EFFECT OF LAND USE ON *DENDROCALAMUS HAMILTONII* REGENERATION DURING EARLY SECONDARY SUCCESSIONAL STAGES IN NORTHEAST INDIA

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RAO, K.S. & SAXENA, K.G. 1995. Effect of land use on *Dendrocalamus hamiltonii* regeneration during early secondary sucessional stages in northeast India. The regeneration potential of a tropical deciduous bamboo, *Dendrocalamus hamiltonii* was studied following 5, 10, 15 and 20 year shifting cultivation (locally known as jhum) cycles. Bamboo and other non-crop plants were weeded two-three times during the cropping period depending on the weed intensity. The below-ground biomass dynamics of bamboo showed drastic reduction during one year of cultivation and one year regeneration. The lower biomass in below-ground organs of bamboos following shorter cycles of shifting cultivation may be an indicator of severity of disturbance. It is concluded that severe disturbances occurring today threaten the availability of bamboo resources in future, and proper management practices are warranted.

Key words: *Dendrocalamus hamiltonii* - secondary succession - northeast India - shifting agriculture - resource management - regeneration

RAO, K.S. & SAXENA, K.G. 1995. Kesan kegunaan tanah pada pertumbuhan semula *Dendrocalamus hamiltonii* semasa tahap-tahap awal sekunder yang berturut-turut di timur laut India. Pertumbuhan semula buluh meluruh tropika, *Dendrocalamus hamiltonii*, dikaji berikutan kitaran 5, 10, 15 dan 20 tahun pertanian pindah (nama tempatan jhum). Merumput dilakukan pada buluh dan pokok-pokok bukan tanaman dua hingga tiga kali. Semasa tempoh tanaman bergantung pada keamatan rumpai. Dinamik biojisim bawah tanah buluh menunjukkan penurunan drastik semasa satu tahun pertanian pindah dan satu tahun pertumbuhan semula biojisim yang lebih rendah dalam organ-organ buluh di bawah tanah berikutan kitaran pertanian pindah yang lebih pendek mungkin ialah penanda tahap teruk gangguan. Kesimpulannya, gangguan-gangguan yang teruk yang berlaku pada hari ini mengancam adanya sumber-sumber buluh pada masa hadapan dan mewajarkan amalan-amalan pengurusan yang sesuai.

Introduction

Tropical humid forests of northeast India are amongst the most productive ecosystems of the sub-tropics (Singh & Ramakrishnan 1982). Apart from providing intangible benefits such as ecological stability, the forests of northeast India are a rich source of renewable raw materials of industrial importance. Bamboos constitute a major component of these renewable raw materials (Richards 1952, Haig *et al.* 1958, Drew 1974, Soderstrom & Vidal 1975, Toky & Ramakrishnan 1983a, Rao & Ramakrishnan 1987a). With increase in industrial demand and consequent depletion of woody vegetation (Saxena *et al.* 1990), additional burden to meet the fuelwood requirement is also put on bamboo forests (Rao &

Ramakrishnan, 1987b). The renewable capacity of constituent components of tropical ecosystem depends on the intensity, duration and frequency of disturbance (Aweto 1981,Toky & Ramakrishnan 1983a). Earlier studies in northeastern India concentrated on the pattern of species changes during succession (Toky & Ramakrishnan, 1983a) and consequent microclimate changes (Mishra & Ramakrishnan 1983, Toky & Ramakrishnan 1983b, Ramakrishnan & Saxena 1984). Effects of repeated disturbance on the regeneration of dominant species were not known. The present study deals with the effects of frequent disturbance caused by indigenous slash and burn agriculture on regeneration of one such dominant species, *Dendrocalamus hamiltonii,* in a tropical moist forest area of northeast India.

Materials and methods

Study area and climate

The present study was conducted at Lailad (200 m altitude), situated at 75 km north of Shillong (26°N and 91°5'E) in the East Khasi Hills District of northeastern extensions of the Himalaya. The bedrocks are of precambrian origin and consist of gneisses. schists and granites. The soil is red sandy loam of lateritic origin, with pH ranging from 5 to 7. The angle of the slope generally ranges from 20° to 40°.

The climate has three distinct seasons, a dry summer season from May to September and a mild and relatively dry winter from October to mid-February. Seventy-three percent of annual rainfall of 1800 mm occur during the rainy season. The average maximum and minimum temperatures during the year are about 31 °C and 14 °C respectively.

Method of study

Slash and burn agriculture (jhum) practised at lower elevations of Meghalaya (Toky & Ramakrishnan 1981, Swamy 1986) represents the typical version practised in northeastern India; hence it is described here in some detail. The average family of two adults and 4 - 5 children hold a jhum plot of 1 to 2 ha. During the dry season (December - January), the forest is cleared by slashing. The boles of the larger trees are left intact by cutting down only branches to be used as support for cucurbits. The dried slash is burnt *in situ*, well before the onset of monsoon (March-April). A bamboo hut is built for living temporarily during the cropping period to protect the field from wild animals (Swamy & Rao 1987). The jhum cycle (the intervening fallow phase between two successive croppings at the same site)varies between 5 to 30 years, though longer cycles are not common except where population pressure on land is minimal. Mixed cropping is an essential feature of jhum. The number of mixed crops in this region ranges from 8 - 35 (Kushwaha 1981). Maize and rice are usually planted at regular intervals using long sticks after the first rain during April-May. Seeds of pulses, cucurbits, vegetables and cereals are mixed with dry soil from the field in order to ensure their uniform distribution and broadcast. After the slash is burnt perennial crops such as ginger, colocasia, tapioca, banana and castor are sown intermittently throughout the growing season. Apart from raising food crops, the farmers also rear silkworms on castor, which is grown on farm boundaries. Though the land is not tilled, weeds pose a major problem with the onset of the monsoon, particularly under shorter jhum cycles. Frequent slashing and hand-hoeing is done by women folk during the cropping to keep the weeds under control.

Based on the local records, areas subjected to four differing lengths of shifting cultivation cycles, 5, 10, 15 and 20 years, were identified. Three replicate plots, varying from 1.5 to 2 ha in size for each length of jhum cycle were selected. Care was taken to select sites with similar slopes (about 30°), aspects and topographic features. For each length of the cultivation cycle, biomass estimates were made just before slashing vegetation, during crop cultivation following the burn and during the first year of fallowing after one year of cropping. Sampling was organized to estimate above-ground standing biomass of trees and shrubs, bamboos and herbaceous vegetation before slashing, contribution of each group in weed biomass on each of the weeding activity during cropping following the burn, and biomass allocation to different components before slashing, after a year of cropping and after a year of fallow development following the cropping phase.

Above-ground standing biomass of tree species was worked out in 30 random quadrats of 10 × 10 m, using allometric regression equations developed by Singh and Ramakrishnan (1982). Complete harvests of equal number of quadrats of 1 × 1 m were taken to measure the biomass of herbaceous constituents. For bamboos, all the clumps covered in a quadrat were carefully uprooted. Above-ground biomass was computed using the culm density values and mean biomass of a culm while below-ground biomass was computed on the basis of fresh weight of excavated material and moisture percentage in a subsample. All the harvested biomass was separated into individual components of bamboos (culm, branches and leaves) and major groups for all the vegetation (trees, shurbs, herbs and bamboos). All the samples were dried at 80 °C for 48 h and dry weights were computed.

Results

Above-ground standing biomass of trees and shurbs considered together increased while that of herbs decreased with increase in the length of cycle (Table 1). Biomass of bamboos increased till 15 years of fallow development only. Although there was a decline in biomass of bamboos after 15 years of fallow, it was not found to be significant ($p > 0.05$).

Table 1. Above-ground standing biomass (t ha^{-1}) of bamboos and other vegetation in different jhum fallows

Component	Fallow age (years)			
	5	10	15	20
Bamboo	0.86 ± 0.085	3.50 ± 0.430	6.20 ± 0.490	6.10 ± 0.460
Trees & shrubs	0.73 ± 0.096	2.50 ± 0.330	4.55 ± 0.600	5.22 ± 0.660
Herbs	0.50 ± 0.039	0.05 ± 0.006	0.03 ± 0.004	0.03 ± 0.008

Bamboos were weeded three times during the cropping phase of one year under all jhum cycles (Table 2). Species other than bamboos considered together were weeded only twice except for the 5-year jhum cycle. Under a 5-year cycle, all the non-crop components were weeded on three occasions. While above-ground biomass of weeded bamboos increased with the increasing length of the jhum cycle, that of the other species decresed ($p < 0.05$). Response of bamboos to weeding was different from that of other species. Above-ground growth of bamboos during successive weedings decreased under all the jhum cycles. On the other hand, growth of other species removed as weeds was influenced by weeding only in the longer cycles of 10 and 20 years. All the weeds considered together were more abundant in the shorter cycles than in the longer ones, bamboos being more abundant in the latter situation. These differences, however, were not as marked between 15 and 20-year jhum cycles as in other cases.

Table 2. Weed biomass (t ha^{-1}) in plots cultivated after 5 to 20 years of regeneration

Component	Time of weeding	jhum cycle (years)			
		5	10	15	20
	May	1.31 ± 0.009	6.91 ± 0.031	18.60 ± 0.07	21.62 ± 0.035
Bamboo	June	1.12 ± 0.009	5.61 ± 0.042	11.73 ± 0.059	11.67 ± 0.017
	Sept.	1.21 ± 0.010	4.30 ± 0.065	5.63 ± 0.009	9.72 ± 0.006
	May	33.19 ± 0.071	31.73 ± 0.076	25.2 ± 0.67	13.37 ± 0.021
Other weeds	June	37.21 ± 0.089	nw	nw	nw
	Sept.	36.11 ± 0.099	30.31 ± 0.089	11.67 ± 0.036	16.32 ± 0.026

nw = no weeding

There was a significant decline in below-ground biomass of bamboos as a result of cropping in all the cycles (Table 3). The below-ground biomass of bamboos further declined during the period of one year of regeneration when the sites were fallowed after the cropping phase was over. The impact of cropping on below-ground biomass was more prominent under the longer cultivation cycles than in the shorter ones. There was about four-fold decline in below-ground biomass under a 5-year jhum cycles compared to over seven-fold decline under a 20-year cycle.

Table 3. Changes in below-ground standing biomass (t ha^{-1}) of *Dendrocalamus hamiltonii* subjected to disturbances after different periods of fallow regrowth

	Fallow regeneration period prior to disturbance (years)			
	5	10	15	20
At the time of clearing the fallow	3.3 ± 0.002	18.3 ± 0.000	1 33.6 ± 0.03	46.3± 0.03
At the time of abandoning after one year of cultivation	0.92 ± 0.002	3.61± 0.005	4.86 ± 0.005	6.21 ± 0.005
At the end of one year regeneration after fallowing	0.0093 ± 0.0001	0.0169 ± 0.0001	0.0186±0.0001	0.0185 ± 0.0001

After one year of regrowth following cropping, proportional allocation to below-ground components of *D. hamiltonii* was significantly higher ($p < 0.01$) under longer cycles of 10-20 years as compared to that under a 5-year cycle. On the other hand, allocation to above-ground parts was high under shorter cycles than the longer ones (Figure 1).

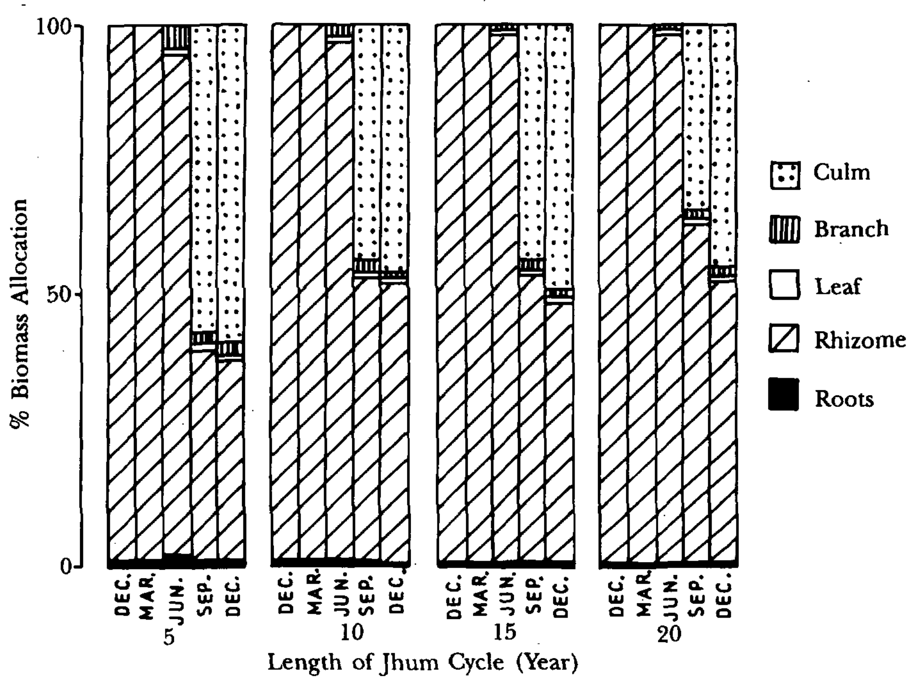

Figure 1. Biomass allocation pattern in *Dendrocalamus hamiltonii* following one year regeneration after shifting agriculture under different jhum cycles

Discussion

An increase in above-ground standing biomass of larger life forms including tree, bamboo and shrub species and decrease in that of shorter life forms including herbaceous species, with increasing length of the fallow phase are the common trends in seral development as also reported elsewhere (Kenoyer 1929, Toky & Ramakrishnan 1983a). The structure and composition of the early successional communities following the burn depends upon the regenerative capacity of the species constituting the pre-burn vegetation and the dispersal capacity of the species encountered in the adjacent areas. After the burn, a species may come up either through sprouting of the underground vegetative organs or through seedlings produced from the soil seed bank or from seeds arriving from adjacent areas or a combination of both (Saxena & Ramakrishnan 1984). Slashing the vegetation and concomitant burning have an adverse effect upon the *in situ* regenerative potential of the system. Because of heavier fuel loads the burn is more intense under longer cultivation cycles of 10 - 20 years than the shorter ones of 4 - 6 years (Toky & Ramakrishnan 1983a) as is also evident from a substantially lower above-ground biomass under a 5-year jhum cycle than 10 - 20 year ones from the present study. Under cultivation cycles of 10 years or longer the herbaceous species regenerating largely through seeds and under-ground rhizome/rootstocks in the surface and sub-surface soil tend to get more damaged than the bamboos regenerating through deeply placed rhizomes. Short fallow phases of 4 - 6 years do not permit adequate recovery of bamboos or colonization by tree species. Under short cultivation cycles of 4 - 6 years, the pre-burn vegetation is dominated by the herbaceous weedy species. Thus, the herbaceous weeds predominate under shorter cycles of 5 years whereas bamboos constitute the major weed under cycles of 10 years or longer. The herbaceous weeds pose more problems than the bamboos as far as adverse effects on crop yields are concerned. Herbaceous weeds are likely to compete directly with the planted crops as both are surface feeders. Further more, rapid growth of the herbaceous species following the burn and their high density reduce the vigour of the planted crops as a result of shading. Bamboo, on the other hand, seems not to be as harmful as the herbaceous weeds. During the first post fire year, bamboo comes up only as fresh culms, with foliage and branches much less than those of herbaceous species. Besides, there is no direct competition for moisture and mineral resources between bamboos and the planted crops as their root zones do not overlap.

Weeding of herbaceous constituents is done differently from that of bamboos. While the former are usually hoed or uprooted manually, the latter are invariably slashed which may cause a sharp decline in buds capable of regeneration. The rapid depletion of below-ground biomass in bamboos during the cropping period and subsequent one year regeneration is understandable, as bamboo generally uses the stored resources in the below-ground rhizomes for production of fresh culms and leaves which again start producing photosynthate to be stored for next year's biological production and clump maintenance in the current year. In the present study the difference between disappearance of below-ground biomass and addition of above-ground biomass in bamboos would be the photosynthate produced during the current year. More intensive studies on photosynthate translocation are needed to confirm this. Such phenomenon was observed in temperate bamboos from Japan (Ueda 1960). Early successional bamboos like *D. hamiltonii* allocate more biomass to bole and branches so that the elongated axes can produce leaves above the fast growing weedy colonizers (Rao & Ramakrishnan 1988a & b). This explains the higher above-ground biomass in a shorter cycle compared to others as weed intensity is higher in this fallow compared to longer cycles.

Disturbance, which is defined as "an act which partly or fully destruct the plant biomass", is common to all ecosystems. In the absence of any anthropogenic interference, there are disturbances frequently in the natural ecosystem. The damage to the system under such circumstances is repaired through a variety of biological mechanisms. Disturbances caused by man are then more frequent and intense than natural ones. Such damage to the system can be beyond the recuperative capacity of the system through natural process. Management of land aimed at maximizing the production of biological components useful to human beings often accompanies disturbance regimes which are beyond the repair capacity of the system. The on-going trend of over-exploitation of resources and severe disturbances caused by anthropogenic pressure in northeast India are said to be causing degradation (Ramakrishnan 1985). The present study too indicates that if some steps are not taken the resource degradation will affect the region as the disturbances are eroding the regenerative powers of the system. The costs of restoration will escalate as time passes and immediate steps are warranted.

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