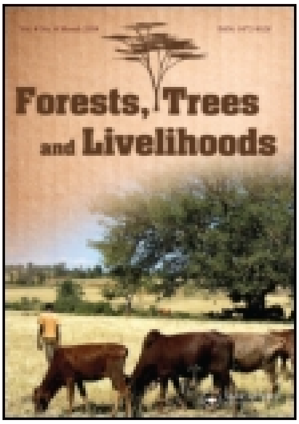

Forests, Trees and Livelihoods
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tftl20

Growth pattern, production, and marketing of Thysanolaena maxima (Roxb.) Kuntze: An important non-timber forest product of Meghalaya, India

B. K. Tiwari [a] , R. P. Shukla [b] , M. B. Lynser [a] & H. Tynsong [a]

[a] [a]Department of Environmental Studies, North-Eastern Hill University, Shillong, 793 022, India

[b] [b]Department of Botany, DDU Gorakhpur University, Gorakhpur, 273009, India

Version of record first published: 23 Oct 2012.

Forests, Trees and Livelihoods
Vol. 21, No. 3, September 2012, 176–187

Growth pattern, production, and marketing of *Thysanolaena maxima (Roxb.) Kuntze*: An important non-timber forest product of Meghalaya, India

B.K. Tiwari[a]*, R.P. Shukla[b], M.B. Lynser[a] and H. Tynsong[a]

[a]*Department of Environmental Studies, North-Eastern Hill University, Shillong-793 022, India;*
[b]*Department of Botany, DDU Gorakhpur University, Gorakhpur-273009, India*

Broomgrass is an important semi-domesticated non-timber forest produce of Meghalaya. The distribution, growth pattern, biomass production, and productivity of broomgrass processing and the cost-benefit analysis of cultivation, along with marketing linkages of the product, have been studied using standard methods employed in ecological and socio-economic research. The study revealed that broomgrass grows in all parts of Meghalaya below 1,600 m.a.s.l., on a wide range of soils. An analysis of growth parameters, namely leaf number, leaf area index, basal area, canopy cover, and tussock height, revealed that broomgrass is a fast growing perennial grass that attains maximum growth in four years. The cost-benefit ratio analysis of broomgrass cultivation was found to be 3.46, 3.32, and 3.19 at 10, 15, and 20% annual interest rates, respectively. The study concludes that broomgrass cultivation could be an effective instrument for generation of cash income in rural Meghalaya, as its cultivation needs minimum input of labour and generates a very attractive economic return.

Keywords: crown structure; productivity; plantation management; marketing linkages; cost- benefit analysis

Introduction

Non-timber forest products (NTFPs) are considered a vital resource for the millions of forest dwellers around the world. They help sustain poor people's livelihoods, as NTFPs provide instant cash in times of need and are often freely accessible. A number of studies have highlighted the importance of NTFPs in contributing to forest conservation and poverty alleviation of local communities (Neumann and Hirsch 2000; Ros-Tonen 2000; Arnold and Ruiz Perez 2001; Shakleton and Campbell 2007). Extraction of NTFPs is viewed as an effective conservation strategy to safeguard biological diversity while enhancing rural income (Arnold and Ruiz Perez 1998). However, excessive harvests have also led to doubts about the potential of NTFPs to serve the said purposes. It was also found that contribution of NTFPs to improve livelihoods can best be assured through a process of gradual domestication of NTFPs in agroforestry systems (Ros-Tonen and Wiersum 2003). Success in domestication of NTFPs is determined by adaptability of the plant in particular agroecosystems, sufficient land holding, profitability in cultivation, and availability of lesser job opportunity in other sectors. Studies have also revealed that trade of forest products offers little scope for boosting people's incomes, unless there is an established market (Henkemans 2001; Tiwari and Kumar 2008).

*Corresponding author. Email: bktiwarinehu@gmail.com

ISSN 1472-8028 print/ISSN 2164-3075 online

http://dx.doi.org/10.1080/14728028.2012.732793
http://www.tandfonline.com

The tribal economy of India is characterized by poverty and backwardness. Nearly 500 million people living in and around forests in India rely on NTFPs as a critical component for their income generation and sustenance (Mallik 2000; Chopra 1993). Meghalaya, one of the states situated in the northeastern part of India, is inhabited mostly by tribal populations. As per the 2001 Census of India, the tribal populations account for 80% of the total population of the state. They mainly live in the rural areas, which cover 99% of the total state area. Topography is rugged and hilly and the state lacks a proper transport network, which may be considered as the main factor for its economic backwardness. Meghalaya State ranked 24th and 28th, respectively, in terms of the Human Development and Human Poverty Indices among the 28 states of India (NHD 2002).

The main occupation is agriculture, despite the fact that 70% of the land area falls under a steep or moderate slope, which makes it unfit or not feasible for permanent agriculture. Besides agriculture, people also depend considerably on forest resources for their subsistence (Ramakrishnan 1985; Gangwar and Ramakrishnan 1990). At least 95 different types of NTFPs are collected in Meghalaya (Tiwari 2000).

Thysanolaena maxima (Roxb.) Kuntze (family—Poaceae), popularly known as broomgrass, is an important NTFP and grows in almost all parts of South and Southeast Asia up to an elevation of 1,600 m and climatic conditions ranging from tropical to subtropical. The inflorescence of *T. maxima* makes broom popular in Asia. It grows wild in the hills of the northeastern region of India and in Darjeeling and Sikkim Himalayas. The contribution of this NTFP toward enhancing the livelihood of the people of the region has been studied by Bisht and Ahlawat 1998, Shankar et al. 2001, and Tiwari 2001. In Meghalaya, broomgrass was first introduced by the state forest department about three decades ago under a silvi-pastoral system in social forestry plantations for generating income during gestation periods, that is, periods between plantation and harvest of timber. Subsequently, the plant has been domesticated and cultivated on large scale by upland farmers. This plant, therefore, provides a typical case for understanding the role of domesticated NTFPs in enhancing the livelihood of the rural poor. Being a recently domesticated plant, little is known about its growth features, productivity, and plantation management. The broom made out of the inflorescence of this plant is sold across South and Southeast Asia and the market is expanding. However, very few studies are available on the economics and marketing of this product. This paper aims to fill the gap in understanding the growth pattern, production, and marketing of *T. maxima*.

Materials and methods

Study area

Meghalaya is located between 25°4′–26°10′ N and 89°48′–92°50′ E (Figure 1) and covers 22,429 sq. km (0.69% of the total area of India). The state is bounded by Assam in the north and east and by Bangladesh in the south and west. It has been divided into seven administrative districts (Figure 1). The soils of Meghalaya are derived from the underlying gneiss, schist, and granite. They have been grouped under the latosol (oxysol) type (Pascoe 1950). Most soils are lateritic in origin and vary from sandy loam to clay loam. The soils of the valleys and plains are more fertile than the upland soils. Organic carbon content varies between 3.2 and 6.4%. The soils are acidic in reaction with a pH range of 4.5–6.5 (Rao et al. 1990). Most of Meghalaya is situated on a plateau, which is a detached block of the Indian peninsula. In the south, the plateau is marked by deep gorges, spurs, and abrupt slopes, but the northern portion is dotted with numerous hills that gradually merge with the Brahmaputra plain.

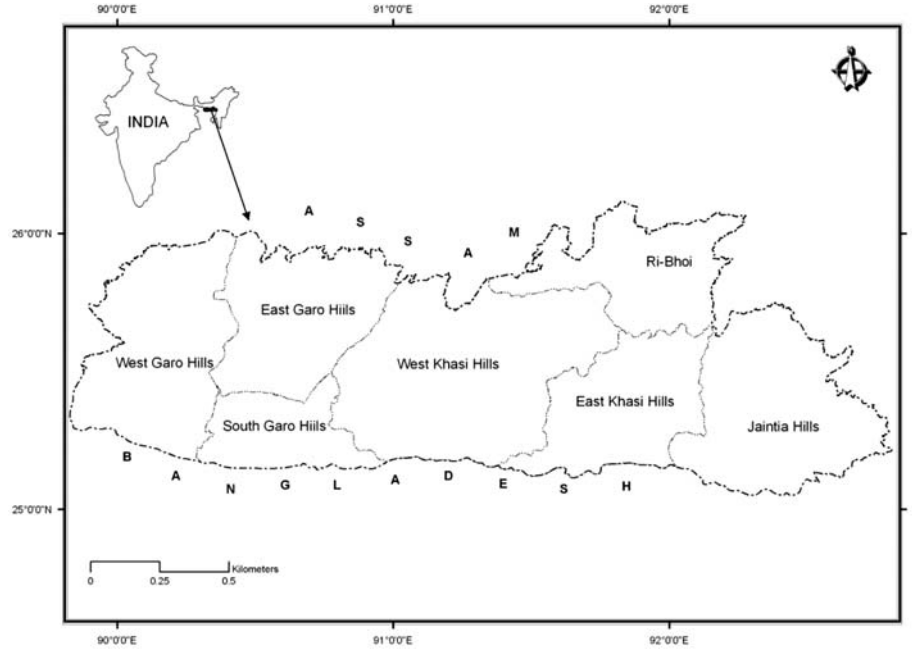

Figure 1. Location map of the study area.

According to the 2011 census, the population of Meghalaya was 2.9 million with a density of 130 persons per km^2. Most people belong to the Khasi, Garo, or Jaintia tribes and have adopted Christianity over the past 150 years.

The state is endowed with rich natural vegetation ranging from sub-tropical to tropical in relation with a diverse topography and variations in rainfall, soil, and temperature. The state harbors a rich flora and fauna once considered as one of the richest in the world (Hooker 1854). According to Forest Survey of India Report 2009, 77.2% of the state area is under forest cover. Natural forests have a very rich flora (Haridasan and Rao 1985–1987) with an estimated 3,000 flowering plants, 300 ferns, and 20 conifer species. Due to high endemism and a threat to the biodiversity, the state is considered an Indo-Burma global biodiversity hotspot.

Methods

A survey was conducted to determine the distribution of broomgrass in the state and the type of soil and climatic conditions where it grows. The plant architecture, growth pattern, leaf area index, biomass accumulation, and productivity of individual culm and tussock of *T. maxima* were studied in broomgrass plantations of ages one to four years located in and around Lakadong village (25°11′N and 92°17′E) of the Jaintia Hills district at an elevation of 850 m.a.s.l., following the methods used by Shukla and Ramakrishnan (1984, 1986). It is presumed that the soil and climatic conditions of these plantations did not differ significantly from each other. The data on growth characteristics should, therefore, be seen in light of aforementioned limitations.

The data on production, marketing, and management of broomgrass were collected through village and market surveys using semi-structured questionnaires. Published and unpublished literatures were also examined to extract relevant information related to the present study. Interviews with different groups of people were carried out regarding plantation, management, production, and economic benefit obtained from the cultivation of broomgrass in the state. Interviewees included officials of State Forest Departments, Autonomous District Councils, the Meghalaya Co-Operative Federation, and Trucks and Train Transport Agencies at Guwahati. The traders, village elders, farmers, and womenfolk were also brought in the purview of discussion to obtain and cross-check data.

Market linkages were assessed through semi-structured and structured questionnaires used to gather information from farmers, middlemen, wholesalers, exporters, and transport agencies in Shillong and Guwahati, as these cities are the commercial nodes through which most broomgrass produced in the state passes. From each category of stakeholders, namely farmers, middlemen, wholesalers, exporters, and transporters, a minimum of 10 persons was interviewed.

The economics of cultivation of broomgrass was studied through a questionnaire-based household survey conducted in 10 villages/townships, namely Kyrdemkulai, Byrnihat, Jirang, and Nongpoh in the Ri Bhoi district, Shillong, Cherrapunji, Pynursla, and Mawkynrew in the East Khasi Hills district, and Khliehriat and Shangpung in the Jaintia Hills district. In each village/township, a minimum of 10 households were interviewed. The benefit-cost ratio was calculated for one hectare area of broomgrass plantation of ages one to six years, as this is the rotation period of the plantation. The gross income was calculated by multiplying the quantity of broom produced with the prevailing sale price. The production cost includes expenses for labour and materials. The net income was computed by subtracting the production cost from the gross income. The benefit-cost ratio was then estimated by integrating realistic annual interest rates (AIRs) of 10, 15, and 20%.

Results and discussion

Distribution

Broomgrass grows in almost all parts of Meghalaya, where it covers an estimated 127 sq. km (Tiwari et al. 1995). Broomgrass grows below 1,600 m.a.s.l. on a wide range of soils. It naturally colonises areas with newly exposed soils due to land slip, road sides, abandoned quarries, abandoned jhum (shifting cultivation) areas, and waste lands. Large areas of abandoned jhum fields have also been converted to broomgrass plantations in the last two decades, due to an increase in demand for brooms from various parts of the country. The Ri Bhoi and East Khasi Hills districts account for more than 70% of the total production of brooms in Meghalaya.

Growth pattern

Broomgrass forms tussocks. The culms arise centrifugally during the peak growth period (June–July) and bear inflorescence at the end of vegetative growth. The appearance and growth of culms in a tussock depict a characteristic order that probably controls the extent of culm growth, as well as the size, number, and length of the leaves and the overall shape of the crown (Figures 2a and 2b). Broomgrass is usually planted during April and May, and peak vegetative growth takes place during June and July. The productive period starts with the flowering of the plant in the months of October to March. The inflorescence becomes ready for harvest by December and January and the harvest continues until March. The maximum height of a tussock is attained in three years, while basal girth and culms numbers continue to increase (Table 1).

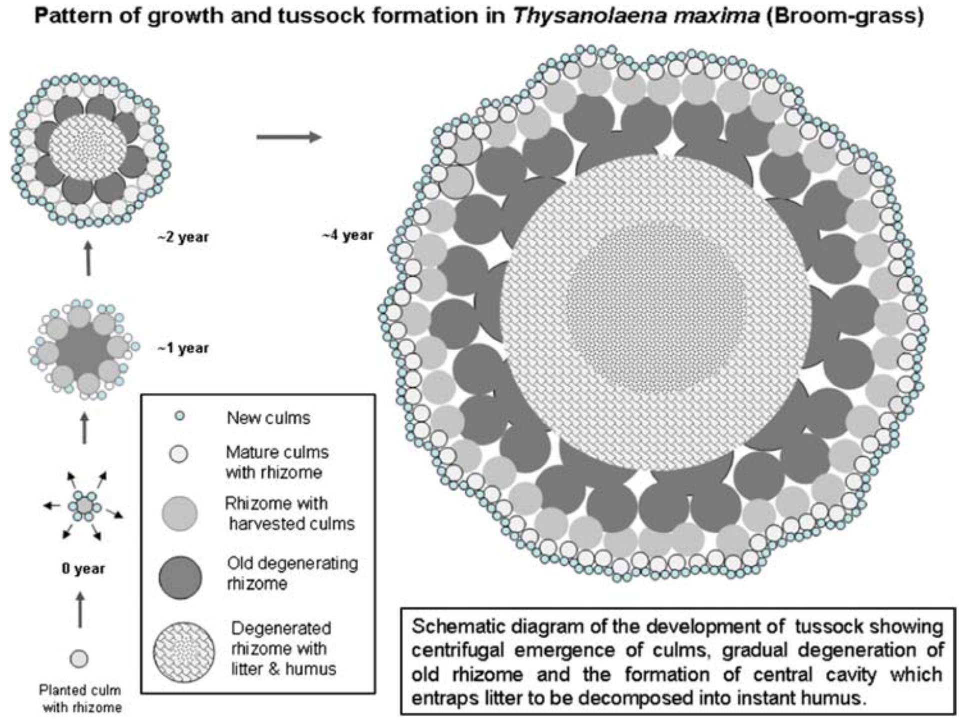

Figure 2. Centrifugal emergence and growth of tussock year-wise.

Crown structure

As the number of culms per tussock and basal area of the culms increased with age of the plantation, the growth became much more vigorous, resulting in longer internode length and larger leaf size. It caused a steady increase in the cumulative leaf area of the tussock up to year 4. The number of leaves per culm, however, remained almost unchanged due to seasonal leaf-fall. The canopy cover of the tussock was measured as the area of shade cast by its canopy when the sun was overhead. The canopy cover increased at a fast rate and reached its maximum at the end of year 4. Likewise, the Leaf Area Index (LAI) also increased fast, up to the third year of growth, but lowered down subsequently. In tussocks of four-year-old plantations, the culms laden with leaves and brooms tended to droop down, resulting in maximum canopy cover and moderate LAI (Table 2). The vigour was fairly sustained during the fourth year with a slight decrease, but it significantly decreased beyond the fifth year.

The culms grow only toward the periphery in centrifugal order. The resulting central cavity of the tussock, therefore, remains devoid of any culm. The growth of the tussocks attained its maximum toward years 3 and 4, after which the tussocks showed signs of withering from the inner side, and the area of central cavity or empty space increased significantly (Table 2). The culms emerged so closely at the periphery of the cavity that most dead leaf and other biomass remains were locked within the cavity. This consequence of the species growth pattern helps conserving nutrients in the close vicinity of the newly arising culms, which is particularly important in degraded sites prone to soil erosion.

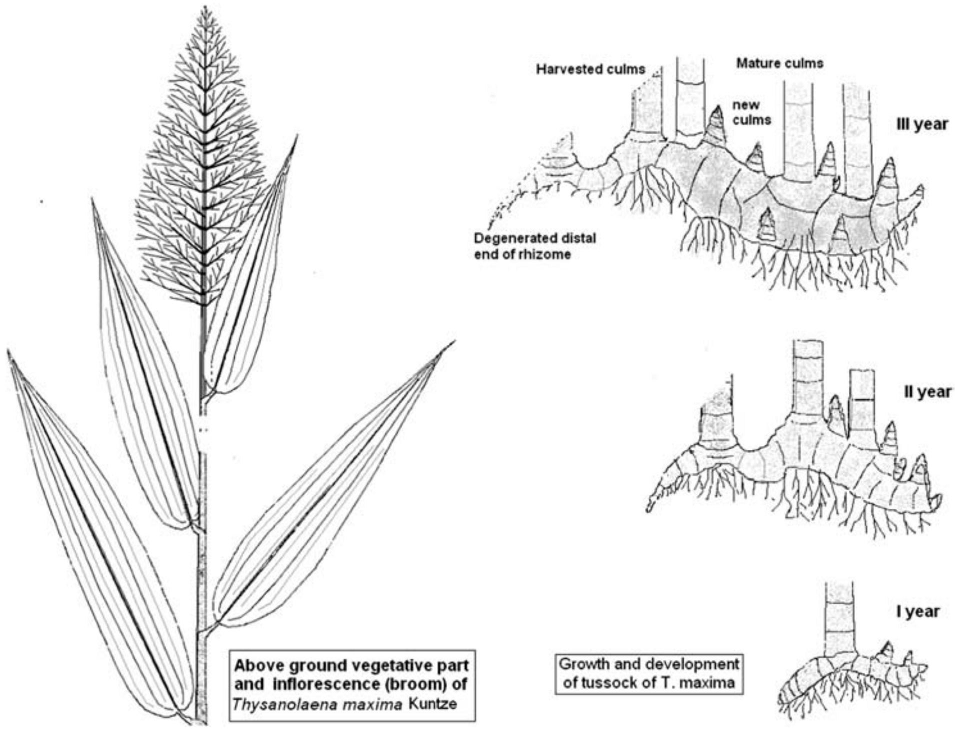

Figure 3. Part of the culm with inflorescence (broom) and year-wise growth pattern of rhizome.

Biomass and productivity

The dry weight of stems or leaves per culm did not increase significantly with the age of the tussock and the overall ratio of the leaf to stem weight per tussock during the first and second year of growth was around 1 (Table 3). The ratio, however, increased slightly during the third year and significantly during the fourth year. On the basis of measurement of reproductive allocation, it was found that the species, on average, allocated around 16% of total aboveground biomass toward its reproductive structure, that is, inflorescence that forms broom, the commercial forest produce. Total biomass per tussock increased from about half a kg at the end of the first year of growth to about 12 kg at the end of year 4. The average productivity increased up to the third year and decreased drastically beyond the fourth year onward. Farmers, however, still harvest the crops as new culms, arising during the fourth and fifth year of growth, providing some brooms even during the

Table 1. Tussock growth of *Thysanolaena maxima* in plantations of increasing age (values are mean ± SD based on 10 replicates).

	Plantation Age (Year)			
Parameters [Sample Size (n) = 10]	1	2	3	4
Height of tussock (cm)	75 ± 4.64	100 ± 4.42	180 ± 12.96	178 ± 10.84
Basal girth of tussocks (cm)	48 ± 6.62	83 ± 5.72	108 ± 8.72	170 ± 8.76
No. of culms /tussock	24 ± 3.68	67 ± 6.73	312 ± 13.45	428 ± 11.28
Basal area/culm (cm^2)	1.3 ± 0.222	1.9 ± 0.245	2.8 ± 0.249	3.5 ± 0.625

Table 2. Detailed parameters of tussock growth of *Thysanolaena maxima* in plantations of increasing age (values are mean ± SD based on 5 to 20 replicates).

Aboveground Components	Sample Size (n)	Plantation Age (Year)			
		1	2	3	4
Leaf number /culm	20	6.2 ± 0.62	7.0 ± 0.73	8.0 ± 0.92	8.2 ± 1.03
Leaf area /culm (cm^2)	20	445.7 ± 21.44	520.7 ± 28.81	956.6 ± 37.93	1102.2 ± 59.75
Internode length (cm)	20	7.5 ± 0.66	13.6 ± 0.58	25.8 ± 1.07	26.9 ± 11.28
Leaf number/tussock	10	148.8 ± 9.03	470.4 ± 14.592	2496 ± 75.44	3424 ± 96.8
Leaf area /tussock (cm^2)	10	11056 ± 627.9	34997 ± 655.1	298521 ± 11238.	472512 ± 6929.4
Area of canopy cover (cm^2)	10	4416 ± 78.24	20096 ± 536.11	42983 ± 646.24	66162 ± 812.0
Leaf Area Index (LAI)	10	2.5 ± 0.149	1.7 ± 0.294	6.9 ± 0.254	4.9 ± 0.316
Area of central cavity (cm^2)	05	22.8 ± 4.13	84.9 ± 8.99	162.8 ± 16.65	314.0 ± 50.38

sixth year. The observations were not extended beyond the fourth year due to disarrayed patterns in vigour loss.

Management of broomgrass plantations

In the last two decades, the demand for broom has increased manifold. This motivated many erstwhile shifting cultivators to take up cultivation of this plant, resulting in increased income (Tiwari et al. 1995). Broomgrass is grown either in monoculture or as an intercrop with *Artocarpus intergrifolia* Linn., *Citrus* spp., *Ananas comosus* (Linn.) Merr., *Psidium guajava* Linn., *Cinamomum tamala* (Buch.-Ham.) T. Nees & Nees, and *Michelia champaca* Linn. In degraded forests and wastelands, where the root stocks are available after slashing and burning the vegetation, broomgrass naturally colonizes the land within short periods, whereas in fallows and cultivated lands, natural regeneration does not occur and broomgrass is thus planted. The rhizome of broomgrass from wild habitat is collected and cultivated in the cleared fields. In case of intercropping, the spacing of plantations varies from 3 m × 3 m to 5 m × 5 m, depending on the associated crop. Whereas in monoculture, the spacing is kept 2 m × 2 m, resulting in a density of at least 16 tussocks per 10 m × 10 m plot. Cleaning and weeding is done one month after burning. Farmers remove weeds, shrubs, and climbers and leave only a few trees. Weeding is absolutely essential during the

Table 3. Pattern of change in aboveground biomass and broom material of *Thysanolaena maxima* in plantations of increasing age at Lakadong village in the Jaintia Hills district.

Parameters	Sample Size (n)	Plantation Age (Year)			
		1	2	3	4
a. Mean number of culms/tussock	10	24	67	312	428
b. Stem dry weight (g /culm)	10	17 ± 2.055	18.8 ± 2.898	30.0 ± 3.30	20.5 ± 3.894
c. Leaf dry weight (g/culm)	10	6.0 ± 1.491	7.0 ± 1.154	8.2 ± 1.032	8.0 ± 1.247
d. Mean dry weight (g/tussock)	a (means of b + c)	552	1729	11918	12198
e. Average aboveground productivity (g/tussock/yr)	Annual increment of aboveground biomass	–	1177	10189	280
g. Dry broom material (g/tussock)	d × 16.2%	89.4	280	1931	1976

first two years of growth. For proper growth twice a year, weeding is carried out. A cattle-proof fence is required to protect the plantation area due to high palatability of the leaves. Adequate fire prevention measures need to be taken during the dry and winter months. The plantations are generally burnt after five or six years and a new plantation is established.

Production and processing

The quality of broom depends upon the time of harvesting. Shorter inflorescences, generally collected in the early stages of inflorescence development, are considered the best quality. The product is classified under three categories:

(a) Class-(I) or best quality: those types in which the flower has not yet opened and are collected in the months of January and February.
(b) Class-(II) or medium quality: those types that are cut immediately after flowering and are collected in the months of (late) February and March.
(c) Class-(III) or inferior quality: those types that have remained in the culms for longer periods and are collected in the months of April and May.

After harvesting, the product is transported to homestead for processing, which is usually a simple process. A frame-like structure in the form of trays made of bamboo is used for drying the inflorescence. Sometimes, the inflorescences are tied in small bundles and hanged over fixed bamboo poles. The drying operation is done over three to four days for hardening the stems in order to prevent rotting. The product is then packed in large bundles and transported to the market or stocked in one place in the villages to sell to middlemen or traders. The majority of the product enters the market and is transported to other places at this level of processing only. Value addition, that is, the making of broom, is done manually by very few households and for a small quantity of the total harvest.

Meghalaya has now emerged as one of the largest producers and exporters of broomgrass in the country. Ninety percent of the brooms produced are exported outside the state. The production of brooms in Meghalaya from the years 2004 to 2009 is given in Table 4. There is a trend of an increase in production, price, and growers' income. This may be attributed to the expanding market for the product. The steady increase in the price shows that the price was regulated by external demand. The drop in price during 2005 and 2006 may be attributed to the doubling in the production within a year, possibly causing a glut in the market. However, during the subsequent years, when production either increased moderately or plateaued, the price continued to increase.

Marketing linkages

The brooms produced in Meghalaya find their way to local, national, and international markets. The brooms are brought to transit points through middlemen and wholesale

Table 4. Annual production of broom (dry inflorescence) and cash income to farmers in Meghalaya.

Year	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009
Production (metric tonnes)	12,873	25,083	27,966	28,347	25,963
Price (INR per metric tonne)	20000	12000	20000	27000	45000
Total annual cash income to farmers (million INR)	257.46	300.99	559.32	765.37	1168.3

Note: Khasi, Jaintia, and Garo Hills District Councils Statistical Abstracts.

dealers. In some cases, the farmers/producers themselves bring the product to the main market in Shillong where it is bought by wholesale dealers.

The local demand is met by the petty retailers who buy brooms from wholesale dealers. The supply for other states and countries is transported by road or railway through the regional traders/wholesalers of Guwahati and Dhudnei (Assam). The quantity of export depends mainly on the orders received from the various dealers across the country.

Since broom is considered as a forest product, royalty has to be paid, at the rate of INR 360/metric ton to the Autonomous District Councils (ADCs) for trading outside the state. On average, a truck can carry six metric tons and the cost of transportation per truck from Shillong up to Guwahati is INR 8000. Once the royalty is paid, a transit pass is issued that is valid until the product reaches the destination. Moreover, each and every truck should have a Certificate of Origin (C.O.) given by the *Syiem Hima* or *Lyngdoh* (traditional chiefs who administer a political boundary and are empowered to issue the C.O. by the Autonomous District Councils) to verify that the product is not brought from elsewhere. Apart from paying a purchase tax, sales tax, and so forth, the traders face problems due to existence of informal check gates in a number of places, especially in Assam. According to the interstate traders, around INR 6000–7000 per truck carrying six tonnes of broom is paid at these informal (read illegal) check posts. Thus, traders are bound to decrease the purchase price of broomgrass to compensate this expense and poor cultivators have to bear the burden of the informal (read illegal) tax collection.

A huge amount of broom is transported from Shillong to other parts of the country via Guwahati through road and railways. The brooms are exported in a raw and unprocessed form to various parts of India. According to the traders operating from Guwahati, the brooms are also exported to other countries like Pakistan, the Middle East, and European countries such as France, Italy, and Germany.

Economics of broomgrass cultivation

Broomgrass cultivation provides a good profit to the growers. The yield varies between 300 and 500 kg of inflorescence (broom material) per hectare, depending upon the quantity

Table 5. Cost-benefit analysis for one-hectare plantation area.

	Year						
	1	2	3	4	5	6	Total
Revenue	3,000	5,200	9,570	12,350	4,500	900	35,520
Production Cost	3,700	1,400	1,550	1,550	850	400	9,450
Labour							
1. Site Clearance	1000						1000
2. Weeding (twice/year) and Harvesting (once/year)	1200	1200	1200	1200	650	250	5700
3. Pit Digging and Rhizome Planting	800						800
4. Transportation to Godown	200	200	350	350	200	150	1450
Materials							
Small Tools and Implements	500						500
Net Income	−700	3,800	8,020	10,800	3,650	500	26,070

Note: Benefit-cost ratio at 10% annual interest rate (AIR) = 3.46; benefit-cost ratio at 15% AIR = 3.32; benefit-cost ratio at 20% AIR = 3.19.

of planting materials, the fertility of the land, and the cultural practices adopted for maintenance. The yield also differs according to the age of the plantation. From a one-year-old plant, less than 0.1 kg of broom is obtained. The highest yield of inflorescence is obtained from three- and four-year-old plants, which is about 2 kg per plant (Table 3). The yield then begins to decline, and in the fifth year, the average yield is 1.5 kg, while in the sixth year, only 0.5 kg of produce per plant is obtained. Similarly, production costs differ for different years. During the first year, the grower has to invest in small tools, implements, and labour, resulting in the highest production cost (Table 5). The growers obtain benefits from the second year onward. From one hectare area, the grower can generate an annual profit ranging from INR 500 to 11,000 solely from the sale of the inflorescence as brooms. The benefit obtained by the growers varies according to labour efficiency, wages, soil fertility, cultural practices, market price and demand, and so forth. The benefit-cost ratio calculated at 10, 15, and 20 AIRs showed that the ratio varied between 3.19 and 3.46.

Conclusion

Broomgrass cultivation is promoted and protected on wastelands, in degraded forests, and in erstwhile shifting cultivation areas of the state. Its domestication in Megalhaya may be attributed to the plant adaptability, to high profit from cultivation, and to the high market demand due to decreasing production in natural forests. The leaves are used as fodder in fodder scarce areas and stems are used as raw material in paper industries and small-scale cottage industries for making mats (Tiwari 2001). However, full utility potential of the broom stem in industries is yet to be realized. In addition to this, the broomgrass, having fibrous root, can bind the soil particles and prevent soil erosion on hill slopes (P.S. Nongbri, personal communication).

Our findings highlighted that cultivation, processing, and marketing of broomgrass are economically viable cropping practices in Meghalaya due to an ever growing demand. The value chain has developed and the growers are receiving a good return for their investments. The trade benefits almost all sections of society, as the landowners benefit from the cultivation, the landless benefit by working as daily wage labour, and the traders and the transporters earn their livelihood by marketing the produce. As a result, broomgrass plantation is gradually becoming popular in rural Meghalaya, particularly among the marginal and subsistence farmers. Even without any external intervention, the farmers are getting good returns because of low investment and quick production, as broomgrass may begin to be harvested one year after planting (Tiwari 2001).

The broomgrass could become an effective instrument for rural development because its cultivation needs minimum input and labour and generates a very attractive economic return. Availability of vast areas of wastelands in the country favors the adoption of a large-scale cultivation of broomgrass in the northeastern states in general and in Meghalaya in particular. Thus there is a need to further evaluate the impact of large-scale plantations of broomgrass on the environment and to develop a management regime to ensure conservation of soil and water while enhancing the livelihood of the rural poor.

Acknowledgements

The authors are thankful to the National Afforestation and Eco-Development Board, Ministry of Environment and Forests, Government of India and Center for International Forestry Research, Bogor, Indonesia, for providing financial assistance. The authors thank Somendro for preparing the maps. They are also grateful to Dr. Hubert de Foresta and two anonymous reviewers for critical comments and suggestions toward improvement of the paper.

References

Arnold JEM, Ruiz Perez M. 1998. The role of non-timber forest products in conservation and development. In: Wollenberg E, Ingles A, editors. Incomes from the forests. Methods for the development and conservation of forest products for local communities. Bogor (Indonesia): CIFOR. p. 17–41.

Arnold JEM, Ruiz Perez M. 2001. Can non-timber forest products match tropical conservation and development objectives? Ecol Econ. 39:437–447.

Bisht NS, Ahlawat SP. 1998. Broomgrass. SFRI, Information Bulletin No. 6. Arunachal Pradesh (Itanagar): State Forest Research Institute.

Chopra K. 1993. The value of non-timber forest products: An estimation for tropical deciduous forests in India. Econ Bot. 47:251–257.

Gangwar A. K, Ramakrishnan PS. 1990. Ethnobiological notes on some tribes of Arunachal Pradesh, northeastern India. Econ Bot. 44:94–105.

Haridasan K, Rao RR. 1985–1987. Forest flora of Meghalaya. Volumes I and II. Dehra Run (India): Bishen Singh and Mahendra Pal Singh.

Henkemans AB. 2001. Tranquilidad and hardship in the forest livelihoods and perceptions of Camba forest dwellers in the northern Bolivian Amazon [dissertation]. Utrecht (The Netherlands): Utrecht University.

Hooker JD. 1854. Himalayan journals. 2 vols. London (UK): John Murray.

Mallik RH. 2000. Sustainable management of non-timber forest products in Orissa: Some issues and options. Indian J Agri Econ. 55:384–397.

NHD (National Human Development Report). 2002. Planning commission, government of India. Available from: http://www.igidr.ac.in/conf/ysp/nhd2001.pdf.

Neumann RP, Hirsch E. 2000. Commercialization of non-timber forest products: Review and analysis of research. Bogor (Indonesia): CIFOR.

Pascoe EH. 1950. A manual of the geology of India and Burma. Vol 1. 3rd Ed. Calcutta (India): Government of India Press.

Ramakrishnan PS. 1985. Conservation of rainforests in northeastern India. In: Singh JS, editor. Environmental regeneration in the Himalaya: Concepts and strategies. Nainital (India): Central Himalayan Environment Association. p. 69–84.

Rao P, Barik SK, Pandey HN, Tripathi RS. 1990. Community composition and tree population structure in a sub-tropical broadleaved forest along a disturbance gradient. Vegetat. 88:151–162.

Ros-Tonen MAF. 2000. The role of non-timber forest products in sustainable tropical forest management. Holz als Roh-und Werkstoff. 58:196–201.

Ros-Tonen MAF, Wiersum KF. 2003. The importance of non timber forest products for forest based rural livelihoods: An evolving research agenda. Paper presented at the GTZ/CIFOR International Conference on Livelihoods and Biodiversity, Bonn, Germany.

Shakleton SE, Campbell BM. 2007. The traditional broom trade in Bushbuckridge, South Africa: Helping poor women cope with adversity. Econ Bot. 61:256–268.

Shankar U, Lama SD, Bawa KS, Shankar U. 2001. Ecology and economics of domestication of non-timber forest products: An illustration of broomgrass in Darjeeling Himalaya. J Trop For Sci. 13:171–191.

Shukla RP, Ramakrishnan PS. 1984. Biomass allocation strategies and productivity of tropical trees related to successional status. For Ecol Manage. 9:315–324.

Shukla RP, Ramakrishnan PS. 1986. Architecture and growth strategies of tropical trees in relation to successional status. J Ecol. 74:33–46.

Tiwari BK. 2000. Non-timber forest produce of North East India. J Hum Ecol. 11:445–455.

Tiwari BK. 2001. Domestication of three non-traditional species by shifting cultivators of north-east India. In: International Fund for Agricultural Development, International Development Research Center, Cornell International Institute for Food, Agriculture and Development, International Center for Research in Agroforestry and International Institute of Rural Reconstruction. Shifting cultivation-towards sustainability and resource conservation in Asia. Cavite (Philippines): IIRR Publisher. p. 98–104.

Tiwari BK, Kumar C. 2008. Forest products of Meghalaya: Present status and future perspective. Shillong (India): Regional Centre National Afforestation and Eco-Development Board, North-Eastern Hill University.

Tiwari BK, Tripathi RS, Barik SK. 1995. Broomstick plantation in Meghalaya: A success story. Shillong (India): Regional Centre National Afforestation and Eco-Development Board, North-Eastern Hill University. p. 20.