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Effect of Plant Density on Economic Return from *Thysanolaena maxima* (Roxb) Kuntze (Broom Grass) Plantation in Jaintia Hills, Meghalaya, India

Etiban Lapasam and B. K. Tiwari

Department of Environmental Studies, North-Eastern Hill University, Shillong 793 022 Meghalaya, India
E-mail: [1]<bktiwarinehu@gmail.com>

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ABSTRACT *Thysanolaena maxima* is a wild grass cultivated by the farmers of Meghalaya for the production of broom panicles, which has high demand in South and South East Asia. Over the years *T. maxima* has emerged as an important cash crop of Meghalaya transforming the economy as well as landscape of the state. This research was aimed at investigating the effect of plant density on cash income of the farmers cultivating this grass. The study revealed that the growth and production of broom panicles were significantly impacted by plant density. The production of panicles in the plantations with lower plant density was significantly higher than those grown in higher plant density. The study concludes that plantation raised at a density of 3333 plants/ha (1.5x2.0 m spacing) gave highest net present value of Rs 126199.8 ha^{-1} $year^{-1}$ up to three harvests. Based on the study, it is concluded that a density of 3333 plants/ha can be recommended for optimum economic return from cultivation of *T. maxima*.

INTRODUCTION

Plant density refers to number of plants per unit area. It influences plant growth and development by regulating the competition among plants for light, space and nutrients. Manipulation of plant density is an age old agronomic practice widely used to optimize the yield, quality and economic return of crops. In case of cash crops, using trial and error methods, farmers standardize optimum plant density to arrive at optimum economic plant density for a particular environmental setting (Shaw et al. 2008; Al-Suhaibani et al. 2013). Plant population density has been widely used in maize and sugarcane for optimizing production (Dahmardeh 2011; Rehman et al. 2014). Optimum plant density varies with climate, soil, management practice and architecture of the plant (Henson and Dolmat 2003). Therefore, determination of optimum plant density for a crop continues to be investigated to standardize the same for the particular crop in a given agroecological region (Larbi et al. 2013).

Address for correspondence:
B. K. Tiwari
Department of Environmental Studies,
North-Eastern Hill University,
Shillong 793 022,
Meghalaya, India
Mobile: 9436100984,
E-mail: bktiwarinehu@gmail.com

Thysanolaena maxima (Roxb.) Kuntze (family-Poaceae), grows throughout South, Southeast Asia and China up to an elevation of 1,600 m. The inflorescence/panicles of *T. maxima* are used to make broom. The broom made from panicles of this grass species is of high quality and has a good market. This species can grow on steep rocky mountain slopes, in shallow soil and in drought and high rainfall conditions. It grows wild in degraded open forests, countryside's and roadsides.

Socio-economic impact of broom grass cultivation has been studied by Bhuyan (2014) who has reported that broom grass cultivation has reduced the dependence of people on forests in the state of Arunachal Pradesh. Effect of plant density on growth of broom grass has been studied by Lapasam and Tiwari (2015) but, no experimental research is available on the effect of plant density on economic return even though broom grass has emerged as a very important cash crop of Meghalaya (Tiwari et al. 2012). This study was undertaken to determine the optimum plant density for optimum economic return from broom grass plantation.

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 asl. located in West Jaintia Hills

District of Meghalaya with annual average rainfall of 310 cm and the average minimum and maximum temperature of 11°C and 21.6 °C respectively. The planting was done in July 2012. The vegetation was cleared off the field during May 2012 and the plants debris was burned after they were fully dried. The rhizomes were collected from the forests in the month of July 2012 and brought to the site where they were split into required sizes of four tillers per root slips. The root slips were then planted immediately after splitting. Weeding was done two times 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 replicate 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: 10000 plants ha^{-1} (1.0x1.0 m spacing), 5000 plants ha^{-1} (1.0x2.0 m spacing), 3333 plants ha^{-1} (1.5x2.0 m spacing), 2500 plants ha^{-1} (2.0x2.0 m spacing) and 2000 plants ha^{-1} (2.5x2.0 m spacing).

Data were collected from five inner plants selected randomly from each plots and recorded continuously up to three harvests. The mean yields from each plant were then multiplied by the number of plant ha^{-1} to get the yield ha^{-1}. The cost of setting up of plantation was taken in to account by adding the per hectare cost of fencing materials, root slips, transportation, digging of pits, weeding, harvesting, labour charges, etc. Benefit was calculated from the average price at which the farmers sold their produce that is, Rs 56 kg^{-1}.

The economic analysis was carried out using benefit-cost ratio, net present value and internal rate of return. Benefits and costs are linked to the age of the crops. At the early stages, there are high establishment costs which are then followed by annual benefits that are non-linear over the life of the crops (Nkang et al. 2007). Due to the time value of money, future cost and benefit values that were discounted to enable comparison with present values. This required discounting and compounding. The costs and benefits were discounted using the discount rate of 12 percent; Net Present Value was calculated on a ha^{-1} basis.

$$\text{Net present value} = \sum_{t=1}^{n} \frac{(Bt - C_t)}{(1+r)^t}$$

Benefit-cost ratio was used to measures the present value of returns per rupee invested. The benefit-cost ratio (BCR) was worked out by using following formula:

$$\text{Benefit-cost ratio} = \sum_{t=1}^{n} Bt\,(1+r)^t / \sum_{t=1}^{n} Ct\,(1+r)^t$$

Internal rate of return was worked out by using following formula:

$$\sum_{t=1}^{n} \frac{(Bt - C_t)}{(1+r)^t} = 0$$

Where,
Bt = Benefits ha^{-1} in each year, t = 1, 2, ..., n
Ct = Costs ha^{-1} in each year, t = 1, 2, ..., n.
n = Number of years, and
r = Discount rate

RESULTS

The analysis revealed that 60-80 percent of the total cost was incurred during the first year depending upon the density of plants, the major expenditures being plantation establishment (site preparation, cost of root slips and planting) and fencing. The expenditure on establishment of broomgrass plantation varied with density of plants (Table 1). The highest expenditure was incurred in plantation density of 10000 plants ha^{-1} with Rs 95700 and the lowest in 2000 plants ha^{-1} density with Rs. 28740. An amount of Rs. 10800 ha^{-1} was spent as cost of fencing which included the cost of labour charges and buying of fencing material like bamboos and wood logs which were the cheapest material available locally.

During the second year, the expenditure was about 7.5-15 percent of the total cost which consist of labour charges only on weeding, harvesting and drying of broom panicles and the remaining 11-23.5 percent was incurred during the third year which also consist of labour charges for weeding, harvesting, drying of broom panicles and also maintenance of fencing. The total cost over a period of three years worked out to be highest in 10000 plants ha^{-1} treatment with Rs 127120 and the least was in 2000 plants ha^{-1} with Rs 61120.

The expenditure incurred on weeding was highest during the first year and dropped with age, whereas the cost of harvesting increased with age of the plantation. In the first and sec-

Table 1: Expenditure incurred during three year cultivation of *T. maxima* at different spacing

Particulars	10000 plants ha^{-1}			5000 plants ha^{-1}			3333 plants ha^{-1}			2500 plants ha^{-1}			2000 plants ha^{-1}		
	1st year	*2nd year*	*3rd year*	*1st year*	*2nd year*	*3rd year*	*1st year*	*2nd year*	*3rd year*	*1st year*	*2nd year*	*3rd year*	*1st year*	*2nd year*	*3rd year*
Clearing	1200			1200			1200			1200			1200		
Fencing	10800		1200	10800		1200	10800		1200	10800		1200	10800		1200
Digging of pits	37200			18600			12399			9300			7440		
Cost of rootslips	46500			23250			15498			11625			9300		
Weeding	7600	6100	4420	7600	7000	4200	8600	7200	4200	8600	7200	4200	8600	7200	4200
Harvesting	1000	4500	4800	600	4000	4800	600	4000	5500	600	3600	5500	600	3000	5500
Drying of panicles	300	600	900	300	600	900	300	600	1200	300	600	1200	300	600	1200
Total	104600	11200	11320	62350	11600	11100	49397	11800	12100	42425	11400	12100	38240	10800	12100
Total 3 yr expenditure			127120			85050			73297			65925			61140
Gross	6104.3	108515.5	117789.1	2853.5	85286.4	118804.2	2022.5	78715.7	184356.2	1489.9	62143.5	188871	1300.3	48491.6	182615.3
Net income			232409			206944			265094			252505			232407

ond year harvest, treatment with 10000 plants ha^{-1} required maximum money for harvesting and the cost decreased as the density of plant decreased but in the third year, the treatments with plant density of 3333 plants ha^{-1}, 2500 plants ha^{-1} and 2000 plants ha^{-1} incurred maximum expenditure for harvesting.

The cost of harvesting increased with age of the plantation. In the first and second year harvest, treatment with 10000 plants ha^{-1} required maximum money for harvesting and the cost decreased as the density of plant decreased but in the third year, the treatments with plant density of 3333 plants ha^{-1}, 2500 plants ha^{-1} and 2000 plants ha^{-1} incurred maximum expenditure for harvesting. Plant density treatment of 3333 plants ha^{-1} produced the maximum panicles over a period of three years with 4734.30 kg ha^{-1} followed by plant density of 2500 plants ha^{-1} and 2000 plants ha^{-1} with 4509 kg and 4150.13 kg respectively (Table 2).

The income from sale of broom panicles in the first year was negligible. The break-even was obtained in the second year, when maintenance and protection cost was offset by the income from broom panicles sales. It was found that up to three years, Plant density treatment of 3333 plants ha^{-1} gave the highest net present value of Rs 126199.8 ha^{-1} year^{-1} followed by treatments of 2500 plants ha^{-1} and 2000 plants ha^{-1} with Rs 123055 and Rs 112271 respectively. Treatment 10000 plants ha^{-1} gave the lowest return of Rs 61173.

It is seen that plant density treatment of 2000 plants ha^{-1} gave the highest benefit to cost ratio with a value of 3.6 followed by plant density treatment of 3333 plants ha^{-1} with 3.15. The lowest benefit to cost ratio was found in plant density of 10000 plants ha^{-1} with 1.71 (Table 3). Similarly, the internal rate of return revealed that broom grass plantation with 2500 plants ha^{-1} gave the best rate of return (79.8 %), followed by 2000 plants ha^{-1} (78.4 %).

DISCUSSION

Rearing cattle and goats is an important economic activity in this part of the state therefore fencing of the plantation against grazing is an important component of expenditure for protection of plantation especially during the initial stage of broom grass plantation. The cost of fencing ranges from 10.3-17 percent depending on plant density.

The expenditure shown in the Table 1 include both family member's contribution as well as payment to labourers, therefore the farmers get more cash than the amount accrued through the sale proceeding. In most cases the farmers employ labourers only for harvesting of broom panicles as the broom panicles have to be harvested within a short period otherwise the quality of broom panicles degrade and command less price in the market as compared to those harvested in time.

The decrease in cost of weeding with age of the plantation was due to the fact that weed density were very high during the initial year and it involved more man-days for weeding but

Table 2: Yield of brooms panicles kg ha^{-1}

	Plant density (plant ha^{-1})				
Year	*10000*	*5000*	*3333*	*2500*	*2000*
1	109	50.95	36.12	26.6	23.22
2	1937.776	1522.971	1405.77	1109.70	865.92
3	2103.376	2121.504	3292.40	3372.70	3260.98
Total	4150.15	3695.42	4734.30	4509	4150.13

Table 3: Economic analysis of *T. maxima* cultivation in Jaintia Hills, Meghalaya at discount rate of 12 percent year^{-1}

		Plant density (plant ha^{-1})				
S. No.	*Parameters*	*10000*	*5000*	*3333*	*2500*	*2000*
1	Net Present Value (Rs.ha-^{1}year^{-1})	61173.5	73544	126199.8	123055.9	112271.3
2	Benefit to Cost Ratio	1.71	2.12	3.15	3.05	3.6
3	Internal Rate of Return (%)	35.15	50	76.46	79.8	78.4

due to weeding and closing-in of broomgrass canopy the weed density decreased with time and so also the cost of weeding. The cost of weeding in the lower density of plants was higher as the densities of weeds were still higher as gaps between plants were higher which provided space for weed growth. Whereas the cost of harvesting increased with age of the plantation, this was due to the higher panicle production ha^{-1} in the lower plant density than in the higher density plantations.

Wongnaa et al. (2013) used net present value, benefit cost ratio and internal rate of return in their study on socio-economics of cashew cultivation and found these measures useful in determining the profitability of the cashew production system. Benefit-cost ratio is an important parameter in which farmers are interested to see the gain in net returns with a given increase in total cost (Rehman et al. 2014). The finding of the present study are similar to those reported by Tiwari (2014) who recorded a benefit to cost ratio of 3.46. Shankar et al. (2001) in their benefit to cost ratio analysis reported a return of 1.7 from six year harvest. Singh et al. (1989) found a ratio of 6.84 which is substantially higher than the present study. The variation in benefit to cost ratio can be attributed to the locally prevailing factors such as soil fertility, labour charges, selling price and plantation management. The low net present value in the higher density plantations was due to the high investment and low production of broom panicles in the third year as compared to the lower plants density. A return of more than three times the amount invested from the sale of broom panicles excluding leaves and stems is lucrative enough for the farmers. The maximum expenditure was incurred on labour charges where, mostly the farmers and their family members are involved therefore the total return is much higher than the income accruing from the sale of panicles. The maximum expenditure was incurred on the establishment of the plantation and from the second year onward only minor expenditure was incurred on labour charges such as weeding, harvesting and protection. In a situation where labour is available in the family, the income is very high and growers get very high return. This is the reason for continuous growth in area and production of broom grass in Meghalaya and it has occupied almost all the land previously used for shifting cultivation (Tiwari and Kumar 2008).

CONCLUSION

The study revealed that lesser spacing limits the growth and production of broom tillers which reduces the production of broom panicles. In the wider spacing the broom panicles production increases significantly during third year of growth. The three economic analysis parameters used for determining optimum density for optimum economic return varied. While 2500 plants ha^{-1} treatment gave the highest internal rate of return and 2000 plants ha^{-1} gave the highest benefits to costs ratio, the highest net present value was recorded in the plots having a plant density of 3333 plants ha^{-1}. Therefore, it can be concluded that 3333 plants ha^{-1} is the optimum plant density for raising broom grass plantation in Jaintia Hills, Meghalaya.

RECOMMENDATIONS

A plant density of 3333 plants ha^{1} corresponding to a plant to plant spacing of 1.5m and row to row spacing of 2.0m is recommended for cultivation of broom grass in Jaintia Hills region of Meghalaya. Cultivation of broom grass is highly profitable. Its cultivation should be encouraged on the unproductive jhum fallows as the growers earn huge income. More studies on economics and ecology of broom grass need to be undertaken as very little is known about environmental impacts of broom grass cultivation.

REFERENCES

Al-Suhaibani N, El-Hendawy S, Schmidhalter U 2013. Influence of varied plant density on growth, yield and economic return of drip irrigated faba bean (*Vicia faba* L.). *Turkish Journal of Field Crops,* 18(2): 185-197.

Bhuyan LR 2014. Viable practice of broom grass cultivation in Arunachal Pradesh. *Manjari*, 1(1): 9.

Dahmardeh M 2011. Effect of plant density and nitrogen rate on PAR absorption and maize yield. *American journal of Plant Physiology,* 6(1): 44-49.

Henson IE, Dolmat MT 2003. Physiological analysis of an oil palm density trial on a peat soil. *Journal of Oil Palm Research,* 15(2): 1-27.

Lapasam E, Tiwari BK 2015. Effect of plant density on growth and yield of *Thysanolaena maxima*: An important non-timber forest product of Meghalaya. *International Journal of Current Research,* 7(7): 18193-18196

Larbi E, Anim-Okyere S, Danso F, Danso I, Afari P, Nuertey BN, Asamoah, TEO 2013. Effect of planting densities on growth, development and yield of oil palm (*Elaeis guineensis* Jacq.) in Ghana. *Interna-*

tional Journal of Current Research, 5(10): 2997-3000.

Nkang M, Ajah EA, Abang SO, Edet EO 2007. Investment in cocoa production in Nigeria: a cost and return analysis of three cocoa production management systems in the cross river state cocoa belt. *Journal of Central and European Agriculture*, 8(1): 81-90.

Rehman A, Qamar R, Qamar J 2014. Economic assessment of sugarcane (*Saccharum officinarum* L.) through intercropping. *Journal of Agricultural Chemistry and Environment,* 3: 24-28.

Shankar U, Lama SD, Bawa KS, Shankar U 2001. Ecology and economics of domestication of nontimber forest products: An illustration of broomgrass in Darjeeling Himalaya. *Journal of Tropical Forest Science*, 13: 171–191.

Shaw S, van de Westelaken T, Sorrenson I. Searle B, Hederley D 2008. Effects of plant population and planting date on growth and development of kumara cultivar Owairaka Red. *Agronomy New Zealand,* 38: 61-68.

Singh KA, Rai RN, Pradhan IP 1989. Grow amliso grass in the NEH region. *Indian Farming,* 38(10): 43-44.

Tiwari BK 2014. Broom grass: Its cultivation and production economic in Meghalaya. *Manjari*, 1(1): 7-8.

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, Shukla RP, Lynser MB, Tynsong H 2012. Growth pattern, production, and marketing of *Thysanolaena maxima* (Roxb.) Kuntze: An important non-timber forest product of Meghalaya, India. *Forests, Trees and Livelihoods,* 21(3): 176–187.

Wongnaa CA, Awunyo-Vitor D 2013. Profitability analysis of cashew production in Wenchi municipality in Ghana. *Botanicals Journal of Agriculture and Applied Sciences*, 9(1): 19-28.