (510.00g) Fruit yield was also high in the said genotypes. Average 100 fruit weight was 226.08g and it varied from a minimum of 165.0g (NRCJ152) to maximum of 270.00g (NRCJ158). Similarly, average 100 seed weight was 50.72g and it varied from a minimum of 34.66g (NRCJ145) to maximum of 61.07g (NRCJ124).

Plant height

Average plant height at the age of six years was 251.95cm (Table 55). Plant height ranged from a minimum of 190.00cm in NRCJ109 to a maximum of 293.00cm in NRCJ144. A total of 42 accessions were recorded above the population mean. The other accessions recorded for more plant height were NRCJ141 (287.50cm), NRCJ159 (277.06cm), NRCJ94 (276.25cm) and NRCJ111 (274.55cm).

Collar girth

Average collar girth at the age of six years was 62.32cm. Collar girth ranged from a minimum of 39.25cm in NRCJ163 to a maximum of 80.13cm in NRCJ89. Out of 85 accessions, 40 were recorded above the population mean. The other accessions recorded for more collar girth were NRCJ140 (78.56cm), NRCJ105 (77.0cm), NRCJ88 (75.0cm) and NRCJ83 (74.78cm).

Number of primary and secondary branches per plant

Average number of primary branches per plant was 5.63 and ranged from a minimum of 4.11 in NRCJ135 to a maximum of 6.91 in NRCJ134. Out of 85 accessions, 36 were recorded for above the population mean. The other accessions for high number of primary branches were NRCJ89 (6.88), NRCJ105 (6.83), NRCJ124 (6.50) and NRCJ99 (6.40). Average number of secondary branches per plant was 39.18 and ranged from a minimum of 24.50 in NRCJ118 to a maximum of 51.80 in NRCJ88. Other genotypes recorded with high number of secondary branches were NRCJ115 (51.67), NRCJ104 (50.33) NRCJ99 (49.10) and NRCJ154 (47.89). Forty two accessions were recorded above the population mean.

Primary branch length

Average primary branch length was 243.32cm and ranged from a minimum of 185.50cm (NRCJ109) to a maximum of 287.80cm (NRCJ144). The other accessions with more branch length were NRCJ141 (280.40cm), NRCJ113 (274.94cm), NRCJ94 (270.50cm) NRCJ111 (268.55cm) and NRCJ159 (267.65cm).

Canopy diameter

At the age of six years, average canopy diameter was 237.81cm and ranged from a minimum of 150.00cm (NRCJ163) to a maximum of 283.10cm (NRCJ144). Other accessions having high canopy diameter were NRCJ154 (281.94cm), NRCJ102

Table 55: Growth performance of different progenies of *J. curcas*

Genotype	Plant height (cm)	Collar girth (cm)	No. of primary branches	Primary branch length (cm)	No. of secondary branches	Canopy diameter (cm)
NRCJ 81	256.00	70.60	6.00	244.35	41.50	263.00
NRCJ 82	232.92	66.00	6.33	224.21	37.00	233.96
NRCJ 83	251.11	74.78	6.22	243.17	47.00	268.89
NRCJ 84	252.00	49.30	5.30	243.40	40.50	246.25
NRCJ 85	262.27	64.09	5.64	251.55	44.27	247.95
NRCJ 86	243.33	72.67	6.17	235.42	46.33	244.17
NRCJ 87	246.25	60.00	6.50	240.63	34.75	231.56
NRCJ 88	239.00	75.00	4.60	223.80	51.80	241.50
NRCJ 89	223.75	80.13	6.88	213.81	40.88	242.19
NRCJ 90	243.64	58.45	5.91	235.18	35.45	245.68
NRCJ 91	254.38	70.25	5.25	245.50	37.13	243.13
NRCJ 92	238.33	61.78	5.44	229.56	33.78	218.72
NRCJ 93	256.25	69.17	6.00	247.58	37.33	226.04
NRCJ 94	276.25	68.87	6.13	270.50	45.50	245.75
NRCJ 95	257.50	68.40	6.10	248.65	46.80	257.25
NRCJ 96	265.00	61.73	5.18	252.41	32.82	223.86
NRCJ 97	244.00	62.60	6.00	233.40	42.80	243.75
NRCJ 98	225.00	62.89	5.56	214.39	36.44	220.83
NRCJ 99	247.00	63.80	6.40	237.05	49.10	221.80
NRCJ 100	265.50	68.70	6.30	254.65	42.90	261.50
NRCJ 101	245.62	73.50	5.63	231.56	38.00	238.06
NRCJ 102	253.13	68.00	6.25	246.31	46.13	277.50
NRCJ 104	256.11	71.00	5.89	245.50	50.33	248.33
NRCJ 105	235.00	77.00	6.83	224.17	44.83	248.75
NRCJ 106	249.17	63.33	6.00	239.08	42.83	224.17
NRCJ 107	236.82	60.64	5.09	233.14	35.82	237.73
NRCJ 108	262.73	58.00	5.18	258.68	42.73	245.68
NRCJ 109	190.00	40.50	5.00	185.50	25.50	171.25
NRCJ 110	249.00	64.10	5.50	240.85	39.90	212.35
NRCJ 111	274.55	62.45	4.82	268.55	35.82	254.09
NRCJ 113	281.11	59.89	4.89	274.94	44.67	230.39
NRCJ 114	240.42	57.67	5.00	230.96	29.75	202.29
NRCJ 115	255.00	65.47	5.87	246.47	51.67	253.83
NRCJ 116	256.25	61.50	5.92	247.33	43.33	257.38
NRCJ 117	251.67	60.00	5.50	243.83	47.33	220.08
NRCJ 118	240.00	60.25	4.75	232.88	24.50	189.38
NRCJ 119	227.22	60.56	5.56	212.61	33.22	204.44
NRCJ 120	250.00	71.22	5.89	239.06	37.33	228.89
NRCJ 121	226.88	54.38	5.75	218.69	32.63	199.69
NRCJ 122	246.00	61.07	5.27	230.33	41.67	238.67
NRCJ 124	241.07	60.79	6.50	233.54	39.57	228.21
NRCJ 125	250.00	53.00	5.08	236.54	36.50	242.96
NRCJ 126	257.86	58.71	5.00	250.29	34.71	227.50

Genotype	Plant height (cm)	Collar girth (cm)	No. of primary branches	Primary branch length (cm)	No. of secondary branches	Canopy diameter (cm)
NRCJ 127	270.45	61.91	5.82	263.23	41.73	250.73
NRCJ 128	257.31	60.08	5.77	250.04	37.77	228.73
NRCJ 129	253.89	65.00	6.00	246.39	40.44	233.89
NRCJ 130	255.00	64.17	5.50	252.25	39.25	239.54
NRCJ 131	218.33	47.67	4.33	205.83	37.00	208.33
NRCJ 132	248.50	63.10	5.30	242.40	40.70	257.00
NRCJ 133	272.00	60.50	4.75	267.50	33.00	226.88
NRCJ 134	235.91	70.18	6.91	227.00	35.91	240.91
NRCJ 135	234.44	42.44	4.11	225.33	28.78	206.94
NRCJ 137	234.78	58.33	5.33	226.67	39.22	227.61
NRCJ 138	262.86	52.86	5.00	255.86	34.43	246.07
NRCJ 139	272.00	60.00	6.00	266.40	38.20	274.50
NRCJ 140	252.22	78.56	6.44	243.83	40.11	247.78
NRCJ 141	287.50	63.80	6.40	280.40	39.50	243.75
NRCJ 142	271.00	51.10	5.30	265.20	42.20	270.50
NRCJ 143	264.50	58.20	5.30	260.10	37.00	258.00
NRCJ 144	293.00	72.40	5.60	287.80	43.00	283.10
NRCJ 145	256.67	58.67	5.89	236.89	37.56	228.61
NRCJ 146	249.55	63.36	5.27	242.82	36.91	237.95
NRCJ 147	245.56	65.00	5.22	238.11	32.22	228.89
NRCJ 148	255.63	64.38	5.63	249.94	43.13	220.00
NRCJ 149	250.71	57.00	5.86	245.50	41.00	259.29
NRCJ 150	255.91	64.18	5.55	246.86	39.09	246.14
NRCJ 151	248.75	61.38	6.88	237.75	41.88	225.94
NRCJ 152	257.86	66.07	5.86	249.07	41.36	247.32
NRCJ 153	242.22	54.78	5.00	235.89	28.78	222.50
NRCJ 154	266.11	66.78	6.00	259.39	47.89	281.94
NRCJ 155	230.56	47.11	5.00	222.06	29.89	187.50
NRCJ 156	262.00	57.20	5.50	251.62	40.90	249.25
NRCJ 157	241.50	65.40	5.30	231.65	37.60	225.75
NRCJ 158	243.64	60.36	5.82	231.64	43.82	247.05
NRCJ 159	277.06	59.94	6.00	267.65	42.00	245.15
NRCJ 160	267.22	50.22	4.33	262.11	26.56	223.61
NRCJ 161	255.56	65.11	5.22	248.39	38.44	249.39
NRCJ 162	267.00	62.00	5.00	262.40	31.20	217.00
NRCJ 163	256.25	39.25	4.25	247.13	23.25	150.00
NRCJ 164	240.45	68.45	5.27	232.23	33.73	227.73
NRCJ 165	253.00	59.40	5.00	248.50	36.80	264.50
NRCJ 166	266.25	53.75	5.25	260.00	47.75	265.63
NRCJ 167	224.00	53.30	5.90	214.15	34.00	204.50
NRCJ 168	253.33	56.33	4.33	246.50	30.67	248.33
Mean	**251.95**	**62.32**	**5.63**	**243.32**	**39.18**	**237.81**
SEM±	**14.61**	**6.21**	**0.61**	**14.75**	**5.31**	**20.72**
CD@5%	**40.49**	**17.20**	**NS**	**40.89**	**NS**	**57.44**
C.V	**11.84**	**20.29**	**-**	**12.38**	**-**	**17.86**

(277.50cm), NRCJ139 (274.50cm) and NRCJ83 (268.89cm). Out of 85, forty four accessions were recorded above the population mean.

(6) National Trial-II (2007)

The seeds of selected 17 superior genotypes of 14 different research centers of the network project were received in Feb. 2007 and their nursery was raised. Their progeny was planted in field during August 2007, following RBD in four replications. Each replication had 16 plants of each genotypes and planted at 3x3m spacing as suggested by the NOVOD board to the centers. During reporting period due to water stagnation while raining season four genotype (CSK24, RJ127, HAUJ39, TNMC33) died. Therefore at the age of five years for thirteen genotypes morphological and yield parameters were recorded and results are being presented here (Table 56).

ANOVA revealed non-significant differences (p>0.05 level) among the genotypes for all the characters. Significantly high positive correlations (r =0.533-0.981, p>0.01 level) were observed between all the traits with each other (plant height, collar girth, number of primary and secondary branches, branch length and canopy diameter).

Seed Yield

A large variation was recorded in the seed yield among all the genotypes. Average seed yield was 134.62 g plant^{-1}. Maximum seed yield of 150 g plant^{-1} was recorded in Orissa 2 & TNMC8. It was followed by PDKV Nov3 (147.50 g plant^{-1}), MPJ55 (138.75 g plant^{-1}), BawalSel (135.00 g plant^{-1}) and Pant J03103 (133.75 g plant^{-1}). Five genotypes had seed yield higher than the average seed yield.

Plant height

At the age of five years average plant height was 276.59cm and ranged from a minimum of 248.75cm in BawalSel to a maximum of 295.00cm in NRCJ2 &

Table 56: Growth performance and seed yield of multilocation National trial-II

Genotype	Plant height (cm)	Collar girth (cm)	No. of primary branches	Branch length (cm)	No. of sec. branches	Canopy diameter (cm)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})
NRCJ2	295.00	56.38	6.13	281.250	67.50	248.13	132.50	147.08
PantJ03103	267.50	55.00	4.00	256.250	49.75	223.75	133.75	148.46
MPJ55	270.45	51.91	4.36	259.318	31.27	197.95	138.75	154.01
PDKV Nov3	293.85	59.69	6.00	280.808	55.00	248.46	147.50	163.73
JA9	288.33	61.67	7.00	277.333	57.00	272.50	130.00	144.30
BawalSel	248.75	46.50	4.25	233.125	29.50	221.25	135.00	149.85
Orissa2	**258.33**	**55.00**	**4.67**	**246.667**	**41.33**	**195.00**	**150.00**	**166.50**
SKNJ2-1	265.00	48.86	5.29	252.143	44.71	200.36	132.00	146.52
NBJ1	266.67	57.67	6.33	243.333	55.67	236.67	125.00	138.75
JawaharJ1	268.33	58.00	4.67	259.167	54.33	225.83	125.00	138.75
NBJ9	258.50	49.50	5.90	246.000	48.60	253.00	130.83	145.22
TNMC8	**256.00**	**35.00**	**6.00**	**246.250**	**58.50**	**217.50**	**150.00**	**166.50**
TNMC19	295.00	54.08	5.67	280.042	43.75	245.00	125.00	138.75
Mean	**276.59**	**53.70**	**5.45**	**263.470**	**47.98**	**232.17**	**134.62**	**149.43**
SEM±	**11.24**	**7.21**	**0.68**	**11.70**	**5.34**	**16.22**	**-**	**-**
CD@5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**-**	**-**
C.V	-	-	-	-	-	-	-	-

TNMC19. Other progenies that showed their superiority for plant height were PDKV Nov3 (293.85cm), JA9 (288.33cm) and MPJ55 (270.45cm). Out of 13 genotypes, four genotypes were recorded above the population mean.

Collar girth

Average collar girth was 53.70cm and ranged from a minimum of 35.00cm (TNMC8) to a maximum of 61.67cm (JA9). The other promising genotypes for high collar girth were PDKV Nov3 (59.69cm), JawaharJ1 (58.00cm), NBJ-1 (57.67cm), and NRCJ2 (56.38cm). Out of 17 genotypes, eight were recorded above the population mean.

Number of primary and secondary branches per plant

Number of primary branches plant^{-1} ranged from a minimum of 4.00 (PantJ03103) to a maximum of 7.0 (JA9). Other promising genotypes were NBJ-1 (6.33), NRCJ2 (6.13), TNMC8 & PDKV Nov3 (6.00) and NBJ-9 (5.90). Out of 17 genotypes, seven were recorded above the population mean. Average number of secondary Branches plant^{-1} was 47.98 and ranged from a minimum of 29.50 (BawalSel) to a maximum of 67.50 (NRCJ2). Other genotypes having high number of secondary branches were TNMC8 (58.50), JA9 (57.00), NBJ-1 (55.67) and PDKV Nov3 (55.00). Out of 13 genotypes, eight were recorded above the population mean.

Branch length

Average primary branch length was 263.47cm and ranged from minimum of 233.13cm (BawalSel) to a maximum of 281.25cm (NRCJ2). Other accessions recorded for more length were PDKV Nov3 (280.81cm), TNMC19 (280.04cm), JA9 (277.33cm) and MPJ55 (259.32cm). Out of 13 genotypes, four were recorded above the population mean.

Canopy diameter

At the age of five years, average canopy diameter was 232.17cm and ranged from a minimum of 195.00cm (Orissa2) to a maximum of 272.50cm (JA9). Other genotypes recorded for high canopy diameter were NBJ9 (253.00cm), PDKV Nov3 (248.46cm), NRCJ2 (248.13cm) and TNMC19 (245.00cm). Out of 13 genotypes, six genotypes were recorded above the population mean.

(7) National Trial-III (2008)

The seeds of selected 18 superior genotypes of 12 different centers 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 as suggested by the NOVOD board to the centers. At the age of four years, all these accessions were recorded for different morphological and yield parameters (Table 57).

ANOVA revealed highly significant differences ($p>0.05$ level) among the genotypes for all the growth traits. Significantly high positive correlations ($r = 0.320$ to 0.992, $p>0.01$ level) were observed between all the traits with each other.

Seed yield

A large variation was observed in the seed yield among the genotypes. Average seed yield was 121.33 g plant^{-1}. Maximum seed yield of 145 g plant^{-1} was recorded in NRCJ89. It was followed by CRJ29 (130 g plant^{-1}) and CALD14 (127.50 g plant^{-1}). Four genotypes *viz.* TNCJC19, PantJCP2, TFRI07 & TR4 seed yield of 125 g plant^{-1}. Eight genotypes had seed yield higher than the average yield.

Plant height

The average plant height was recorded 214.06cm that ranged from a minimum of 180.00cm (MNJ006) to a maximum of 232.86cm (TFRI07). The other progenies that showed their superiority for plant height were TNCJC20 (225.38cm), CRJ29 (223.75cm), LBJJ23 (223.76cm) and TNCJC19 (222.95cm). Out of 18 accessions, seven were recorded above the population mean.

Collar girth

Average collar girth was 41.39cm and it ranged from a minimum of 34.47cm (NRCJ18) to a maximum of 51.50cm (MNJ001). The other promising accessions were TNCJC19 (46.90cm), PantJCP2 (45.18cm) JJ2 (44.06cm), and TFRI07 (44.0cm). Out of 18 accessions, nine were recorded above the population mean.

Number of primary and secondary branches

Number of primary branches plant^{-1} ranged from a minimum of 3.22(NDJC1) to a maximum of 5.43 (TFRI07). Out of 18 accessions, nine were recorded above the population mean. Other promising accessions were CALD14 (5.00), TNCJC19 (4.90), PantJCP2 (4.71) and NRCJ18 (4.60). Average number of secondary branches plant^{-1} was 22.36 and ranged from a minimum of 14.50 (MNJ006) to a maximum of 28.0 (TNCJC19). Other genotypes having more number of secondary branches were JJ2 (27.62), TFRI07 (27.00), PantJCP2 (26.71) and

Table 57: Growth performance and seed yield of multilocation National trial.

Genotype	Plant Height (cm)	Collar Girth (cm)	No. of primary Branches	Branch Length (cm)	No. of Sec. Branches	Canopy diameter (cm)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})
PDKV Nov19	218.06	41.39	4.11	213.94	21.67	193.33	115.00	127.65
NRCJ2	208.81	37.14	3.52	204.86	16.95	177.02	105.00	116.55
NRCJ18	213.00	34.47	4.60	208.40	16.67	170.67	117.50	130.43
NRCJ89	205.50	36.00	4.30	201.30	20.30	181.50	145.00	160.95
TFRI07	232.86	44.00	5.43	231.14	27.00	222.36	125.00	138.75
JJ2	221.00	44.06	4.44	216.69	27.62	227.81	121.25	134.59
CRJ29	223.75	41.50	4.25	219.75	21.75	204.69	130.00	144.30
LBJJ23	223.67	37.87	3.67	216.50	19.87	183.17	115.00	127.65
CALD14	209.09	40.73	5.00	203.86	23.09	184.09	127.50	141.53
TNCJC19	222.95	46.90	4.90	218.65	28.00	216.00	125.00	138.75
TNCJC20	225.38	43.79	4.00	221.73	26.54	221.67	123.33	136.90
TNCJC25	214.44	37.44	3.78	209.11	20.78	174.89	120.00	133.20
PantJCP1	204.29	42.86	3.71	200.57	25.57	210.00	115.00	127.65
PantJCP2	214.41	45.18	4.71	209.79	26.71	208.68	125.00	138.75
TR4	183.75	43.25	3.75	176.13	19.38	193.44	125.00	138.75
MNJ001	190.00	51.50	4.33	185.17	18.00	154.58	110.00	122.10
MNJ006	180.00	41.25	3.25	175.38	14.50	133.75	121.33	000.00
NDJC1	198.89	37.33	3.22	194.28	15.22	155.00	115.00	000.00
Mean	**214.06**	**41.39**	**4.20**	**209.52**	**22.36**	**194.76**	**105.00**	**134.68**
SEM±	8.37	2.46	0.30	8.35	2.70	13.65	-	-
CD@5%	23.92	7.04	0.85	23.87	7.73	39.01	-	-
C.V	7.95	12.26	14.57	8.11	24.54	14.18	-	-

TNCJC20 (26.54). Out of 18 genotypes, seven were recorded above the population mean.

Branch length

Average branch length was recorded 209.52cm which ranged from minimum of 175.38cm (MNJ006) to a maximum of 231.14cm (TFRI07). Other accessions recorded for more length were TNCJC20 (221.73cm), CRJ29 (219.75cm), TNCJC19 (218.65cm) and JJ2 (216.69cm). Out of 18 genotypes, seven were recorded above the population mean.

Canopy diameter

Average canopy diameter was recorded 194.76cm and ranged from a minimum of 133.75cm (MNJ006) to a maximum of 227.81cm (JJ2). Other accessions which were recorded for more canopy diameter were TFRI07 (222.36cm), TNCJC20 (221.67cm), TNCJC19 (216.00cm), PantJCP1 (210.00cm) and PantJCP2 (208.68cm). Out of 18 genotypes, seven were recorded above the population mean.

[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 apart following randomized block design with three replications. The growth and yield data recorded during December 2012 is presented hereunder.

Morphological traits

Data pertaining to morphological traits has been presented in Table 58. It is clear that at the age of seven years, average tree height was 465.91cm with the range from a minimum of 368.57cm in NRCP-14 to a maximum of 524.00cm in NRCP-16. Other progenies recorded for more tree height were, NRCP-9 (506.38cm), NRCP-7 (495.83cm), NRCP-6 (490.00cm) and NRCP-13 (487.50cm). A total of 8 accessions were recorded above the population mean.

The collar girth ranged from a minimum of 40.43cm (NRCP-14) to a maximum of 63.60cm (NRCP-16) with the population mean of 51.74cm. The other progenies which proved their superiority for collar girth were NRCP-13 (57.50cm), NRCP-21 (56.86cm), NRCP-6 (56.50cm) and NRCP-9 (56.15cm). A total of 10 accessions were recorded above the population mean.

Similarly, the average number of primary branches tree^{-1} was 2.64 and ranged from a minimum of 2.00 (NRCP-23) to a maximum of 3.15 (NRCP-9). More number of primary branches tree^{-1} recorded in other progenies was NRCP-26 (2.89), NRCP-22 & 25 (2.80), NRCP-18& 6 (2.73) and NRCP-16 (2.75). Seven accessions were recorded above the population mean.

Average canopy diameter was recorded 494.45cm in the population and nine accessions were recorded above the population mean. Tree canopy diameter ranged from a minimum of 347.5cm (NRCP-23) to a maximum of 567.67cm (NRCP-16). The other progenies which were recorded for high canopy diameter were NRCP-21 (555.00cm), NRCP-7 (552.50cm) and NRCP-12 (531.25cm).

Correlation study revealed highly significant positive correlation ($p > 0.01$ & $p > 0.05$ level) between all the morphological traits (tree height, collar girth, number of primary branches and canopy diameter) except number of pods which was having positive relationship only with canopy diameter.

Table 58: Growth performance and pod yield of different progenies of *P. pinnata*

Genotype	Plant Height (cm)	Collar girth (cm)	No. of primary branches	Canopy diameter (cm)	Ave. No. of pods
NRCP 6	490.00	56.50	2.75	477.50	415.00
NRCP 7	495.83	55.17	2.50	552.50	379.20
NRCP 9	506.38	56.15	3.15	528.85	69.33
NRCP 10	446.11	42.44	2.56	470.56	144.00
NRCP 11	455.45	46.55	2.27	510.00	249.44
NRCP 12	432.50	54.75	2.50	531.25	47.67
NRCP 13	**487.50**	**57.50**	**2.50**	**526.25**	**985.00**
NRCP 14	368.57	40.43	2.29	405.00	175.20
NRCP 16	524.00	63.60	2.73	567.67	199.90
NRCP 17	458.57	49.57	2.43	473.57	432.25
NRCP 18	412.50	44.33	2.75	464.83	164.20
NRCP 20	472.86	47.29	2.57	435.71	36.40
NRCP 21	**445.71**	**56.86**	**2.57**	**555.00**	**1616.86**
NRCP 22	453.00	49.00	2.80	445.25	178.36
NRCP 23	460.00	44.00	2.00	347.50	150.00
NRCP 24	484.44	52.22	2.44	439.72	303.75
NRCP 25	463.00	54.40	2.80	506.00	60.40
NRCP 26	479.44	55.67	2.89	525.56	158.43
Mean	**465.91**	**51.74**	**2.64**	**494.45**	**310.97**
SEM±	**33.06**	**4.86**	**0.23**	**42.81**	**243.17**
CD@5%	**95.48**	**14.04**	**NS**	**123.31**	**702.23**
C.V	**12.56**	**16.65**	**-**	**15.48**	**144.79**

Fruiting in Karanja

Pods counted during December, 2012 revealed a large variation between and within the genotypes. It was observed that all the accessions were in bearing. Out of 135 plants representing all the accessions, a total of 96 trees bear pods in varying quantity. The average number of pods was 310.97 with a minimum of 36.40 in NRCP-20 to a maximum of 1616.86 pods plant^{-1} in NRCP-21. The other accessions that beard more number of pods were NRCP-13 (985.00), NRCP-17 (432.25) and NRCP-6 (415.00). On per tree basis maximum number of pods 6654 & 2025 was recorded in two plants of NRCP-21 followed by 1755 in NRCP-7 and 1565 & 1355 in two plant of NRCP-13. However, NRCP- 21 showing steady performance since last few years. Besides it, good variation was observed in size and shape of pods among the different accessions.

ICAR, IINR & G, Ranchi

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

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

The main objective of the project is to develop agroforestry models including gum and resin yielding trees for livelihood security and horizontal dissemination of technologies. During the year growth of established gum yielding tree based AF model was monitored. A new agroforestry model was planted on NRCAF farm and boundary plantations were done in farmer's field. Besides, gum tapping techniques for *Butea monosperma* were standardized.

1. DEVELOPMENT OF AGRO-FORESTRY MODEL

A. NRCAF Farm

Data on survival and plant growth in four AF models (42 months old) raised on NRCAF farm have been given in Table 59.

In agri-horti-silviculture model, maximum survival was recorded in *Aegle marmelos* and plant height in *Acacia senegal*. The minimum survival and growth was observed in *Carrisa carandus*. In horti-silviculture-I model, *Acacia senegal* planted in rows shown lesser survival (27%) than on boundary (90%). In term of plant height and other growth parameters, rows plantation attained better growth than boundary. *Terminalia arjuna* has shown 100% survival. In horti-silviculture –II model, *Acacia nilotica* has shown maximum growth. In both horti-silviculture models, fruit yielding species *viz. Citrus limon* and *Psidium guajava* could not survive. Survival of *Acacia Senegal* block plantation on rocky site was 100% and plants attained mean height of 194 cm with collar dia of 2.5 cm. In general, survival and growth of *A. nilotica* was better than *A. senegal*.

In newly planted agri-silvi model, maximum survival was recorded by *A. senegal* at 10 X 10 m spacing while least by *A. nilotica* at 10X5 m spacing (Table 60). On

Table 59: Growth and survival of trees in the agroforestry models at NRCAF farm (42 MAP)

Agroforestry Models	Collar diameter (cm)	Height (cm)	Canopy (m²)	Survival (%)
Agri-horti-silviculture (Field No. 25)				
Acacia senegal (Kumat)	9.19	389.17	10.85	82
Citrus limon (Lemon)	4.88	240.95	4.56	91
Aegle marmelos (Bael)	8.11	305.00	4.98	96
Carrissa carandus (Karonda)	0.65	74.41	0.095	75
Horti-Silviculture I (Field 20)				
Acacia senegal (Kumat)	9.09	379.44	15.17	27
Terminalia arjuna (Arjun)	4.87	155.4	1.65	100
Acacia senegal (Kumat) (boundary)	6.49	268.6	5.92	90
Horti-Silviculture II (Field 20)				
Acacia nilotica (Babul)	41.56 (GBH)	621.60	35.04	100
Terminalia arjuna (Arjun)	4.83	167.80	2.63	100
Acacia senegal (Kumat) (boundary)	5.39	209.80	3.81	90
Block plantation				
Acacia senegal (Kumat)	2.49	194.03	1.12	100

Table 60: Growth and survival of gum yielding trees in Agri-silvi model planted in 2012 at NRCAF farm

Tree species	Spacing	Collar diameter (cm)	Height (cm)	Survival (%)
Acacia nilotica (Babul)	10x10m	0.58	43.4	86
	10x5m	0.48	45.84	61
	5x5m	0.87	52.71	84
	Mean	0.64	47.32	77
Acacia senegal (Kumat)	10x10m	0.78	38.79	90
	10x5m	0.72	37.94	69
	5x5m	0.88	33.81	84
	Mean	0.79	36.85	81

an average, *A. senegal* shown better survival (81%) than *A. nilotica* (77%).

Growth and yield data of mustard grown in agri-horti-silvi model is given in Table 61. Different tree species had significantly reduced grain yield up to 0.5m distance from tree trunk while yield at 2.5m and 4.5 m distance was not affected.

B. On Farmer's field

Data on survival and growth of various species planted in different agroforestry model at farmer's field in GKD watershed and Ambabai village have been given in Table 62, 63 and 64.

After 42 months 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 (18%). In terms of plant height *A. senegal* was better than *A. nilotica* whereas, reverse was true in case of collar dia. Newly planted *A. senegal* recorded 70 to 96% survival in GKD watershed. In Ambabai village after 18 months of planting, survival of *A. senegal* was 41% with plant height of 161 cm and collar dia 3.14 cm.

2. Gum Tapping Technique for *Butea monosperma*

A. Effect of lac production on gum yield and *vice versa*

To assess effect of inoculation of lac insect on gum yield of butea trees, a trial was conducted at naturally occurring 15-20 year old trees of butea. Lac insect was inoculated in the month of November 2012 and lac yield will be harvested in July 2013. For exudation of gum knotching was done in the month of December on both lac inoculated and un-inoculated trees. It is revealed that inoculation of lac insect increased gum exudation in butea trees (Fig. 54). Trees inoculated with lac insect yielded more gum (76.0 g m^{-2}) than un-inoculated trees.

Table 61: Growth and yield attributes of Mustard *(Pusa jagganath)* under agroforestry model including gum and resin yielding trees (2012)

Tree spp.	Plant population m^{-2} (No.)				Plant height (m)			
	Distance from tree line (m)							
	0.5	2.5	4.5	Mean	0.5	2.5	4.5	Mean
Acacia senegal	4	9	15	9	1.23	1.45	1.95	1.54
Citrus limon	8	11	14	11	1.71	1.93	1.99	1.87
Aegle marmelos	15	16	17	16	1.71	1.88	1.85	1.81
Control	20	20	20	20	2.10	2.10	2.10	2.10
Mean	12	14	16		1.69	1.84	1.97	
	t	d	txd		t	d	txd	
C.D. (0.05%)	1.11	0.97	1.93		0.17	0.14	0.29	
Tree spp.	Total biomass (g m^{-2})				Grain yield (g m^{-2})			
	0.5	2.5	4.5	Mean	0.5	2.5	4.5	Mean
Acacia senegal	40.38	130.55	348.38	173.10	7.33	40.98	111.91	53.40
Citrus limon	280.55	425.54	420.57	375.55	81.99	147.45	106.26	111.90
Aegle marmelos	470.73	444.71	470.72	462.05	127.09	133.52	199.31	153.31
Control	745.46	745.46	745.46	745.46	274.12	274.12	274.12	274.12
Mean	384.28	436.56	496.28		122.63	149.02	172.90	
	t	d	txd		t	d	txd	
C.D. (0.05%)	76.10	65.90	131.80		50.18	NS	NS	

Table 62: Growth parameters of trees in the agroforestry models at GKD Watershed (42 MAP)

Plantation	Collar diameter (cm)	Height (cm)	Canopy (m^2)	Survival (%)
Thakur Das				
Acacia nilotica (Babul)	37.67	237.50	1.96	53
Psidium guajava (Guava)	2.28	117.36	0.72	98
Carrissa carandus (Karonda)	0.6	73.00	0.11	12
Himmat				
Acacia senegal (Kumat)	6.43	258.33	6.63	78
Emblicaofficinalis (Anola)	10.31	377.29	10.85	54
Carrissa carandus (Karonda)	0.63	48.00	0.08	18

Table 63: Growth of trees in the agroforestry models (Boundary) at Ambabai village (18 MAP)

Plantation	Collar diameter (cm)	Height (cm)	Canopy (m^2)	Survival (%)
Mani Ram				
Acacia senegal (Kumat)	3.14	161.36	2.76	41

Table 64: Survival of boundary plantation of gum yielding tree -*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	84
2	Shambhu	50	2.5 m apart	88
3	Gangadhar	50	2.5 m apart	80
4	Soni Pal	50	2.5 m apart	90
5	Saligram	10	4 m apart	80
6	Ghanshyam	50	2.5 m apart	96
7	Ram Swarup	20	3 m apart	80
8	Sumer	20	3 m apart	70
9	Manoj	10	4 m apart	70
	Total	310		

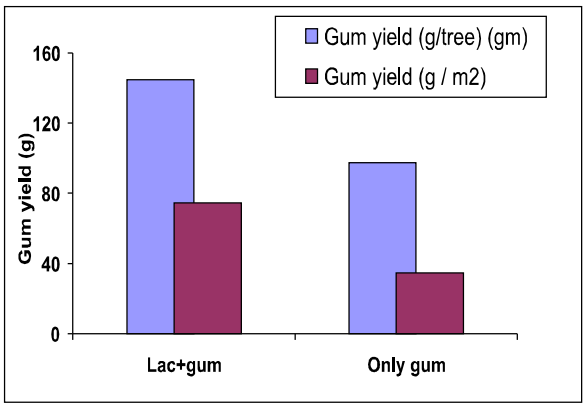


Fig 54: Effect of lac production on gum yield and vice versa in *Butea monosperma*

B. Effect of different types of cuts on gum yield

A separate trial was conducted on naturally occurring 10-15 years old trees of butea for assessing whether type of incision on bark had any effect on yield of gum-butea. Four types of cuts *viz*.knotching (control), vertical, slant cut and horizontal cut on bark of stem were evaluated. Findings reveal that maximum gum-butea was obtained by knotching followed by vertical cuts (Fig. 55). The slant cuts yielded minimum gum-butea.

C. Effect of Ethephon on yield of gum-butea

A trial conducted on naturally occurring 15-20 years old trees of butea at NRCAF farm to assess effect of gum inducer (Ethephon) on yield of gum-butea. Trial consisted of four treatments *viz.* control, spray of Ethephon on tree surface before knotching, spray of Ethephon after knotching and injection of Ethephon at base of tree before knotching; and three doses *viz.* 4 ml of 10%, 4 ml of 20% and 4 ml of 30% Ethephon. The finding revealed that yield of gum butea was significantly influenced by application of Ethephon, however, doses did not affect the yield. Maximum gum-butea was obtained when Ethephon was sprayed on tree surface before knotching (Table 65).

D. Effect of fire on yield of gum-butea

The yield of gum-butea (g m^{-2}) was higher in trees subjected to accidental fire than the trees not affected by fire. However, total gum yield obtained from whole tree was more in trees not subjected to fire (Fig. 56) as compared to those trees which were subjected to fire.

E. Effect tree growth parameters on yield of gum-butea

Data on correlation matrix of tree growth parameter and gum yield is given in Table 66. The yield of gum-butea was positively correlated with tree height basal girth bole surface area and bark thickness. However, sugar content in bark was negatively correlated with all tree parameters and gum yield.

Table 65: Effect of Ethephon application on gum yield (g m^{-2}) from *B. monosperma*

Method of Ethephon application	Dose of Ethephon			
	4 ml of 10%	4 ml of 20%	4 ml of 30%	Mean
Control	38.4	22.5	45.4	35.4
Spray of Ethephonon tree surface before knotching	369.6	272.7	269.1	303.8
Spray of Ethephonon tree surface after knotching	89.5	46.0	47.9	61.1
Injection of Ethephonat the base of tree trunk+ knotching	10.0	15.7	16.9	14.2
Mean	126.8	89.2	94.8	
Level of significance (P-value) for samples Methods				9.96E-07
Level of significance (P-value) for Ethephon dose				5.53E-01
Level of significance (P-value) for interaction				9.36E-01

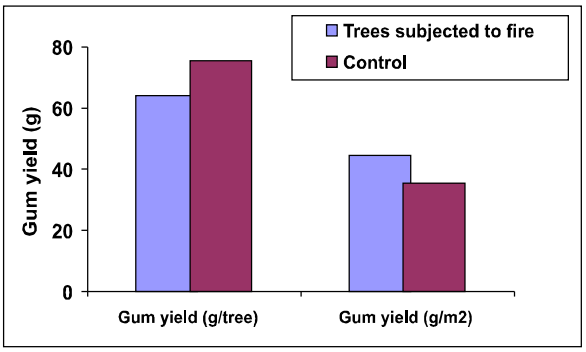


Fig. 56: Effect of fire on gum yield of *B. monosperma*

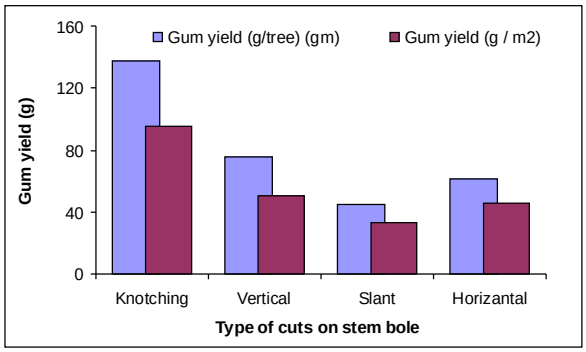


Fig. 55: Effect of different methods of incision on stem-bark on gum yield of *B. monosperma*

Table 66: Correlation matrix of tree growth parameters and gum yield for *Butea monosperma*

Parameters	Tree height (m)	Tree basal girth (cm)	Bole surface area (m^2)	Bark thickness (mm)	Canopy spread (m^2 $tree^{-1}$)	Sugar in bark (mgg^{-1})	Gum yield (g $tree^{-1}$)	Gum yield (gm^{-2})
Tree height (m)	1.000							
Tree basal girth (cm)	0.847	1.000						
Bole surface area (m^2)	0.546	0.806	1.000					
Bark thickness (mm)	0.872	0.941	0.797	1.000				
Canopy spread (m^2 $tree^{-1}$)	0.482	0.448	0.168	0.415	1.000			
Sugar in bark (mgg^{-1})	-0.412	-0.505	-0.291	-0.501	-0.465	1.000		
Gum yield (g $tree^{-1}$)	0.639	0.485	0.458	0.663	-0.014	-0.214	1.000	
Gum yield (g m^{-2})	0.615	0.430	0.384	0.606	-0.079	-0.190	0.987	1.000

2. RESEARCH ACHIEVEMENTS

2.4. HRD, Technology Transfer & Refinement Programme

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

Kisan Goshties & Field Days

Centre organized four Field Days/*Kisan Goshti* in Sakuli (23rd January), Asati (14th February) and Kundar (29th March) villages of Tikamgarh (M.P.) and village Ganeshgarh (17th March, 2012) of Jhansi (U.P.) under FPARP programme during January to March, 2012. More than 100 farmers, farm women and members of NGOs participated in each programme.

Centre organized Field Day on 30th October, 2012 in Parasai-Sindh Watershed of district Jhansi (U.P.). About 100 farmers participated in the field day. The event was organized in Sh. Bala Ram's field where 9 ground nut varieties were sown for evaluation. Crop sample from 5x5m area from all 9 varieties were taken to demonstrate, evaluate and educate all farmers about comparative field performance of these varieties with local varieties.

Training on Ber Pruning and Budding

Centre organized ber pruning and budding from 22nd to 24th May and 28th – 30th August 2012 at village Ganeshgarh, block-Babina of district Jhansi. More than 50 farmers, farm women and members of NGOs participated in the programme.

Innovative Farmer's Day & *Kisan Mela*

A Farmer's fair and Innovative farmer day was organized on 23 November, 2012 at Village Chhatpur (Parasai-Sindh watershed) block babina in Jhansi of U.P. About 250

farmers including farm women and rural youth participated. It was emphasized that farmers should adopt agroforestry system for fulfilling their needs for fodder, fuel, food and fruits and for sustainable land use management of the existing natural resources. On the occasion, farmers, farm women, State government officials and NGO people also expressed their views. During question-answer session the farmers have shown keen interest regarding growing of fruit trees in association with crops and plantations of MPTS on field boundaries.

Innovative farmers were awarded by Director, NRCAF, Jhansi. These farmers are: Sh. Chhatrapal Pateria (Sanoura, Datia, M.P.), Sh. Veer Singh Rajput (Ganesh Garh, Jhansi, U.P.), Sh. Himmat Ahirwar (Shivrampur, Tikamgarh, M.P.), Sh. Om Prakash Adjariya (Garh Kunadar, Tikamgarh, M.P.), Sh. Ram Prakash Kumhar (Garh Kunadar, Tikamgarh, M.P.), Sh. Achhe Lal Yadav (Bachhauni, Jhansi, U.P.), Sh. Kalyan Singh (Parasai, Jhansi, U.P.), Sh. Gulab Singh (Parasai, Jhansi, U.P.), Sh. Badam Singh (Chhatpur, Jhansi, U.P.), Sh. Narayan Singh (Chhatpur, Jhansi, U.P.), Sh. Balaram (Chhatpur, Jhansi), Sh. Gyan Singh (Bachhauni, Jhansi) and Sh. Abraham Prince (Isagarh, Jhansi, U.P.). Exhibition of NRCAF was also organized in which farmers, farm women and rural youth visited and gained the knowledge about agroforestry.

Exhibitions

Centre participated in the exhibition in 2nd ASEAN-India Ministerial Meeting on Agriculture & Forestry and Agriculture Expo & Symposium from 17th to 19th October, 2012 held at NASC Complex, New Delhi. Agroforestry Stall was exhibited by the Scientists. Centre participated in the District Level Kisan Mahotsav-2012 from 21st to 23rd

December 2012 organized by Uttar Pradesh Agricultural Commissioner, Lucknow at Deendayal Auditorium, Jhansi (U.P.). Agroforestry Stall was exhibited by the Scientist.

Trainings Imparted

During the year 28 trainings were conducted for Integrated Watershed Management Programme on Natural Resource Management and Agroforestry, production system and micro-enterprises, livelihood support activities and accounting. These trainings were organized in response to request from Land Development and Water Resources and Deptt. of Agriculture (PIAs of IWMP) from Jhansi, Lalitpur, Jalaun, Mahoba, Hamirpur and Banda districts. They were sponsored by respective IWMP. Farmers, office bearers of watershed committee, self-help groups, users group, watershed development team members

S. No.	Subject	Sponsored By	Duration	Number of Trainings & Participants
1.	Integrated watershed Management	BSA, LDWR, Lalitpur , Jalaun, Jhansi	07th to 19th January, 2012	Three (90 Participants)
2.	Natural Resource Management and Agroforestry	BSA, LDWR, Mahoba, Hamirpur	9th April to 16th May, 2012	Five (500 Farmers)
3.	Watershed Management and Planning and execution	BSA, LDWR, Mahoba & National Watershed, Jhansi	07th June to 10th August, 2012	Seven (177 Participants)
4.	Natural Resource Management and Agroforestry	BSA, LDWR, Mahoba & National Watershed, Jhansi	11th June to19th December, 2012	Eight (330 Participants)
5.	Livelihood development in watershed	BSA, National Watershed, Jhansi, Banda & Mauranipur	25th October to 31st December, 2012	Four (125 Participants)
6.	Production system and micro enterprises development in watershed	BSA, LDWR, Lalitpur	29th & 30th October, 2012	(One) 32 Participants

(contractual) field functionaries and BSAs were imparted training. Thus, a total of 1254 participants attended training. A sum of ₹4.33 lakh was earned as institutional charges from training. Pre and post training evaluation suggested 20-100% improvement in knowledge of trainees. Trainings conducted under IWMP at the Centre during 2012 as follows:

Visits

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

Technology Transferred

Prevention of Leakage/Seepage through Rainwater harvesting structures

Leakage of old checkdams is a common problem which requires technological support to bring them back to service. Many such structures have been constructed by panchayats and line departments. For want of technology, huge investment on construction is wasted. Therefore, the leak proofing technique developed in Garhkundar-Dabar watershed was applied in many structures in Bundelkhand region and successfully checked leakage. The technology is in great demand by panchayats and line departments (Plate 6).

Cost effective Design of Rainwater Harvesting Structures (RWHS)

Required increase in food production to meet increasing demand has to come largely from 94 m ha of rainfed areas under cultivation. In turn, Government of India has to invest huge sum towards rainwater

Plate 6: Rectified water harvesting structure of Dhikauli gram panchayat, Jhansi

harvesting structures to augment water availability in such region. Therefore, cost effective design of water harvesting structures developed in Garhkundar-Dabar watershed leads to significant saving of public money (Plate 7 & 8).

Construction cast of water harvesting Structures (masonry checkdam) was reduced through decreased width of foundation after 50 to 70 cm below ground level till depth of foundation.This technique will reduce the expenditure by about ₹ 30,000 to ₹ 1,00,000 in construction of each checkdam.

The technique was applied in all the checkdams constructed in Garhkundar-

Plate 7: Construction of cost effective checkdam at Parasai-Sindh watershed, Jhansi

Plate 8: Demonstration of cost effective construction of checkdam and prevention of seepage to the officials of Deptt.of Ag. and farmers of Jhansi district

Dabar, Domagor–Pahuj and Parasai-Sindh watersheds and these checkdams are serving the community efficiently since 2006 without any repair and maintenance. Technology was advocated and demonstrated to the Project Implementing Agencies (PIAs), watershed committee and gram panchayats' members, students, researchers and policy makers through more than 45 trainings and site visits. Technique has been widely adopted by PIAs of watershed projects under Integrated Watershed Management Programme in U.P. and M.P., gram *panchayats* of Jhansi and Tikamgarh districts.

Rainwater harvesting and recycling on watershed basis for Bundelkhand region

Bundelkhand region was reeling under severe drought during 2004 to 2007 resulted into huge migrations due to scarcity of water. Agroforestry in conjunction with *in-situ* and *ex-situ* soil and water conservation measures are key to sustainable development of natural resources in Bundelkhand region as the region depends upon perched water for drinking and irrigation purposes. Poor ground water availability, low moisture retention of red soil, uncertain rains and severe drought during 2004-2007 in Bundelkhand region led to unprecedented migration. The drought spell was so intense that for the first time in recent past drinking water sources have dried up and resulted in

huge loss of livestock (Plate 9).

NRCAF, Jhansi selected and implemented in participatory mode the Garhkundar-Dabar watershed from 2005-06. The watershed is located near Niwari, 65 km. away from Jhansi in Tikamgarh district of Madhya Pradesh. The district is one of the most disadvantaged/ backward as per the Planning Commission, GOI. The watershed, drains into Betwa River, covering an area of 850 ha. It is located between 78^0 52′ 41″ - 78^0 54′ 44″ E longitude and 25^0 26′ 24″ - 250 28′ 31″to N latitude. The elevation varies from 200 to 280 m above mean sea level. According to Strahler's system of stream ordering, the natural drainage system of the watershed was classified and the main stream was found as 4^{th} order stream.

To check erosion and conserve moisture, 150 gabions of various sizes were laid mainly on 1^{st} and 2^{nd} order streams. To improve the condition of water resources, a provision of about 23 thousand cubic meter rain water harvesting was made by constructing eight drop structures/ checkdams mainly on 2^{nd}, 3^{rd} and 4^{th} order streams in series. Besides, sizable amount of water was temporarily stored against gabions, which are spread all over the watershed and is helping in increasing opportunity time for water to infiltrate. Three *khadins* (water spreader) were constructed in series to reduce erosive velocity of running water, apprehend soil loss and create water storage to augment the ground water recharge. Besides these structures, field/ contour bunding was done in an area of about 40 ha with the provisions of drainage structures.

Impact of Technology

- Number of dry wells reduced to 15 % in May 2012 from 86% in year 2006.
- Surface water in *nallah* is available throughout the year against four months only in untreated area
- Runoff and soil loss reduced by 34 to 46% and 43%, respectively in treated watershed as compared to untreated watershed.
- The peak discharge from the treated watershed delayed by maximum 51 minutes as compared to untreated watershed.
- Loss of storage due to sedimentation was about 5 times less in treated watershed as compared to untreated watershed during the span of 4 years (2007-2010).
- Better moisture management through different kinds of bunding, and *khadins* resulted in increased productivity of cropland and Common Property Resources (CPRs).
- The work done has made significant contribution by impacting community and environment positively in following manner:

ON COMMUNITY

a) Enhanced Income

Watershed management through agroforestry interventions increased the flow of income by 250 per cent.

b) Reduction in Drudgery

Prior to implementation of project in the watershed area village women used to bring water from 2-3 km on head or 4-5 km by bicycle/bullock cart. The drudgery has been greatly reduced through availability of water in wells and hand pumps due to augmented groundwater recharge. People specially women and children from about ten nearby villages using harvested water for day to day needs for human and animals need (washing and bathing). Even after cremation of bodies

the last rites and rituals are performed on the banks of checkdams, otherwise they used to travel more than 5 km away from the villages for the same.

c) Improved Animal Health

Livestock getting enough water in *nallah* to quench their thirst even in peak summer time (May-June). As such, animal mortality reduced. Increased forage availability from bunds of irrigated fields resulted in greater productivity. On the other hand, stray cattle, wild animal menace increased due to surface water availability.

d) Social Upliftment Indicators

During the past three years, 03 more tractors, 61 *pucca* rooms, 31 diesel pumps, 06 motor cycles and 02 flour mills have been added in the watershed. Before execution of the technologies, about 10 diesel pumps were operating in the watershed. This is in consonance with the increased availability of water for irrigation. Few dwellers in the watershed even have constructed toilets in their premises which enhanced sanitation.

e) Resolved Social Conflicts

It was observed that the higher caste people were getting priority in drinking water supply over down trodden community. Consequent upon the application of S & T interventions based on watershed and agroforestry, conflicts among the villagers have reduced drastically due to year round availability of water (drinking and agriculture) and employment.

f) Increased Value of Cultivable Land

The land cost has gone up by 150% due to increased productivity on account of year round availability of surface/ground water.

On Employment

During 2006-07, about 7000 days employment was created through construction activities and adoption of agroforestry interventions. Now, more than 34,000 additional man days were created due to increased cropping intensity, crop demonstrations, agroforestry interventions, etc. The difference in gross cultivated area was considered as basis for calculation of increased employment taking into account 100 days per hectare per year labour requirement.

Environment

There is reduction in runoff and soil and nutrient loss from the watershed which resulted into better productivity. The productivity of common property resources (CPRs) increased significantly due to better moisture regime.

Plate 9: Rainwater harvesting and recharge of open wells

3. AICRP ON AGROFORESTRY

A. Research Achievements

The AICRP on Agroforestry was initiated in 1983. At present, there are 37 co-ordinating centres located in 25 SAUs, 11 ICAR Institutes and one ICFRE Institute.

Acacia mangium provenance evaluation trial at Thrissur showed marginal growth variation among provenances after 11 years of tree age. Among the provenances Papua New Guinean provenances performed better in the humid high rain fall conditions of Kerala. The better performers include Balimo and Upper Aramia, (R)sso Kuranda, Arufi village, and Oriomo, WP. With the primary objective of standardizing ideal planting densities for various end uses a planting density-cum-pruning trial on *Acacia mangium* was established during 2001 at the centre. Tree heights though significantly varied among planting densities, a leveling trend was observed with advancing age. However, dbh (12 to 20 cm) and mean tree volume (0.15 to 0.4 m^3) registered significant increase with decreasing planting density. Stand volume on the other hand, was considerably higher for closely spaced stands (5000 trees ha^{-1}; 743 m^3 ha^{-1}) indicating the central role of population density on stand volume production. High MAI in volume (74 m^3 ha^{-1} yr^{-1}) at the age of 10 years further highlight the fast growth potential of *Acacia mangium*.

Jabalpur centre conducted studies related to tree biomass, volume equations etc. It has done a good work on management practices in different agroforestry systems particularly tree management through pruning to reduce the competition for light between tree and crop component for higher productivity. In one of the studies conducted at the centre in 14 years old agrihorticulture system (Guava + Mustard), pruning at 1.0m height recorded higher yield (421 kg ha^{-1}) closely followed by pruning at 1.5m height (395 kg ha^{-1}) whereas, pruning at 2.0 m height recorded significantly lowest yield (303.7 kg ha^{-1}). The per cent reduction in grain yield under no pruning, pruning at 1.0m, 1.5m and 2.0m as compared to open was 64.8, 27.43, 31.8 and 47.8%, respectively. The centre also evaluated different varieties of mustard for intercropping with guava. The results showed that among four varieties of mustard namely Pusa tarak, Pusa agadi, Jaikishan and Menthol, variety Pusa tarak recorded significantly higher yield over other varieties. Guava + mustard based agrihorticulture system with pruning was more profitable (₹11,195) without pruning (₹9,750) or fruit tree alone as orchards (₹8,000) or crop alone (₹11,109) on per hactre basis.

At UAS, Dharwad centre, germplasm of Tamarind was evaluated and it was found that growth of NTI-14, NTI-80 and NTI-5 provenances were significantly higher and fruit yield was higher in SMG-13 and NTI-14 as compared to other provenances. In teak based legume cropping system, grain yield of soybean with teak was higher as compared to teak with other legumes. Teak growth was significantly higher with soybean as compared to with redgram. The centre was one of the pioneer centres under the project to initiate work on biofuel. The pilot plant on biofuel at the centre is producing 350 liters of biodiesel per month using seeds of *Pongamia*, Jatropha etc. The biofuel so produced is used to blend at 10% in Jeep, transport buses, tractors and oil engines in the University. The Forest Research Station, Prabhunagar under AICRP on Agroforestry was adjudged as the best maintained and high revenue generating research station

among the 23 research stations of the university during annual convocation 2011 and 2012. This is the third consecutive year and for the fourth time in the last 10 years the research station is getting the award.

In this Project, Kattupakkam is the centre working exclusively with animal component, which is an integral part of agroforestry. As tree fodder is one of the major concerns in livestock production, hence, a survey covering all the 13 blocks of Kanchipuram district of Tamil Nadu with 15 farmers in each block on predominant tree fodders used by farmers for feeding their livestock was carried out by the centre. The two salient features of this survey are, i) Tree fodders are harvested and fed (as stall feeding) to cattle/ goats/sheep during rainy season and dry season (drought feed), ii) Farmers are feeding more than one type of tree fodder to animals. The pattern of usage of tree fodders among the farmers were arrived and found that *Inga dulce* is used predominantly and ranked No. I followed by *Leuceana leucocephala* (rank II) and *Azadirachita indica* (rank III). In hortipasture system of agroforestry model of this centre, *Cenchrus ciliaris* cultivated under guava tree recorded a yield of 11.6 t ha^{-1} $cutting^{-1}$. Further *Crotolaria juncea* (sunhemp), a leguminous fodder cultivated in the hortipasture system under coconut recorded a yield of 5 t ha^{-1} of green fodder after 60 trees days of sowing.

Integration of sheep with silvipasture

- A sheep trial with twelve madras red sheep was designed to assess the impact of dry fodder based complete feed in comparison to complete feed + 1 hour supplemental feeding of subabul leaves.
- The experimental (complete) diet - sorghum stover 60 parts (roughage component); maize 5 parts; groundnut cake 10 parts; soyabean cake 15 parts; molasses 4 parts; Deoiled rice bran 4 parts and mineral mixture and salt 1 part each. The complete diet contained 14% DCP and 60% TDN.
- The second group was offered 1 hour feeding of subabul leaves (pruned from silvipasture component trees) in addition to complete diet *ad libitum*.
- The resultant gain due to supplemental feeding of subabul leaves was to the tune of 2.40 kg weight gain per sheep for 90 days.

Parameters (kg)	Control	Treatment
Live weight	18.05 ± 0.87	20.34 ± 1.03
Skin weight	1.01 ± 0.14	1.47 ± 0.10
Deskinned weight	14.45 ± 0.87	16.64 ± 0.88
Carcass weight	1.23 ± 0.48	9.75 ± 0.48

The UAS, Bangalore centre, conducted the D & D Survey in Southern dry zone of Karnataka. The study indicated that coconut (69%) in Hassan and *Melia dubia* (61%) in Chamarajnagar districts are the important tree based agroforestry systems, besides, bund planting is also common practices with tree species like Jack, Ficus, Melia, Neem, Teak, Pongamia and Thespesia etc. In tree improvement, fourteen elite clones of Simarouba, comprising seven each in "Kaali and Gauri' and Hosakote-15 & GKVK-17 in tamarind are identified as high yielding selections. The clonal seed orchard of tamarind and Simarouba comprising of 14 and 27 selections respectively are established. The survival rate is more than 98 per cent. The one ha Integrated farming system model with agroforestry on watershed approach developed by the centre clearly demonstrated the positive trend on productivity, livelihood security, employment generation besides recording improvement in net income. The fertility of the soil is also improved due to application of organic manures. The data on net returns, B: C ratio and employment generation in the IFS system recorded 3-5 times higher as compared to that of sole crop and cropping system.

The candidate plus trees (CPTs) in *Ceiba pentendra* were identified in Tamil Nadu and Kerala states by Mettupalayam Centre and 14 CPTs were selected. The results showed that a significant difference in height, basal diameter and pod characteristics were observed among CPTs and MTPCP 4 excelled other CPTs in terms of yield attributes *viz.*, pod length, pod breadth, pod weight and floss weight whereas the CPT *viz.*, MTPCP 3 and MTPCP 2 excelled in terms of number of pods and total pod weight respectively. Among the six fodder crops tried under *Pongamia pinnata, Cenchrus*, guinea grass and *Desmanthus* were found to be compatible.

At Dapoli, the growth performance of

17 years old ten nitrogen fixing tree species was evaluated. The maximum height (19.75m) and dbh (63.25 cm) were observed in *Acacia holosericea*. The mean annual increment (MAI) in case of plant height was higher in *Casuarina equisetifolia* (1.80m year^{-1}) followed by *A. holosericea* (1.25m year^{-1}). The MAI in dbh was highest in *A. holosericea* (3.25cm year^{-1}). Five agricultural crops *viz.*, fingermillet, prosomillet, niger, sesamum and groundnut were grown in mango plantation with recommended package of practices. The groundnut intercropped in mango gave maximum gross returns of '1,27,022 per ha and was found relatively more promising and profitable than all remaining agricultural crops giving maximum Benefit Cost Ratio of 1:1.94.

In multilocation trial of Neem at Hyderabad, the line-115 recorded maximum height (6.5 m) and girth (62.2 cm) followed by Line-109 (6.5 m and 57.5 cm). The same germplasm line (L-115) recorded higher azadirachtin content of 0.5343% on kernel basis which is 6% superior over the control variety. A total of 94 germplasm lines of *Pongamia* were collected in collaboration with NBPGR, Regional Center, Hyderabad. At the age of seven years line SRJ-39 recorded the maximum height (5.7 m) and girth (52.0 cm). In II set of 65 lines planted during 2010, a lot of variability was observed for the traits like plant height, collar diameter, branching pattern, leaf shape, leaf colour, leaf venation and plant type etc.

At SK Nagar, under Simarouba based silvipasture system, *Guinea* grass variety *Makuni* yielded 13 per cent higher dry fodder biomass compared to variety *Riversdale*. In custardapple based hortipastoral system under rainfed conditions, the fodder production of pearlmillet sole (22716 kg ha^{-1}) was significantly higher than pearl millet with custardapple system. Among the different tree spices at 17th year of age, the addition of litterfall and subsequent return of nutrient was significantly higher under *Ailanthus* tree speices. The litterfall was higher in the month of October to December (2466 kg ha^{-1})

Nagpur centre has carried out design and diagnostic survey for studying the adoption of agroforestry practices in region. It has been observed that teak based agroforestry systems have become more popular in the region. Teak + cotton in *kharif* and teak + wheat /gram in *rabi* have been adapted by many farmers in this region. Among the fruit based systems Nagpur mandarin (orange) + vegetables and Nagpur mandarin + cotton /soybean + Teak (on border) is widely accepted system in the region. In southern district of Vidarbha region biomass based energy plants have been established. Farmers in this region have started growing *Leucaena leucocephala* and bamboo as biomass crop and are supplying raw material to energy plants at price of '1600-1800 t^{-1}. The biomass plantations are becoming popular among the dryland farmers.

At Hisar, the yield of both sorghum and cowpea grown for fodder under different spacing (5x4, 10x2, 18x2x2m) of 4.5 years old poplar increased with increase in spacing of poplar. The mean decrease in yield of cowpea under different spacing of poplar was less compared to sorghum indicating more compatibility of cowpea with poplar. Poplar attained maximum height and girth at 10x2m spacing. Similarly girth of poplar was better under agroforestry than sole poplar. The total carbon storage potential of poplar based agroforestry system up to four years of age has been found 22.5, 39.5 and 33.7 per cent higher at 5x4m,10x2m and 18x2x2m spacing, respectively than sole agriculture in Sorghum-berseem crop rotation. Eucalyptus planted on saline soils attained significantly higher girth and height at 3x3m spacing than

6x1.5m and 17x1x1m spacing. The green biomass yield of *Sesbania* grown for green manuring at 3x3m and 6x1.5m spacing was significantly less than 17x1x1m spacing. Poplar planted on East-west and North-South field bunds affected the green fodder yield of sorghum up to 6-9m distance in the both the cases. Whereas, eucalyptus planted on North-South and East-west field bunds of a saline field affected the green biomass yield of Dhaincha only up to 0-3m distance from the tree line. Under tree improvement programme a promising clone of poplar has been characterized from the existing clones (G3, G48) using RAPD molecular marker. It was found that the similarity between G3 and HAUS-1 is 0.29 & G48 and HAUS-1 is 0.46 which shows that G3 and G48 are divergent from HAU selection and this clone can be further used in subsequent improvement programme of poplar.

Among the second coppice of different Eucalyptus species after the age of ninth years at Rahuri, the coppice of *Eucalyptus* FRI-4 recorded maximum plant height (16.00 m), collar diameter (21.65cm), dbh (18.47cm). DNA Finger Printing of 8 selected *Prosopis juliflora* genotype conducted to assess the variation at molecular level. For this total genomic DNA from 8 *Prosopis* genotypes was isolated by using the modified CTAB-method. Total 15 primers were used for PCR amplification. The RAPD analysis of genomic DNA of 8 *Prosopis* genotypes was carried out in a thermal cycler. In the study of the effect of irrigation systems along with mulch on the growth of grafted and seeded *Pongamia pinnata*, it was observed that the percentage increment in plant height and collar diameter was more for grafted material than seeded plants under weekly surface irrigation (10 lit) treatment with mulching.

Fatehpur Shekhawati centre is working on two MPTs, *Prosopis cineraria* and *Dalbergis sissoo* allotted to this centre and seeds of thirteen improved germplasm and 15 plus trees of *P. cineraria* and 19 plus trees and 6 provenances of *D.sissoo* were planted in field. Traditional method plus micro site improvement planting method was found suitable, pertaining to growth and mortality. Studies on intercropping of rainfed *kharif* crops with *P. cineraria*, *Hardwickia binata* and open field indicated that clusterbean and pearlmillet performed better and gave highest gross returns as compared to other crops.

In mango based agrihortisilvicultural system involving 3 MPTs (*Acacia mangium, Dalbergia sissoo* and *Gmelina arborea*) at Bhubaneshwar, the growth and yield of four inter crops (pineapple, *Aloe vera,* kalmeg and mango ginger) were assessed. Highest *Aloe vera* fresh leave and pineapple fruit yields were recorded in association with *Acacia mangium*. Analysis of three years cost of production and returns from the systems and sole crops recoded that pineapple was the best suitable crop to be included in the mango based agrihortisilvicultural system with mean net returns of ₹ 87,348, 77,110 and 75,954 ha^{-1} $year^{-1}$ with B:C ratios 2.12, 1.98 and 1.97 when intercropped with *Acacia mangium*, *Dalbergia sissoo* and *Gmelina arborea*, respectively, as against a net return of ₹56,000 with B:C ratio 1.82 when grown as a sole crop.

At Raipur, progenies from 45 provenances of *Dalbergia sissoo* were evaluated on the basis of morphological growth parameters. Overall performance of individual tree stand was found most promising on the basis of total and straight height of bole and collar diameter for Faizabad followed by Pantnagar and Raipur. Multitier mixed plantation of *Acacia mangium, Eucalyptus officinalis, Jatropha curcas* and *M. koinghii* showed that top storey *A. mangium* attained maximum height (15.3m) and dbh (13.8cm) followed *E. officinalis* as second story tree species. The yield of turmeric was 126.8

and 152.8 q ha^{-1} as intercrop under Multitier mixed plantation while, 166.7 and 195.6 q ha^{-1} was as sole crop for 2 and 3 rows cultivation respectively. The total annual curry leaves production was 1430.2 and 1476.1q ha^{-1} with economic gain of ' 71,508 and 73,803 ha^{-1} as AFS and sole crop, respectively, from July to March. Overall soil nutrient status was much better under *A. mangium* tree species with three rows intercropping system of turmeric crop.

At Ranchi, the plant height of Gamhar and Teak was more in forage crops, whereas collar diameter of trees was more in pure plantation in the silvipasture systems. It was also observed that the growth of Gamhar is faster than Teak. The green yield of forage was maximum in Hybrid Napier (sole) 314 q h^{-1} which was 161% more than the lowest yield of Sudan grass (sole) (120 q h^{-1}). In provenance trial of *Pongamia pinnata* maximum height was recorded under Latehar seed source (121cm).

BCKVV, Jhargram is working on collection and evaluation of two trees species of *Gmelina arborea* and *Acacia auriculiformis* and have established seed orchards. Last year 4 new accessions of each of *Gmelina arborea* and *Acacia auriculiformis* were collected from various parts of West Bengal and planted at a distance of 3x3m during August, 2011. Presently the centre is having total 32 and 36 accessions of *Gmelina arborea* and *Acacia auriculiformis* respectively which are being maintained and evaluated. *Gmelina arborea* + mango, *Gmelina arborea* + guava, *Gmelina arborea* + sweet orange, *Eucalyptus tereticornis* + guava, *Eucalyptus tereticornis* + mango, *Eucalyptus tereticornis* + sweet orange, *Acacia auriculiformis* + guava, *Acacia auriculiformis* + sweet orange and Mahua + Aonla fruit-based agroforestry system have been found to be best alternative land use system in red and laterite zone of West Bengal. Some fruit based agroforestry technologies developed through different on-station trial at Jhargram have been tried in the farmer's field. This year also an initiative has been taken by the centre to popularize the practice of agroforestry in the districts Hogly, Paschim Medinipur, 24 Parganas (N) and Nadia. Agroforestry system like mango + paddy in *kharif* and boro season, Mango + wheat, mango + mustard, mango + cauliflower fruit-based agroforestry system were evaluated in the farmers' field and found very profitable.

The PAU, Ludhiana centre in addition to tree crop interaction and tree improvement studies on the allotted priority species such as poplar and *Melia*, has undertaken studies on genetic transformation of commercial *Populus deltoides* clones *viz.*, PL-5 and PL-7 with salinity tolerance *Glyoxalase II* gene from *Oryza sativa* (*Osgly II*). In the particle gun gene transfer method, embryogenic calli and axillary buds were used as the target tissue. Different bombardment parameters such as helium pressure distance between rupture disc and macrocarrier and number of bombardments were optimized using histochemical GUS assay. GUS analysis revealed five GUS positive plants from randomly selected 22 putative plants. PCR analysis of 46 putative transgenic plants with a *Osgly II* - specific primer confirmed the presence of the gene in five plants. The plants were hardened and successfully transferred to the glasshouse. This is a preliminary step towards the achievement of higher

ECONOMICS OF AGROFORESTRY SYSTEMS

Tree species	Spacing (m)	Rotation (years)	Number of trees / acre	Returns (Rs /acre / year)
Poplar (block plantation)	8.0 x 2.5 or 5.0 x 4.0	6 – 7	200	80,000 – 100,000
Poplar (boundary)	3.0	6	80	35,000 – 45,000
Eucalypts (clonal – block plantation)	4.0 x 2.0	4 (poles)	500	30,000 – 35,000
Burma dek (block plantation)	5.0 x 4.0 or 7.0 x 3.0	7 – 8	200	45,000 – 55,000

productivity in the problematic soils with the plantation of salt tolerant poplar clones.

PAU, Ludhiana, CCSHAU, Hisar and GBPUA&T, Pantnagar working on Poplar germpalsm evaluation exchanged 12 clones developed at these centres with 2 check clones for a uniform coordinated trial of poplar. Similar trials will be initiated this year among the centres working on *Gmelina arborea* in humid and sub humid regions and second Neem multilocation trial.

Among different agroforestry systems evaluated at Faizabad centre, *Casusrina equisetifolia* based agrisilvihorticultural systems resulted in better amelioration of sodic soil and carbon sequestration. Pruned biomass for fuel wood consumption was also estimated higher than other agroforestry systems. In this system the guava fruit yield was maximum at 50% NPK + 50% FYM level. The fruit yield was minimum in case of the 100% NPK application. The rhizomatous yield was obtained maximum (6 t ha^{-1}) when 50% N P + 50% FYM dose was applied to the crop under present investigation. Minimum rhizome yield was obtained under 100% NPK level.

In an intercropping trial in 6-years-old *Emblica officinatis* (NA07) planted at 6x6m spacing under rainfed calciorthent soil at Pusa, intercrops grown were turmeric, ginger and *Colocasia*. The results indicated that the production of fruits significantly increased due to intercrops and it was maximum in association with turmeric (14.00 t ha^{-1}) followed by ginger (12.60 t ha^{-1}) and *Colocasia* (12.22 t ha^{-1}). On the other hand, reduction in yield of intercrops was 7.5-18.5 % for turmeric, 12.2-28.2 % for ginger and 15.7-34.5 % for *Colocasia* compared to the yield in open area without trees. The system resulted in significant increase in organic carbon, available nitrogen and phosphorus. Economic analysis of the systems in terms of benefits: cost ratio revealed that aonla+turmeric gave a higher value (4.48) followed by aonla+ginger (2.93) and aonla+ *Colocasia* (2.58). The interspaces of the aonla orchard in calcareous belt of eastern India could be utilized for growing various intercrops to generate substantial additional income without adverse effect on the soil fertility and productivity of the main crop.

Studies were carried out at Solan to know the performance of different field crops *viz.*, tulsi, ginger, turmeric, soybean and aloevera under bamboo species- *Dendrocalamus hamiltonii, D. asper* and *Bambusa balcooa*. Among the different bamboo species tried, *D. asper* displayed superiority over *D. hamiltonii* and *B. balcooa* in respect of the growth characters *viz.*, average height (6.6 m), average diameter (3.6 cm), average number of tillers (33.8), clump weight (85.78 kg ha^{-1}) and above ground production (19.06 t ha^{-1}). However, average crown spread was quite higher in *D. hamiltonii* and *B. balcooa*. Among the different field crop tested, *D. asper* intercropping with ginger gave maximum returns (₹ 4, 04,693 ha^{-1}) followed by combination of tulsi- *D. asper* (₹ 2, 77,093 ha^{-1}). In another study on effect of vermicompost on growth, yield and economic returns of *Andrographis paniculata* and *Stevia rebaudiana* grown under plum based agroforestry system the use of organic manures plus chemical fertilizers has been found to be more beneficial than organic manure alone. *Stevia rebaudiana* grown in plum based agroforestry systems provided better economic returns (₹ 99,952ha^{-1}) than *Andrographis paninculata* (₹ 89,939 ha^{-1}).

Under the tree improvement programme at Srinagar 76 selections of *Salix* spp. and 34 seed sources of *Ulmus wallichiana* are being evaluated. Out of these 16 selections of *Salix* and 8 sources of *U. wallichiana* found promising have been planted in the field as boundary/ block plantation. Further, four

clones of *Salix alba* var. *caerulea* (Cricket bat willow) were identified and collected from various places in the valley. These half sib clones will be multiplied for further evaluation. Six thousand (6,000) seedlings of *U. wallchiana* were distributed free of cost to farmers for plantation and conservation of this endangered tree species. Besides, 750 seedlings of *U. wallichiana* elm and 1000 seedlings of Salix were also distributed under TSP (Tribal Sub Plan) programme at village Faqir Gujri, District Srinagar. Agrihorticulture based system involving Apple with agriculture crops (Beans, Peas), fodder crops (Lucerne, Orchard grass, Berseem and White clover) and medicinal plants (Artemisia), under evaluation at the centre. Out of all the seven combinations a maximum fruit yield of 12.39 t ha^{-1} was obtained when apple was integrated with Lucerne (*Medicago sativa*) followed by 12.07 t ha^{-1} in a tree crop combination comprising apple with *Artemisia absinthium* during the fifth year of evaluation. Contrary to this a fruit yield of 6.28 t ha^{-1} was recorded under the control (Apple alone). Orchard grass (*Dactylis glomerata*) yielded a maximum fodder production of 22 t ha^{-1} followed by 20 t ha^{-1} for Lucerne.

Introduction of *Morus* an important tree fodder for Himalayan region in wastelands at Palampur with *Setaria* grass as intercrop resulted in tree leaf fodder yield of 4 t ha^{-1} and Setaria grass yield of 28t ha^{-1}. This indicated that on wastelands where productivity of traditional pastures was only 10t ha^{-1}, it can be enhanced to 32t ha^{-1} through improved silvipasture systems and even during the summer season when green fodder is very scarce such systems produced around 15 t ha^{-1} of green fodder.

At Kahikuchi, interspaces of 29 years old fruit bearing coconut was utilized by growing vegetables, turmeric, pineapple and fodder crops. Coconut yield in intercropped plot was 10 to 17 per cent higher in comparison to sole coconut plot (7050 nuts ha^{-1}).French bean yielded 45.50 and 79.30 q ha^{-1} as intercrop and in open conditions. Green fodder yield of maize was only 10 per cent less in intercrop plot than in open conditions (17.20 t ha^{-1}). Nineteen seed sources of *Gmelina arborea* attained plant height of 12.50 to 14.80 m in 10 years of growth with their corresponding dbh of 23 cm to 38 cm.

B. Annual Group Meeting

The Annual Group Meeting of All India Coordinated Research Project on Agroforestry organized at JNKVV, Jabalpur from 19th -21st May, 2012. This group meeting was attended by 24 coordinating centres of the project located at different SAU. There were seven Technical sessions including inaugural and plenary sessions.

4. AWARDS AND RECOGNITIONS

- Dr. Badre Alam, Sr. Scientist received the BESTPOSTER (2nd prize) for the paper "Atmospheric CO_2 sequestration versus Water Use and Canopy Transpiration in *Albizia procera* under Agroforestry system" authored by Badre Alam, Mayank Chaturvedi, Anil Kumar Singh, Chhavi Baronia, Ram Newaj and S K Dhyani in the National Symposium on "Sustainable Production of Forages From Arable and Non-Arable Land And Its Utilization" during 2nd to 3rd November, 2012 held at IGFRI, Jhansi.
- Dr. Badre Alam, Sr. Scientist received the Fellow (2012) of the Indian Society for Plant Physiology (FISPP) for the contributions in field of Plant Physiology and Cognate Sciences. He also received the Fellow Award 2012 as the Fellow of the Society for Applied Biotechnology (FSAB) in the National Seminar during 19th-20thNovember, 2012 held at Thrissur.
- Dr. D R Palsaniya, a former scientist of NRCAF, received prestigious P. S. Deshmukh Young Agronomist Award of Indian Society of Agronomy, New Delhi for the year 2010. He received this award at 3rd International Agronomy Congress held during 26th-30thNovember, 2012 in New Delhi. Dr. Palsaniya was honored with this award for his contribution in silvipasture, agroforestry and watershed management while working as scientist at the Centre.

- Best Paper Award was conferred to Dr. Ramesh Singh, Sr. Scientist (Land and Water Management Engg.) on the paper "Integrated Watershed Management for Natural Resource Conservation and Livelihood Security in Semi-Arid Tropics of India" authored by Palsaniya, D R, Singh, R, Tewari, R K, Yadav, R S and Dhyani, S K published in Indian J. Agricultural Sciences, 82 (3): 241-7, 2012 by NRCAF, Jhansi on 08thMay, 2012 on its Foundation Day. This paper was 6th in the top 10 downloaded papers from the Indian Journal of Agricultural Sciences.
- Best Poster Award (1st prize) was conferred to Dr. Ramesh Singh, Sr. Scientist (Land and Water Management Engg.) on the paper "Horti-pasture land use system for livelihood improvement and sustaining productivity in rainfed situation authored by Kumar, Sunil, Shukla, AK, Singh, Ramesh, Kumar, Sunil, Rai, AK and Singh, H V in National Symposium on "Sustainable Production of Forages from Arable and Non-Arable Land and Its Utilization" during 2nd-3rd November, 2012, held at IGFRI, Jhansi (UP).
- Best Poster Award (1st prize) was conferred to Dr. Ramesh Singh, Sr. Scientist (Land and Water Management Engg.) on the paper "*Sukhagrast Bundelkhand Kshetra Me Jalagam Kriaon Dwara Ajeevika Suraksha*" authored by Singh, Ramesh, Tewari, RK, Palsaniya,

D R, Dhyani, S K, Dwivedi, RP, Rizvi, RH and Singh, RK during Hindi Pakhwara during Hindi Pakhwara 14th -29th September, 2012by NRCAF, Jhansi.

- Garhkundar Mahotsav Ayojan Samiti-2012, Govt. of M.P. on 29th December 2012 Honored members of Garhkundar-Dabar Watershed Development team of National Research Centre for Agroforestry, Jhansi for their contribution in conservation of natural resources through bio-engineering measures and productivity enhancement. A letter of citation was given to each team member.

5. ONGOING RESEARCH PROJECTS (2012-13)

Project code	Title of project / sub project	Duration	Project leader	Associates
(1) Systems Research: Programme Leader: Dr. Anil Kumar				
AF01.17	Analysis of Eucalyptus based agroforestry for crop- lands in Jhansi	2003-2013	Dr. A K Handa	Dr. Ram Newaj, Dr. BadreAlam, Dr. Anil Kumar, Dr. Ajit & Dr. Ramesh Singh
AF02.12	Effect of irrigation on performance of aonla under agroforestry systems	2005-2015	Dr. R K Tewari	Dr. Ramesh Singh & Dr. D R Palsaniya
AF02.14	Nutrient management in ber based agri-horti system	2010-2019	Dr. Sudhir Kumar	Dr. Anil Kumar Dr. Rajendra Prasad & Dr. D R Palsaniya/ Dr. Inder Dev
AF03.9	Initiation of pruning and its intensity on productivity of *Albizia procera*	2006-2020	Dr. D R Palsaniya	Dr. Inder Dev
Observational Trial	Development of bamboo based agroforestry systems in six agroclimatic zones	2007-2013	Dr. Inder Dev	
(2) Natural Resource & Environment Management: Programme Leader: Dr. Ram Newaj				
AF01.16	Evaluation of shade tolerance of crop species for agroforestry systems	2007-2013	Dr. Badre Alam	Dr. Ram Newaj
AF01.24	Studies on arbuscular mycorrhizal fungi of important MPT's	2008-2016	Dr. Anil Kumar	---
AF 01.25	Development of soil quality index for assessing soil health of different agroforestry systems	2008-2013	Dr. Rajendra Prasad	Dr. Ram Newaj
AF 05.6	Model watershed project on natural resource management through agroforestry interventions at Garhkundar, Tikamgarh, M.P. **Programme Coordinator:** **Dr. S K Dhyani**	2005-2016	Dr. R K Tewari	Dr. Ramesh Singh Dr. R P Dwivedi Dr. D R Palsaniya Dr. R H Rizvi
AF 05.11	Multi-Source Inventory Methods for Quantifying Carbon Stocks through Generalized Volume/Biomass Equations for Prominent Agro-forestry Species in India	2011-2017	Dr. Ajit	Dr. A K Handa & Dr. R H Rizvi
NPCC*	Studies on mitigation potential of different agroforestry systems on climate change **Lead Institute: CRIDA, Hyderabad**	2008-2013	Dr. Ram Newaj	Dr. BadreAlam, Dr. AK Handa, Dr. Ajit, Dr. Rajendra Prasad & Dr. Ramesh Singh

Project code	Title of project/ sub project	Duration	Project leader	Associates
NICRA*	National Initiative on Climate Resilient Agriculture **Lead Institute: CRIDA, Hyderabad** **Programme Leader: Dr. S K Dhyani**	2011-2017	Dr. Ram Newaj	Dr. Rajendra Prasad, Dr. AK Handa, Dr. BadreAlam, Dr. Ajit & Dr. R H Rizvi
MoRD, New Delhi*	Model watershed for sustaining agricultural productivity and improved livelihoods (a) Domagor- Pahuj watershed (b) Parasai- Sindh Watershed **Lead Institute: ICRISAT, Hyderabad.** **Programme Coordinator: Dr. S K Dhyani**	2009-2015 2011-2016	Dr. Ramesh Singh	Dr. RK Tewari, Dr. DR Palsaniya, Dr. Inder Dev, Dr. R H Rizvi & Dr. K. B. Sreedhar
Inter Institutional project	Evaluation of aonla based horti-pasture system under different soil & water conservation practices in Central India **Lead Instt.:IGFRI, Jhansi**	2007-2018	Dr. Sunil Kumar	Dr. Ramesh Singh & Dr. Sunil Kumar, Head, IGFRI
Observational trial	Weed dynamics studies in different agroforestry systems	2012-2014	Dr. Inder Dev	
(1) Tree Improvement, Post-Harvest and Value Addition (Programme Leader: Dr. A K Handa)				
AF01.22	Studies for augmenting pistillate flowers with exogenous application of growth regulators and chemicals in *Jatropha curcas*	2007-2013	Dr. Badre Alam	Dr. Sudhir Kumar
AF01.23	Comparative studies on seedling and clonal plants of *Pongamia pinnata* with special reference to their adaptability to rainfed dry agroclimate	2007-2015	Dr. Badre Alam	Dr. A K Handa
AF 04.1b	Exploration, evaluation and conservation of germplasm of *Acacia nilotica*	2002-2013	Dr. S Vimala Devi	Dr. Badre Alam
AF 04.5	Genetics and breeding of *Jatropha* species	2004-2013	Dr. Sudhir Kumar	Dr. R V Kumar and Dr. D R Palsaniya (IGFRI)
AF 04.6	Age- age correlation model for juvenile selection of trees in agroforestry	2004-2014	Dr. R H Rizvi	Dr. Ajit & Dr. K B Sreedhar
AF 05.10	Lac based agroforestry in Bundelkhand region: Introduction and evaluation	2008-2013	Dr. Sudhir Kumar	Mr. Rajendra Singh, Dr. S Ghosal, Dr. Md.Monobrullah, IINRG.

Project code	Title of project/ sub project	Duration	Project leader	Associates
AF 04.9	Assessment of candidate genes for oil biosynthesis in *P. pinnata* using eco-tilling approach	2012-2015	Dr. S Vimala Devi	Dr. A K Handa, Sh. K. Rajrajan & Dr. Sudhir Kumar
NOVOD Board Project*	National network on integrated development of Jatropha and Karanj	2005-2013	Dr. Sudhir Kumar	Dr. R V Kumar (IGFRI) & Dr. D R Palsaniya
ICAR, IINR&G Ranchi*	Harvest and post-harvest processing and value addition of natural resins, gums and gum resins	2008-2013	Dr. Rajendra Prasad	Dr. AK Handa Dr. Ajit, Dr. Ramesh Singh & Dr. Badre Alam
(4) HRD, Technology Transfer & Refinement (Programme Leader: Dr. R K Tewari)				
PROJECTS CONCLUDED IN 2012				
AF02.13	Tree density optimization in bael based agri-horti system under rainfed semiarid situation	2010-2019	Dr. R. K. Tewari	Dr. Sunil Kumar & Dr. Rajendra Prasad
AF01.20	Studies on temporal variations in concentration of inorganic and organic constituents in the leaves of some MPTS under agroforestry	2005-2011	Dr. Badre Alam	Sh. Munna Ram
AF 04.8	Standardization of nursery technique, spacing and pruning practices for *Jatropha curcas*	2009-2014	Dr. D R Palsaniya	---
AF 05.9	Evaluation of Ber budding programme in Bundelkhand region of central India	2008-2012	Dr. R P Dwivedi	Dr. R K Tewari & Dr. R H Rizvi
UGC*	Screening and selection of efficient VAM species for *Jatropha curcas* and *Pongamia pinnata*	2007-2012	Dr. Anil Kumar	----
DST Project*	Carbon-di-oxide sequestration potential of agroforestry systems under irrigated and rainfed conditions	2008-2011	Dr. Ram Newaj	Dr. Badre Alam, Dr. R S Yadav, Dr. Ajit & Dr. R H Rizvi

*Outside Funded Project

6. PUBLICATIONS

(A) Research Journals

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(C) Popular Articles

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7. IMPORTANT MEETINGS / ACTIVITIES

Research Advisory Committee

15th Research Advisory Committee (RAC) meeting of NRCAF was held on 3rd & 4th April, 2012. Chairman Dr. V P Singh, Regional Representative for South Asia, WAC, New Delhi and other members were present in this meeting. Dr. S K Dhyani, Director, NRCAF presented the action taken report on the earlier RAC and other activities of the Centre. All the programme leaders presented significant research findings of their programmes and actively participated in the discussions.

Institute Management Committee

16th Institute Management Committee (IMC) meeting was held on 8th June, 2012 at NRCAF Jhansi under the chairmanship of Dr. S K Dhyani, Director, NRCAF, Jhansi. Dr. Ram Newaj, Pr. Scientist presented brief research achievements of NICRA project and Dr. R K Tewari, Pr. Scientist presented HRD activities of the Centre during 2012. Thereafter, the agenda items were placed and discussed in the meeting.

Institute Research Council

Annual Institute Research Council (IRC) meeting was held on 9th - 10th and 13th July, 2012. All the Scientists of the Centre participated in the meeting and presented the progress and significant findings of their projects. New project proposals were also discussed during IRC.

Quinquennial Review Team

Director General, ICAR vide letter No. F.No. 16-7/2011-IA.II dated 4th May, 2012 constituted the Quinquennial Review Team (QRT) to review the work done by National Research Centre for Agroforestry, Jhansi and All India Coordinated Research Project on Agroforestry for the period from 2007 to 2011. Chairman Dr. D N Tiwari, Former Member Planning Commission & DG, ICFRE and all the members of QRT visited the Research Farm and laboratories from 6th to 7th July, 2012 to review the progress of the Centre and also watershed activities at village Garkundar-Dabar of District Tikamgarh. All

the programme leaders presented significant research findings of their programmes and all the Scientists actively participated in the discussions.

Workshop on Climate Change

NRCAF and Development Alternative (a NGO) jointly organized a Workshop on Climate Change on 26th March, 2012 for the Scientists and SHG members. The main objective of the Workshop was to highlight the effect of Climate change in agriculture and environment and other related aspects.

ICAR-Industry Day and Agricultural Education Day

NRCAF organized ICAR-Industry Day & Agricultural Education Day on 28th February, 2012. About hundred participants including thirty four graduation and post-graduation students along with two faculty members from Bipin Bihari Post Graduate College, Jhansi, SRF, RA, M.Sc. dissertation students and Ph.D. Scholars participated in the function. All scientific, technical, administrative and other staff members actively participated in the event. Lectures on agricultural education scenario in India and status of agri-based industries in Jhansi were delivered. Possibilities of promoting agri-based and forestry-based enterprises in Bundelkhand region were also discussed.

Foundation Day

NRCAF celebrated its 24th Foundation day on 8th May 2012. On the eve of Foundation Day on 7th May 2012 a cultural progamme was organized. In the inaugural function salient activities and achievements of the Centre were presented by the Scientists. In the morning *Prabhat Pheri* & *Shramdan*, Scientific, Cultural and other activities were also organized. Scientists and academicians from neighboring institute participated in the function. On the occasion, best paper, best worker awards were given to Scientific, Technical and supporting staff of the Centre.

Farm Innovator's Day

NRCAF, Jhansi organized "Farm Innovator's Day and Kisan Mela" on 23rd November, 2012 in Parasai-Sindh watershed of Jhansi district in Bundelkhand region. Watershed is being implemented by the Centre in participatory mode with farming community in collaboration with ICRISAT,

Hyderabad. Exhibits, posters and live materials pertaining to agroforestry innovation and natural resource management were displayed on the occasion. Demonstrations on micro-irrigation with rain gun, sprinkler systems and cultivation through Tropicultor were organized in farmer's field.

Republic Day and Independence Day

Republic Day (26th January, 2012) and Independence Day (15th August, 2012), respectively were celebrated at NRCAF, Jhansi. Flag hoisting ceremony was observed on both the occasions. Cultural programmes, sport events were organized for the staff along with their family members on these occasions.

8. PARTICIPATION IN WORKSHOP/COORDINATION/ TRAINING/MEETINGS/SYMPOSIA

- Sh. K Rajarajan, Scientist, participated in "Three Months Professional Attachment Training" in Biotechnological tools in Crop Improvement studies during 28th January to 28th April, 2012 at Sugarcane Breeding Institute, Coimbatore (T.N.).
- Dr. A K Handa, Dr. Ajit, Pr. Scientists & Dr. Badre Alam, Sr. Scientist participated in the 3rd International Conference on "Climate Change & Sustainable Management of Natural Resources" during 5th to 7th February, 2012 at ITM Universe, Sithouli, Gwalior (M.P.).
- Dr. S K Dhyani, Director; Dr. R P Dwivedi; Dr. Ajit, Pr. Scientists & Dr. Badre Alam, Sr. Scientist participated in the International Conference on "Climate Change, Sustainable Agriculture and Public Leadership" during 7th to 9th February 2012, NASC, New Delhi and presented research papers.
- Dr. Sudhir Kumar, Dr. A K Handa, Dr. R P Dwivedi, Dr. Inder Dev, Pr. Scientists; Dr. K B Sridhar; Sh. K Rajarajan, Scientists and Sh. S B Sharma, AF&AO participated in the Annual Group Meeting of the All India Coordinated Research Project on Agroforestry during 19th to 21st May, 2012 held at JNKVV, Jabalpur (M.P.).
- Dr. R K Tewari, Pr. Scientist; Dr. Ramesh Singh, Sr. Scientist and Dr. D R Palsaniya, Scientist attended three days Review and Planning Meeting of Model Watershed Projects during 23rd to 25th May, 2012 held at ICRISAT, Hyderabad (A.P.).
- Dr. Rajendra Prasad, Pr. Scientist and Dr. R H Rizvi, Sr. Scientist attended First Review Workshop of NICRA project for presenting progress report during 11th to 13th June, 2012 held at CRIDA, Hyderabad (A. P.).
- Dr. K B Sridhar, Scientist participated in the Training Workshop on "Institutional Innovations in Agri Extension for Inclusive Growth" from 1st to 7th August, 2012 held at NAARM, Hyderabad (A.P.).
- Dr. K B Sridhar, Scientist participated in the DST NRDMS sponsored Summer Training Programme on "Geospatial Technologies and Applications" from 22nd August to 11th September, 2012 at TNAU, Coimbatore (T.N.).
- Dr. Ajit, Pr. Scientist; Sh. S B Sharma, AF&AO; Sh. A K Chaturvedi, P.S. to Director and Sh. Dalbir Singh Rawat, AAO participated in the Guest Lecture on "RTI Act-2005: An Overview of Sh. M L Sharma, Hon'ble Information Commissioner from CIC, New Delhi on 18th August, 2012 held at Project Directorate of Rapeseed and Mustard, Bharatpur (Raj.) .
- Dr. Anil Kumar, Pr. Scientist participated in the MDP Workshop on "Policy and Prioritization, Monitoring and Evaluation (PME) Support to Consortia-based Research in Agriculture" from 11th to 17th September, 2012 held at NAARM, Hyderabad (A. P.).
- Dr. S Vimala Devi, Sr. Scientist attended the NAIP sponsored training program on "Computational Genome Analysis Techniques in Discovery of

Agronomically Important Crop Genes" during 24th to 29th September, 2012 at National Bureau of Plant Genetic Resource & National Agricultural Bioinformatics Grid, IASRI, New Delhi.

- Sh. K Rajarajan, Scientist participated in International Symposium on "New Paradigms in Sugarcane Research" (ISNPSR) during 15th to 17th October, 2012 held at SBI, Coimbatore (T.N.).
- Dr. R P Dwivedi and Dr. Inder Dev, Pr. Scientists participated in the International Symposium on "2nd ASIAN- Indian Agriculture & Forestry Expert" from 17th to 19th October, 2012 held at NASC Complex, New Delhi.
- Dr. S K Dhyani, Director and Dr. A K Handa, Pr. Scientist presented invited lecture in Brain Storming Session-cum-Workshop on "Action Plan for Sustainable Himalayan Agroecosystems" during 19th to 20th October, 2012 organized by Dr. Y.S. Parmar University of Horticulture & Forestry, Solan (H. P.).
- Dr. Inder Dev, Pr. Scientist participated in the National Training on "Advances in Weed Management" during 31st October to 09th November, 2012 organized by Directorate of Weed Science Research, Jabalpur (M. P.).
- Dr. Ram Newaj, Dr. Inder Dev and Dr. Ajit, Pr. Scientists participated in the Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods" organized by Indian Society of Agronomy and ICAR, New Delhi during 26th to 30th November, 2012 held at New Delhi.
- Dr. R K Tewari, Dr. Rajendra Prasad, Dr. Sudhir Kumar, Dr. Ajit, Dr. R P Dwivedi, Pr. Scientists; Dr. Ramesh Singh, Dr. Badre Alam, Sr. Scientist, Dr. K B Sridhar Scientist participated in National Symposium on "Sustainable Production of Forages from Arable and Non-Arable Land and Its Utilization" during 2nd & 3rd November, 2012 held at IGFRI, Jhansi (U. P.).
- Dr. Badre Alam, Sr. Scientist participated and presented a paper in National Symposium on "Innovative Approaches and Modern Technologies for Crop Productivity, Food Safety and Environmental Sustainability" during 19th & 20th November, 2012 held at Thrissur (Kerala).
- Dr. R K Tewari, Pr. Scientist & Nodal Officer (RFD) and Dr. Rajeev Tiwari, Sr. Tech. Officer participated in the RFD Meeting of NRM Division on 19th November, 2012 held at IASRI, New Delhi.
- Dr. Sudhir Kumar, Pr. Scientist and Dr. R H Rizvi, Sr. Scientist participated in the Agricultural Research -Development Conclave for Uttar Pradesh & U P Kisan Vigyan Sangam-2012 on 23rd and 24th November, 2012 at IISR, Lucknow organized by four ICAR institutes *viz.* IISR, CISH, NBFGR and CSSRI Regional Research Station, Lucknow (U. P.).
- Dr. S Vimala Devi, Sr. Scientist and Sh. K Rajarajan, Scientist attended the NAIP sponsored training programme on "Apomixis: Components, Importance and Utilization/Exploitation" during 3rd to 16th December, 2012 held at IGFRI, Jhansi (U. P.).
- Dr. R H Rizvi, Sr. Scientist attended National Symposium on "Space Technology for Food & Environment Security" organized by Indian Society of Remote Sciences during 5th to 7th December, 2012 held at NASC Complex, New Delhi.

- Dr. Anil Kumar, Pr. Scientist participated in the Review Workshop on "PME Cells of ICAR" on 8th December, 2012 organized by PIU-NAIP held at NDRI, Karnal (Haryana).
- Dr. Badre Alam, Sr. Scientist participated in the National Seminar on "Physiological and Molecular Approaches for Development of Climate Resilient Crops" organized by the Indian Society for Plant Physiology, during 12th to 14th December, 2012 held at ANGRA University, Hyderabad (A.P.). He delivered an invited lead lecture on "Prospects of Agroforestry for Improving Natural Resource Utilization and Coping with Environmental Challenges including Climate Change Adaptation and Mitigation".
- Dr. R P Dwivedi, Pr. Scientist participated in the National Seminar on "Emerging Challenges and Paradigm for Sustainable Agricultural Rural Development" during 18th to 20th December, 2012 held at YSPUH&F, Nauni (H.P.).
- Dr. Rajendra Prasad, Pr. Scientist participated in the National Workshop on "Sustainable Management of Natural Gums and Resins" during 21st to 22nd December 2012 at organised by SFRI, Jabalpur (M.P.).

9. WOMEN IN AGRICULTURE

NRCAF constituted a Women Cell at the Centre in 2007 as per the ICAR guidelines. Its regular meetings are organized at the Centre. During this year regular meetings of Women Cell under the Chairmanship of Director were held at NRCAF Jhansi. Gender equality and congenial environment in the office was appreciated by all the members. The Centre 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 Total members in WSHGs are 270 and their cumulative savings are ' 2,18,800. Sixteen WSHGs have started different activities (goatary, vegetables and sewing) with the assistance from the revolving fund.

Meeting of SHG in Domagor-Pahuj watershed

Vegetable cultivation by women in Domagor-Pahuj watershed

Women behind successful agroforestry system in Domagor-Pahuj watershed

10. राजभाषा गतिविधियाँ

हिन्दी पखवाड़ा

केन्द्र में दिनांक 14-29 सितम्बर, 2012 तक हिन्दी पखवाड़े का आयोजन किया गया। हिन्दी पखवाड़े का शुभारम्भ दिनांक 14 सितम्बर, 2012 को किया गया। कार्यक्रम प्रारम्भ करने के पूर्व आई.सी.ए.आर. कुलगीत सभी को सुनाया गया। कार्यक्रम के मुख्य अतिथि डा. पी. के. घोष, निदेशक, भारतीय चरागाह एवं चारा अनुसंधान संस्थान, झाँसी ने अपने उद्‌बोधन में सभी से अपील की कि हिन्दी को बढ़ावा देना हम सभी भारतीय नागरिकों का कर्तव्य है इसलिए सरकारी कामकाज में ज्यादा से ज्यादा हिन्दी का प्रयोग किया जाए। कार्यक्रम में श्री शरद पवार, माननीय कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री, भारत सरकार तथा डा. एस. अययप्पन, महानिदेशक, भारतीय कृषि अनुसंधान परिषद, नई दिल्ली की अपीलों को पढ़कर सुनाया गया।

हिन्दी पखवाड़े के अन्तर्गत प्रतिदिन आयोजित प्रतियोगिताओं में निर्णायक मण्डल द्वारा प्रथम, द्वितीय, तृतीय एवं प्रोत्साहन पुरस्कार हेतु प्रतिभागियों का चयन किया गया। दिनांक 15.9.2012 को केन्द्र में हिन्दी आशुभाषण-1 मिनट प्रतियोगिता तथा लघु कथा का आयोजन किया गया। जिसमें केन्द्र के वैज्ञानिकों, अधिकारियों एवं कर्मचारियों ने भाग लिया। दिनांक 18.09.2012 को वाद-विवाद प्रतियोगिता का आयोजन किया गया जिसका शीर्षक ''सूचना का अधिकारः कितना साकार-पक्ष एवं विपक्ष'' था। जिसमें केन्द्र के अधिकारियों एवं कर्मचारियों ने भाग लिया। दिनांक 20.09.2012 को निबन्ध प्रतियोगिता का आयोजन किया गया जिसका शीर्षक ''साहित्य का समाज पर असर'' था। इस प्रतियोगिता में केन्द्र के अधिकारियों एवं कर्मचारियों (चतुर्थ श्रेणी के कर्मचारियों को छोड़कर) ने भाग लिया। दिनांक 21.09.2012 को सुलेख प्रतियोगिता का अयोजन किया गया जिसमें केन्द्र के तकनीकी एवं प्रशासनिक श्रेणी के अधिकारियों एवं कर्मचारियों ने भाग लिया। दिनांक 22.09.2012 को प्रश्न मंच प्रतियोगिता का आयोजन किया गया जिसका शीर्षक ''आओं-बताओं-पाओं'' था। प्रतियोगिता में सभी वर्ग के कार्मिकों के बच्चों (कक्षा 8 तक) ने भाग लिया। प्रतियोगिता उपरान्त बच्चों को पुरस्कृत किया गया। दिनांक 24.09.2012 को तकनीकी एवं प्रशासनिक श्रेणी के अधिकारियों एवं कर्मचारियों के लिए इमला प्रतियोगिता का आयोजन किया गया। दिनांक 25.09.2012 को कुशल सहायक कार्मिकों तथा समानवेतन श्रमिकों का इमला प्रतियोगिता तथा चिकित्सा अवकाश हेतु प्रार्थना पत्र प्रतियोगिता का आयोजन किया गया। दिनांक 26.09.2012 को हिन्दीभाषी तथा अहिन्दीभाषी क्षेत्रों के लिए अनुवाद प्रतियोगिता का आयोजन किया गया, जिसमें केन्द्र के समस्त तकनीकी एवं प्रशासनिक श्रेणी के अधिकारियों एवं कर्मचारियों ने भाग लिया। दिनांक 27.09.2012 को वैज्ञानिकों के लिए हिन्दी में शोध पत्र पोस्टर प्रतियोगिता का आयोजन किया गया, जिसमें 05 पोस्टर का प्रदर्शन किया गया। दिनांक 27.09.2012 को एक वर्ष (अक्टूबर, 11 से सितम्बर,12) के दौरान प्रशासनिक वर्ग से 20,000 या उससे अधिक शब्द हिन्दी में लिखने के लिए निर्णायक मण्डल द्वारा श्रीमती कौशल्या देवी, कनिष्ठ लिपिक को प्रथम, श्री महेन्द्र कुमार, सहायक को द्वितीय एवं श्री बीरेन्द्र सिंह, सहायक को तृतीय पुरस्कार प्रदान किया गया।

केन्द्र निदेशक डा. एस. के. ध्यानी की अध्यक्षता में दिनांक 29.9.2012 को हिन्दी पखवाड़े का समापन समारोह सम्पन्न हुआ। समापन समारोह के मुख्य अतिथि श्रीमती नीलम कलसी, पूर्व प्राचार्या, गुरू हरकिसन महाविद्यालय,

झाँसी थीं। इस अवसर पर मुख्य अतिथि महोदया द्वारा प्रतियोगिता में विजयी प्रतिभागियों को पुरस्कार वितरित किये गये। कार्यक्रम में हिन्दी वार्षिक पत्रिका ''कृषिवानिकी आलोक-2012'' शष्टम अंक का विमोचन भी मुख्य अतिथि महोदया द्वारा किया गया।

हिन्दी कार्यशालायें

केन्द्र पर वर्ष 2012 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 केन्द्र के समस्त वैज्ञानिकों, अधिकारियों एवं कर्मचारियों ने भाग लिया। वर्ष 2012 के दौरान आयोजित कार्यशालाओं का विवरण निम्नवत है :

राजभाषा कार्यान्वयन समिति की बैठकें

केन्द्र में वर्ष 2012 के दौरान राजभाषा कार्यान्वयन समिति की कुल चार (28.03.2012, 08.06.2012, 01.09.2012 एवं 14.12.2012) 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 केन्द्र निदेशक द्वारा केन्द्र के सभी वैज्ञानिकों, अधिकारियों एवं कर्मचारियों से धारा 3(3), पत्राचार एवं फाइलों पर टिप्पणियां हिन्दी में लिखने के लिए अपील किया गया। बैठकों में केन्द्र निदेशक द्वारा पिछले बैठकों की बिन्दुवार समीक्षा की गई। सभी बैठकों का संचालन प्रभारी अधिकारी (राजभाषा) द्वारा किया गया। बैठक में केन्द्र के राजभाषा कार्यान्वयन समिति के सदस्य उपस्थित रहें।

दिनांक	विषय	वक्ता
28.03.2012	राजभाषा कार्यान्वयन, संवैधानिक प्रावधान : हमारा उत्तरदायित्व एवं अपेक्षायें	डा. सी. के. बाजपेयी, वरिष्ठ तकनीकी अधिकारी
08.06.2012	1. कृषिवानिकी के प्रचार–प्रसार, कृषक सहभागी कार्यवाही अनुसंधान परियोजना तथा डाबर–गढ़कुण्डार जल समेट परियोजना 2. कृषिवानिकी क्षेत्र का मानचित्रण, जी.आई.एस. रिमोट सेंसिंग, कार्बन सिक्वेस्ट्रेशन, सी.ओ–2, रेनफेड ऑवला आधारित कृषिवानिकी, पेड़ों की सघनता तथा पेड़ों की प्राथमिकता	डा. आर. के. तिवारी, कार्यक्रम प्रमुख (मानव संसाधन विकास) डा. राम नेवाज, कार्यक्रम प्रमुख (कृषिवन)
14.09.2012	''यूनीकोड''	डा. आर. एच. रिजवी, वरिष्ठ वैज्ञानिक एवं प्रभारी अधिकारी (संगणक प्रकोष्ठ)
14.12.2012	''जलवायु परिवर्तन एवं कृषिवानिकी''	डा. राम नेवाज, कार्यक्रम प्रमुख (कृषिवन)

11. VISITORS

- Hon'ble Dr. A K Singh, DDG (NRM), ICAR, New Delhi.
- Sh. Gaurav Dayal (IAS), District Magistrate, Jhansi (U.P.).
- Dr. D N Tiwari, Former Member Planning Commission & DG, ICFRE, Allahabad (U.P.).
- Dr. V P Singh, Regional Representative for South Asia, WAC, New Delhi.
- Dr. J C Dagar, ADG (AF & Agron.), ICAR, New Delhi.
- Dr. Brahma Singh, Advisor, Nauni Foundation, Chennai.
- Dr. S D Kashyap, Dean, Dr. Y.S. P. U. of Horti. & Forestry, Solan (H.P.).
- Dr. D K Das, Former Head, IARI, Pusa, New Delhi.
- Prof. S B Nahatkar, Division of Agriculture Economics, J.N.K.V., Jabalpur (M.P.).
- Dr. V K Gupta, Ex-Principal Scientist, Bangalore (Karnataka).
- Dr. R N Misra, IFS, (Former PCCF Chhattisgarh), Raipur (Chhattisgarh).
- Dr. S R Arya, Ex- DDG (ICFRE), Shimla (H.P.).
- Dr. J P Mishra, Dean, College of Hort. & Forestry, N.D.U. A. & T., Faizabad (U.P.).
- Dr. S S Raju, Pr. Scientist (Economics), National Centre for Agricultural Economics & Policy Research (NCAEP), New Delhi.
- Dr. S N Pandey, Project Coordinator, Taragram, Jhansi (U.P.).
- Sh. Bhairam Singh, Dy. Director (Hort.), Jhansi (U.P.).
- Dr. P K Ghosh, Director, Indian Grassland and Fodder Research Institute, Jhansi (U.P.).
- Smt. (Dr.) Neelam Kalsi, Ex. Principal, Guru Harkishan Post Graduate College, Jhansi (U. P.).
- Dr. Suresh Singh Tomar, Director Extension Services, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.).

Field Visit of RAC

Field Visit of QRT

12. PERSONNEL

Dr. S K Dhyani, Director

Scientific

1. Dr. Anil Kumar, Pr. Scientist (Plant Pathology)
2. Dr. R K Tewari, Pr. Scientist (Horticulture)
3. Dr. Ram Newaj, Pr. Scientist (Agronomy)
4. Dr. Rajendra Prasad, Pr. Scientist (Soil Science)
5. Dr. Sudhir Kumar, Pr. Scientist (Horticulture)
6. Dr. A K Handa, Pr. Scientist (Forestry/Agroforestry)
7. Dr. Ajit, Pr. Scientist (Agriculture Statistics)
8. Dr. R P Dwivedi, Pr. Scientist (Agriculture Extension)
9. Dr. Inder Dev, Pr. Scientist (Agronomy)
10. Dr. Badre Alam, Sr. Scientist (Plant Physiology)
11. Dr. (Er.) Ramesh Singh, Sr. Scientist (SWE)
12. Dr. R H Rizvi, Sr. Scientist (Computer Application)
13. Dr. S Vimala Devi, Sr. Scientist (Plant Breeding)
14. Dr. D R Palsaniya, Scientist (Agronomy) (Up to September, 2012)
15. Dr. K B Sridhar, Scientist (Forestry)
16. Sh. K Rajarajan, Scientist (Genetics & Plant Breeding)

Technical

1. Sh. B Singh, Sr. Farm Manager (T-9)
2. Dr. Rajeev Tiwari, Sr. Technical Officer (T-9)
3. Dr. C K Bajpai, Sr. Technical Officer (T-9)
4. Dr. A Datta, Sr. Technical Officer (T-7/8)
5. Sh. Sunil Kumar, Sr. Technical Officer (T-7/8)
6. Sh. Rajendra Singh, Sr. Technical Officer (T-7/8)
7. Smt. Uma, Sr. Technical Officer (T- 7/8)
8. Sh. Rajesh Srivastava, Technical Officer (T-6) (Art & Photo)
9. Sh. Prabhu Dayal, Technical Officer (T-5)
10. Sh. R K Singh, Technical Officer (T-5)
11. Sh. S P Singh Yadav, Technical Officer (T-5)

12. Sh. Ram Bahadur, Technical Officer (T-5)
13. Km. Sheja Tamrkar, Technical Assistant (T-3)
14. Sh. Het Ram, (T-3), Driver
15. Sh. Prince, (T-2), Mechanic
16. Sh. Kashi Ram, (T-2), Driver

Administrative

1. Sh. D D Dhamani, AO (Up to 31st August, 2012)
2. Sh. S B Sharma, A F& A O
3. Sh. Dalbir Singh Rawat, AAO
4. Sh. A K Chaturvedi, Personal Secretary
5. Sh. Hoob Lal, P. A.
6. Sh. K P Sharma, Assistant
7. Sh. Mahendra Kumar, Assistant
8. Sh. Birendra Singh Tomar, Assistant
9. Sh. Jai Janardan Singh, Assistant
10. Sh. Om Prakash, Stenographer (Grade-III)
11. Sh. Deepak Vij, Stenographer (Grade-III)
12. Sh. Tridev Chaturvedi, Stenographer (Grade-III)
13. Sh. Vir Singh Pal, Sr. Clerk
14. Smt. Kaushalya Devi, Jr. Clerk

Skilled Supporting Staff

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

13. MISCELLANEOUS

New Scientist/ Staff

- Dr. Inder Dev joined the Centre as Pr. Scientist (Agronomy).
- Dr. S Vimala Devi joined the Centre as Sr. Scientist (Plant Breeding).
- Sh. Jai Janardan Singh joined the Centre as Assistant.
- Miss Shelja Tamrkar joined the Centre as Library Assistant (T-3).

Promotion

- Dr. Sudhir Kumar, Sr. Scientist (Horticulture) promoted to Pr. Scientist from 1st January, 2009 under the provision of Career Advancement Scheme.
- Dr. Ajit, Sr. Scientist (Agril. Statistics) promoted to Pr. Scientist from 13th February, 2010 under the provision of Career Advancement Scheme.
- Dr. R P Dwivedi, Sr. Scientist (Agril. Extension) promoted to Pr. Scientist from 25th July 2010 under the provision of Career Advancement Scheme.
- Dr. Inder Dev, Pr. Scientist (Agronomy) promoted to Pr. Scientist from 14th November, 2011 under the provision of Career Advancement Scheme.
- Dr. Rajeev Tiwari, Sr. Technical Officer (T –7/8) promoted to the post of Sr. Technical Officer (T–9) w.e.f. 3rd February, 2012.
- Dr. C K Bajpai, Sr. Technical Officer (T–7/8) promoted to the post of Sr. Technical Officer (T–9) w.e.f. 3rd February, 2012.
- Sh. Het Ram, T-2 (Driver) promoted to the post of T-3 (Driver) w.e.f. 29th June, 2011.

Selection

- Dr. D R Palsaniya, Scientist (Agronomy) of the Centre selected for the post of Sr. Scientist (Agronomy) at IGFRI, Jhansi.

Retirement

- Sh. D D Dhamani, Administrative Officer of the Centre retired on 31st August, 2012.
- Sh. Harprasad, SSS of the Centre retired on 31st December, 2012.

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 last 2 years *i.e.* from 2010-11 and 2011-12 of the Centre from 10th to 26th September, 2012.

ICAR Inter-zonal Sport's Meet

Sh. Attar Singh, SSS of the Centre participated in the ICAR Inter-zonal Sport's Meet from 16th to 19th January, 2012 held at CRIJAF, Barrakpore (W.B.).

ICAR Zonal Sport's Meet

A contingent of 19 participants from the Centre participated in ICAR Zonal Sports Meet at ICAR Research Complex for Eastern Region, Patna (Bihar) from 16th-19th February, 2012.

ANNEXURE-I

Research Advisory Committee

S. No.	Name	S. No.	Name
1	Dr. V P Singh **(Chairman)**, Regional Representative for South Asia, World Agroforestry Centre, New Delhi.	2	Dr. J C Dagar, (Member) ADG (AF & Agron.), ICAR, New Delhi.
3	Dr. S D Kashyap, (Member), Dean, Dr. Y.S. P. U. of Horti. & Forestry, Solan (H.P.).	4	Dr. D K Das, (Member), Former Head, IARI, Pusa, New Delhi.
5	Prof. S B Nahatkar, (Member), Division of Agriculture Economics, J.N.K.V., Jabalpur (M.P.).	6	Prof. Brahma Singh, (Member), Advisor, Nauni Foundation, Chennai (T.N.)
7	Dr. V K Gupta (Member), Ex-Principal Scientist, Bangalore (Karnataka).	8	Dr. S K Dhyani, Director (Member) NRCAF, Jhansi (U.P.)
9.	Dr. Anil Kumar, Pr. Scientist & Member Secretary, NRCAF, Jhansi		

ANNEXURE- II

Institute Management Committee

S. No.	Name	S. No.	Name
1	Dr. S K Dhyani, **(Chairman)** Director, NRCAF, Jhansi (U.P.)	7	Sh. K N Gupta Fin. & Accounts Officer, IIPR, Kanpur (U.P.)
2	Dr. S N Pandey, Project Coordinator, Development Alternatives, Taragram Orchha -Tikamgarh (M.P.)	8	Dr. G P Juyal, Head, (H &T), CSWCRTI, Dehradaun (Uttrakhand)
3	Mr. Pyare Lal, Chief Executive, Pragati Biotechnologies, Clonal Research and Production Centre, Village Semi, P.O. Khajurla Jalandhar (Punjab)	9	Dr. Rajendra Prasad, Pr. Scientist (Soil Science), NRC for Agroforestry, Jhansi (U. P.)
4	Dr. R K Tewari, Pr. Scientist (Horticulture), NRC for Agroforestry, Jhansi (U.P.)	10	Director Agriculture, Government of U.P., Krishi Bhawan, Lucknow (U.P.)
5	Dr. D R Malviya, Pr. Scientist, IGFRI, Jhansi (U.P.)	11	Deputy Director (Horticulture), Government Garden, Narayan Bag, Jhansi (U.P.)
6	ADG (Agron./AF) ICAR, KAB-II, Pusa, New Delhi -110012.	12.	Dr. Inder Dev, Pr. Scientist, H.O. & Member Secretary, NRC for Agroforestry, Jhansi (U.P.)

ANNEXURE- III

Institute Joint Staff Council

Chairman : Dr. S K Dhyani (Director)		
Staff Side		**Office Side**
Category	***Name and Designation of the Govt. Servant***	***Name and Designation of the Govt. servant***
Technical	Sh. Kashi Ram, T-2, Tech. Asstt. - **Secretary**	Sh. D S Rawat, AAO - **Member Secretary**
	Sh. Ram Bahadur, T-5, Tech. Officer - Member	Sh. S B Sharma, AF&AO - Member
Administration	Sh. Birendra Singh, Assistant - Member, **CJSC**	Sh. A K Chaturvedi, Personal Secretary - Member
	Sh. Tridev Chaturvedi, Stenographer (Gr.-III) - Member	Dr. Anil Kumar, Pr. Scientist - Member
Supporting	Sh. Attar Singh, SSS- Member	Dr. Rajendra Prasad, Pr. Scientist - Member
	Sh. Ram Singh, SSS- Member	Dr. Inder Dev, Pr. Scientist - Member
		Dr. S Vimala Devi, Sr. Scientist - Member
		Smt. Uma, T-(7-8), Sr. Tech. Officer - Member

ANNEXURE- IV

Women Cell

1.	Dr. S Vimala Devi, Sr. Scientist	-	Chair Person
2.	Smt. Uma, T-(7-8), Sr. Tech. Officer	-	Member
3.	Km. Sheja Tamrkar, Tech. Assistant (T-3)	-	Member
4.	Smt. Kaushalya Devi, Jr. Clerk	-	Member
5.	Smt. Sadhna Pandey, Sr. Scientist, IGFRI, Jhansi	-	Member
6.	Dr. Inder Dev, Pr. Scientist &HO	-	Member
7.	Sh. D S Rawat, AAO	-	Member
8.	Sh. Kashi Ram, Sec. IJSC	-	Member

भाकृअनुप
ICAR

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agri search with a human touch

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