Chapter

Ginger Based Agro-Forestry Systems for Livelihood to Rainfed Areas

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Abstract

In rural areas particularly belonging to tropical rainfed zone, agro-forestry is a very common strategy adopted as a common popular tool for saving environmental degradation, in which multipurpose trees (MPTs) are planted with common agriculture crops. These MPTs play also a very vital role for rehabilitating degraded lands and enhancing the total productivity of the land with proper combination of these MPTs with different crops. Such kinds of agroforestry systems provide livelihood security to the farmers of rainfed areas. In India, ginger is planted as intercrop with different tree species and being a shed-loving plant, and its yield was increased as compared with monoculture system.

Keywords: agroforestry, ginger, livelihood, rainfed

1. Introduction

Rainfed areas are mainly dependent on uncertain rainfall which generally deficient to water requirements [1] and vagaries of weather [2]. In India a large part nearly 57 per cent of the agricultural land spread across the country, comes under rainfed areas and hence considered very important for agricultural productivity and livelihood for millions of rural households. Generally rainfed areas are lacking or short of some important natural resources mainly like water availability and critical environment, which also leads to land degradation due to water and wind erosion, also lower water use efficiency (WUE) resulted in low economic yield of field crops [3–5]. However, if these areas managed properly they also can share in good amount in food grain production. These high potential areas provide opportunities for improvement in agriculture production.

The primary reason for land degradation in rainfed areas is poor land use and disordered agriculture production leads to shortage of the natural resources. There are some following natural resources and their relationship between soil and water degradation [6] need to be focused [6], are:

1. Soil organic matter loss and physical degradation: Soil organic matter plays a very crucial role to managing water cycles in any of ecosystem. Decayed in level

of organic matter have significant effect on soil physical properties like negative impacts on infiltration, porosity and water holding capacity of the soil.

2. Chemical degradation and nutrient depletion of soil: In rainfed areas, due to lack of proper water sufficiency and distribution causes the imbalance of essential nutrients in agricultural soil and making the soil deficient particularly in terms of macro nutrients like N, P and K [7]. Sometime, imbalance of nutrients also leads to salt stress problems like salinity and alkalinity due to accumulation of Na salts on soil surface.

3. Soil erosion and sedimentation: Surface soil loss through erosion due to high thunder storm and poor soil aggregate stability and vegetative cover, is an extreme problem of rainfed areas [8]. These erosion activities lead to nutrient loss from upper soil layer resulting lower soil productivity in these areas. It also results in high sediment yields in downstream areas, and negative environmental impact [9].

4. Water scarcity: Sometimes due to high and increase in dry spell creates to drought like conditions in rainfed areas [10] resulting in decreased water availability and negative impact on crop growth and yield. Additionally, the combined effect of higher temperature and low water availability leads to higher crop evaporation demand. Consequentially higher temperature results in lower crop growth, yield and productivity [11].

2. Socio economic status of rainfed area

At present around 55 percent area of net sown area of the country comes under rainfed, which is considered as home for around 65–70% of total livestock and 40–50% of total human population. The poor socio economic condition of these areas comprising low irrigation facility as compared to irrigated regions, lower productivity and lesser employment opportunities leads to migration of the people for their livelihood (**Table 1**).

In rainfed areas for sustainable development, there is a considerable scope for land use diversification and crop intensification in areas having high NRI (Natural Resource Index) and low or medium ILI (Integrated Livelihoods Index). Crop production in uncertain rainfall areas is risky. Low and unstable yields are common and so is the income of dryland farmers. For imparting stability and providing sustainability to the farming systems, a tree-crop (Agroforestry) integration holds promise. Agroforestry systems can meet the multiple requirements of food, fodder, fuel, fertilizer, etc., besides improved pasture management.

Agroforestry is a multifarious approach for sustainable utilization of land and other natural resources by incorporating the trees in to diverse agricultural farming systems on same land and time to achieve economic, environmental, ecological, and cultural benefits [12]. An agroforestry system has three main objectives [13]:

- Protecting and stabilizing impact on the ecosystems;
- Producing a high level of output of economic goods and services;
- Improving income and employment to rural population

Parameter	Rainfed region	Irrigated region
Poverty ratio (%)	37	33
Proportion of agricultural labor (%)	30	28
Land productivity (INR/ha)	5716	8017
Proportion of irrigate area (%)	15	48
Per capita consumption (kg/year) of:		
Cereals	240	459
Pulses	20	12
Total food grains	260	471
Cooperative credit (INR/ha)	816	1038
Infrastructure development index	0.30	0.40
Social development index	0.43	0.44

Source 1. GoI (2006)-NSSO 2006, p. 18.

Table 1.
Comparison of rainfed vis-à-vis irrigated regions.

And to fulfill these objectives, there is a need to elucidate a proper combination of crop and tree, which must be complimentary or supplementary among the components in the system.

Ginger is the most suitable spice/aromatic shade loving crop for intercropping in agro-forestry systems in north regions from lowlands (500 mt.) to medium elevation (500–1000 mt.) [14]. Ginger, (*Zingiber officinale*), belongs to the family Zingiberaceae, is an herbaceous perennial commercial plant, used as a spice, flavoring, food and medicine. Besides consuming fresh ginger as a vegetable, several value added products are prepared from fresh ginger such as ginger paste, ginger candy and essential oils and Oleoresins. Ginger paste offers convenience to consumer's along with easy storage, long shelf life and authentic taste, to suit the requirements of consumers. There is a huge demand of such type of packaged ginger products in commercial shops like hotels and restaurants specially. In the same way, the demand of ginger oil and oleoresins is also raising in food processing, pharmaceutical and nutraceutical sector.

Ginger is an important commercial horticultural crop, and is cultivated in more than 35 countries around the world. In 2019, the global production of ginger was 4,081,374 tons. India is among the top leading producer of ginger in the global economy, having 45 percent share in area and 35.2 percent share in production and Nigeria was second, accounting for 16.94% [15]. The area under ginger in India was 53,900 hectares in 1990–91, showed a gradual increase over the years, and was 172,040 hectares in 2019–20 [16]. Recently the ginger paste and oil, has raised its demand in Ayurvedic system of medicine, due to its carminative and stimulant properties. A number of attempts have been made from last two-three decades to sustain its productivity by screening of new and high yielding varieties, optimization of nutrient doses, improved agronomic practices and protection measure [17]. The shade-loving nature of ginger [17, 18] have encouraged the researchers to explore its potential as an intercrop and many intercropping models have also been developed with ginger under different tree canopies viz., teak [18], coconut [19], areca nut [20], paulownia [21] and ailanthus [22].

3. Trees for plantation in agroforestry

In dryland or rainfed regions trees are planted on field bunds or boundaries as live fences or serving as wind break, to utilize the space. For this purpose, mostly those trees are planted with straight growth habit to avoid the interference and disturbance by their shading to the associated crop [23, 24]. The common tree species grown as boundary plantations in dry land systems are *Tectona grandis*, *Leucaena leucocephala* (pollarded for fodder), *Borassus flabellifer*, *Cocos nucifera*, *Acacia nilotica* var. cupressiformis, *Dalbergia sissoo* and *Prosopis juliflora* [23, 24]. In the last few years, systematic experiments are being conducted at several locations of India covering aspects on agroforestry, as a result of which several recommendations have emerged [25] for different agro-climatic regions of the country for rainfed conditions (**Table 2**).

In the era of climate change, accommodation of ginger as an intercrop in diverse agroforestry models can be a vital production system for environmental amelioration, realizing higher monetary returns and for sustaining the fertility of the soil. The various study inferred that ginger yield, soil physico-chemical and nutrient contents were higher [27] when grown in association with any plant spp. in agroforestry system (**Table 3**) as compared to sole cropping (**Table 4**). For effective, beneficial and

Traditional farm forestry	*Acacia nilotica, Albizia odoratissima, Annona squamosal, Azadirachta indica, Butea monosperma, Gmelina arborea, Mangifera indica, Tectona grandis, Syzigium cuminii, Terminalia bellirica, Terminalia arjuna, Ziziphus mauritiana*
Farm boundary plantations	*A. catehu, A. indica, Albizia lebbeck, A. nilotica, A. procera, Bambusa arundinacea, B. vulgaris Dalbergia sissoo, Dendrocalamus strictus, Eucalyptus* spp.*, Gliricidia maculata, G. arborea, Leucaena Leucocephala, Pongamia pinnata, T. grandis*
Block plantations/Farm wood lots	*A.mangium, Casuarina Equisetifolia, D. sissoo, D. strictus, Eucalyptus spp., L. leucocephala, T. grandis,*
Natural silvopasture	*A. lebbeck, A. nilotica, Annona Squamosal, Erythrina Indica, Emblica Officinalis, Hardwickia binate,, M. indica, Z. mauritiana*
Live hedges	*A. Senegal, P. juliflora, Bamboo spp., CaesalpiniaSepiaria, Dodonaea Viscosa, Ipomoea carnia, Lawsonia Inermis, Lantana camara, Vitexnegundo, Z. oenoplia*

Source: [26]

Table 2.
List of some woody species integrated in Agroforestry system of dry land.

Items	**Agroforestry models**		
	Acacia – Pineapple (TK)	**Acacia – Ginger (TK)**	**Acacia – Turmeric (TK)**
Total gross income	442,900	665,100	413,507
Total production cost	201,000	239,244	214,726
Net income	241,900	425,856	198,781
BCR	2.20	2.78	1.93

**TK = taka (Bangladeshi currency).*

Table 3.
Cost of production, total income and net income of diverse agroforestry models in hectare per year.

Treatment	Garlic production	Net return (Tk/ha)	BCR
S_1 + G_1 + Garlic	30,900	259,473	4.15
S_1 + L_1 + Garlic	44,625	234,905	3.99
S_2 + G_2 + Garlic	40,230	226,654	4.11
S_2 + L_2 + Garlic	66,150	219,498	4.12
S_3 + G_3+ Garlic	50,317	176,979	3.90
S_3 + L_3+ Garlic	78,635	181,945	4.04
Open	182,400	120,860	3.14

S_1 = Dalbergia Sissoo (spacing 4 m × 4 m); S_1 = D. sissoo (spacing 5 m × 5 m); S_1 = D. sissoo (spacing 5 m × 5 m); G_1 = guava (spacing 2 m × 2 m); G_2 = guava (spacing 2.5 m × 2.5 m); G_3 = guava (spacing 3 m × 3 m); L_1 = lemon (spacing 2 m × 2 m); L_1 = lemon (spacing 2.5 m × 2.5 m); L_1 = lemon (spacing 3 m × 3 m); Open = sole cropping of ginger; BCR = benefit to cost ratio.
(Source: [28])

Table 4.
Economics of ginger production under Dalbergia Sissoo based multistrata cropping system.

Treatments	Total cost of production (₹/ha)	Net income (₹/ha)	BCR
Sapota + Jatropha + Ginger (var. Navsari local)	159343.88	240598.65	2.52
Sapota + Jatropha + Ginger (var. Udaipur local)	159343.88	279293.65	2.76
Sapota + Ginger (var. Navsari local)	159343.88	95755.65	1.60
Sapota + Ginger (var. Udaipur local)	159343.88	136631.65	1.87
Jatropha + Ginger (var. Navsari local)	159343.88	171396.15	2.08
Jatropha + Ginger (var. Udaipur local)	159343.88	222063.65	2.40
Ginger (var. Navsari local)	152323.88	59698.63	1.40
Ginger (var. Udaipur local)	152323.88	105031.13	1.70

(Source: [29])

Table 5.
Comparative economics of Ginger based agroforestry models.

compatible cultivation of ginger as intercrop in any agroforestry model, multistrata system can also be a highly remunerative approach (**Table 4**) to overcome a number of problems like to poverty by improving the socio-economic status and reducing the side effect of global warming. Research revealed ginger based cropping models result in higher net income and benefit cost ratio [29] with lower cost of production (**Table 5**).

4. Factor affecting ginger production in agri-silviculture system

Temperature: Ginger prefers the warm and humid climate with the temperature 22–28°C,at seedling stage and 25°C during rhizome enlarging stage [30] however, also adaptable to low temperature. Rising in temperature increase the germination but weakens the sprouting of the rhizome.

Light: Ginger comes under category of shade loving plants and grows well I low to medium light intensity. During germination stage it needs darkness while medium light at seedling stage and high light during growing stage [31].

Water: Ginger plant cannot withstand in water stress condition as the soil water availability directly affect the rhizome growth [32]. For optimum growth of the plant well drained soil with proper irrigation facility is suitable.

Seed size: The growth of seedling largely depends upon the seed size as higher the seed size increases the sprouting and grow vigorously. However too big seed size should always be avoided.

Spacing: Ginger is one of the best suited crops for intercropping due to its shade loving nature. It needs around 30–40% illumination through radiation for optimum growth of the plant and rhizome as well [17]. For intercropping 5 m x 3-4 m spacing is found best spacing for rhizome production in agroforestry system.

Fertilizer: During the whole life cycle ginger needs changing NPK proportion at its different stages [33] as in early stage it needs more K followed by N and P while later in stage K uptake is lesser and N and P uptake is more for its luxurious growth and higher rhizome yield. However, during its growth period ginger need NPK in proportion of 11:1:16.1.

Although ginger often gains attention for its potential to generate high profits for farmers, limited attention has been given to expanding production aspects for the betterment of smallholder farmers engaged in production and marketing activities. In the climate change era, ginger based agroforestry models can be a vital production system for environmental amelioration, realizing higher monetary returns and for sustaining the fertility of the soil. The study inferred that ginger yield, soil physico-chemical and nutrient contents were higher when grown as intercrop sole cropping. Overall it can be concluded that there is tremendous potential for ginger cultivation to strengthen the agricultural sector by adopting suitable strategies. But this needs to happen scientifically at every stage from production to post harvest and processing stage. There is scope to widen markets in both domestic and international markets for this crop as well as its value additions.

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