Contour Hedgerow Farming in North-east India

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Introduction

The north-east region of India is home to over 100 tribal communities (total population 31 million); its 260,000 sq.km land area accounts for 7.8% of all India. All the traditional societies are intimately dependent on the natural resources. 'Jhum' (shifting cultivation) is the predominant land use and economic activity. This practice aims at maintaining high crop diversity, achieving food security through utilising locally available organic resources for sustained yields, and cooperation/social integration at a local scale (Ramakrishnan 1993). Jhum was a sustainable practice in the past due to transfer of resources within and between different human managed systems, as well as within and between the village ecosystem and the natural forest systems. Unfortunately the recent rapid depletion of natural resources has remarkably reduced the productivity of the land. Due to their low socioeconomic status, the indigenous people are not in position to accept high quality technologies for land use development. Furthermore, the imported technologies require high inputs, and thus do not receive local attention. The government policies seek to discourage jhuming in the region, and thus the whole jhum system is marginalised.

This paper highlights some experiences gained through establishment of contour hedgerow farming systems in the jhum fields of Nagaland and Arunachal Pradesh.

Materials and Methods

Study area and experimental sites

The project was started in early 1994 with financial and technical support from the International Centre for Integrated Mountain Development (ICIMOD). Four sloping agricultural land technology (SALT) models, each with a minimum area of 1 ha, were established at Longnak, Nagaland, following the methodology recommended in the Planning Workshop of the Appropriate Technologies for Soil Conserving Farming Systems (ATSCFS 1994).

SALT-I was composed of traditional crop systems with double hedgerows of different N_2-fixing species.

SALT-II was an agro-livestock model, incorporating agriculture, hedgerows, and livestock components. Three fishery tanks including one duckery-cum-water reservoir and one piggery were established as a part of this model.

SALT-III consisted of an agroforestry system incorporating agriculture and hedgerows and timber/firewood species. For the initial two years, a few traditional crops (rice, maize) were grown along with *Crotalaria tetragona* hedgerows, which were discontinued from the third year onwards due to the shading effect of trees on crops and die back of hedgerows. *Gmelina arborea, Terminalia myriocarpa, Duabanga grandiflora, Albizia lebeck, A. chinensis, Parkia roxburghii, Melia azaderch, Canarium resineferae*, and *Mesua ferea* trees are now being maintained in this model.

SALT-IV represented a cash-crop based horticulture farm with hedgerows. Citrus, litchi, banana, mango, guava, coconut, pineapple were raised and maintained in this plot.

All these plots had similar vegetation cover and were used for jhum cultivation before being used for the present work. The control site was a traditional jhum plot without any hedgerows, and all local crops (i.e., rice, maize, tapioca, and colocasia) raised as grown by farmers; this plot was maintained for measurement of runoff and soil erosion.

Seeds of different nitrogen fixing species were procured from various sources and tested for their germination, growth, and biomass production. Germination tests for different hedgerow species were conducted in the laboratory as well as under field conditions. Various crops were grown on each plot, and records of all the inputs and outputs in each treatment were made. To monitor the effects of nitrogen fixing species on soil conservation, five plots of 20m x 5m were established initially, representing four SALT models and a control site with traditional jhum practices. Since 1998 only three treatments have been maintained for measuring runoff and soil erosion: the traditional jhum site (control), jhum+hedgerows, and an agroforestry model; each treatment has three replicates. Runoff and soil erosion were collected at the bottom of each plot in a tank. The impact of hedgerow biomass mulching on crop yield was measured with reference to the control site. The soil samples were collected from two depths, 0-15 cm and 16-30 cm, from different plots at the beginning of the demonstration work and thereafter each year at five different seasons, (January, April, June, September, and November). Soil samples were analysed for physical and chemical properties. On-farm research on biomass assessments, plant and soil nutrient analysis, soil fertility management, plant diversity, and crop yield analysis were done as per standard methods (Piper 1942 and other). In the course of model development, cost:benefit analyses were conducted for the jhum, jhum+hedgerow, and agroforestry sites.

Results and Discussion

Selection of hedgerow species

The land preparation activities at the Longnak site were initiated after slash and burn of the vegetation. Hedgerows were established by direct seeding in all the designated SALT models. A total of 10 species (*Flemingia macrophylla, Tephrosia candida, Cajanus cajan, Crotalaria pallida, Crotalaria tetragona, Desmodium rensonii, Acacia manguim, Gliricidia sepium, Indigofera anil*, and *Calliandra calothrysus*) were tested as hedgerows. All these hedgerow species were fast growing, and have multiple uses with N_2-fixing ability. The germination tests were done in the field as well as in the laboratory. The germination rate of most of the species was 56-98% in the laboratory and 20-80% in the field. *Tephrosia candida, Flemingia macrophylla, Cajanus cajan, Crotalaria tetragona* and *Desmodium rensonii* had high germination in both the field and laboratory. *Calliandra* *calothrysus* had poor germination under field conditions. Other species had medium rates of germination. Establishment of *Tephrosia candida* was very easy, required minimum inputs, and produced high biomass; thus it had a high impact on controlling soil erosion. Unfortunately the species recorded high mortality in the second and third years after germination and required high labour for maintenance; therefore it cannot be recommended for permanent agricultural areas, but could be adopted as the best hedgerow species for traditional jhum fields, which are left fallow after two successive croppings. *Flemingia macrophylla, Desmodium rensonii,* and *Indigofera anil* showed good growth, minimum mortality, and produced significant biomass in the three years of the experimental phase. These species also had high fodder values and affected soil and nutrient conservation; therefore they are recommended as the best species for this region. *Leucaena leucocephala* was recently introduced at the Midphu site and is still under observation.

Species biomass production

All the hedgerows need to be pruned to reduce shading of crops. The number of prunings also affected the biomass production of each species. Species that sustained 3-4 prunings with good biomass production on an annual basis were considered better. *Flemingia macrophylla* produced the maximum biomass, followed by *Tephrosia candida, Desmodium rensonii,* and *Indigofera anil*; therefore they are considered as the best performing species. *Acacia mangium, Cajanus cajan, Calliandra calothrysus, Crotalaria pallida,* and *Crotalaria tetragona* produced low biomass and did not respond well to pruning, and therefore are not considered good species for hedgerows.

Runoff and soil loss under different treatments

The runoff and soil loss have been monitored for different SALT models since 1995 at the Longnak site. In all the treatments (a traditional jhum plot and four SALT models), the runoff was very high at the start of the experiment, as was soil loss. Compared to the control figure of 60 m^3/ha, runoff was reduced significantly after the establishment of different models. The initial rate of soil loss was as high as 38.1 t/ha/year. However, there was a continuous decrease in soil loss in subsequent years in all the treatments, except for the control site. The soil loss was least in SALT 3, followed by SALT 1. Hedgerow incorporation brings significant reduction in soil loss even though the same agricultural practices were continued. The soil loss reduced to <5 t ha^{-1} in SALT 3 and <10 t ha^{-1} in SALT 1 after five years of the experiment. The control plot, however, had a similar level of soil loss to that recorded at the beginning of the study.

Change in soil nutrients

Hedgerows have a significant impact on the moisture content of soil. When applied as mulch, the pruned biomass maintained the soil moisture level for a long period due to less evapotranspiration from soil. There was a clear increase in soil nitrogen and carbon status in all the treatments, except for the control plot that showed a net decrease for C (Table 1).

Table 1: Impact of hedgerow mulching on soil nitrogen and carbon for different SALT models				
Treatment	At the beginning of study		After 4 years of mulching	
	C (%)	N (%)	C (%)	N (%)
Control	1.25	0.115	1.00	0.144
SALT I	1.34	0.160	2.06	0.193
SALT II	1.15	0.135	1.48	0.166
SALT III	1.03	0.180	1.53	0.190
SALT IV	1.51	0.160	1.49	0.166

Impact of hedgerow biomass mulching on crop yield

Hedgerow mulching had a positive impact on the crop yield except for rice (Table 2). For most of the crops grown with hedgerows, the yield increased by 1.5 to 3 times. The impact of mulch was more significant on vegetable and root crops.

Table 2: Impact of hedgerow mulch on yield (t/ha) of some crops		
Crops	Traditional practice	Plots with hedgerows
Rice	3.25±0.38	2.92±0.41
Maize	1.67±0.24	2.47±0.24
Ginger	4.45±0.33	25.15±0.36
Peanut	2.61±0.20	3.15±0.31
Turmeric	24.00±1.50	29.93±3.38
Taro	3.90±2.00	6.60±2.50
Tapioca	10.80±2.30	16.30±4.00
Tomato	20.60±3.56	51.60±4.95
Cauliflower	21.90±2.15	36.62±4.58
Green chilli	22.00±3.04	32.00±5.21
Lady's finger	11.70±1.58	16.00±2.49

Other appropriate technologies

Some other appropriate technologies were also included as an integral part of the project, with each activity identified based on its need and usefulness to farmers. Some important technologies incorporated were low-cost water harvesting by construction of deep earthen dams, which was also used as a fishery-cum-duckery; polythene tanks for rainwater harvesting; bio-briquetting; weed composting; and bamboo propagation. These activities received wide acceptance from farmers and NGOs.

Economic analysis

A comparison of major inputs and outputs from jhumland (traditional system), jhum + hedgerows, and agroforestry showed that in the first year profit was higher from the jhum system than from any other treatment. However this decreased in the second year of cropping. The high first-year inputs in the hedgerow + agriculture system were due to the cost of seeds of hedgerow species and of the establishment of hedgerows and maintenance costs, while in the agroforestry model this was due to the cost of seedlings. However, the contour hedgerow farming system provides a regular income year after year and also ensures food production, which is not possible in jhum practice. In the agroforestry model, there was no income through the fourth year, but in the fifth year the plots were thinned and 2.7 tonnes of firewood were harvested. This system seems highly profitable and could be adopted by farmers who have large landholdings, but may not be a good option for small landholdings. Poor farmers generally have small landholdings and their main priority has been food production, which can be achieved by applying the contour hedgerow farming approach.

Impact

Hedgerow technology has been tested and demonstrated from 1994 to 2001. The focus was to develop a prototype through careful trials for selection of hedgerow species and investigation of the impact on soil structure, fertility, crop yield, and runoff-erosion control. The impact in terms of replication of the model was not very high. However, a great deal of awareness was generated on the subject and a few NGOs are in the process of implementing the technology. Training programmes and short-term exposure visits were arranged for the planners, social workers, NGOs, and farmers to build their capacity to use the technology. The technology has positive effects on crop yields, runoff and soil conservation, and maintenance of fertility, and produce continuous financial returns year after year, which provides enough incentive to the farmers and developmental agencies to adopt the technology.

Future Implications

The jhum fields in north-east India are used for two successive cropping seasons and thereafter left fallow. Agricultural production is high in the first year after slash and burn of the land because of the high nutrient content of the soil; the production decreases in the second year due to reduced soil fertility and serious soil erosion. The field is then left fallow, as there is no concept of applying any fertiliser or manure fields to maintain soil fertility. As most jhumlands are prone to severe soil erosion, incorporation of hedgerow technology plays an important role in maintaining and improving soil fertility through pruning and mulching of hedgerow species and conserving soil through thickly planted hedgerows.

The experiments showed that the crop yield increased significantly after establishing hedgerows; thus permanent cropping is possible in jhum fields without external inputs. The technology is an integrated farming approach that contains agriculture, animal husbandry, agroforestry, and horticulture components (Jamir et al. 1998). Hedgerows reduced the runoff by over 50% and soil erosion by 6 times. The productivity for major crops increased by 1.5 to 3 times in agricultural fields. Similar results have been reported from other areas (Tang Ya 1998).

The initial labour requirement is higher than for traditional farming, and therefore some incentive to the farmers in the initial stages is highly desirable. Incorporation of economic species along with the hedgerow species may increase farmers' interest. There is a further need to evaluate more local and indigenous nitrogen fixing species as hedgerows; the criteria should include good germination and survival, high biomass production on a unit area basis, fodder and firewood production, high seed production, drought tolerance, and resistance to diseases and pests (Tacio 1992). It will also be wise to develop more such models in diverse situations before large-scale replication of the technology. Such models should incorporate multipurpose hedgerow species with cash and food crops, and livestock components, as the farmers choices vary from area to area.

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