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Tree - Crop - Soil interaction in Agroforestry system

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Abstract

Agroforestry is one of the sustainable approaches to land use management where both agriculture and forestry combine into an integrated production system to get maximum benefits. Improvement in soil fertility under agroforestry systems occurs mainly through addition of plant biomass. However, in certain situations trees may have an adverse effect on soils. The magnitude of benefits or adverse effects depends on a number of site-specific factors and attributes of associated tree species. In simultaneous agroforestry systems, trees and food crops interact in many ways, leading to positive and negative impacts on the growth of both tree and crop. The balance between negative and positive interactions determines the overall effect of interactions in a given agroforestry system and helps in doubling the farmers income.

Introduction:

Agroforestry is an ideal scientific approach for Eco restoration of degraded lands and sustainable resource management. The importance of tree-based land use systems in restoring soil fertility and improving the economy of farmers having small land holdings has been realized during the last 2 decades. Improvement in soil fertility under agroforestry systems occurs mainly through addition of plant biomass. However, in certain situations trees may have an adverse effect on soils. The magnitude of benefits or adverse effects depends on a number of site-specific factors and attributes of associated tree species. The fertility of soil improves under the tree cover, which checks soil erosion, adds soil organic matter, available nutrients and replenishes the nutrients through effective recycling mechanisms. The pressure on the agricultural lands has increased manifolds due to overpopulation, urbanization and industrialization process. These factors have not only affected the agricultural production but the environmental conditions have also got degraded (Nair, 1984).

Agroforestry is one of the sustainable approaches to land use management where both agriculture and forestry combine into an integrated production system to get maximum benefits. In agroforestry systems trees can share space and time (simultaneous systems), or crop and tree phases can be sequential (fallow systems). In simultaneous agroforestry systems, trees and food crops interact in many ways, leading to positive and negative impacts on the growth of both tree and crop. Interactions can be positive, neutral or negative. When the interaction is positive, there is complementarity between the components, while there is competition, interaction is negative. Positive interaction includes shading trees (stress reduction), efficient use of light (PAR), biomass contribution, microclimatic amelioration, balanced utilization of nutrients, and efficient use of aerial space, water conservation, weed suppression and soil conservation. Negative interaction includes shading, root competition, alternate host to pests and diseases, weed growth increasing, and allelopathy effect *etc*. The agro-forestry has both productive and protective potential and it can play an important role in enhancing the productivity of the lands to meet the demand of ever-growing human and livestock population.

Positive effects:

Improvement of soil fertility: Incorporation of trees in the croplands can help in maintaining the nutrient pool and enhance soil fertility both under sequential and simultaneous agroforestry. Tree litter and pruning's improve soil fertility not only through the release of nutrients in the soil by mineralization but by also adding soil organic matter.

Microclimate: The interaction between trees and crops is the improvement of microclimate through modification of temperature to reduce heat stress and evapotranspiration,

Maintaining water quality: Agroforestry can also help in improving water quality by reducing levels of pollution and soil erosion. Agroforestry also improves water-use efficiency and increases environmental sustainability.

Negative effects:

Shading effect: Shading by agroforestry trees generally has negative effects on crop productivity. The physiological mechanism by which shading affects crop productivity could be the interception of photosynthetically active radiations (PAR) and thus the quantity and quality of light reaching crops.

Resource competition: Competition for essential growth substances including water and nutrients is one of the most severe negative effects that trees can have on crops.

Allelopathy: Allelopathy is another negative interaction between trees and crops that operates under SAFS. It mediates through the release of chemicals by one plant into the surrounding environment and retards or suppresses the growth of other plants. (Noordwijk and Hairiah, 2000)

Types of interactions

a) Complementary: when the interaction is positive, there is complementarity between the components.

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b) Supplementary: Complementary force = Competitive force

c) Competitive: if interaction is negative, competition is seen instead of complementarity

Table 1. Some important pests and diseases that are shared by taxonomically unrelated crop and tree species

Pest or disease	Affected crop species	Affected tree species
Insects: *Helopeltis clavifer*	Cocoa (*Theobroma cacao*)	*Flemingia candida, Eucalyptus deglupta*
Planococcus citri	Coffee, cocoa, Citrus	*Leucaena leucocephala, Erythrina, Tephrosia*
Scirto thrips	Orange (*Citrus sinensis*)	*Grevillea robusta*
Viruses Cucumber mosaic virus (vectors: aphids)	> 200 crop species from 40 families	Many legumes, e.g. *Robinia pseudoacacia, Sesbania exaltata*
Fungi:*Phythophthora cinnamomi* (root rot)	> 1000 species e.g. avocadopineapple,peach, macadamia	*Eucalyptus* spp, *Pinus* spp.
Pellicularia koleroga	Coffee, mango, orange	*Acacia mangium*
Soil borne fungi, Armillaria,Fomes,Ganodem Rosellinia, Verticillium	Many cultivated and wild tree species	Many cultivated and wild tree species
Nematodes *Radopholus similis*	Banana,maize,sorgham, cowpea, pegeon pea, groundnut, tomato, egg plant	*Podocarpus macrophyllus Cupressus* spp. *Sesbania* spp. bamboos

Schroth *et al*., (2000)

Table: 2. Important Nitrogen fixing tree species

Species	Age (years)	Rate of N fixation (kg ha^{-1} $year^{-1}$)
Acacia angustifolia	2	61
Acacia magnium	2.5	66
Acacia senegal	4	7-12
Albizia lebbeck	1	60-120
Calliandra calothyrsus	2	67-93
Casuarina equisetifolia	2	82-94
Gliricidia sepium	1.3	700
Inga edulis	1-2	100
Leucaena leucocephala	-	934
Prosopis glandulosa	1	40
Senna siamea	1-4	119

Nair *et al*., (2021)

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Table: 3. Allelopathic activity of some agroforestry species

Agroforestry species	Target spp.	Plant parts/ allelochemicals
Azadirachta indica	rice, wheat, *Zea mays*	Leaf extracts, wood and leaf litter leachates
Leucaena leucocephala	*Lactuca sativa* (leafy vegetables), rice, Sorghum	Aqueousleachat extracts of leaves/litter/dry leaf mulch(mimmosine)
Melia azedirachta	*Lepidium sativum* (mustard)	Leaf leachate
Populus deltoides	wheat	Soil, leachate
Tamarindus indica	*Amaranthus spinosus*	Ethanolic extracts of leaves and seeds
Eucalyptus globulus	*Cucumis sativus, Phaseolus aureuslactuca sativa*	Leaf extract and leachate , soil percolate
Gmelina arborea	*Zea mays*	Leaf
Moringa oleifera	Rice, black gram	leaves

Rizvi *et al*., (1999)

Conclusion

Agroforestry has a great scope and potential in terms of social, economic, and environmental services. The balance between negative and positive interactions determines the overall effect of interactions in a given agroforestry system and helps in doubling the farmers income. Agroforestry has a great potential to improve the lives of people within a reasonably short time, particularly in developing countries. Need to develop agroforestry as an ecologically sustainable land-use system that involves interplay between various positive and negative interactions leading to human development, conservation, management and utilization of natural resources in an efficient manner.

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