Merits and Demerits of Tree Crop Combinations

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Introduction

A proverb in India says, "Farming without tree culture is incomplete". There has been a practice of growing one or the other tree species with agricultural crop for multipurpose uses. Farmers from time immemorial are in the habit of planting various economic tree species on the field bunds, corners of field or sporadically or zonally or sequentially for fuel, fodder, fruits, fertilizers (manure), finance and timber. A rigorous selection has been imposed by the farmers in the past as regards to their suitability in respect of supplementary / complimentary efforts or competitive nature. The goal was to realies higher economic returns from these combinations. Along with tree-crop combinations some drought tolerant grass species were also introduced with an objective of arresting soil loss, enhancing soil moisture and to harvest fodder for the cattle. In olden days each village had its own Gauthana (grazing area) which is fast disappearing and pressure is being built (on forest areas as cattle graze in the forest. As a result, forests are getting degraded and the ecosystem is being disturbed coupled with this kind interference, man in his zest to cultivate more and more area to produce required food, fodder, fuel etc. is causing further degradation. The increased and continuous deforestation has resulted in serious scarcity of fuel for the rural households. Consequently village women have to trek long distances under harsh conditions for final collection. All most half to three fourth day is spent by human in the collection of fuel every day. It is sheer waste of human resources.

Concomitantly the practices of burning crop residues and other organic wastes are increasing to meet out the daily needs of fuel for cooking, heating water and other purposes. This has resulted in the non-availability of organic matter to cultivable land considering the various faces of the problems, therefore, and absolute need to incorporate one or other tree species along with cultivated crops, which may help to meet the human, animal and land needs.

Possible Tree, Crop combinations

Over a period of time, the farming community are identified a number of economic tree species which have a complimentary effects on field crop and similarly there are examples of trees suited for planting on field bunds and in the non-accessible areas such evidences are found in various states of India. Eg. Cultivation of *Prosopis cineraria* in Rajasthan and in black soils of Maharashtra and Karnataka. This tree species is considered as a holy plant and being worshipped and also an indicator of the soil fertility status. This is kind of growing economic trees zonally or sequentially is termed as "Agro-forestry". Agro-forestry is a collective word for land use systems and practice in which woody perennials are deliberately mixed on the same piece of land with crops and/or animals. In recent past there system is proving to be an important alternative land use system in the face of increasing population, poverty, land and environmental degradations.

System approach in Agro-forestry

From the foregoing paragraph it is clear that Agro-forestry provides an insurance cover to the farming system. Even in the worst possible years of drought, the tree species grow and yield the economic returns. The various agroforestry systems differ from state to state under based on land capability classes.

Agro-climatic conditions and the possible systems are indicated below.

i) Random planting of economic trees
ii) Hedge row planting to commonly cultivated crops
iii) Coverage on the field bunds
iv) Planting to serve as shelter belt and wind breaks
v) Planting in gullies for control measures.
vi) Block plantation
vii) Offshore plantation
viii) Multipurpose system
ix) Planting in the irrigation channels, roadside under social forestry system.

In the words of alternative land system, the above approaches could be grouped into following agroforestry system.

a) Agri-silvi system
b) Agri-Horti system
c) Agri-Pastoral system
d) Agri-Silvi pastoral system
e) Agri- Silvi- Horti. System
f) Agri –Horti- pastural system
g) Agri –Horti- silvi- pastoral system

These above combinations may be with or without animal component and agricultural crops are the major component. Alternatively if a system emphasizes on fodder, fuel etc. these became the major component and the field crops are subsidiary components. A list of suitable agro system in different phase of the country is indicated in Table 1.

Table-1 Trees in Agrosilviculture

Zone		Tree species
Himalayas	Existing	Alnus nepalensis (Alder)
		Grewia optiva (Bhimal)
		Parkia roxburghii
		Prunus Persica
		Morus arba
		Poplar
		Salix alba
	Recent	Robinia pseudoacacia (Robinia)
		Acacia auriculiformis

	Upcoming	Pawlonia Sp. Populus deltoids (Poplar)
Indo-Gangetic	Existing	Acacia nilotica Albizia lebbeck Butea grandosa Anogcissus latifolia Azadirachta indica Cordia myxa Dalbergia sissoo Madhuca latifolia Terminalia arjuna Tarmarind Syzygium cumini (Jamun)
	Recent	Populus deltoides (Popular) Leucaena leucocephala Eucalyptus
	Upcoming	Paulonia
Humid & Sub humid	Existing	Pongamia pinnata, Mangifera indica Psidium guajava (Amrud)
	Recent (Sub-humid)	Acacia auriculiformis Leucaena leucocephala
	Upcoming	Edible bamboo
Arid & semiarid	Existing	Prosopis cinereria Ailanthus excelsa Lawsonia inermis (Mehandi) Madhuca indica Hardwickia binata (Anjan) A. lebbeck (Siris) Acacia nilotica (Babul) Prosopis juliflora
	Recent	Acacia tereticornis (Israel babool) Eucalyptus Acacia albida Leucaena leucocephala
	Upcoming	Pawlonia sps.

Cold Arid	Existing	Juriperus macropoders Hippophone rhamnoides (seabuck thorn) Ephidra geradiana Hyoscyarurs niger Capparis spinosa Rosa arbhiana Rheum mooncorfiaun
	Recent	Poplar Willow

Tree species for Agricultural fields and field boundaries

Table 2 Provides a series of trees suited for agriculture field and field boundaries for the different conditions in India.

Table 2: Agro-silviculture System

System	Location	Tree (s)
Trees in Agriculture Fields	Arid Rajasthan	Prospects cineraria (Khejri)
	J&K; HP; NW,UP	Grewia optiva (Bhindi) Celtis austilis Morus serrata
	Arid tracts of Punjab, Haryana & Rajasthan, Tamil Nadu	Acacia nilotica A. Leurcophloa A. planiforus Borasus flabellifera
	South India	Tamarind indica Custard apple
Trees on-farm Boundaries	All over	Eucalyptus SP Leucaena leucocephala Prosopis juliflora Palmyrah
	J&K, HP	Willow Populus deltoides (Poplar) Bambusa arundinacea
	NW India Coastal belt	Poplar, Eucalyptus Casurina equisetifolia

Similarly, combination of horticulture species with trees is presented in Table-3.

Table 3: Silviculture systems

System	Location	Tree(s)
Plantation crops Under shade trees	(i) Tea-NE India	Albizia Sp
		Acacia lenticularis
		Deris robusta
		Dalbergia sissoo
	South India	Grevillea robusta
	(ii) Coffee S. India	Temporary shade
		Erythrina lithosperma
		Permanent shade
		Ficus gromerata
		Albizia spp
	(iii) Papper S.India	Erythrina Indica
		Garuga pinnata
		Spondica mangifera
	(iv) Betel vine coastal	Sesbenia spp
Agril. Crops with Commercial trees	I) Coconut	Cassiva
		Elephant foot
		Greater yam
	ii) Arecanut	Banana
		Cocoa
		Black pepper
		Pine apple
		Betle vine
		Cassava
		Elephant foot yam
		Paddy
		Sorghum, Turmeric
		Ginger
	ii) Mango	Rainy seasons vegetables
		Winter vegetables
		Grain legumes
	iv) Orange	Monsoon-Green Manure crop
		Post Monsoon – Vegetables
		Grain legumes
	v) Apple	Grasses & grain legumes
	vi) Poplar	Soybean, Maize, Grain legumes
		Mustard, Wheat, Potato

4. Postoral- silvi system

This kind of alternate land use system consists of grazing grasses, with tree component and may differ on the basis of agro-climatic regions such examples are indicated in table 4.

Table 4: The pastoral- silvi systems that would sustain based on rainfall.

Rainfall (mm)	Grass component	Tree-component
150-250	Lasiurus sindica	Prosopis juliflora, Caligonum polynoids, ziziphus nummularia, Salvadora olcoides, S. persica
250-400	Cenchrus ciliaris Panicum antidotale	Acacia senegal Prosopis juliflora
	Lasirsus sindicus	P. cineraria, Tecomella, Calligonum polygonoids
	Cenchurs ciliaris C. setigerus Panicum Dicanthium	Prosopis cineraria Acacia senegal Acacia nilotica Tecomilla undulata
	Sehima nervosum	Ailanthus excelsa, Albizia lebbeck

Alley cropping

Food crops are grown in alleys formed by hedgerow or by the shrubs in arable lands. It also known as hedgerow intercropping. These hedgerows are pruned at certain height, preferably at 30-.45 cm from the ground level as frequently as possible so that these hedgerows do not shade the companion crop and also do not compete with arable crops. The leaf material harvested from the hedgerows is either utilized as a fodder for the mulch animals or as a mulch material between the crop rows in seeder to check the soil moisture evaporation.

Advantages

1. Provides green fodder even during the lean period of the year
2. Yields high total biomass production pee unit area than arable crops alone.
3. Efficient use of off-season precipitation in the absence of arable crops.
4. Creates additional employment opportunities during off season and
5. Serves as a barricade to surface runoff, resulting in soil and water conservation

Based on the objectives, there are three types of alley cropping:

A) Forage- Alley cropping: eg. Leucaena or gliricidia based
B) Forage-cum-Mulch system; eg. Leucaena / gliricidia
C) Forage- cum -Pole system: eg. Leucaena / agave

In very shallow soils where arable cropping is not possible, system of growing Subabul for timber purpose and agave for fibre as resulted in better economic returns compared to sole arable crop. This system is called as TIM – FIB System.

Multi purpose tree species for social forestry

Trees are not common and uniform for the entire country. The adaptation of trees where is based on agro-ecological conditions and also the purpose for which they are grown. The multipurpose trees have considerable usages such as fodder, fuel, finance, fruits, timber, gum, medicine and manure. The leaf litter falling on the ground adds large quantity of organic matter, which gets connected into humus after decomposition, which alternately helps to build the organic content of the soils. The trees are also used as natural drains to ameliorate the water logged soils eg. Eucalyptus has the capacity of draining considerable amount of water which acts as natural drainage.

7) Potential benefits of trees on soils

Trees help to improve the soils through various processes. They provide huge biomass, atmospheric nitrogen, protect against water and wind erosions, addition of plant nutrient enriches the soil improves the physical soil conditions and also biological activities. The Table 5 provides the most potential beneficial efforts of trees in soils.

Table-5: Potential beneficial efforts of trees on soils

Nature of processes	Processes	Main effect on soil
Input Processes (augment additions to the soil)	Biomass production	Addition of web on and its transformation
Output process (reduce losses from soils)	Protection against water and wind erosion	Reduce loss of soil as well as nutrients
Improvement processes	Nutrient retrieval/ cycling / release surface via litter	Uptake from deeper layers and "deposition" on withholding nutrients that can be lost by leaching. Timing of nutrient release. This can be regulated by management interventions.

Catalytic processes	Physical processes (indirect influences)	Improvement of physical properties (water holding capacity permeability drainage etc) at the microsite as well as at watershed (macrosite)
	Root growth and Proliferation enhanced.	Addition of (more) root biomass, growth promising substance; Microbial associations.
	Litter quality and Dynamics; plant species; better timing of quantity and micro-climatic processes	Improvement of litter quality through diversity of method of application of litter possible
		creation of more favorable microclimate processes, shelter belt and windbreak effect, moderating effect on extreme conditions soil acidity, alkalinity, water logging etc.

Table-6: Microbial population (surface soil) under MPTS in arid sandy soil.

Species	Number of dry soil			
	Bacteria ($x10^5$)	Fungi ($x\ 10^3$)	Actinomycetes ($x\ 10^5$)	Bacteria (MPN)
P. cineraria	32	29	16	1.430
A. lebbeck	22	18	11	1.630
T. undulata	25	20	12	1.430
P. juliflora	20	16	10	1.030
Open field (without trees)	15	10	7	450
* most probable numbers				

Adverse effect of trees on crops

Dryland farmers are reluctant to grow trees in cultivated field mainly for the region that tree adversely effect the crop by way of their extensive and exhaustive rooting habitat, shading and also allelopathy certain toxic substance are revised from the leaf litter falling on the ground which may some times improve the germination of seeds. The roots compete for moisture with that of agricultural crop. This is quite evident from a study undulated in black soils of Bellary and Bijapur.

Table-7: Grain yield of safflower as influenced by the border effect of different tree species at the end of 10th year.

S.No.	Trees & species	Grain yield of safflower (kg/ha)	Border effect (m)
1	Dalbergia sissoo	635	7.0
2	Teak	497	7.2
3	Casuarina	366	10.5
4	Acacia auriculiformis	299	15.1
5	Albizia lebbeck	278	15.1
6	Eucalyptus	277	15.5
7	Acacia nilotica	243	15.9
8	Acacia catechu	248	16.1
9	Subabul	245	7.1
10	Control	840	0

9) Economic benefits

The summary of various economic benefits are indicated in table 8.

Table 8: Economic viability of Tim-Fib system (subabul + Agave) in marginal systm.

Timb-Fib	Timber Equivalent Yield (m^3/ha)	Cost of Cultivation (Rs/ha)	Gross Income (Rs/ha)	Net benefit (Rs/ha)	Benefit cost ratio (Rs/ha)	Organic carbon content (%)
Subabul + Agave (1:2)	62.8	25.25	37680	55155	13.92	0.73

Economic analysis over12-year period

Treatment	**Av. cost of culti-vation (R/ha/yr)**	**Average income (Rs/ha/yr)**	**Av. net Return (Rs/ha/yr)**	**Av. compounded Income at 10% interest (Rs/ha/yr)**	**NPV At 20% interest (Rs/ ha/yr)**	**IRR (%)**
1. FC	5362	10590	5228	19934	-	-
2. FC+T+P	6176	20703	14527	28334	26754	113.46
3. FC+T+P+G	6366	18102	117236	26473	23020	106.82
4.FC+T+P+S	6303	17850	11547	25436	21025	105.90

FC: Field Crop; T-Teak; P-Papaya; G-Guinea grass; S-subabul

Benefit cost ratio (BCR) and pay back period (PBP) after 12 years

Treatment	At 15% discount rates			
	BCR	PBP (Yrs)	BCR	PBP (yrs)
	At present costs		At 10% increase in costs (Sensitivity analysis)	
1.Only Agril. Crops	9.26	0.62	7.43	0.37
2.Agril crops + T + P	9.46	1.32	8.60	1.42
3.Agril.crops+T+P+G	8.06	1.26	7.23	1.36
4.Agril.crop+T+P+S	7.61	1.22	6.88	1.16

T – Teak, P-Papaya, G-Guinea grass, S- subabul