TREE CROP INTERACTIONS IN AGROFORESTRY

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Concept

- ✓ Interactions literally mean influence or mutual or reciprocal action.

- ✓ Component interaction refers to the influence of one component of a system on the performance of other component.

- ✓ According to the definition of ICRAF, agroforestry systems are not simply a systems where trees and crops or animals give useful products to the farmers, but systems where tree and crop (and or animal) interact.

- ✓ In agroforestry systems trees are grows in close proximity to crops and pastures. Various interactions take place between the trees and herbaceous plants (crops or pastures) which is referred to as tree-crop interface.

- ✓ ICRAF researchers have developed an equation for quantifying tree-crop interaction (I), considering positive effects of tree and crop yield through soil fertility enrichment (F) and negative effects through competition (C) for growth resources between tree and crop. This equation also called Tree-Soil-Crop interaction. The simple form of this equation is $I = F - C$. If $F > C$, interaction is positive i.e., agroforestry system is beneficial or productive; if $F < C$ interaction is negative i.e., agroforestry system is harmful or not productive; and if $F = C$, interaction is neutral.

- ✓ Interaction takes place through the media of soil and microclimate and may exert favorable or adverse effect on the crop.

- ✓ In agroforestry systems, interaction between trees and crops and/or animals is the heart because of sharing the common resources by different species is the common phenomenon.

- ✓ Interaction helps to know

  - How the components of agroforestry utilize and share the resources of the environment, and

  - How the growth and development of any of the components will influence the others.

- ✓ Interaction occurs both above and below ground and includes a complex set of interactions relating to-

  - Radiation exchange

  - The water balance

  - Nutrient budget and cycling

  - Shelter and

  - Other microclimatic modifications.

Types of interactions

Interactions usually termed as complementary, supplementary and competitive.

- ▪ **Complementary**: When the interaction is *positive*, there is complementarity between the components.

- ▪ **Supplementary:** Complementary force = Competitive force

- ▪ **Competitive:** there is competition if interaction is *negative*
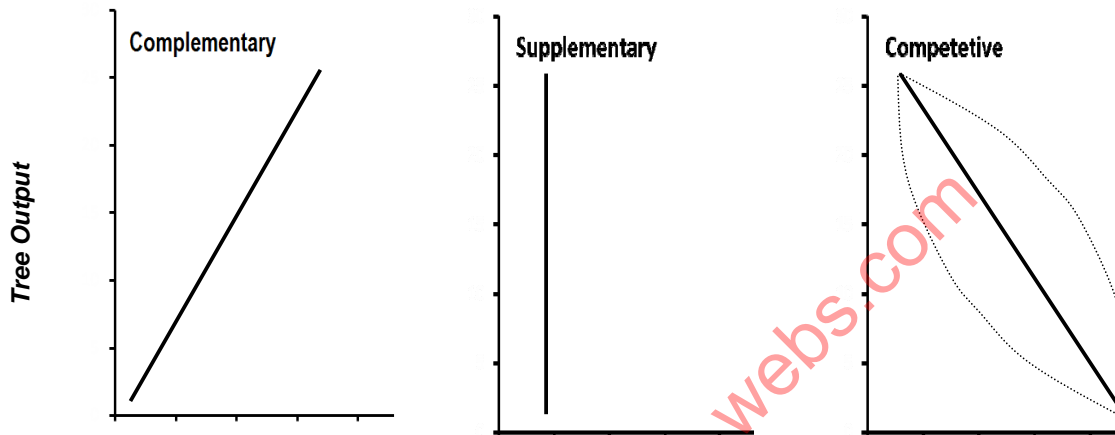
Crop and/or livestock output

Figure : Complementary, supplementary and competitive interactions between agroforestry components (Torquebiau, 1994)

Interactions based on components

Woody perennials (trees) are important of all agroforestry systems. Based on components, interactions types are as:

- A. Tree-Crop interactions or Tree- Crop interface (TCI)

- B. Tree- Animal interactions or Tree- Animal interface (TAI).

Interactions at Tree- Crop Interface (TCI)

- ▪ Positive or production enhancing or beneficial interactions.

- ▪ Negative or production decreasing or harmful interactions.

These positive or negative effects can be direct or indirect or both. Both positive and negative interactions may further divided into above and below ground interactions.

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                    ┌──────────────┐
                    │ Interactions │
                    └──────┬───────┘
              ┌────────────┴────────────┐
        ┌──────────┐              ┌──────────┐
        │ Positive │              │ Negative │
        └────┬─────┘              └────┬─────┘
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   ┌─────────┐ ┌─────────┐  ┌─────────┐ ┌─────────┐
   │ Above   │ │ Below   │  │ Above   │ │ Below   │
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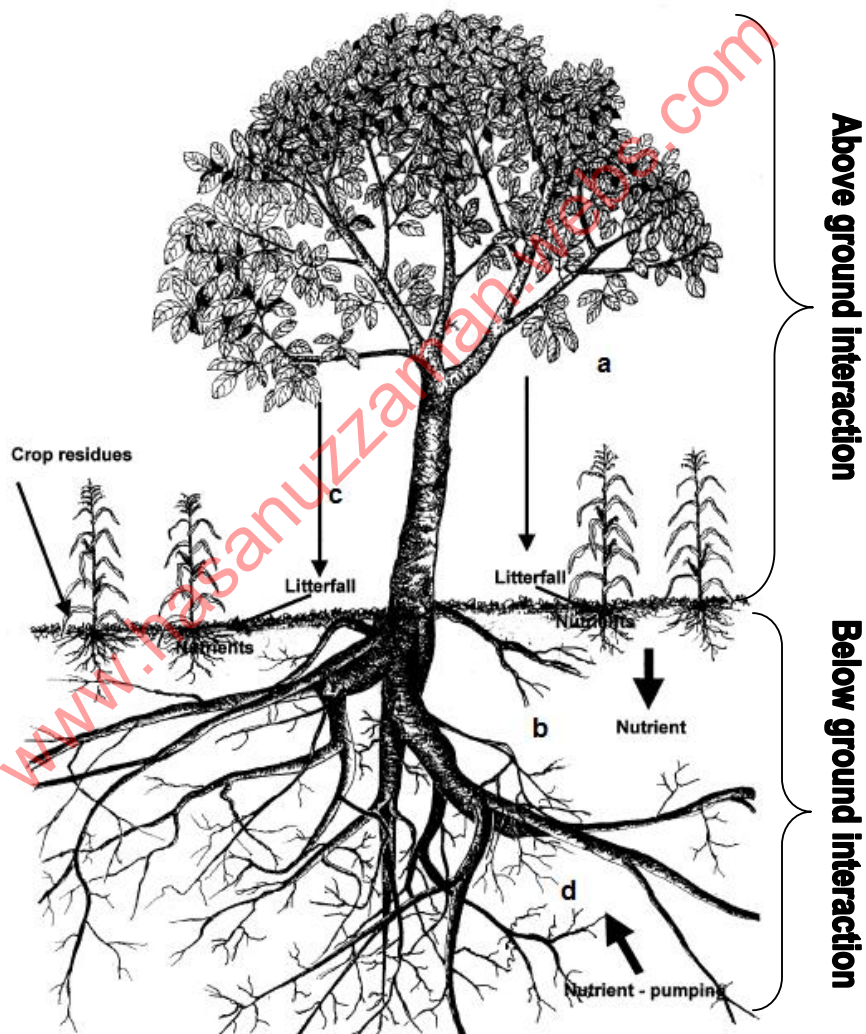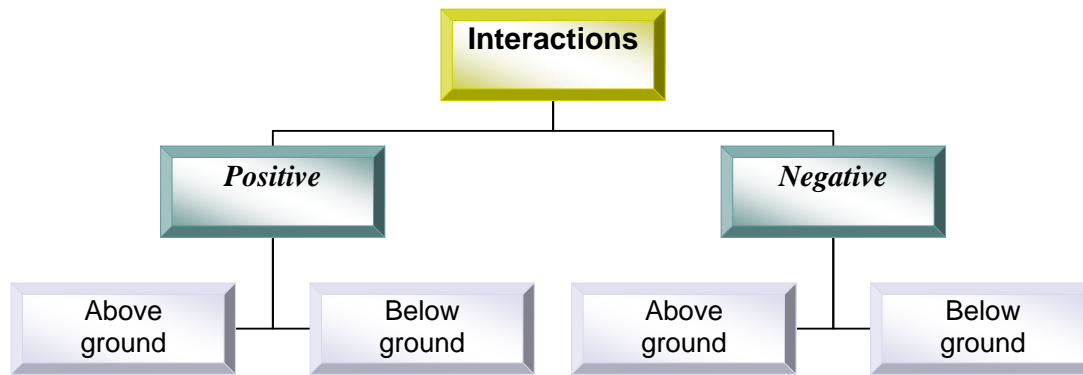**Above ground interaction**

Below ground interaction

Figure: 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 Crop Interaction in Agroforestry

Interactions at Tree-Animal Interface (TAI)

- Positive or production enhancing or beneficial interactions.
- Negative or production decreasing or harmful interactions

Possible interactions between two components at TCI

Gliessman (1986) and Vandermeer (1989) combindly proposed the following interactions between the two components (A and B) in an agroforestry system:

Table: Analysis of interactions between two populations A and B (modified from Torquebiau, 1994)

Types of interactions	Effect of the interaction on the population		Nature of the interactions	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 (aboveor below ground) growth resources	Alley cropping (poorly managed)

0 : No significant interaction;
+ : Advantage for the population in question (growth, survival, reproduction etc.);
 - : disadvantage for the population in question)

Possible interactions at TCI and TAI

Type	At Tree-Crop Interface (TCI)	At Tree-Animal Interface (TAI)
Positive	a) Shading trees (stress reduction) b) Efficiently use of light (PAR) or reduce waste of light resources c) Biomass contribution d) Microclimatic amelioration e) Balanced utilization of nutrients f) Efficient use of aerial space g) Water conservation h) Weed suppression i) Soil conservation	a) Shading b) Manure deposition
Negative	a) Light competition b) Nutrient competition c) Water competition d) Weed growth increasing e) Allelopathy	a) Phytotoxins b) Browsing damage c) Trampling d) Disease or pest host

Tree Crop Interaction in Agroforestry

Positive (Production enhancing) interactions

a. Shading trees (Stress reduction)

Shading causes reduction of temperature and temperature fluctuation causes as well as vapor pressure deficit (VPD). A reduction of VPD will cause a corresponding reduction in transpiration and thereby reduce water stress for the shaded crop, especially beneficial during short period of drought. e.g., cocoa, coffee, tea etc. Shading is beneficial concomitantly in this regard. Shade is always beneficial to livestock in silvipasture and agrosilvipastural systems.

Shading is always beneficial for shade loving crops like betel leaf, turmeric, zinger etc and shade tolerant crops like pineapple, some vegetables e.g., okra, Indian spinach, aroids etc.

It has been reported that the average maximum temperature 5.4^0c lower and the minimum temperature 1.5^0c higher in shaded versus open grown coffee plantations in Mexico.

b. Efficiently Use of light (PAR) or reduce waste of light resources

Light interception by **monoculture** never be achieved **100%**, where as in agroforestry system under storey crops can utilize these lights, that might be lost otherwise, even light can pass through the gaps of fully developed canopy or it is minimize by shoot pruning.

A **multilayered agroforestry system** efficiently utilizes light (PAR) or reduces waste of light by using light in different layers.

c. Biomass contribution

Biomass can add by pruning materials, leaf litters, and root residues etc. which add nitrogen, organic matter, improve soil condition and thereby increase the productivity.

d. Microclimate amelioration

Change of microclimate which is favorable for agroforestry components (tree, crop, animal etc.) e.g.

- Increasing soil moisture
- Reducing soil temperature
- Augment organic matter and nutrients through litter and root decomposition
- Trapping and recycling of nutrients from deeper zone etc.

e. Balanced utilization of nutrient

- Crop utilized nutrient from upper 6 inch which is continuously enriched by litter fall and pruning materials and root residues decomposition.
- Bringing up nutrients released by weathering in lower soil horizons.
- Trapping and recycling of nutrients that would otherwise have been lost by leaching.

Tree Crop Interaction in Agroforestry
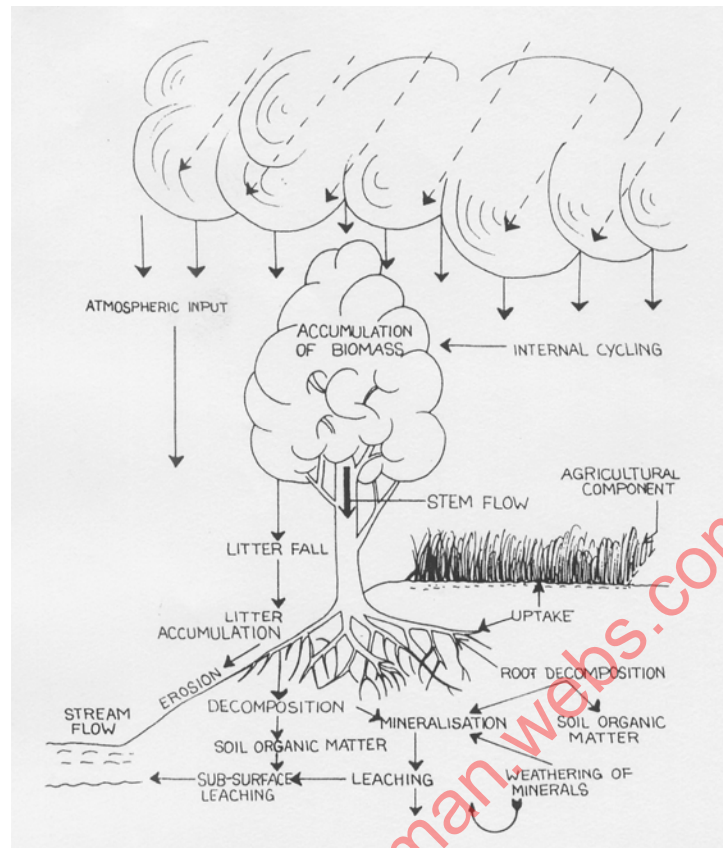
Fig. Nutrient recycling in Agroforestry System

f. Efficient utilization of aerial space

Tree crop association ensures optimal utilization of aerial space both horizontally and vertically. e.g. Mixed dense, Mixed sparse, Homestead agroforestry etc.

g. Water conservation

Reducing transpiration, pumping water from the deep soil which makes the surface soil moistened.

h. Weed suppression

Effect of shade is more severe for light demanding weeds. e.g. in alley cropping system *Cassia siamea* reduce weed infestation.

i. Soil conservation:

Trees alone do not normally protect soil against erosion. Closely planted shrub hedges can do so. In agroforestry systems appropriate tree crop association control soil erosion efficiently, e.g. SALT models, Hedge row barrier (alley cropping).Wind-breaks directly serve to control wind erosion.

Negative (production reducing) interactions

a. Light competition

Light is very important resource for production because it is the energy source for photosynthesis and transpiration. Growth and development of pants largely depends on photosynthesis. In agroforestry systems, light availability is the most important limitation to the performance of under storey annual crops when it is associated with densely planted unprunned MPTs. Under such situation photosynthetic rate in understory crops decrease with the reduction of light intensity.

b. Nutrient competition

In agroforestry systems, as both the components are taking nutrients from a limited nutrient pool in the soil, competition is likely to occur. Since tree species may have lateral roots in the surface soil and thereby could compete with crops for nutrients.

c. Water competition

Like nutrient, agroforestry systems also compete for water. Trees in agroforestry systems tended to compete with crops for moisture thereby depress crop production. According to some studies, moisture competition was the principal cause for reduced crop yields at the tree-crop interface.

d. Weed growth increasing

In tee-crop association shade cast by the upperstorey perennial sometimes encourage the growth of some weeds which affect crop growth.

e. Allelopathy

The phenomenon of one plant having detrimental effect on another through the production and exertion of toxic chemical compounds is called allelopathy. Allelopathy is the indirect harmful effect through exertion of chemical substances. Allelopathic substance was first detected by Davis (1928) in black walnut tree (*Juglans nigra*) whose foliar leachate containing Juglone was found to damage germination and seedling growth of crops beneath the tree.

Several phytotoxic substances termed as allelochemicals are generally present in plants (leaves, stems, roots, rhizomes, fruits, seeds etc.) and released in environment and rhizosphere under appropriate conditions to affect neighboring plants. These chemicals interfere with metabolic pathways of plants growing in the vicinity causing suppression of growth.

Tree species	Annual crops whose growth is inhibited
Alnus nepalensis	Soybean
Casuarina equisetifolia	Cowpea, sorghum, sunflower
Eucalyptus spp.	Cowpea, sorghum, sunflower, potato
Gliricidia sepium	Maize, rice
Leucaena leucoceplala	Maize, rice, cowpea, sorghum, sunflower

Tree Crop Interaction in Agroforestry

How to quantify tree-crop interactions?

The success of any intercropping depends on the balance of *positive* and *negative* interactions between the components.

A simple equation is:

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

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.

The question whether or not agroforestry has any advantage over separate crop fields and woodlots, can now be rephrased as:

Positive interaction, if $F > C$

Negative interaction, if $F < C$

Management option in competitive tree-crop interface

Management options to achieve	
(1) Increased Growth	*(2) Decreased Growth*
- Microclimate amelioration - Fertilization - Application of mulch/manure - Irrigation - Soil tillage - Adapted species - Supplemental feeding	- Pruning - Pollarding - Trenching - Excessive shading - Herbicides - Grazing/browsing
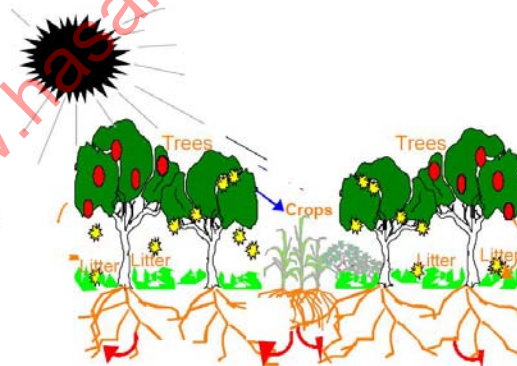
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