National Research Centre for Agro-foresty, Jhansi

AGROFORESTRY - IN NATIONAL PERSPECTIVE

In India, agroforestry has been a way of life. Our social, religious and cultural ethics have been closely linked with the planting and protection of various trees. Tree worship is still continued in many societies of our country. Tree biodiversity has been preserved in many areas because of its role in farming and other land use systems. However, with increase in demographic pressure resulting in over exploitation of resource base leading to degradation and vast gap between demand and supply of woody produces, agroforestry has once again been identified as the most appropriate land use option. Accordingly, the Indian Council of Agricultural Research (ICAR) has initiated a network project for organized research in agroforestry in 1983. To strengthen and coordinate the agroforestry research the National Research Centre for Agroforestry came into existence on 8th May, 1988 at Jhansi (U.P.).

Presently, it has one of the largest network with 36 centers of AICRP on agroforestry at 25 SAUs and 11 ICAR institutes in various agro- climatic zones in India. Agroforestry research is very much accepted by the researchers, policymakers and farmers for its apparent ability to contribute significantly to economic growth, poverty alleviation and environmental amelioration.

MISSION

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

VISION

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

MANDATE

- To undertake basic and applied research for developing and delivering technologies based on sustainable agroforestry practices on farms, marginal and wastelands for different agroclimatic zones in India.
- To coordinate network Research with the State Agricultural University/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 (b) use and application of technologies developed, at various levels.
- To develop technological packages of different agroforestry practices for various agroclimatological 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 above objectives.
- To provide consultancy.

Agrihorticulture and Silvipasture Programme

Research under this programme is strengthened with scientists, technical, supporting staff, adequate land, laboratory equipped with latest equipments, facility for qualitative and quantitative analysis of fruits & pasture and one field nursery with net house facility for multiplication of quality planting material etc.

- Fruit trees viz. guava (*Psidium guajava*), ber (*Zizyphus mauritiana*), anar (*Punica granatum*) and kinnow (*Citrus reticulate*) with three spacing (5x5m, 5x10 m and 10x10m) were evaluated under agrihorticulture (irrigated condition) system during 1989-97. The interspaces between fruit tree were utilized for growing sorhgum-wheat, sorghum-chickpea, groundnut-wheat and groundnut-chickpea. After six years, 1.13 t ha^{-1} fruit from guava, 4.691 ha^{-1} biomass (fuel + fodder) from subabul, 1.461 ha^{-1} grains from intercrop (wheat) were obtained from agrisilvihorticultural system (P. guajava + crop + subabul). The grain yield of intercrop (wheat) reduced by 77.6% with P. guajava (0.841 ha^{-1}) as compared to pure crop (3.78 g ha^{-1}) in 8th year of the experiment. Similarly, the reduction in grain yield of wheat was 76 and 70% with Z. mauritiana and C.reticulata, respectively.
- Four varieties of ber (*Zizyphus mauritiana*) viz. Seo, Gola, Banarasi karaka, and Desi, at two spacing and five crop sequences were studied (1992-1997). The soil of experimental field was red gravelly, having pH 7.7, organic carbon 0.15%, EC 0.17 ds/m ESP 0.62 me/100g, available nitrogen 1.10 kg ha^{-1}, phosphorus 12.2 kg ha^{-1} and potassium 120.5 kg ha^{-1}. The productivity of whole system (average of six year 1992-97) indicated that 894 to 1097 kg ha^{-1} of fruit, 385 to 475 kg ha^{-1} of fuel wood and 59 to 78 kg ha^{-1} of fodder from ber and 68 to 374 kg ha^{-1} grain from different crops were obtained every year. Among different crops, blackgram was most suitable as it gave highest (374 kg ha^{-1}) grain yield followed by green gram (267 kg ha^{-1}).

- Four varieties of aonla (*Emblica offidnalis*) viz. chakaiya, kanchan, krishna and NA-7 as fruit trees, Leucaena as multipurpose tree and blackgram as intercrop in rainfed area were evaluated. At the age of 6 year, average fruit yield was upto 93 kg plant^{-1}. The fruit yield of E. offidnalis varied year to year and alternatively. Fruit yield was higher and had inverse relation with total annual rainfall received during preceding year. Besides fruit yield 256 kg ha^{-1} year^{-1} grain was obtained from blackgram every year. Leucaena was cut twice a year and it provided on an average 1325kg fuel wood and 799kg leaves ha^{-1} every year. The leaves of Leucaena were utilized as mulch to minimize moisture loss from soil during summer, which is very essential in alfisols in rainfed areas. Besides fuel and fodder yield from Leucaena, it also helped in improving soil fertility. If offidnalis in Bundelhand region on shallow gravelly red soil under rainfed condition showed short life span (15 years) due to presence of rocks in sub surface which caused growth seizure and otherwise mortality.
- Agro technique for aonla (*Emblica officinalis*) based agrihorticulture system under rainfed conditions employing in situ water harvesting technique has been developed. E. offidnalis variety NA-7 and kanchan have been identified as most remunerative under agrihorticultural system as it yielded 90-120 kg fruit tree^{-1} at 7-8 years age under rainfed conditions.
- Bundelkhand experience continued drought from 2004-07. The crops in farmer's field as well as experimental farm have shown drastic reduction in yield to the extent of 60 to 78% in rainfed conditions. However, fruit plants under agroforestry situation such as aonla, ber, bael and other have invariably given higher returns from fruit, wood and top feed besides crop yield.
- Softwood cleft grafting technique in aonla, jackfruit, mango, bael and guava have been developed. Bench grafting technique in aonla and ber developed. Top working technique of *Carisa spinarum* with C. carandus developed.

- Four varieties of guava (L-49, Allahabad Safeda, Sweta and Lalit) five varieties of bael (NB-5, MB-9, B-1, B-2 and Kagji Etawah) are being evaluated for agrihorticulture landuse.
- Four varieties of mango (Dashehari, Langara, Mallika and Amrapali) were evaluated with annual crops in deep black soil (mar) under irrigated condition. All four varieties performed well. However, crop yield in association with mango reduced drastically and became un-economical due to dense evergreen canopy of mango. Cropping was feasible only upto 6 years of plantation.
- Minor fruits like chironjee, lasoda, bael, imli, custard apple, shahtoot, wood apple were introduced and evaluated under hortipastoral system. A propagation technique of most of these fruit crops has been standardized. Chironjee, custard apple and Khirni showed poor

establishment under natural rangelands. Ber, Aonla, Bael, Lasoda, Imli were found quite adaptive and compatible.

- 19 species of medicinal plants viz., Emblica officinalis, Tamarindus indica, Terminalia arjuna, T. beierica, T. chebula, Bauhinia purpurea, Cassia fistula, Ceiba pentandra, Syzyg/um cuminii, Ficus racemosa, Pterospermum marsupium, Nictanthus arbortristis, Holoptelea integrifolia, Acacia concina, Caesalpinia bounducella, Ponsamia pinnata, Cordia myxa and Saracca indica planted in degraded land (shallow gravelly red soil). Mean annual increment in plant height was recorded between 12.3 to 97 cm yr^{-1} and in collor diameter between 0.12 to 2.77 cm yr^{-1}. Ceiba pentandra was fastest growing species but it showed frost susceptibility. As a result terminal bud was damaged every year and plant showed branching each year. A. conncina was slow growing. Cassia aungustifolia as ground storey crop had a plant population of 12.75 m^2 with mean plant height of 43.85 cm. Mean biomass yield was 37.1 g $plant^{-1}$.
- In-situ moisture conservation techniques (stone mulching, deep basin, deep tillage + deep basin) in aonla resulted in 31% increase in fruit yield as against control (16.9 kg $tree^{-1}$). During drought years.
- Growth and biomass production of three tree species (Acacia nilotica Var. Cupressiformis, Dalbergia sissoo and Hardwickia binata) with and without pasture and with and without pruning were studied up to 14^{th} year. Results revealed that D. sissoo recorded significantly higher height (9.3 m), dbh (17.2 cm), canopy diameter (4.76 m) followed by H. binata. However, unpruned trees showed significantly higher growth in all the three MPTS. Total biomass yield 6.31 t ha^{-1} (forage + leaf fodder + fuel wood) obtained with D. sissoo based silvipasture was higher than other two silvipastoral systems as well as pure pasture. Pruning of trees upto 50% height gave on an average 20.5% higher forage yield than unpruned trees. After 13-years, irrespective of MPTs (H. binata, D. sissoo & A. nilotica var. cupressiformis) canopy and pruning, silvipastoral system decreased soil pH by 0.27 units and increased soil organic carbon by 28 per cent in comparison to pasture alone. Similarly, available K, soil microbial biomass carbon and dehydrogenase activity increased by 16, 83 and 104 per cent, respectively.
- Studies on performance of goat and sheep each 10 and their offsprings maintained on 2 ha silvipastoral system consisting of Leucaena leucocephala, Dichrostachys cinerea and natural grassland were continued for four years. The total of 42 kids and 27 lambs were added to the flock by lambing and kidding, respectively within 44 months after attaining maturity. The average total weight gain of newly born kids and lambs was 61.1 and 83.5 g day $head^{-1}$, respectively. On the basis of 4 year studies, the B:C ratio was worked out to be 1.07 at 10% discount rate.
- Initiation of pruning and its intensity on productivity of Albizia procera based silvipastoral system with grass (Chrysoposon fulvus) + legume (Stylosanthes seabrana) pasture is being evaluated. Previous experience indicates that legume component disappears after 3 years, hence, needs resowing. Grass component requires reaping from ground every 3 years. Further, Ailanthus excelsa and Grew/a optiva with S. seabrana are being evaluated for fodder production in rakar soils.

Agrisilviculture Programme

Agrisilviculture programme is well equipped with experienced scientists with specialization in agronomy, soil science, plant physiology, plant protection & forestry. State of

arts and equipments are available in laboratories. Mist chambers, Shade houses and Glass house facilities provide an edge to research endeavor.

- 12 MPTs viz. *Acacia nilotica, A. nilotica var. cupressiformis, Albizia lebbeck, Casuarina equisetifolia, Dalber$ia sissoo, Emblica officinalis, Eucalyptus tereticornis, Hardwickia binata, Leucaena leucocephala, Madhuca latifolia, Melia azadirach* and *Syzigium cuminii* planted at 3 spacing (2x4m, 2x6m and 2x1 Om) with 4 crop rotations (sorghum -wheat, sorghum-gram, pigeonpea-wheat, pigeonpea-gram) were studied during 1990-98. The results indicated that the average grain yield of wheat under agrisilviculture system reduced by only 16% by 8th year of plantation. *A. nilotica* was found most compatible at 2 x 10m spacing under agroforestry system.

- Perennial pigeonpea (Var. ICP 6443, ICP-6443, ICP 8860 and BSR-1) were evaluated under alley system with two crop sequences viz. sorghum (CHS-9) - lentil (local), groundnut (Kaushal)-linseed (local) during 1991 to 1993. The results showed that perennial pigeonpea is compatible with groundnut.
- Anjan (*Hardwickia binata*) based agroforestry system with blackgram and mustard was evaluated at 200, 400 and 800 trees ha^{-1} density. Trees withstand pruning upto 70% by height and facilitate crop growth upto 6 years. After 6 years *H. binata* warrants thinning to facilitate cropping. As such, a density of 400 trees ha' is recommended for commercial purposes.
- Root management through deep planting, trenching around tree basin, physical barrier to root growth in shisham (*Dalbergla sissoo*) under agroforestry system indicated that deep planting and deep ploughing in interspaces was best practice to minimize root competition and 70% pruning of trees by height facilitated growth of blackgram and mustard in interspaces till 15 yrs of tree plantation
- Study on Carbon and Nitrogen Dynamics in safed siris (*Aibizia procera*) based agroforestry system revealed that tree growth (dbh and height) was significantly higher in control (un-pruned tree) than 70 and 50% canopy pruning. Biomass, carbon and nitrogen accumulation in tree was higher in control (un-pruned tree) than 50 and 70% canopy pruning and it increased with increasing age of tree. At the age of five year, A. procera tree accumulated 34.501C ha^{-1} under naturally grown condition, 30.41 and 23.6 t C ha^{-1} under 50% and 70% canopy pruning in above and belowground biomass. N accumulation under 50%, 70% and naturally grown trees was 290, 222 and 325 kg N ha^{-1}. The results indicated

that naturally growing trees are most efficient in C sequestration closely followed by 50% pruning.

- Tree-crop interaction in safed sin's (Aibizia procera) based agroforestry system in relation to soil moisture, light and nutrients revealed that tree growth was in order of irrigation>pruning>soil barrier. Root barrier and irrigation eliminated the competition for soil moisture and nutrient between tree and crop. The yield increase of intercrops due to pruning, irrigation (as per requirement of crop) and root barrier was 32-79, 11-25, 7-14% respectively as compared to un-pruned, without root barrier and irrigation (one or two irrigation). C and N dynamic studies in the system indicated total C fixation was maximum under agroforestry system with 50% tree pruning.
- *Albizia procera*, *Tectona grandis* and *Azadirachta indica* in agrisilviculture system were studied for nutrient budgeting. Irrespective of cropping, 6.14, 10.9 and 4.36 kg of N; 0.21, 0.37 and 0.07 kg of P and 2.32, 4.07 and 1.31 kg of K ha' were removed by T. grandis, A. procera and A. indica, respectively. Out of which 66, 69 and 70% of N; 45, 55 and 86% of P and 93, 92 and 93% of K were returned to the soil by *T. grandis*, *A procera* and *A. indica*, respectively. After eight years, amongst all tree, A. procera based agroforestry system brought greater improvement in soil fertility due to higher litterfall and pruned biomass addition.
- 19 species of forestry trees, 7 of horticultural trees, 10 field crops and 8 fodder crops were positively tested for the presence of AM fungi in their roots. Local soils were found to be rich in AM spore populations. Glomus was predominant genus, apart from this Acaulospora, diaspora and Sclerocystis were also present.

- In agroforestry system, trees acted as AM inoculum reservoir for intercrops. Cross inoculation test performed by using AM fungi isolated from trees showed that these could colonize the roots of important kharif (blackgram, greengram and maize) and rabi (gram, pea and wheat) intercrops. Intercropping increase AM activity in rhizosphere of trees. Tree shade reduces the rate of mycorrhization of intercrops, specially during winter months, AM activity in terms of spore population and mycorrhizal diversity was more in light soils as compared to heavy soil. Excessive stagnation of water during rainy season in aonla orchard was found to be harmful for colonization of plants with arbuscular mycorrhizal fungi. Glomus was more adapted to such conditions.
- Six cultures of Glomus sp. and one culture of Acaulospora were purified from trap cultures set to isolate AM fungi from rhizosphere of trees. Growth and phosphorus uptake

byEmblica officinalis, *Zizyphus maruritiana, Buchanania lanzan, Cordia myxa, Albizia procera, Eucalyptus tereticornis, Dalbergia sissoo* and *Leucaena leucocephala* seedlings was significantly increased by inoculation with suitable AM species under nursery conditions.

- *Eucalyptus tereticornis* based agrisilviculture and boundary plantation system is being evaluated with that of sole plantation since 2003. Agroforestry system initially favored tree growth but 3rd year onwards growth was at par with sole plantation. After 3 years, blackgram and wheat yield reduced drastically to the tune of 44% under agroforestry system and 28% in boundary plantation. Soil fertility under agroforestry system showed improvement in terms of OC, P, K, MBK, pH and EC. Under agroforestry system 2x1 Om spacing was found suitable for the species with respect to crop productivity and tree growth. Total biomass-dbh models were developed. Model parameters were established using non linear regression procedure for the observed data set. The parameter of the model stabilizes at the age of 3 years under both the systems.

- Study on poplar based agroforestry systems in Punjab, Haryana, Western U.P. and Uttrakhand revealed that tree productivity and rotation varies with site specific conditions, variety and market prices. Poplar is grown under different systems viz. Agroforestry, silvi-medicinal and acqua silviculture etc. Crops like sugarcane (initial years only), wheat, turmeric, rose, vegetables etc. were found common throughout rotation. In another study Prosopis cineraria based agroforestry system of Rajasthan was studied. P. cineraria was found to enrich soils and sustain cropping. The species has multiple uses. Natural regeneration of the species is slow due to collection of pod by the villagers for vegetables. Further, mechanization and irrigation appears to be hampering natural regeneration. Farmers are readily agreeing to plant provided good planting material is made available.