Agriculture and Natural Resources 51 (2017) 20–24

Contents lists available at ScienceDirect

Agriculture and Natural Resources

journal homepage: http://www.journals.elsevier.com/agriculture-and-natural-resources/

Original Article

Cultivation, production and management techniques of broom grass (*Thysanolaena maxima* Roxb.) in hilly areas of Bangladesh

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ARTICLE INFO

Article history:
Received 26 March 2015
Accepted 30 August 2016
Available online 20 February 2017

Keywords:
Artificial plantation
Chemical properties of soil
Rhizome cutting
Thysanolaena maxima
Yield

ABSTRACT

This paper presents the results on appropriate cultivation, plantation, production and management techniques of *Thysanolaena maxima* for domestication at age 1–4 yr (grown 2007–2011). Rhizome cuttings were planted in research experimental plots at spacings of $T_1 = 1.0$ m × 1.0 m, $T_2 = 1.5$ m × 1.5 m and $T_3 = 2.0$ m × 2.0 m in a randomized complete block design with six replications and three treatments. The results showed that the number of panicles produced was 1048, 41,237, 78,737 and 105,094 in year 1 to year 4, respectively. The average total green weight (kg/plot) was 10.26, 632.15, 423.34 and 543.40 and the average dry weight (kg/plot) was 9.88, 287.65, 216.93 and 241.60 in year 1 to year 4, respectively. Composite soil samples were collected and the soil pH values of the surface soil from the different treatments varied from 5.1 to 5.2. There was no significant difference among the treatments in the available P and S. The available Ca, Mg and K were higher in the T_3 treatment compared with the other treatments. Planting rhizome cuttings at 2.0 m × 2.0 m spacing gave the maximum broom/panicle production.

Introduction

Bangladesh is situated in the northeastern part of South Asia between 20°34′N and 26′ 38′N and 88°10′E and 92°41′E. It has an area of 1,47,570 km^2 and a population of 152.25 million (Bangladesh Bureau of Statistics, 2014). Forest makes up 16.7% of the country with 6.5% under tree cover and in addition, village forests composed of woodlots and other multipurpose fast-growing trees, bamboo, cane and shrubs cover 0.27 million ha (Kibria et al., 2000). The forests of Bangladesh are very rich floristically with diverse ecosystems in which trees are a major component of the forest ecosystem as Bangladesh is a transitional zone between the flora and fauna of the subcontinent and that of Southeast Asia, because of her geographic location at the eastern end of the Indian subcontinent (Stanford, 1991).

The forests of Bangladesh are generally uneven aged and multistoried. Based on tree height, the floristic composition is divided into both a top and a middle canopy or storey and the species growing on the forest floor as undergrowth. Ecologically the forest of Bangladesh is classified into four major forest types: tropical wet-evergreen, tropical semi-evergreen, tropical moist-deciduous and tidal (Das, 1990). Broom grass (*Thysanolaena maxima* (Roxb.) O. Ktze) of the family Poaceae is a tall, tufted, reed-like perennial grass which grows well along hill sides (Bor, 1960; Clayton and Revoize, 1986). Its inflorescence is made into brooms, hence its common name and it is also known as *Chorondhora*, *Arjunphool* and *Mio* in the Chittagong Hill Tracts and as *Phool jhadu* in general (Alam, 2007). It grows naturally in temperate and subtropical parts of India, Bhutan, Myanmar, China, East Asia, Nepal, New Guinea and Malaysia up to 2000 m elevation (Watson and Dallwitz, 1992). It flowers during June–July and bears inflorescence on the shoot apex at the end of vegetative growth. It is an important non-timber forest resource and is widely used for cleaning floors, lime washing of building walls, it leaves and tender culms make good forage and its woody culms are used for fuel and

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http://dx.doi.org/10.1016/j.anres.2016.08.006

as mulch material (Mohiuddin and Alam, 1987). It also has medicinal value, with a decoction of the roots used as a mouthwash during fever and the dried paste of fresh roots is applied on the skin to check boils (Rai and Sharma, 1994). Its tender twigs are good cattle feed for improving milk production and also elephants feed on the whole plant and there are also reports that its fruits have antifertility properties (Mudgal and Pal, 1980).

The plant has a significant role in the conservation of soils of the denuded hilly areas (Khisa et al., 1999) and has been identified as an important non-timber economic forest product for integrating hill farming and agroforestry systems (Alam, 1995, 1998). Its fibrous root mat effectively protects the top soil and nutrients from erosion on hill slopes, in landslides affected areas and in agricultural fields as the water run-off and soil loss are reduced by up to 88% compared with bare areas (Bhuchar, 2001; Sharma et al., 2001).

In Chittagong and the Chittagong Hill Tracts of Bangladesh, broom grass is collected by the tribal ethnic community and local people during November–March from its natural habitat. It is also traded at a high price at home and abroad and is exported to the Middle East, Pakistan and Japan as a non-traditional product (Alam et al., 2013). However, scarce information is available on its cultivation, management and production system (Barik et al., 1996).

Considering the increasing demand for this produce, it is necessary to determine its cultivation and management techniques on the fallow and marginal lands in the forest in hilly areas of Bangladesh. The present study aimed to develop appropriate cultivation, plantation, production and management techniques for *T. maxima*.

Materials and methods

Description of the research site

The experiment was carried out during 2007–2011 at the Keochia Silvicultural Research Station, Satkania, Bangladesh Forest Research Institute, Chittagong, Bangladesh. It is situated at 22°11′N and 92°13′E and is 45 km south of Chittagong city. It lies on both sides of the Bandarban Road at 3 km east from the Chittagong-Cox's Bazar Road transect and parts of Keochia, Sharashia, Mahalia and Sodaha Mouzas of Satkania Upazilla are located within the station boundary.

The topography of the experimental site is hilly to flat having an altitude of 15 m above mean sea level with medium to gentle slopes. The annual rainfall ranges from 3000 mm to 3200 mm with a minimum annual temperature of 21.4 °C and a maximum of 33.4 °C. The soil is brown with stones and small gravel pieces and is shallow to deep with good drainage conditions; the soil texture is a sandy loam to sandy clay loam (Hossain et al., 1989; Hassan et al., 1992).

Preparation of propagules

In total, 950 rhizomes of *T. maxima* were collected from the Bandarban hill district. The culms were cut to obtain stem lengths of 15–20 cm with roots. These were cut into pieces of length 5–10 cm each weighing 40–60 g and having one or two dormant buds. Then, 700 rhizome cuttings were sorted for setting in nursery beds for sprouting new shoots. After 2 mth, 648 rhizome cuttings were selected for planting in the experimental area.

Experimental design and treatments

The planting site was cleared and made free from weeds through jungle cutting and weeding. A total of 648 rhizome cuttings was required for the 0.1628 ha experimental plot. Three spacings—T_1 = 1.0 m × 1.0 m, T_2 = 1.5 m × 1.5 m and T_3 = 2.0 m × 2.0 m—were laid out in six replications using a randomized complete block design. The pit size was 25 cm × 25 cm × 20 cm with 36 rhizomes per plot. Emerging and established plantations were protected from cattle browsing and grazing and from uprooting by wild boars.

Data collection

Data were collected from the experimental plot at three times (September, December and March) annually. Data on the survival percentage, number of culms produced, culm length, culm diameter, leaves produced per tussock, leaf length and broom length were collected. Biomass production as green weight and sun dried weight was also measured. Brooms were harvested depending on maturity during January–March when the inflorescence became tough and had changed color to light green/red. Harvesting of mature brooms was done very carefully. Every year, broom panicles were collected in January–February and dried for up for 30 d in full sunshine. The culms were harvested by cutting with a pair of sharp scissors 35–40 cm above the ground. The panicle was collected by hand pulling and properly sun dried for 25–30 d.

Soil sample collection and analysis

Soils samples were collected from the selected site. Each sample was a composite sample of three subsamples. The soil samples were put into polythene bags for transporting to the laboratory. Soil samples were air dried, ground, sieved (to less than 2 mm) and preserved in plastic bottles.

Soil pH (soil to water ratio of 1:2.5), organic matter (Walkley and Black, 1934), total N content (micro Kjeldahl distillation method) and available soil P (Bray and Kurtz, 1945) were determined using the ascorbic acid blue color method (Murphy and Riley, 1962) and available soil S (Fox et al., 1964) was determined using the turbidimetric method (Hunt, 1980). Available Ca and Mg in the soil were extracted using 1 N neutral ammonium acetate solution followed by atomic absorption spectrophotometry and K in the soil was extracted using the same method with a flame photometer.

Statistical analysis

Analysis of variance (ANOVA) for the randomized complete block design was performed using the SPSS software package (SPSS Inc.; Chicago, IL, USA). Duncan's Multiple Range Test at $p < 0.05$ and $p < 0.01$ was used when an ANOVA table indicated that there were significant treatment effects (Steel et al., 1997).

Results and discussion

Spacing of the rhizomes significantly influenced the mean growth production parameters of above ground vegetation of broom grass at different ages (Table 1 and Fig. 1). Initially (year 1) the maximum number of culms produced (35) was observed in T_1, maximum culm length (73.31 cm) in T_2, maximum culm diameter (5.8 cm) in T_3, maximum number of leaves per tussock (13) in T_3, maximum leaf length (15.51 cm) in T_3 and the maximum broom length (12.24 cm) was attained in T_3. Similar trends were also observed in the second year. At age 4 yr, it was observed that the maximum number of culms (3235), maximum culm length

Table 1
Growth performance of broom grass under different treatments in the experimental plots.

Year	Treatment[†]	Average[‡]					
		Culms produced	Culm length (cm)	Culm diameter (cm)	Leaves per tussock	Leaf length (cm)	Broom length (cm)
1	T_1	35.00^a	56.21^c	3.30^c	8.00^c	10.18^c	8.32^c
	T_2	29.00^b	73.31^a	4.38^b	11.00^b	13.24^b	9.60^b
	T_3	27.00^c	69.80^b	5.80^a	13.00^a	15.51^a	12.24^a
	F	402.82	2183.95	175.48	74.85	506.15	176.73
	p	0.000	0.000	0.000	0.000	0.000	0.000
	Significance	**	**	**	**	**	**
2	T_1	1347.00^a	75.80^c	4.81^c	15.00^b	18.44^b	15.21^b
	T_2	1183.00^c	132.36^a	5.84^b	14.00^b	12.49^c	18.14^b
	T_3	1237.00^b	105.97^b	6.46^a	18.00^a	24.00^a	22.78^a
	F	731.67	11714.20	37.20	14.19	821.08	542.73
	p	0.000	0.000	0.000	0.006	0.000	0.000
	Significance	**	**	**	**	**	**
3	T_1	2214.00^b	119.22^c	6.58^b	20.00^c	27.33^b	26.75^b
	T_2	2214.00^c	121.51^b	7.16^a	23.00^b	28.99^b	25.55^c
	T_3	2625.00^a	133.01^a	6.42^c	25.00^a	32.80^a	30.66^a
	F	542.90	256.90	7.50	17.70	24.40	112.00
	p	0.000	0.000	0.021	0.013	0.0015	0.000
	Significance	**	**	*	*	*	**
4	T_1	3150.00^b	139.70^c	7.60^a	26.00^c	33.00^{ab}	32.70^b
	T_2	2931.00^c	151.90^b	7.40^b	27.00^b	34.10^a	33.00^{ab}
	T_3	3235.00^a	168.80^a	6.70^c	29.00^a	32.50^b	33.70^a
	F	2390.50	621.20	12.50	10.20	4.50	3.40
	p	0.000	0.000	0.000	0.015	0.019	0.040
	Significance	**	**	**	*	*	*

[†] T_1 = 1.0 m square spacing, T_2 = 1.5 m square spacing, T_3 = 2.0 m square spacing, *F* and *p* are standard statistical parameters; * = significant at $p < 0.05$, ** = significant at $p < 0.001$.
[‡] Values are the mean of three treatments and values with different superscript letters differ significantly at the 5% and 1% level.

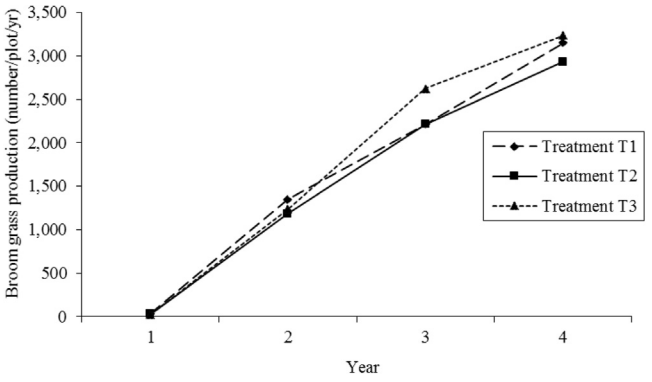

Fig. 1. Average broom grass production with different treatments at 4.7 yr.

(168.8 cm) and maximum number of leaves per tussock (29) were observed in T_3 followed by T_1 and T_2, respectively, which were different at the 1% level of significance.

A similar trend was also found in yield and biomass production (Table 2). Initially (year 1) the maximum number of broom panicles per year (32) and green weight (10.26 kg) were found at the closest spacing (T_1) followed by T_3 (26 and 7.5 kg, respectively) and T_2 (22 and 6.7 kg, respectively). However, the maximum dry weight of broom (9.88 kg) was found at the widest spacing (T_3) followed by T_1 (4.18 kg) and T_2 (2.28 kg). At age 3 yr and 4 yr, the maximum number of harvested broom panicles per year (2149 and 2840, respectively) and dry weight (216.93 and 241.6 kg, respectively) were recorded at the widest spacing (T_3) and these were significant, but the green weight maximum among treatments was recorded in the T_2 treatment for age 2 yr and 3 yr with values of 632.15 kg and 423.34 kg, respectively.

At age 4.7 yr, the maximum number of harvested broom panicles was found growing in soil having the maximum depth

Table 2
Production of *T. maxima* at age 4.7 yr in the experimental plots.

Year	Treatment[†]	Harvested broom/ panicle[‡] (number)	Total weight[‡] (kg)		Average soil depth[‡] (cm)
			Green	Dry	
1	T_1	32^a	10.26^a	4.18^b	11.39^a
	T_2	22^c	6.7^c	2.28^c	9.56^c
	T_3	26^b	7.5^b	9.88^a	10.45^b
	F	55.37	100.19	100.19	9.94
	p	0.000	0.000	0.000	0.002
	Significance	**	**	**	**
2	T_1	1112^a	550.69^b	261.1^b	18.62^c
	T_2	903^c	632.15^a	287.65^a	22.58^b
	T_3	1057^b	504.08^c	234.1^c	24.6^a
	F	573.10	746.53	385.39	75.78
	p	0.000	0.000	0.000	0.000
	Significance	**	**	**	**
3	T_1	1976^b	365.95^c	183.24^b	29.94^c
	T_2	1737^c	423.34^a	181.29^c	31.04^b
	T_3	2149^a	370.19^b	216.93^a	32.91^a
	F	5298.60	557.90	384.30	6.80
	p	0.000	0.000	0.000	0.030
	Significance	**	**	**	*
4	T_1	2449^c	485.1^c	203.4^b	33.9^b
	T_2	2532^b	491.5^b	195.5^c	33.9^b
	T_3	2840^a	543.4^a	241.6^a	35.3^a
	F	5995.00	619.90	334.20	8.90
	p	0.000	0.000	0.000	0.001
	Significance	**	**	**	**

[†] T_1 = 1.0 m square spacing, T_2 = 1.5 m square spacing, T_3 = 2.0 m square spacing, *F* and *p* are standard statistical parameters; * = significant at $p < 0.05$, ** = significant at $p < 0.001$.
[‡] Values are the mean of three treatments and values with different superscript letters differ significantly at the 5% and 1% level as indicated by the asterisks.

(Table 2), with numbers being 1048, 41,237, 78,737 and 105,094 for plantations aged 1 yr–4 yr, respectively. The maximum yield was recorded in year 3 and year 4. Biomass production (panicles) of broom grass increased from year 2. Barik et al. (1996) reported that culms and broom production in a plantation increased till the

fourth year after planting and then declined. The maximum biomass production from the rhizome-propagated culms was in year 3 and declined thereafter (Bhuchar, 2001). In the current experiment, the yield of broom grass (number of panicles/ha) was 41,237, 78,737 and 105,094 in years 2, 3 and 4, respectively. Consequently, harvesting of broom grass started from year 2 (Fig. 2).

The soil pH values of the surface soil from the different treatments varied from 5.1 to 5.2. The organic matter content of the surface soil was higher in the T_3 treatment and lower in the T_2 treatment. The total N content was higher in the T_1 treatment followed by the T_3 and T_2 treatments, respectively. There was no significant difference among the treatments for the available P and S. The available Ca, Mg and K were higher in the T_3 treatment compared to the other treatments (Table 3). Naturally, broom grasses grow well on the steep slopes and undisturbed fallow areas of Chittagong and the Chittagong Hill Tracts where no management is required (Khisa et al., 1999). However, the experiment was set on a gentle hill slope and it needed care and maintenance to be economically viable. In an artificial plantation, 2–3 weeding sessions during the first 2 yr are essential and commercial cultivation needs protection from grazing animals and wild boar as well as from fire during the dry season (Khisa et al., 1999). Consequently, broom grass production may vary from area to area both in natural and artificial plantations. Regardless, the growth and yield of broom grass mainly depends upon the quality of the planting material, type of land and cultural practices (Bisht and Ahlawat, 1998).

In summary, the experiment revealed that 2.0 × 2.0 m spacing produced the maximum number of brooms/panicle in strongly acid soil. Though broom grass is naturally grown in the steep hilly areas of Chittagong and the Chittagong Hill Tracts, Bangladesh, it is possible and there is a need to grow it in artificial plantations due to the increasing population resulting in increased local and export demands. Not only abroad, but also in Bangladesh it is a profitable cash crop and development of a cottage based industry in the Chittagong Hill Tracts. This paper provides guidelines for the scientific cultivation, production and proper management of *T. maxima* in the hilly areas of Bangladesh.

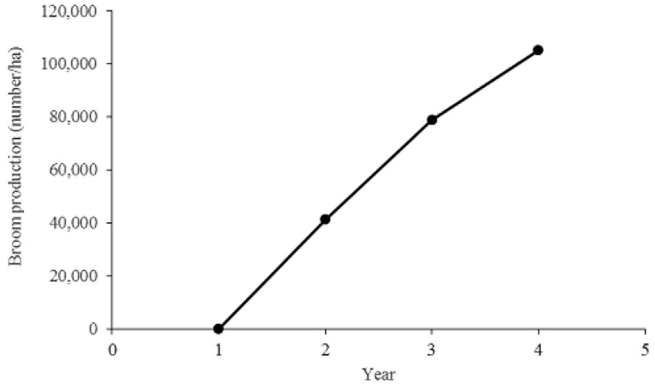

Fig. 2. Cumulative broom grass production.

Table 3
Important chemical properties of soil samples from broom grass experimental plots of Keochia Silvicultural Research Station.

Treatment†	pH	Organic matter	Ca	Mg	K	Total N	P	S
		(%)	(cmol/kg soil)			(%)	(μg/g)	
T_1	5.1	1.2	2.92	0.85	0.24	0.13	3	8.5
T_2	5.2	0.69	1.54	0.29	0.18	0.09	3	9
T_3	5.2	1.19	3.16	1.56	0.31	0.12	3	8.5
F	1.134	11.512	11.927	5.444	5.107	6.486	0.000	0.033
p	0.348	0.001	0.001	0.017	0.020	0.009	1.000	0.967
Significant	NS	**	**	*	*	*	NS	NS

† T_1 = 1.0 m square spacing, T_2 = 1.5 m square spacing, T_3 = 2.0 m square spacing, *F* and *p* are standard statistical parameters; * = significant at $p < 0.05$, ** = significant at $p < 0.001$, NS = not significant.

Conflict of interest

None.

Acknowledgements

The authors are thankful to Dr Md Khairul Alam, Chief Research Officer (retired) and Mr Md Zashimuddin, Divisional Officer (retired) for their cooperation and critical suggestions in designing this experiment and preparing the manuscript. Thanks are also due to Mr Pradip Kanti Das, Forest Ranger, and to all the staff at the Keochia Silvicultural Research Station, Bangladesh Forest Research Institute for their assistance in maintaining the experiment.

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