Research for Mountain Development : Some Initiatives and Accomplishments
Published in 1998 by Gyanodaya Prakashan, Nainital
ISBN 81-85097-47-X

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Large Cardamom Farming : An Appropriate Livelihood Option for the Mountain People

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SUMMARY

Large cardamom (*Amomum subulatum*) farming is the most appropriate livelihood option for the mountain people in Sikkim. More than 23,000 ha of land area is under its cultivation which has increased by 2.3 times in the past 20 years. It is an important native cash crop whose capsules are used as spice/condiment. It is a shade loving plant thereby keeping trees intact in the agroforestry system. New plantations of large cardamom has extensively used N_2-fixing *Alnus nepalensis* as shade trees. The role of *Alnus* in large cardamom based agroforestry on productivity, yield and nutrient cycling has been emphasized in this article. The productivity and yield have increased conspicuously under the influence of *Alnus*. Biogeochemical cycling of both nitrogen and phosphorus has been accelerated on planting *Alnus* in large cardamom agroforestry. This crop has been a boon for the mountain people as it does not require much external inputs, is less labour intensive, provides basic natural resources from the agroforestry itself for the farm-families, and gives high economic return apart from its qualities of being low-volume and non-perishable.

14.1 INTRODUCTION

Mountain people in the Sikkim Himalayan region have either farming or tourism as their primary livelihood. Sikkim is a small Indian state in the eastern Himalaya where majority of the people depend on farming. Agricultural production could be increased with the use of large amounts of external inputs in addition to irrigation and introduction of new high yielding varieties of crops. These green revolution techniques were not successful in the Himalayan region where adequate external inputs were

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not available in time, irrigation could not be developed and soils are fragile. Mountain agriculture in Sikkim comprises of traditional and cash crops. Cash crops such as large cardamom (*Amomum subulatum*), mandarin orange (*Citrus reticulata*), ginger (*Zingiber officinale*) and potato (*Solanum tuberosum*) are extensively cultivated here. Large cardamom, a native plant of the Sikkim Himalaya, is a perennial low-volume, high-value, non-perishable cash crop grown beneath the forest-cover on marginal lands. Traditional cultivation of this crop is an example of harnessing the local mountain niche. Its cultivation is a unique example of the ecological and economic viability of a traditional farming system based on indigenously evolved agroforestry practices. Population growth and consequent fragmentation of farm-families has caused reduction in per capita agriculture land. Reduction in land holding size forced farmers to cultivate cash crops such as ginger and orange that caused nutrient depletion from soil at a fast rate (Sharma *et al.*, 1995, 1998). However, large cardamom farming has been a boon to the people of Sikkim. The Institute has carried out a number of activities for economical and ecological sustenance of large cardamom farming by using N_2-fixing *Alnus nepalensis* as shade tree and some of the achievements are documented in this article.

14.2 OBJECTIVES

The objectives of this study were (i) to study productivity, (ii) yield ,and (iii) nutrient cyclying of large cardmom under *Alnus* trees, a well defined agroforestry system of Sikkim Himalaya.

14.3 METHODOLOGY

14.3.1 *Sikkim Himalaya and Large Cardamom Farming*

Sikkim is a small state with an area of 7096 km^2 and a population of 405505, with an average density of 57 persons per km^2 in 1991. The state extends between 27°4'46" to 28°7'48" N and 88°58" to 88°55'25" E with an altitudinal variation from 300 m at the valley to 8548 m at the peak of the Mount Khangchendzonga. Nepal bound it on the west, on the north by Tibet, on the east by Bhutan and Tibet, and with the Darjeeling district of West Bengal stretching along its southern boundary. Average annual rainfall varies from 1300 mm at the valleys to 4300 mm at the mountain ridges, and 60-75% of this rain falls during the monsoon season, i.e., June through September. The humidity remains very high during the rainy season (85-97%). The state is regarded as a hot spot for biodiversity. It is rich in cultural diversity with distinctive ethnic groups such as the Lepchas, Bhutias, Nepalese and Limbus. The Lepchas are the aboriginal inhabitants of Sikkim. They collected capsules of large cardamom from natural forests from time immemorial but later on these forests passed into village ownership and the crop was domesticated. However, 1316 ha of reserved forest in Sikkim is still used for under canopy large cardamom cultivation on lease to farmers with no rights of cutting the tree (Sharma *et al.,* 1994). Its cultivation has been confined to the eastern Himalaya. Other than Sikkim, Darjeeling hills in West Bengal of India, Nepal and Bhutan produces large cardamom. Sikkim contributes about 60% to the world's large cardamom production.

Large cardamom is the most important perennial cash crop of the Sikkim Himalaya. The crop is a native of Sikkim that spread to the eastern Nepal and Bhutan. The cultivated variety of large cardamom is *Amomum subulatum* Roxb. belonging to the family Zingiberaceae. Seven species of wild relatives of cardamom such as *A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. corynostachyum*, *A. dealbatum*, *A. costatum* and *A. pauciflorum* are still found in the region. The cultivated species has six varieties such as 'Ramsey', 'Sawney', 'Golsey', 'Bharlang', 'Madhusey' and 'Ramla' (Subba, 1984). 'Ramsey' is suitable for cultivation above 1500 m, 'Sawney' between 1000-1500 m and 'Golsey' below 1000 m elevation. These varieties have evolved to suit various environmental situations such as elevation, water deficit, resistance to frost, etc. This crop is cultivated between 600 and 2000 m elevation.

Large cardamom perhaps is one among the oldest spices known to the mankind. In India it was used in Ayurvedic preparations as mentioned by Susruta as early as 6^{th} Century B.C. It's capsule (fruit) is used as spice and condiment, and contains about 3% essential oil rich in cineole (Gupta *et al.,* 1984).

The plant is a shrub by habit having several tillers comprising of pseudo-stems with leaves on the upper part. Inflorescence (spike) appears on the rhizome from the point where the pseudo-stem shoots up. It is essentially a cross-pollinated crop although capable of self-fertilization. Each spike consists of about 40-50 flowers which open in acropetal sequence, but normally fruit-set is limited to about 10-15 capsules in a spike. The flowering sets in before the rainy season (March to April) and harvesting takes place after the rainy season (September to November depending on the elevation). The harvested capsules are cured using fuel-wood in traditional kilns.

The large cardamom is cultivated usually on steep hill slopes under tree cover either in natural forest or plantations, which forms an age-old agroforestry system in the region (Singh *et al.*, 1989). A total of 16949 holdings of large cardamom cultivation have been recorded in Sikkim State that is classed into different size of holdings and highest number of holdings is for the class below one hectare. About 30% of the total area under large cardamom are for 1 to 3 ha class land holdings. It is a major source of cash income to supplement subsistence farming in the region. It is a shade loving plant and requires high moisture and is usually cultivated in areas where mean annual rainfall varies between 1500-3500 mm. New plantations and large patches of large cardamom based agroforestry systems have been recently converted into mono-culture of N_2-fixing actinorhizal *Alnus nepalensis* as shade trees. Some other common shade trees are *Schima wallichii, Engelhardtia acerifolia, Eurya acuminata, Leucosceptrum canum, Maesa chisia, Symplocos theifolia, Ficus nemoralis, Ficus hookerii, Nyssa sessiliflora, Osbeckia paniculata, Viburnum cordifolium, Litsaea polyantha, Macaranga postulata,* etc. Land area under large cardamom cultivation was 10,000 ha in 1975 and increased to 23,500 ha in 1995, and N_2-fixing *Alnus nepalensis* has been extensively used as shade tree in the new plantations (Plate 14.1). Therefore, evaluation of the use of *Alnus* as shade tree in large cardamom based agroforestry has been felt essential.

Influences of N_2-fixing actinorhizal *Alnus nepalensis* in cardamom agroforestry was studied with respect to soil fertility maintenance. The study on influences of this N_2-fixing species on cardamom agroforestry systems were broadly divided into (a) biomass, productivity and yield, (b) litterfall, decomposition and nutrient release, (c) seasonal soil nutrient dynamics, and (d) stand nutrient dynamics. A temperate site with cardamom-based agroforestry was selected having N_2-fixing *A. nepalensis* as an associate and referred as *Alnus*-cardamom stand, with a control plot having mixed tree species (non-N_2-fixing) which was designated as forest-cardamom stand. These sites are located in the Mamlay watershed in the South District of Sikkim. Density and basal area of trees were 517 trees/ha and 5.6 m^2/ha and 850 trees/ha and 6.3 m^2/ha, respectively in the *Alnus*-cardamom and forest-cardamom agroforestry stands. Tiller number and basal area of large cardamom in the *Alnus*-cardamom stand were 2.3 times higher than the forest-cardamom stand.

14.3.2 <u>*Analyses of yield, productivity and nutrient cycling*</u>

The agronomic yield of large cardmom was calculated by counting the tillers thata have fruited in the sample area of each stand in October and by multiplying with mean capsule weight per tiller. After the harvest of capsule, the tillers that have fruited in the current year were slashed and estimated the leaf and pseudo stem fractions and their contribution to floor litter. Decomposition studies were carried out by enclosing litter fractions separately in nylon bags and the value of all the fractions were pooled, and annual mass loss and nutrient release on unit basis were calculated.

Soil total nitrogen was estimated using modified Kjeldhal method (Anderson and Ingram, 1989) and inorganic phosphorus by chloromoly - bdophosphoric blue colour mentioned (Jackson, 1973). Plant samples were dry ashed and estimated phosphorus using sulphomolybdophosphoric blue colour method (Jackson, 1973). Total nitrogen was estimated by modified Kjeldahl method. The nutrient contents of tree and cardmom components were computed by multiplying component biomass with respective nutrient concentration. Nutrient flow from leaf and twig and cardmom to floor was estimated through litterfall, cardmom slashed residues and their nutrient concentration estimations. Nitrogenase enzyme activity was estimated using acetylene reduction technique and analysing in gas chromatography (Perkin Elmer, USA).

14.4 RESULTS AND DISCUSSION

14.4.1 Production and Yield

The stand total biomass, and tiller number, basal area and biomass of cardamom were much higher under the influence of N_2-fixing *Alnus*. Annual net primary productivity of *Alnus* trees was slightly higher than mixed tree species in spite of its lower stand density. The cardamom productivity was more than double under the influence of *Alnus*. The agronomic yield of cardamom also increased by 2.2 times under the canopy of *Alnus* (Table 14.1). More pronounced effect of N_2-fixing trees on cardamom biomass in *Alnus*-cardamom system could be because of much greater density of N_2-fixing *Alnus*. Greater biomass accumulation, net primary productivity, yield and higher litter production under the influence of N_2-fixing species in the agroforestry system are the direct expression of better performance consequent to higher soil fertility (Sharma *et al.*, 1994).

Nitrogenase enzyme activities in the root nodules of *A. nepalensis* from the *Alnus*-cardamom stand were carried out throughout the growing season from April to October 1994. The N_2-fixation rate was 55 μmol N/g nodule dry weight/day and root nodule biomass in the peak growing period was 388 g/tree (Sharma, 1995; Sharma and Purohit, 1996).

Table 14.1 : Productivity, yield and nutrient dynamics of large cardamom agroforestry under *Alnus* and mixed tree species as shade tree.

Parameters	*Alnus*-cardamom	Forest-cardamom
Biomass (kg/ha)	28422	22237
Net primary production (kg/ha/year)	10843	7501
Agronomic yield (kg/ha/year)	454	205
Nitrogen		
Standing state in biomass (kg/ha)	395.15	205.26
N_2-fixation (kg/ha/year)	65.34	-
Uptake from soil (kg/ha/year)	78.49	80.56
Retention (kg/ha/year)	56.12	49.55
Return to soil (kg/ha/year)	83.67	29.23
Exit through agronomic yield (kg/ha/year)	4.04	1.78
Use efficiency*	73	93
Back-translocation from senescent tree leaf (%)	3.85	17.49
Phosphorus		
Standing state in biomass (kg/ha)	32.357	17.900
Uptake from soil (kg/ha/year)	13.178	6.517
Retention (kg/ha/year)	6.328	3.840
Return to soil (kg/ha/year)	6.146	2.347
Exit through agronomic yield (kg/ha/year)	0.704	0.330
Use efficiency*	823	1151
Back-translocation from senescent tree leaf (%)	22.62	31.37

Source: Sharma *et al.* (1994)
*Nutrient use efficiency is the ratio between annual net primary productivity and nutrient uptake

14.4.2 Nutrient Cycling through Litterfall

Total annual litter+cardamom residue production was 1.6 times higher in the *Alnus*-cardamom stand than the forest-cardamom stand. This difference in the stand values was mainly attributed to higher cardamom residue production under the influence of *Alnus*. The floor litter was 1.3 times higher in the *Alnus*-cardamom stand than the forest-cardamom stand. The ratio of litter+residue production to floor litter was higher in the *Alnus*-cardamom than forest-cardamom stand. The tree litterfall occurred throughout the year with a marked seasonal distribution in all the agroforestry systems. The temporal distribution of litterfall in these agroforestry systems have an inverse relationship with rainfall. Nitrogen and phosphorus contributions in litter+crop residue production and floor litter were conspicuously higher under the influence of *Alnus* in cardamom agroforestry. Total soluble polyphenolics in decomposing litter fractions showed exponential relationship with time having 77-93% loss during the first 3 months in the cardamom agroforestry systems. The initial concentration of total soluble polyphenolics was higher in N_2-fixing *Alnus* leaf. Most of the total soluble polyphenolics are leached out exponentially during the initial phase of decomposition, levels falling to less than 1% in 3 months in cardamom agroforestry system. A decrease to below 1% level was critical for rapid decomposition and it is presumed that at higher levels of polyphenolics some of the early successional microbes are inhibited from colonizing the litter. Cumulative ash-free mass loss from tree leaf litter/crop residue fractions was negatively dependent on polyphenol/nitrogen ratio of the material in the cardamom agroforestry system (Sharma *et al.*, 1997a).

The turnover time and the time required for the loss of half the initial ash-free mass, nitrogen and phosphorus from litter fractions were least in N_2-fixing leaf litter. The litter from N_2-fixing species generally decomposed faster than litter of non-N_2-fixing species and the addition of N_2-fixer litter may have accelerated the decomposition of other litter types as well. The turnover time for ash-free mass and nitrogen for N_2-fixing and non-N_2-fixing species twigs were nearly the same, but phosphorus turnover in N_2-fixing twigs was found to be remarkably faster i.e., nearly three times faster in *Alnus* as compared to mixed species twigs. Sampling interval and cumulative loss of both nitrogen and phosphorus from decomposition bags were highest in *Alnus* leaf and twig combined, compared to mixed tree species leaf and twig, and cardamom residue in the cardamom agroforestry system. The mixed tree species showed lowest losses of nitrogen and phosphorus. The loss of nitrogen and phosphorus was high in N_2-fixers mainly because of higher concentration in their tissues. The mobility of phosphorus was higher than nitrogen from all the litter fractions. Most of the litter fractions were nutrient rich showing no net immobilization of nitrogen and phosphorus except for a brief period in the twigs of mixed species tree litter.

The nitrogen and phosphorus release from an unit area of floor was much higher in the stand with *Alnus* in cardamom agroforestry, where higher contribution was recorded from all the litter fractions specially from the leaf litter of *Alnus* compared to non-N_2-fixing stand. The N_2-fixing species, *Alnus* in the cardamom agroforestry have accelerated the nitrogen and phosphorus cycling through aboveground litter+residue production and influenced greater release of these nutrients to the soil (Sharma *et al.*, 1997a).

14.4.3 *Soil Nutrient Dynamics*

Soil was acidic in cardamom agroforestry Mixed stands with N_2-fixing trees commonly have lower pH than non-N_2-fixing stands. In the cardamom agroforestry, effect of N_2-fixing *Alnus* for lowering soil pH was difficult to assess as it was compared with forest-cardamom stand having old mixture of natural trees whose soil was highly acidic. Soil organic carbon levels are good indicators of soil fertility status. The sequence of land management transformation from forest to forest-cardamom (comprising of mixed natural trees) and to *Alnus*-cardamom (having planted *Alnus* trees) have resulted into the sequential reduction in soil organic carbon levels (Figure 14.1).

The availability of nitrogen limits production, and nitrogen supply rate and N-limitation are closely linked in many agroforestry systems. Total-N in soil in the forest-cardamom stand was highest and decreased in the *Alnus*-cardamom stand (Figure 14.1). The soil total-N showed annual fluctuations that seem very small relative to the total pool. Therefore, to see more of seasonal dynamics the inorganic-N as ammonium-N and nitrate-N were estimated although they showed small quantity relative to annual fluxes. Ammonium-N was highly seasonal in its concentration in the soil showing very low values in rainy season in stands. The ratio of seasonal maximum and minimum for ammonium-N showed upto six-fold variation. Nitrate-N also showed seasonality with variation upto six-fold in the ratio of maximum to minimum concentration. The ratio of total-C/total-N in soils in some cases is regarded as better index of N-availability than total-N alone. The higher C/N ratios in the cardamom agroforestry indicate lower N-availability in these stands, *Alnus*-cardamom stand showed relatively lower C/N ratio indicating higher N-availability than the forest-cardamom stand. Nitrogen mineralization is highly dependent on levels of soil organic matter and moisture, and these factors along with the temperature regulate mineralization in the field. Organic matter and moisture levels were higher in the cardamom-based agroforestry than the other (mandarin) agroforestry. The organic matter levels decreased sequentially from the forest-cardamom to the *Alnus*-cardamom and then to mandarin agroforestry systems, consequently rate of mineralization from the forest-cardamom stand decreased by seven-fold in the mandarin stand. The presence of N_2-fixing species in cardamom, while changing land-use from natural forest tree mixture to sparsely tree based agroforestry with traditional crops have helped in maintaining the soil organic levels and relatively higher mineralization rate which show potential of sustenance with this N_2-fixing species as associate (Sharma *et al.*, 1997b).

Amount of organic phosphorus exceeds inorganic phosphorus in most soils, and turnover of organic-P pools provides a large portion of phosphorus taken by plants. The total soil phosphorus of all the agroforestry stands was in the organic form except during spring in the mandarin stand which showed higher inorganic phosphorus mainly because of intensive cultivation activity in this stand. Ratios of inorganic-P/total-P were lower in cardamom-based agroforestry than the mandarin-based agroforestry, clearly indicating relatively higher inorganic-P available for plant uptake in the mandarin agroforestry system. Availability of phosphorus is highly pH dependent and it was quite evident in this study. Available phosphorus in *Alnus*-cardamom is higher than forest-cardamom stands (Figure 14.1). Lower soil pH values in all the seasons in the cardamom agroforestry resulted into low levels of available phosphorus in soil; in contrast, the mandarin agroforestry system seemed to have slightly acidic to neutral pH, relatively higher pH than cardamom agroforestry, consequently showing higher available-P especially in the rainy season (Sharma *et al.*, 1997b).

In acidic condition of soil most of the phosphates are secondarily fixed in the form of Ca-PO_4, Al-PO_4, Fe-PO_4 and occluded Fe-PO_4, therefore in this study these forms of phosphates were fractionated in different seasons and in all the agroforestry stands. In spite of seasonal fluctuation, considerable amount of phosphates are not available to plants as they are fixed in the occluded Fe-PO_4 form in all the stands quite characteristic to soils in the Himalayan region. Certain amounts of phosphates are fixed by calcium, aluminium and iron, and their seasonal fluctuation in contents regulate to some extent on the availability of phosphates for plant uptake.

14.4.4 Stand Dynamics

Nitrogen and phosphorus concentrations of different tissues of *Alnus* were higher than those of mixed tree species in the *Alnus*-cardamom agroforestry system. Nitrogen and phosphorus back translocation from leaf to branch before abscission were lower in N_2-fixing *Alnus* than mixed tree species (Table 14.1). This is because of higher availability and uptake of these elements in the stand with N_2-fixing associate compared to stand without N_2-fixing species. The general concept of inverse relationships between nutrient availability and conservation stands well in this study.

N_2-fixing *Alnus* has more availability of these elements than mixed tree species and hence recorded lower back translocation indicating their poor conservation strategy.

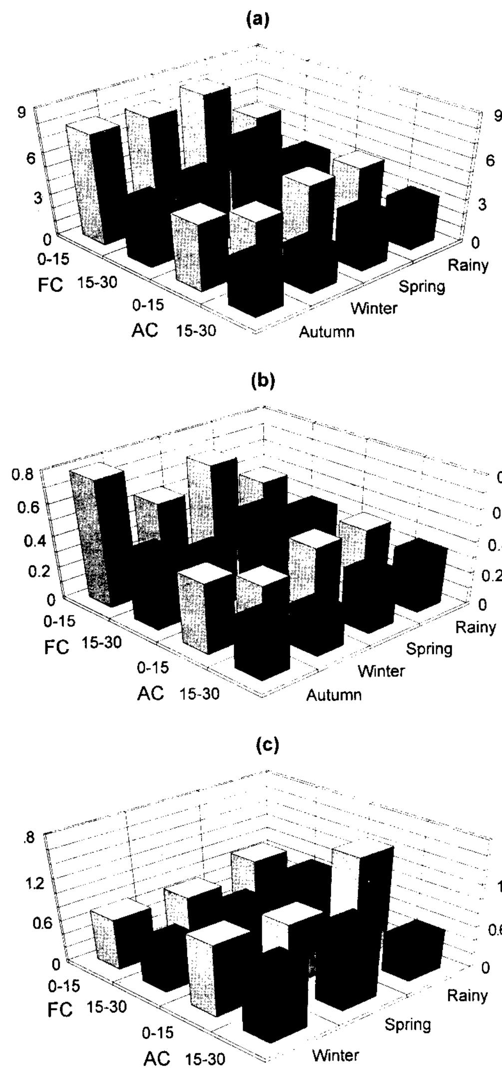

Figure 14.1 : Seasonal variation in soil organic carbon, total nitrogen and available phosphorus in large cardamom based agroforestry system in the Sikkim Himalaya. FC = Forest-cardamom, AC = *Alnus*-cardamom; (a) organic carbon (%), (b) total nitrogen (%), and (c) available phosphorus (mg/100 g soil).

Annual uptake and return of nitrogen to the soil in the *Alnus*-cardamom stand were higher than forest-cardamom that is attributed to N_2-fixation by *Alnus*. The rates of phosphorus uptake and return through litterfall and decomposition were also higher in *Alnus*-cardamom compared to forest-cardamom stands, which has probably resulted from an increase in the rate of phosphorus supply attributable to geochemical and biological factors influenced by *Alnus* (Table 14.1). The mandarin-based agroforestry system is a high nutrient exhaustive system as compared to large cardamom-based agroforestry evaluated on annual nutrient exit from the system through the removal of agronomic yield. Pooled data for agroforestry system showed that mandarin-based agroforestry is 15 times more exhaustive for nitrogen and 11 times for phosphorus than the large cardamom-based agroforestry (Sharma, 1995).

Nitrogen and phosphorus cycling in the cardamom-based agroforestry system appeared very malleable (flexible) under the influence of N_2-fixing *Alnus*. The magnitude of malleability of nutrient cycling was much greater for large cardamom-based agroforestry under the influence of N_2-fixing *Alnus* than the mandarin-based agroforestry stand under *Albizia* influence. Nutrient use efficiency may be expected to drop as utilization of that nutrient increases because availability of some other resource limit production. The nutrient use efficiencies in cardamom-based agroforestry systems were generally consistent with this hypothesis. It decreased as an influence of N_2-fixing *Alnus*, a pattern consistent with the expectation that efficiency should decrease with increasing rates of uptake (Table 14.1).

The cardamom-based agroforestry system under the influence of N_2-fixing *Alnus* was more productive having faster rates of nutrient cycling. The poor nutrient conservation and low nutrient use efficiency of *Alnus*, and malleability of nutrient cycling under its influence makes it an excellent associate promoting higher availability and faster cycling of nutrients. Therefore, the role of N_2-fixing species such as *Alnus* could be indispensable in efficiently managing the cardamom-based agroforestry systems. Density of 517 trees/ha of *Alnus* seemed quite reasonable to maintain N and P balance in *Alnus*-cardamom plantations. Efficiency of *Alnus* decreased with age as reported earlier and hence 1000 trees/ha density is suggested to be planted in the beginning. This will provide opportunity for annual thinning of *Alnus* trees for cardamom curing and domestic consumption. A rotational cycle of 20 years for both *Alnus* and cardamom is suggested with a phase-wise compartmental planting. This will ensure sustained yield and nutrient balance, and provide additional income at the end of rotational cycle by harvesting *Alnus* timber and branch wood. Cardamom grows down to 600 m elevation beyond ***Alnus*** zone, and below 1200 m elevation *Albizia stipulata* could be a potential symbiotic N_2-fixing species for cardamom agroforestry. *A. stipulata* has also been used as shade tree in large cardamom agroforestry system. The annual nitrogen fixation by *A. stipulata* was 12.04 kg/ha in large cardamom agroforestry. This N_2-fixing tree substantially regulated the maintenance of soil fertility and enhanced biomass productivity and yield by 9 to 13% in rain-fed areas under sub-tropical condition.

14.5 CONCLUSIONS AND FUTURE PROSPECTS

Biodiversity is an another indicator for sustainability, and biologically diversified systems have a greater capacity for resilience and show more sustenance. Large cardamom has many wild relatives in the region, and is cultivated as mono-crop where agri-biodiversity issue does not arise in this system. However, this practice has supported highly diverse tree components as shade trees and the system supported as many as 23 tree species. The diversity index of the tree species in the large cardamom based agroforestry has been high compared to general agroforestry in Sikkim. The trees in the large cardamom agroforestry have multiple uses for farmers, e.g., fodder, fuel, timber, materials for field implements, and residues for animal bedding. These trees also support birds and other wildlife, and this has direct bearing on the ecosystem structure and function.

Mountain farming has remained at the subsistence level much depending on the forest-based natural resources in spite of green revolution elsewhere in the plains. In this situation a traditional agroforestry based large cardamom crop was found to be most suitable. Large cardamom is a low-volume, high-value and non-perishable perennial cash crop compatible with the mountain niche. Its farming has been found to have a comparative advantage over other livelihood options (Sharma and Sharma, 1997). Cultivated land area, state production and state gross income from large cardamom has substantially increased in the past 20 years. Its agronomic yield per unit area has decreased which potentially can be improved with plantation age and disease management. In recent years nutrient exhaustive crops such as mandarin orange and ginger have become popular, but these crops will have limited impact in the long-term as they require high inputs and are high-volume crops with low keeping quality. Large cardamom keeps the forestry intact, as it requires shade trees that protect the landscape from soil erosion and nutrient loss from the system. Its agroforestry is a closed system and a bare minimum nutrient goes out of the system that too only in terms of agronomic yield. The fuel-wood requirement for curing the large cardamom harvest is easily met from the woody biomass production within the system. Use of N_2-fixing *Alnus* as an associate tree in large cardamom agroforestry has been highly beneficial in terms of stand production, large cardamom yield and nutrient cycling. In the current scenario of a very fast rate of the forest depletion in the fragile mountains, a cash crop with a strong forestry component meeting the basic requirements of fuel, fodder, timber and high economic return provides comparative advantage both ecologically and economically over other livelihood options. This cash crop has been a boon for mountain people as it does not require much external inputs, is less labour intensive, provides basic natural resources (fuel-wood, fodder, timber and other minor forest products) from the agroforestry itself, and gives high economic return apart from its qualities of being low-volume and non-perishable.

14.6 ACKNOWLEDGMENTS

Mr Ghanashyam Sharma and Mr M.V.S. Manian assisted in the work.

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