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## RESEARCH ARTICLE

# EFFECT OF PLANT DENSITY ON GROWTH AND YIELD OF *THYSANOLAENA MAXIMA*: AN IMPORTANT NON-TIMBER FOREST PRODUCT OF MEGHALAYA

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**ABSTRACT**

*Thysanolaena maxima* is a wild grass cultivated by the farmers of Meghalaya. When the demand for broom increased, many erstwhile shifting cultivators got motivated to take up cultivation of this plant. In this paper, we report the findings of field experiments conducted to investigate the effect of plant density on growth and yield of *T. maxima*. The experiments were laid in Mynska village of Meghalaya and the study was conducted between July 2012 and February 2014 using Randomized Complete Block Design with four replicates and five spacing treatments. The study revealed that the growth and yield parameters are not impacted by plant density during the first year of its growth. During the second year, the effect of density on growth and yield became pronounced and 1.5x2.0 m spacing gave optimum number of tiller, tiller diameter, internodal length, leaf number, panicles number, harvest index and height and diameter of tussock. The yield of panicles was however maximum in the treatment 1.0x1.0 m spacing. The study concludes that up to two time harvests 1.5x2.0 m spacing may be adopted if farmers are interested for green biomass (fodder). However, for optimum production of broom grass panicles (broom), 1.0x1.0 m spacing is most appropriate.



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## INTRODUCTION

*Thysanolaena maxima* (Roxb.) Kuntze (family—Poaceae), popularly known as broom grass, is an important non-timber forest product and grows in almost all parts of south and southeast Asia up to an elevation of 2000 m and climatic conditions ranging from tropical to subtropical (Tiwari and Kumar, 2008). The inflorescence of *T. maxima* is used to make broom. It grows wild in the hills of the northeastern India and in Darjeeling and Sikkim Himalayas. In the last two decades, the demand for broom have increased manifold. This motivated many erstwhile shifting cultivators to take up cultivation of this plant, resulting into increased income (Tiwari *et al.*, 2012). *T. maxima* is immensely important, both ecologically and economically for the hill dwellers of northeast India. It is a multipurpose species with its inflorescence (panicle) used for tying brooms, leaves and tender shoots for forage, and woody stem for fuel, paper pulp, reed-pens, mulch material and support sticks in crop fields for peas, beans and other trailing crops. Broomgrass forms tussocks. It is usually planted during April-May and the culms arise centrifugally during the peak growth period (June–July) and bear inflorescence at the end of vegetative growth (Tiwari *et al.*, 2012). The inflorescence becomes ready for harvest by December-January and the harvest continues until March (Bisht and Ahlawat, 1998). The tussocks (plants) of broomgrass are then cleared of old tillers since each tiller produces panicle only once.

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In central Himalayas, broom grass is grown with other grass species to sustain large livestock population of cattle, especially during lean season. The root-mat effectively protects topsoil and nutrients from erosion on sloping terrain and landslide-affected areas (Shankar *et al*., 2001). The plant has also been reported to have medicinal properties (Rai and Sharma 1994: Lachungpa 1998). The yield of broom panicles depends up on the age of the plant, soil fertility and management practices. The yield of broom panicles is reported to be highest during the 3rd and 4th year of the plant age and thereafter the production declines (Tiwari, 2014). The contribution of this NTFP towards enhancing the livelihood of the people of the region has been studied by Bisht and Ahlawat (1998), Shankar *et al.,* (2001) and Tiwari (2001). One kg of air dried broom panicles in 2014 fetched the farmers Rs. 65 (approx. US$1 at current exchange rate). Even though, *T. maxima* has emerged as a very important cash crop of Meghalaya (Tiwari *et al*., 2012), no experimental research is available regarding the effect of plant density on growth and yield. This paper is an attempt to fill this gap in the knowledge about this important cash crop of South and South-East Asia

## MATERIALS AND METHODS

The experiment was laid out at Mynska village situated at $25^0$26'32.09'' N and $092^0$25'17.84'' E at 1158 m a.s.l. located in West Jaintia Hills District of Meghalaya with annual average rain fall of 310 cm and the average minimum and maximum temperature of 11 $^oC$ and 21.6 $^oC$, respectively (Figure 1). The planting was done in July 2012. Clearing of vegetation in the field was done during May 2012 and the plants debris was burned after few days after they have been fully dried. The rhizomes were collected from the forests in the month of July 2012 and were brought to the site and split into required sizes of four tillers per root slips. The root slips were planted immediately after splitting. Weeding was done twice in a year using hand held hoe. No fertilizer and pesticides were used in the experiment. The experiment was conducted using Random Complete Block Design (RCBD) with four replications and five treatments. The size of each treatment plot was 8.0x8.0 m = $64m^2$. The experiment was of a single factor treatment. The treatments were: -

1.0x1.0 m spacing which gave a plant population density of 10000 plants/ha
1.0x2.0 m spacing which gave a plant population density of 5000 plants/ha
1.5x2.0 m spacing which gave a plant population density of 3333 plants/ha
2.0x2.0 m spacing which gave a plant population density of 2500 plants/ha
2.5x2.0 m spacing which gave a plant population density of 2000 plants/ha

Data were collected from five inner plants selected randomly from each plots and tagged to measure the growth and yield parameters viz., mean number of tillers tussock$^{-1}$, tiller diameter, mean number of nodes tussock$^{-1}$, mean length of internodes, height of tussock measured from the base to the tip of the tussock, diameter of tussock measured at the level at which tussocks were widest; number of leaves tussock$^{-1}$ and yield tussock$^{-1}$. Yield ha$^{-1}$ was calculated by multiplying the value of yield tussock$^{-1}$ with the number of plant ha$^{-1}$. Aboveground dry weight tussock $^{-1}$ was calculated by adding the dry weight of leaves, dry weight of tillers and dry weight of panicles. Total dry weight ha$^{-1}$ was calculated by multiplying the aboveground dry weight plant$^{-1}$ with the number of plant ha$^{-1}$.

Percentage of tiller producing panicles was calculated using the formula:

$$\text{Percentage of panicles producing tillers} = \frac{\text{Number of panicles}}{\text{Number of tiller}} \times 100$$

Harvesting index (HI) was calculated using the formula:

$$HI = \frac{\text{Dry weight of panicles (economic yield)}}{\text{Dry weight of aboveground plant parts}} \times 100$$

The data were analyzed statistically and mean differences adjudged by Tukey's HSD Test with the help of SPSS software 16.0 at 5% level of significance.

## RESULTS

The effect of plant density on mean number of tiller tussock$^{-1}$, tiller diameter, number of nodes tiller-$^{1}$ and internodal length was statistically not significant in the first harvest. In the second harvest the number of nodes was not affected by plant density but the tiller diameter and internodal length were significantly affected. Spacing of 2.5x2.0 m exhibited maximum tiller diameter and internodal length with 0.81 cm and 28.05 cm respectively. Spacing 1.0x1.0 m exhibited the least tiller diameter and internodal length with 0.65 cm and 23.75 cm respectively (Table 1). The height of tussock, diameter of tussock and number of leaves tussock$^{-1}$ were not significantly affected by plant density in the first harvest but the same were significantly different in the second harvest (Table 2). In the second harvest, spacing of 2.0x2.0 m exhibited the highest tussock height with 222.67 cm followed by spacing 2.5x2.0 m with 221.25 cm whereas the shortest tussock was found in spacing of 1.0x1.0 m. Spacing of 2.5x2.0 m exhibited the highest tussock diameter and number of leaves with 139.4 cm and 295.64 respectively. Whereas, spacing of 1.0x1.0 m gave the least tussock diameter and number of leaves with 99.75 cm and 216.27 respectively.

However, treatments of 1.5x2.0 m, 2.0x2.0x m and 2.5x2.0 m spacing were found to be statistically at par. The mean yield of broom (kg tussock$^{-1}$) increased with the decrease in plant density, yet it was not found to be significantly different in the first harvest. In the second harvest the increase in yield was significantly different. The highest yield was obtained in treatment 2.5x2.0 m with 0.443 kg tussock$^{-1}$. However, treatments 1.5x2.0 m and 2.0x2.0x m were also found at par with the above treatment. The lowest yield tussock$^{-1}$ was found in 1.0x1.0 m spacing (Table 3). The lowest spacing of 1.0x1.0 m gave the highest yield of 1937.7 kg ha$^{-1}$ of broom panicles and in 2.5x2.0 m spacing the yield was found lowest with 866 kg ha$^{-1}$.

**Table 1. Effect of spacing on number of tillers tussock$^{-1}$, tiller diameter, number of nodes tiller$^{-1}$ and internodal length**

| Treatments | Number of tiller tussock$^{-1}$ | | Tiller diameter (cm) | | Number of nodes tiller$^{-1}$ | | Internodal length (cm) | |
|---|---|---|---|---|---|---|---|---|
| Plant densities | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 1.0x1.0 m | 6.20 | 43.65b | 0.53 | 0.65b | 4.23 | 5.25 | 11.84 | 23.75d |
| 1.0x2.0 m | 6.65 | 54.22ab | 0.55 | 0.65b | 4.57 | 5.31 | 12.63 | 24.66cd |
| 1.5x2.0 m | 6.70 | 60.40a | 0.57 | 0.74ab | 4.21 | 5.23 | 12.46 | 27.15bc |
| 2.0x2.0 m | 6.75 | 59.05a | 0.57 | 0.78ab | 4.30 | 5.31 | 12.54 | 27.97b |
| 2.5x2.0 m | 6.80 | 60.15a | 0.58 | 0.81a | 4.36 | 5.37 | 12.55 | 28.05a |

Means with the same letter (s) within a column are not significantly different according to Tukey's HSD test at P < (0.05)

**Table 2. Effect of spacing on height of tussock, tussock diameter, number of leaves/tussock and percentage of tiller producing panicles**

| Treatments | Tussock height (cm) | | Tussock diameter (cm) | | Leaves number Tussock$^{-1}$ | |
|---|---|---|---|---|---|---|
| Plant densities | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 1.0x1.0 m | 74.50 | 199.50c | 37.25 | 99.75c | 27.85 | 216.27b |
| 1.0x2.0 m | 75.10 | 206.65bc | 38.60 | 122.1b | 29.10 | 263.05ab |
| 1.5x2.0 m | 76.15 | 216.10ab | 38.65 | 134.7a | 29.65 | 270.85ab |
| 2.0x2.0 m | 78.20 | 222.67a | 39.40 | 137.0a | 31.05 | 284.60ab |
| 2.5x2.0 m | 77.95 | 221.25a | 43.15 | 139.4a | 32.30 | 295.64a |

Means with the same letter (s) within a column are not significantly different according to Tukey's HSD test at P < (0.05)

**Table 3. Effect of spacing on yield, dry weight, percentage of tiller producing panicles and Harvesting Index of *T. maxima***

| Treatments (Plant densities) | Yield (kg tussock$^{-1}$) | | Yield (kg ha$^{-1}$) | | Dry weight (kg tussock$^{-1}$) | | Dry weight (kg ha$^{-1}$) | | Percentage of tiller producing panicles (%) | | Harvesting Index (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| 1.0x1.0 m | 0.011 | 0.1937c | 109a | 1937.7a | 0.077 | 1.49b | 775.19a | 14869.9a | 38.19 | 87.44 | 14.49 | 13.32b |
| 1.0x2.0 m | 0.010 | 0.304b | 50.95b | 1522.9b | 0.081 | 2.08a | 407.82b | 10414.4b | 41.65 | 86.83 | 12.72 | 14.77ab |
| 1.5x2.0 m | 0.0108 | 0.421a | 36.12c | 1405c | 0.079 | 2.44a | 263.92c | 8136.4bc | 41.87 | 87.75 | 13.44 | 17.46a |
| 2.0x2.0 m | 0.0106 | 0.432a | 35.4bc | 1109c | 0.080 | 2.45a | 199.66cd | 6251.8c | 43.24 | 91.08 | 13.45 | 17.70a |
| 2.5x2.0 m | 0.011 | 0.443a | 26.92c | 866c | 0.084 | 2.5a | 168.55d | 4906d | 46.74 | 88.39 | 14.44 | 18.45a |

Means with the same letter (s) within a column are not significantly different according to Tukey's HSD test at P < (0.05)

However, treatments 1.5x2.0 m, 2.0x2.0xm 2.5x2.0 m remain statistically at par. Similar result was recorded for aboveground dry weight of broom grass tussock$^{-1}$. The aboveground dry weight tussock$^{-1}$ increased with the decrease of plant density but dry weight kg ha$^{-1}$ increased with the increase in plant density. Treatment of 1.0x1.0 m spacing gave the highest aboveground dry weight with 14869.9 kg ha$^{-1}$ and the lowest was recorded in 2.5x2.0 m with 4906 kg ha$^{-1}$. The effect of plant density on percentage of tiller producing panicles was statistically not significant in the first as well as the second harvest. Harvesting index (HI) was significantly affected by plant density in the second harvest. The highest harvesting index was recorded in 2.5x2.0 m with 18.45% in the second harvest. However, treatments 1.5x2.0 m and 2.0x2.0xm remain statistically at par with the above treatment. The least harvesting index was recorded in 1.0x1.0 m spacing with a value of 13.32% (Table 3).

## DISCUSSION

The plant density did not affect the number of tiller tussock$^{-1}$, tiller diameter, number of nodes tiller$^{-1}$ and internodal length in first harvest. This might be due to the lesser canopy (shoot) and also the root system that developed during the first year of broom grass growth and hence, there was negligible or no competition for sunlight and soil nutrient (Rehman *et al*., 2013). However, all these growth parameters except the number of nodes tiller$^{-1}$ were significantly affected by plant density in the second year. There may be also the overcrowding of rhizome in the narrower spacing which restricted the production of new culms. Similar results were reported by Shankar *et al.* (2001) and Barua *et al*. (2011). Mosavi *et al*. (2009) also reported that tiller number and stem diameter decreased with the increased of plant density in the case of sorghum. The height, diameter of the tussocks, number of leaf tussock$^{-1}$ and yield of broom panicles tussock$^{-1}$ were not found to be significantly affected by density during the first year growth of broomgrass. This may be due to the wider gap among the adjacent plants; even in the narrow spacing of 1.0x1.0 m, there were still enough gaps among the plants to cause any competition.

But by the second harvest (2013-14) the effect of plant density on these growth parameters became pronounced which may be due to higher availability of soil nutrients and space for absolute vegetative growth in the plots with lesser density of plants. Barua *et al*. (2011) also reported that the height of *T. maxima* was lower in narrow spacing. Similar results were reported by Bell and Garside (2005) and Ghaffar *et al*. (2012) in case of sugarcane; Abuzar *et al.* (2011) in case of maize and Bitew *et al*. (2014) in case of Field Pea (*Pisum sativum* L.). However, this result is in contrast with the findings of Kumar *et al*., (2014) in case of Stevia (*Stevia rebaudiana*). The yield of broom panicles in kg ha$^{-1}$ was however found to be significantly higher in lower spacing which was due to the higher number of plants ha$^{-1}$ which is in general conformity with the findings of Naim *et al*. (2011) in case of Groundnut (*Arachis hypogaea* L.). Total above ground dry matter production was also recorded significantly higher in case of wider plants spacing. The reason might be because plants used the nutrients efficiently as a result of which more assimilates were produced, resulting in more aboveground dry matter tussock$^{-1}$.

Wider plant spacing had higher harvesting index (HI) than the lower spacing. This may be due to better utilization of resources by plants at wider spacing as compared to narrower spacing in which plants compete with each other for resources which resulted in lower HI. This trend explains that as the number of plants increased in a given area, the competition among the plants for nutrients and sunlight also increased (Sangakkara *et al*., 2004). It can be concluded that up to two years, increase of spacing more than 1.5x2 m do not have any significant effect on the growth parameters. Thus, treatment 1.5x2.0 m was found to be the best spacing for vegetative growth of broomgrass; however, the highest yield of panicle ha$^{-1}$ was recorded in 1.0x1.0 m spacing.

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