PRACTICAL MANUAL

Interactions in Agroforestry systems
Course No. FSA 505 Credit Hrs. 2(1+1)

M.Sc. Forestry (SAF) II Semester

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Syllabus

Different methods for quantifying interactions, Studies on allelopathy, Effect, microclimate modifications, different plant mixtures, tree-soil-crop interactions. Estimation of Land Equivalent Ratio, Estimation of competition indices, Measurement and interpretation of light interception in agroforestry systems, Interpretation of yield responses to shelter, soil water and drainage measurement, transpiration measurement, quantifying root distribution.

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CERTIFICATE

This is to certify that Shri/Km……..Id No……has completed the practical of course……Course No……as per the syllabus of M.Sc. forestry (SAF)……..semester ……in the year……in the respective lab/field of college.

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Practical No. 1:

Objective: To study quantification of interactions from Tree–Crop Yield Performance

Interactions:

Material Required:

Procedure:

Conclusion:

Practical No. 2:

Objective: To study quantification of interactions from Tree–Crop Interaction Models

Models:

Material Required:

Procedure:

Conclusion:

Practical No. 3:

Objective: To study Allelopathic Interference from mulches of plant residue

Allelopathy:

Mulch:

Material Required:

Procedure:

Conclusion:

Practical No. 4:

Objective: To study Allelopathic Interference from leaching and root exudation

Leaching:

Root exudation:

Material Required:

Procedure:

i) Leaching

ii) Root exudation

Conclusion:

Practical No. 5:

Objective: To study microclimate modifications in agroforestry systems

Microclimate:

Material Required:

Procedure:

Microclimate models:

Conclusion:

Practical No. 6:

Objective: To study effect of different plant mixtures in agroforestry systems

Plant mixture:

Material Required:

Procedure:

Conclusion:

Practical No. 7:

Objective: To study tree-soil-crop interactions in agroforestry systems

Tree-soil-crop interactions:

Material Required:

Procedure:

i) Interference

ii) facilitation

Conclusion:

Practical No. 8:

Objective: To study estimation of Land Equivalent Ratio of agroforestry systems

Land Equivalent Ratio (LER):

Material Required:

Procedure:

Conclusion:

Practical No. 9:

Objective: To study estimation of competition indices in agroforestry systems

Competition:

Competition indices:

Material Required:

Procedure:

i) **Distance independent stand density indices**

ii) Spatial pattern indices

Conclusion:

Practical No. 10:

Objective: To study measurement and interpretation of light interception in agroforestry systems

Light interception:

Material Required:

Procedure:

Conclusion:

Practical No. 11:

Objective: To study interpretation of yield responses to shelter in agroforestry systems

Yield:

Shelter:

Material Required:

Procedure:

Conclusion:

Practical No.12:

Objective: To study soil water and drainage measurement in agroforestry systems

Soil water:

Drainage:

Material Required:

Procedure:

i) **Soil water measurement**

ii) Drainage measurement

Conclusion:

Practical No. 13:

Objective: To study transpiration measurement in agroforestry systems

Transpiration:

Evaporation:

Evapo-transpiration (ET):

Material Required:

Procedure:

Conclusion:

Practical No. 14:

Objective: To study use of line quantum sensor for light measurement in agroforestry systems

Material Required:

Line quantum sensor:

Principle:

Advantages:

Disadvantages:

Conclusion:

Practical No. 15:

Objective: To study quantification of root distribution in agroforestry systems

Root types:

Material Required:

Procedure:

i) Traditional Method

ii) Geo-electrical method

Conclusion:

Practical No. 16:

Objective: To study use of SPAD chlorophyll meter in agroforestry systems

Chlorophyll meter:

Material Required:

SPAD Chlorophyll Meter:

Principle:

Advantages:

Disadvantages:

Conclusion:

Glossary

Additive series intercropping An intercropping system in which the plant population of the main crop is kept constant into which an intercrop is introduced by adjusting or changing the crop geometry.

Agricultural intensification An increase in agricultural production per unit of inputs (which may be labor, land, time, fertilizer, seed, feed or cash).

Cropping system The cropping patterns used on a farm and their interaction with farm resources, other farm enterprises, and available technology.

Crown The canopy or top of a tree or other woody plant that carries its main branches and leaves at the top of
the stem.

Cultivation factor (R) Inverse of the land-use factor (L), which is the ratio of the sum of the length of cropping and fallow periods to that of the cropping period.

Cut-and-carry Fodder or other plant products, which are harvested and carried to a different location, usually to be fed to the animals in pens or sheds.

Cutting (plant) A piece of a branch or root cut from a living plant for propagating the plant; genetically identical to the original parent (a clone).

Decomposition (litter) The conversion of litter to soil humus.

Deforestation Human-induced conversion of forested land to non-forested land.

Degraded lands Land that has been seriously eroded or overgrazed, or is highly saline or alkaline.

Denitrification The biochemical reduction of nitrate or nitrite to gaseous nitrogen, either as molecular nitrogen or as an oxide of nitrogen.

Ecological resilience The capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.

Ecosystem services (ES) The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth.

Evaporation Loss of moisture from surfaces other than plants.

Evapotranspiration The combined loss of water from a given area during a specified period, by evaporation from the soil surface and by transpiration from plants.

Fallow Land resting from cropping, which may be grazed or left unused, often colonized by natural vegetation.

Farm enterprise An individual crop or animal production function within a farming system, which is the smallest unit for which resource-use and cost-return analyses are normally carried out.

Farm forestry Commercial tree planting on farmers' private lands as woodlots, shelterbelts, scattered trees, or
boundary rows.

Farming system All the elements of a farm which interact as a system, including people, crops, livestock, other vegetation, wildlife, the environment, and the social, economic, and ecological interactions between/among them.

Fodder Parts of plants that are eaten by domestic animals. These may include leaves, stems, fruit, pods, flowers, pollen, or nectar.

Fodder banks Designated, often enclosed, areas where fodder trees and shrubs – especially leguminous ones – are grown intensively for a steady supply of fodder, especially during the dry season.

Foliage The mass of leaves of a plant or tree, or leaves on the stems or branches on which they are growing.

Food security Food security exists "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (The World Food Summit, 1996).

Forage Vegetative material in a fresh, dried, or ensiled state which is fed to livestock (hay, pasture, silage).

Hedgerow intercropping Also known as alley cropping: an agroforestry practice in which perennial trees or shrubs are grown simultaneously with an arable crop. The trees, managed as hedgerows, are grown in wide rows and the crop is planted in the interspace or "alley" between the tree rows.

Homegarden Multispecies combinations of a variety of economically useful plants including trees, shrubs, vines, and herbaceous species in small landholdings around or adjacent to the home.

Intercropping Growing two or more crops in the same field at the same time in a mixture.

Isotope dilution technique An analytical technique used to determine the concentration of n element in a sample by means of a mass spectrometer.

Leaf area index (LAI) The ratio of leaf area (one surface only) of a plant to the ground area on which it grows.

Land equivalent ratio (LER) Ratio of the area needed under sole cropping to the area under intercropping, at the same management level, that is required to provide an equivalent yield.

Lopping Cutting one or more branches of a standing tree or shrub.

Mineralization The conversion of an element from an organic form to an inorganic state during microbial decomposition.

Mixed cropping Growing other perennials in the interspaces of perennial plantations.

Mixed farming Cropping systems which involve the raising of crops, animals, and/or trees.

Monoculture The repetitive growing of the same (sole) crop on the same land.

Mulch Plant or nonliving materials used to cover the soil surface with the object of protecting the soil from the impact of rainfall, controlling weeds or moisture loss and, in some cases, fertilizing the soil.

Multifunctionality The condition of being able to provide one or several functions in addition to its primary role.

Multipurpose trees Those trees and shrubs which are deliberately kept and managed for more than one preferred use, product, or service.

Multistoried Relating to a vertical arrangement of plants so that they form distinct layers, from the lower (usually herbaceous) layer to the uppermost tree canopy.

Multistrata systems Agroforestry systems composed of several strata of trees and tree crops.

N2 fixation potential (NFP) The highest N2-fixing ability of a given species when no limiting factors are present.

Net assimilation rate Net gain of (photosynthetic) assimilates, per unit of leaf area and time.

Nitrogen cycle The sequence of chemical and biological changes undergone by nitrogen as it moves from the atmosphere into water, soil, and living organisms, and is recycled upon death of the organism (plant/animal).

Nitrogen fixation The biological conversion of elemental nitrogen (N2) (continued) to organic combinations or

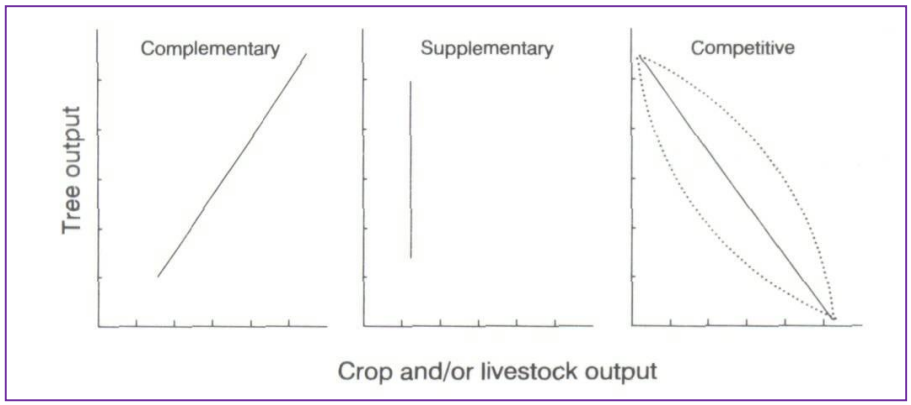
to forms readily utilized in biological processes.

Nutrient cycling Continuous, dynamic transfer of nutrients in the soil-plant system, such as a farmer's field. It involves the exchange and movement of these elements and inorganic compounds that are essential to life between living and non-living components of the biosphere.

Nutrient pumping Biological nutrient pumping refers to the tree-mediated transfer of nutrients from lower soil depths to surface layers.

Nutrient recovery The extent to which nutrients are taken up by the current (and subsequent) season's crop.

Component interactions refer to the influence of one component of a system on the performance of the other components as well as the system as a whole.

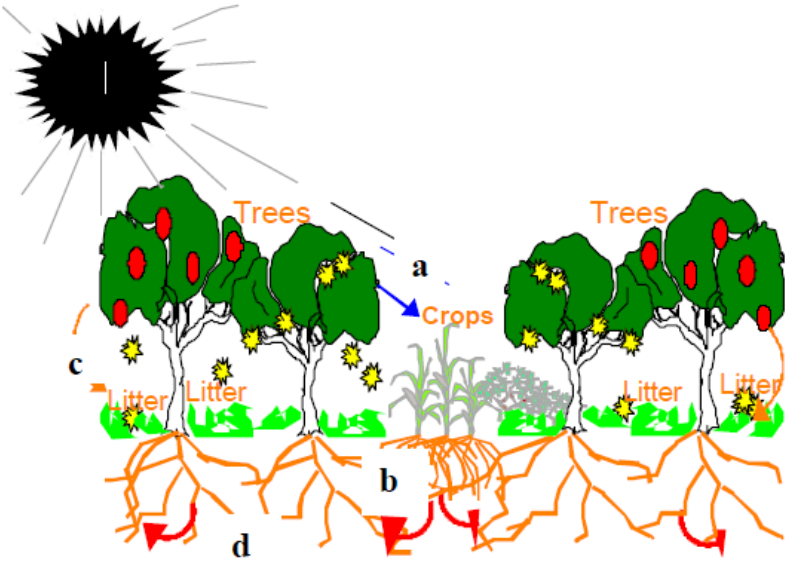


Nature of common types of biological interactions in agroforestry systems

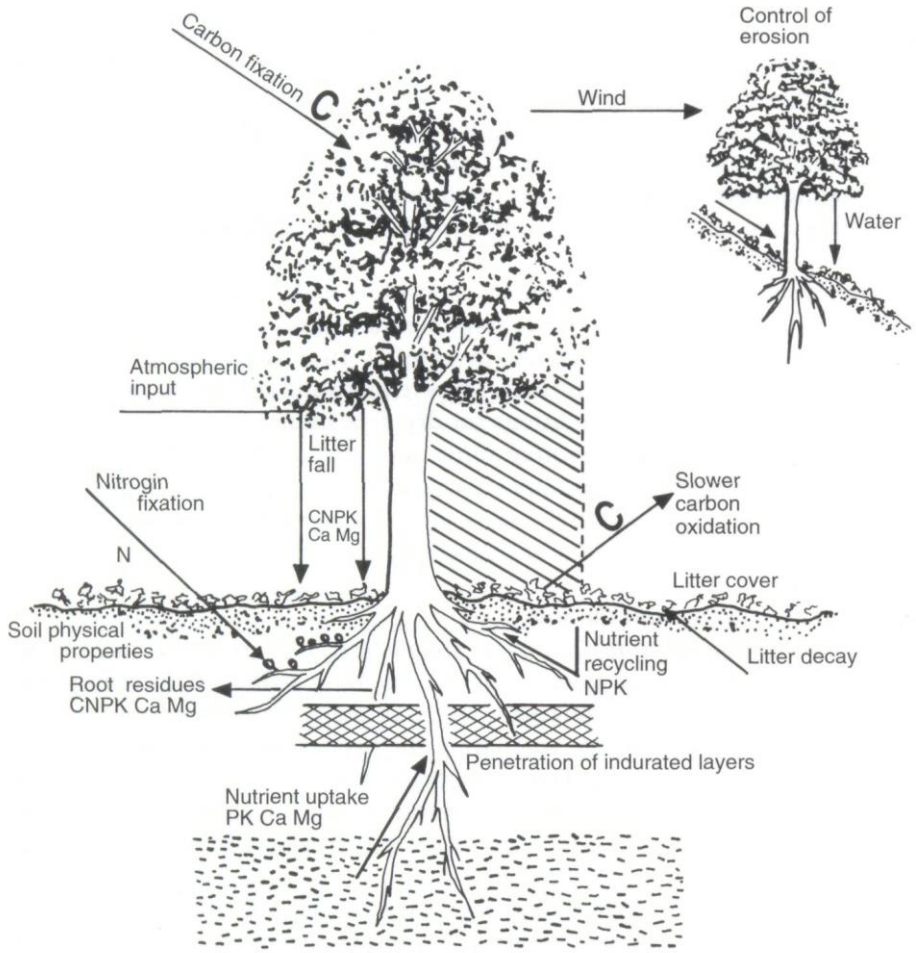
The major positive and negative effects at the tree-crop interface (TCI)

	At the TCI
Positive	- Shading trees (stress reduction) - Biomass contributions - Water conservation - Soil conservation
Negative	- Light competition - Nutrient competition - Water competition - Allelopathy

Interaction between trees and crops in a simultaneous agroforestry system (a = shading; b= competition for water and nutrient; c = litter fall of trees increases C, N, P and other nutrients; d = deep rooted trees play a role as a 'safety-net' for leached nutrient in the deeper layer)



Tree-soil -crop interactions



Analysis of interactions between two populations A and B (modified from Torquebiau, 1994). (0 : No significant interaction; + : Advantage for the population in question (growth, survival, reproduction etc.); - : disadvantage for the population in question)

Type of interaction	Effect of the interaction on the population		Nature of the interaction	Agroforestry example
	A	B		
Mutualism	+	+	Interaction favourable to the two populations	Mycorrhizae, Rhizobium - legume
Facilitation	+	0	Interaction favourable for A but not obligatory; B not affected	Windbreaks, shade trees Alley cropping (well managed)
Commensalism	+	0	Interaction obligatory for A; B not affected	Support trees for vines; Improved fallows
Neutralism	0	0	None of the populations affects the other in crop land	Scattered trees
Parasitism/predation	+	-	Interaction obligatory for A; B is inhibited	Pest and disease
Amensalism	-	0	A inhibited; B not affected	Allelopathy
Competition and interference	-	-	Each population is inhibited by the others use of (above- or below ground) growth resources	Alley cropping (poorly managed)

Quantification of tree-crop interaction

A simple equation is:

Equation 1: $$Y_{system} = Y_{tree} + Y_{crop} = Y_{tree} + Y_{crop,0} + F - C$$

With
Y_{system} = yield of tree + crop system
Y_{tree} = yield of tree products
Y_{crop} = yield of crop products
$Y_{crop,0}$ = crop yield in a monoculture on the same soil
F = Positive effects of trees on crop growth via soil fertility improvement
C = Negative effects via competition for light, water and nutrients.

A direct experimental separation of the terms in the equation is combined with quantification of key processes and followed by model synthesis to explore management options and system-site matching.

Y_c =	Y_0 +	F_l +	F_ω +	C_l +	C_{w+n} +	M
Crop yield in interaction	Crop yield in monoculture	Direct fertility effect	Long term fertility effect	Competition for light	Competition for water and nutrients	Micro-climate effects
1. Experimental method		Mulch transfer	Residual effect (tree removal vs. control)	Tree removal vs. control	Root barriers	
2. Process-level understanding		Litter quality, mineralisation rates	Functional soil organic matter fractions	Canopy shape, light profiles	Root architecture	
3. Synthesis model		W A N U L C A S				

How to set up experimental treatment to test tree-crop interactions?

Parameter	*Experimental treatment*
Shading	• Without canopy pruning • With canopy pruning
Competition of water and nutrient	• Without root barrier • With root barrier
Mulching	• Without mulch transfer • With mulch transfer
Long term residual effect	• Without tree removal • With removal of complete hedgerows
Total plot	8 sub plot per tree species

Suggested readings:

Book chapters

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Web site

http://www.icraf.cgiar.org/sea