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Tree Crop Interactions in Agroforestry

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INTRODUCTION:

Agroforestry had its origin in developing nation with limited land resources. Looking into the current scenario, it is not possible to divert the fertile agriculture land to forests in view of prevailing socio–economic & agro–climatic conditions favourable for agriculture. By integrating tree species with agricultural crop, agroforestry practices is the only way to expand the area covered by trees. The incorporation of trees offers various soil-related ecological services, including improvements in soil fertility and enhancements in physical, biological and chemical properties fostering plant development. Additionally, it provides multiple benefits like production of food, wood and fodder.

In agroforestry system, various interactions take place between trees and crops, which are referred to as the tree-crop interface. Interactions help 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 component will influence the others (Toppo and Toppo, 2018). The interactions between tree and crops influence their growth, yield and overall ecosystem functioning through complex physical and biological processes. These interactions mainly revolve around the sharing and competition for natural key resources such as sunlight, water and nutrients. Trees can alter the amount of sunlight available to crops by creating shade, which can have both positive and negative effect on crops. Shade from the trees helps to protect crops from heat stress, retain soil moisture, and improve the microclimate for plant growth in hot and dry areas. On the other hand, too much shade may restrict photosynthesis, which is necessary for agricultural productivity, especially for species that require sunshine. Water competition is

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also an important factor as tree root penetrate deeper into the soil profile than crop roots. This allows trees to access water from the deeper layers and reduce competition during dry period. The main benefits of interactions are increased production, better soil fertility, nutrient cycling, and soil conservation whereas competition for light, space, nutrients, and moisture is the primary adverse consequences of the relationship, which significantly lower crop growth and yield. Besides these factors, crop productivity in agroforestry is also governed by allelopathy that play a critical role in determining the success of tree-crop associations (Blanco, 2007). Allelopathy can be defined as an interference in which allelochemicals (beneficial or harmful) produced by one organism affect the physiological processes of other surrounding organisms. Allelochemicals are secondary metabolities that are produced by plants and release secondary metabolities or allelochemicals into the environment in several ways such as volatilization, root exudation, leaching and decomposition of plant residues (Koocheki *et al*., 2013). Allelopathy is a form of amensalism in which one taxon is inhibited or destroyed whilst the other is unaffected through special metabolites triggered into the environment (Scavo *et al*., 2018). The biochemical and eco-physiological interaction, executed by allelochemicals is common both in nature and in agroecosystems.

In agroforestry, tree crop interaction plays an important factor that defines the productivity and sustainability of these system. By incorporating the trees and agricultural crop in agroforestry promotes climate resilience, support ecosystem services, and improves resources use efficiency. While the interaction between trees and crops can be complex so by careful planning and management this ensures that the benefits outweigh the challenges.

Tree Crop Interaction:

Interaction is defined as the effect of one component of a system on the performance of another component or the overall system (Nair.,1993). Studying about interaction helps us to know about the component 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. Regarding this, 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 crop competition(C) for growth resources between tree and crop I=F-

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C. If F> C, interaction is positive, if F< C interaction is negative and if F=C interaction is neutral.

Nature of Interaction:

Complementary: If increase in one result in increase in the other
Example: Nitrogen fixing trees

Supplementary: If increase in one does not decrease or increase the other
Example: Silvopasture system (tree with grazing animals

Competitive: If increase in one result in decrease in the other
Example: Shade intolerant crops under densely spaced trees

Possible Interaction between two components at Tree Crop Interaction:

Types of Interaction	**Effect of the interaction on the population**		**Nature of the interaction**	**Agroforestry examples**
	A	**B**		
Mutualism	+	+	Interaction favourable to the two population	*Mycorrhizaee, Rhizobum*-legume
Commensalism	+	0	Interaction obligatory for A; B not affected	Support trees for vines; Improved fallow
Neutralism	0	0	None of the population affects the other in crop land	Scattered trees
Parasitism/ predation	+	-	Interaction obligatory for A ; B is inhibited	Pest and disease
Ammensalism	-	0	A inhibited; B not affected	Allelopathy

Competition and interference	-	-	Each population is inhibited by the other use of (above or below ground) growth resources	Alley cropping (poorly managed)

Positive interaction:

Positive tree-crop interactions in agroforestry systems are advantageous partnerships between crops and trees that improve the farming system's resilience, sustainability, and productivity. Ecological processes give rise to these interactions, in which crops and trees enhance rather than rival one another. Some important examples are:

1. **Carbon Sequestration and Climate Regulation**

Trees sequester carbon, helping mitigate climate change while contributing to sustainable farming practices.

2. **Nutrient cycling and Soil fertility:**

Leucaena leucocephala and *Gliricidia sepium* are examples of Leguminous trees that fix nitrogen from the atmosphere, improving crop soil.

Contribution of Organic Matter: As tree pruning and leaf litter break down, they release nutrients and organic matter into the soil, enhancing its fertility and structure. Deep Nutrient Access: Trees with deep roots can retrieve nutrients from subsurface strata that crops with shallow roots cannot access. They then return these nutrients to the surface through litterfall.

3. **Microclimate Regulation:**

Trees offer partial shade, which improves water use efficiency and lessens heat stress on crops that can withstand it. Trees serve as windbreaks, lowering evapotranspiration, crop damage, and wind erosion.

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Temperature Moderation: By reducing temperature swings, the canopy improves growing conditions for crops.

4. **Increased Biodiversity:**

Increased biodiversity in tree crop interaction improves ecological balance and system resilience by naturally increasing crop yields also trees offer habitat for pollinators and pest predators. Higher biodiversity supports pollinators and other beneficial organisms that improve crop productivity.

5. **Economic Benefits**

Diversified Income: Trees provide products like fruits, nuts, timber, fodder, and medicinal plants, offering additional income sources.

Risk Reduction: By integrating trees and crops, farmers reduce the risk of complete crop failure due to pests, diseases, or climate extremes.

Negative Interaction:

1. **Above ground competition:**

The primary aboveground competition between trees and companion crops is for sun radiation. One of the key limitations is low light intensity for higher yield. Dhillion *et al*., 2005 concluded that the causes of reduction in growth and yield losses due to *Eucalpytus* tree plantation was due to direct competition for moisture, light and nutrients from the nearby rows of pear trees.

2. **Below -ground competition:**

In the top soil, tree roots may compete with annual crops for available nutrients and water. The fight between underground roots for nutrients, moisture, and space is relatively more significant in agroforestry systems than above-ground crown competition. Because light is comparatively more abundant than nutrients and moisture. It is necessary to have information on the nature of root development in two types of crop plants. Dadhwal and Tomar 2005 found tree root pruning was very helpful in enhancing crop yields in marginal and degraded lands of north-western Himalaya of Uttaranchal thus indicating reducing in the root competition.

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3. Allelopathy:

Allelopathy was coined by the Hans Molisch in his book "*The Influence of One Plant on Another: Allelopathy"*. The phenomenon of one plant having detrimental effect on another through the production and exertion of toxic chemical compounds is called 'allelopathy'. Allelopathy substance was first detected by Davis in black walnut (*Juglans regia*) whose foliar leachate containing Juglone was found to damage germination and seedling growth of crops beneath the tree.

Conclusion:

Tree-crop interactions in agroforestry systems plays a vital role in creating sustainable and resilient agricultural landscapes. These systems enhance soil fertility through nutrient cycling, improve water management, and provide beneficial habitat for organisms, thereby increasing biodiversity and ecological balance. The integration of trees with crops also helps to mitigate climate change by sequestering carbon, while offering diversified income opportunities for farmers through the production of timber, fruits, fodder, and other resources. Agroforestry systems can optimize beneficial interactions through careful species selection and management, guaranteeing long-term productivity for farming communities, economic gains, and environmental sustainability.