Range Mgmt. & Agroforestry 34 (2) : 186-191, 2013
ISSN 0971-2070

Fodder yield, broom and economics of broom grass [*Thysanolaena maxima* (Roxb.) O. Ktze] and solar radiation interception as influenced with row proportion under different tree species in Arunachal Pradesh

V. K. Choudhary*, R. A. Alone, P. Suresh Kumar, Devendra Singh and R. Bhagawati

ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar-791101, Arunachal Pradesh, India.
Corresponding author email: ind_vc@rediffmail.com

Received: 10th March, 2012 Accepted: 29th May, 2013

Abstract

Growth and yield attributes, yield and economics of broom grass *(Thysanolaena maxima* (Roxb.) O. Ktze) was compared under different row proportions and four tree species predominantly found in North Eastern Region. The growth parameters *viz.* height of tussock, average yield of culm, leaf length and leaf breadth were higher with *Alnus nepalensis* followed by *Grevillea robusta*. Tussock height increased with increasing row proportions. *Alnus nepalensis* registered higher yield attributes like number of inflorescence bearing clump (258.8 x 10^3), inflorescence bearing tiller (78.5%), inflorescence length (117.7 cm), dry matter production (9.68 Mg/ha) and fodder yield (11.95 Mg/ha). Yield performance of the broom grass followed the trend of *Alnus nepalensis>Grevillea robusta>Terminalia myriocarpa>Morus alba*. Yield attributes were improved under two rows than the one row, whereas, during 3rd year, yield attributes were enhanced from previous year. Correspondingly, *Alnus nepalensis* recorded higher economic parameters and solar radiation interception, whereas, *Morus alba* had lower returns.

Keywords: *Alnus nepalensis,* Broom grass, Fodder, Fuel, *Grevillea robusta,* Intercropping, *Morus alba,* Shade, Solar radiation interception, *Terminalia myriocarpa*

Abbreviations:

B:C: Benefit to cost ratio, **LSD:** Least significant difference, **NTFP**: Non-Timber Forest Produce

Introduction

Agroforestry is now a collective name for land use system and technologies involving trees combined with crops and/ or animals on the same land management unit (Ibrahim and Sinclair, 2005). In Eastern Himalaya, subsistence level evolved through trial and error practices of farmers to meet their needs of food, fiber, fodder, fuel wood, medicine and timber. Characterized by substantial diversity and high degree of self-reliance (Nautiyal *et al.*, 2003; Sharma and Liang, 2006; Sharma *et al.*, 2006), Agroforestry system promote low cost sustainable development in ecosystems, protect and conserve ecological systems, and improve economic efficiency of the farming community. Arunachal Pradesh is blessed with a number of economically important species that are directly useful to the mankind and can form the basis of economic upliftment in rural areas. Prominent among them are the Non-Timber Forest Produce (NTFP) like bamboo, canes, thatch, broom grass and medicinal plants (Bisht, 1998). NTFP can be a mean of sustainable land management and a tool for reclamation of wastelands, *jhum* fallow, *etc*. Broom grass *(Thysanolaena maxima* (Roxb.) O. Ktze) is one of the important plants in Arunachal Pradesh, belonging to the family *Poaceae.* It is found on the slopes of hills, damp steep banks along ravines and on sandy banks of the rivers. It is a multipurpose species which provides brooms, fuel fodder and has high soil conservation value. It can thrive in wider and harsher conditions and check soil erosion while improving the habitat and economy of the local people.

In most tropical grasses, the varying response in yield under shade has been reported. Broom grass varies with its morpho-types, and grows better under the shade of the canopy of various trees. The higher yield under tree canopy are mostly due to the beneficial effect like leaf drop, better nutrient cycling, improved soil organic matter and soil physical structure (Young, 1989), and beneficial nitrogen fixation with leguminous trees. Intercropping, through more effective use of water, nutrients, solar energy and other resources, reduces soil erosion, suppresses weed growth, and thereby significantly enhanced crop productivity compared to the growth of sole crops (John and Mini, 2005).

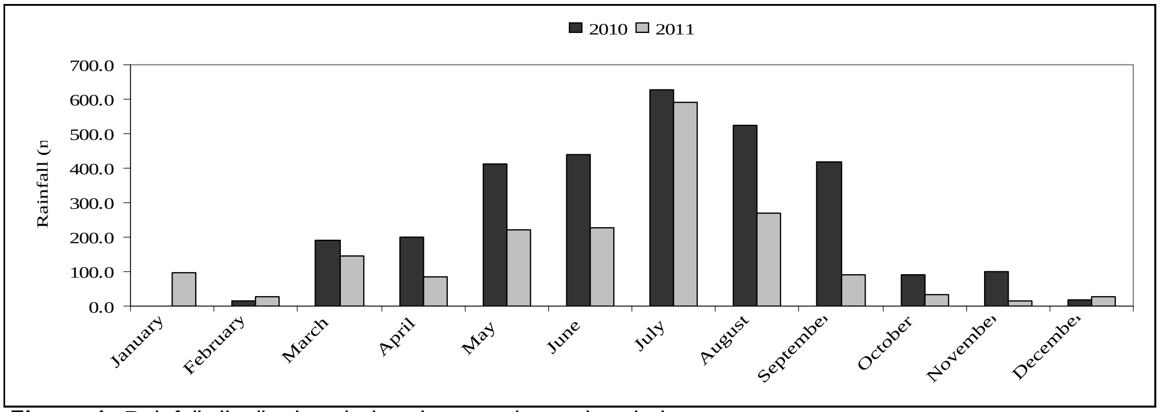

Figure 1. Rainfall distribution during the experimental period

Present study was designed with the objective to evaluate the growth, yield and economics of broom grass *(Thysanolaena maxima* (Roxb.) O. Ktze) and solar radiation interception in different row proportion with tree species under mid hill condition of Arunachal Pradesh.

Materials and Methods

The experiment was conducted at ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar, West Siang District of Arunachal Pradesh, India (27° 95 ôN, 94°76ôE and 660m above MSL) during 2010 and 2011. The site experiences humid climate with mean annual rainfall of 2473 mm (Fig. 1).

The tree species were planted at 3.0 m row intervals in 1997-98. Broom grass was intercropped during April, 2009 with four tree species *viz.*, *Alnus nepalensis, Grevillea robusta, Terminalia myriocarpa* and *Morus alba. Terminalia myriocarpa* and *Grevillea robusta* have been included in study because of large scale plantation by the stakeholders in the state, *Alnus nepalensis* was included due to its ability to restore wasteland and improve soil by N_2-fixation. Similarly, *Morus alba* was selected as it provides additional returns through sericulture intervention. The observation and data measurement are recorded during 2010 and 2011. The experiment was laid out in a factorial randomized block design with three replications. Broom was intercropped at least 1.0 m away from the tree trunks on both the sides and gross plot was 33.0 m x 12.0 m. The broom grass was planted with spacing of 1.0 m x 1.0 m of plant geometry in one and two row proportion (1.5 m away in one row and 1.0 m away in two row from tree trunk), and no additional nutrients were applied from outside. The decomposed leaves (organic matter) were used as source of nutrients for crop production. Crops were subjected to earthing up and three hand weeding (June, August and October). Other cultural practices were done as and when required.

Observations on growth parameters (height of tussock, average yield of culm, leaf length and leaf breadth), yield attributes (number of inflorescence bearing clump, percent of inflorescence bearing tiller, inflorescence length and dry matter production) and yield was measured from five selected plants. However, economics (cost of cultivation, gross and net return and B: C ratio) was measured as per the input required and output obtained from experimental area and it was converted to per hectare basis. Solar radiation interception was recorded with the help of Digital Lux Meter (TES 1332- TES Electrical Electronic Corporation) at noon 1.00 pm during clear sunny day on top canopy of broom and the radiation interception. The area having no tree species in an around are considered as zero percent interception (100% transmission) and compared with recorded data of intercropping.

SRI= (Q_1/ Q_0)*100, Where, Q_1 is solar radiation to canopy of broom grass and Q_0 solar radiation to pure stand. Intercrop could not receive cent percent of radiation because of having marginal shadowiness due to planted trees. The different parameters were statistically analyzed using SAS 9.2 programme, by *F*-test and least significant difference (LSD) at 5% probability level.

Results and discussion

Growth parameters

Growth parameters of broom grass *viz.* height of tussock, average yield of culm, leaf length and leaf breadth varied with different multipurpose trees and row proportions of intercrop (Table 1). The height of tussock, average yield of culm and leaf length were significantly ($P \leq 0.05$) higher when broom grass was intercropped with *Alnus nepalensis* (227.0 cm, 331.4 x 10^3 and 53.8 cm, respectively) followed by *Grevillea robusta* and lowest with *Morus alba*. However, leaf breadth did not show any trend and were statistically similar with the different tree species. Among the years, the height of tussock, average yield of culm, leaf length and leaf breadth were recorded higher during 3rd year of broom over the 2nd years after planting. Similar findings are also reported by Bhatt *et al.* (2010).

Row proportions of broom under tree species significantly ($P \leq 0.05$) varied with growth parameters. The height of tussock, average yield of culm and leaf length were recorded higher when broom was intercropped with two row proportions (223.9 cm, 355.0 x 10^3, 54 .0 and 53.8 cm, respectively) followed by one row. However, leaf breadth was higher with one row proportion (5.63 cm). 3rd year of broom recorded higher growth parameters as compared to 2nd year of broom.

***Yield attributes*:** Yield attributing parameters of broom grass *viz.*, number of inflorescence bearing clump, percent of inflorescence bearing tiller, inflorescence length and dry matter production varied with different multipurpose trees, row proportions and years (Table 2). All the yield attributing characters were recorded significantly higher ($P \leq 0.05$) with *Alnus nepalensis* (258.8 x 10^3, 78.5%, 117.7 cm and 9.68 Mg/ha, respectively) followed by *Grevillea robusta*. However, lower yield attributes were obtained from the *Morus alba*. Percent of inflorescence bearing tillers during 2nd year was recorded almost similar to 3rd year and did not show any trend.

Among the row proportions, two rows of broom recorded higher number of inflorescence bearing clump and dry matter production (259.5 x 10^3 and 9.87 Mg/ha, respectively) over one row intercropping. However, percent of inflorescence bearing tiller and inflorescence length were higher with one row proportion (77.5% and 117.6 cm, respectively). On the other hand, yield attributes were recorded significantly higher during 3rd year than the 2nd year of broom grass.

***Yield*:** The yield of broom grass *viz.* total culm yield/ tussock, total number of broom and fodder yields varied with different multipurpose trees, row proportions and years (Table 3). The highest total culm yield/tussock, total broom number and fodder yield were obtained with *Alnus nepalensis* (206.0, 7394 and 11.95 Mg/ha, respectively) followed by *Grevillea robusta* and lowest with *Morus alba*. It was also reported by Semwal *et al.* (2003) that *Alnus nepalensis* has higher N and lower poly-phenol concentration which helped the broom to grow and produce more clump and fodder.

Among the row proportion of intercrop, the yield was higher when the broom grass was planted with two row proportions (224.4, 7414 and 12.64 Mg/ha, respectively) than the one row proportion. However, yield attributes were significantly higher during 3rd year over the 2nd year of broom.

Fodder yield from the broom grass under different tree species varied greatly from 6.67 ï 8.53 Mg/ha, being highest in *Alnus nepalensis* and lowest with *Morus alba*. Among the row proportion, it was higher in two row followed by one row and ranged from 6.28 - 8.85 Mg/ha during 2010. However, fodder yield varied during 3rd year (2011). The fodder yield ranged from 9.45 ï 11.95 Mg/ha, being highest with *Alnus nepalensis* and lowest with *Morus alba*. Among the row proportions it ranged from 8.82 ï 12.64 Mg/ha (Fig. 2). Similar findings are also reported by Bhatt *et al.*, (2010). Irrespective of tree species and row proportions, total dry matter production showed a positive linear relationship with fodder yield (R^2=0.95, $P \leq 0.05$) during 2nd and (R^2=0.98, $P \leq 0.05$) 3rd year. This information is useful to predict the total dry matter production of broom with the different tree species, as total dry matter production is important parameters which contribute the overall development of plants, and determination of total dry matter is time consuming, labourious. Similarly, number of broom inflorescence under different tree species varied from 1613 ï 1971, being highest under *Alnus nepalensis* and lowest with *Morus alba*. Among the row proportion, it was higher with two row followed by one row (ranged from 1559 - 1958 during 2nd year). However, number of broom inflorescence ranged from 5759 ï 7394, and among row proportions it was 5418 ï 7414, the similar trend of 2nd year during 3rd year (Fig. 3). Irrespective of tree species and row proportions, number of broom showed a positive linear relationship with fodder yield (R^2=0.93, $P \leq 0.05$) during 2nd and (R^2=0.92, $P \leq 0.05$) during 3rd year. As number of broom increased, it contributed to production of more culm and had the higher leaves, leading to production of higher fodder.

***Solar radiation interception*:** Solar radiation interception is one of the important parameter in intercropping system. It was measured that the well established tree species infiltrate lower radiation as compared to solar radiation received (Fig. 4). *Alnus nepalensis* intercepted more radiation followed by *Grevillea robusta* and lowest by *Morus alba*. The data presented in figure 4 are the mean of 2010 and 2011. It was also noticed that the solar radiation interception was not influenced by row proportion of intercrop. The solar radiation was intercepted highest to lowest on broom grass with the trend, *Alnus nepalensis* > *Grevillea robusta*>*Terminalia myriocarpa*>*Morus alba*.

Table 1. Growth parameters of broom grass intercropped unit with multipurpose tree species

Tree species	Height of tussock (cm)		Average yield of culms (x 10^3)		Leaf length (cm)		Leaf breadth (cm)	
Years	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**
Tree species								
Alnus nepalensis	181.5[a]	227.0[a]	93.6[a]	331.4[a]	46.1[a]	53.8[a]	4.95[a]	5.53[a]
Grevillea robusta	173.8[a]	218.3[ab]	89.0[ab]	305.7[b]	44.3[a]	51.6[ab]	4.82[a]	5.47[a]
Terminalia myriocarpa	162.5[ab]	202.0[bc]	80.1[ab]	285.4[c]	42.9[ab]	48.3[b]	4.67[a]	5.25[a]
Morus alba	149.0[b]	187.3[c]	70.0[b]	273.8[d]	38.6[b]	46.8[b]	4.49[a]	5.12[a]
LSD (P=0.05)	19.91	22.72	22.9	10.5	4.92	5.54	0.68	0.57
Row proportion							(NS)	(NS)
One	149.8[b]	193.4[b]	73.8[b]	243.1[b]	37.1[b]	46.2[b]	5.08[a]	5.63[a]
Two	183.6[a]	223.9[a]	92.5[a]	355.0[a]	48.8[a]	54.0[a]	4.38[b]	5.07[b]
LSD (P=0.05)	13.47	16.27	16.33	20.35	3.15	3.32	0.34	0.28

Average yield of culms from 1800 tussocks; Means followed by the same letter in column are not different at 0.05 probability level using least significant difference

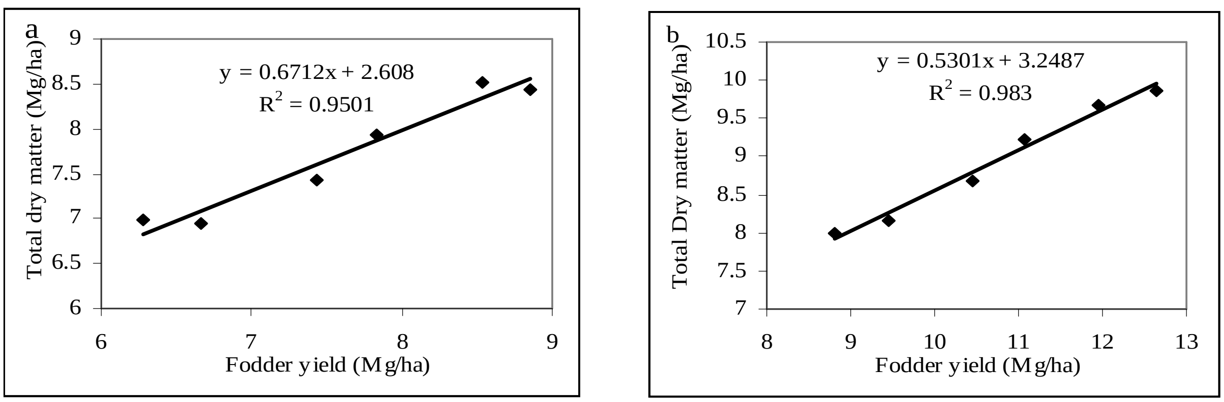

Figure 2. Relationship between fodder yield and total dry matter (irrespective of tree species and row proportions) a. 2nd year, b. 3rd year

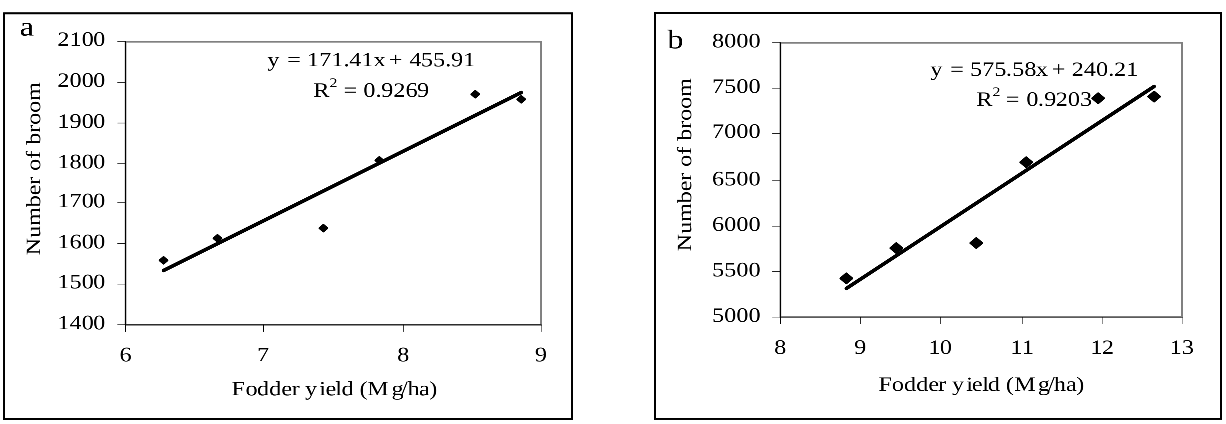

Figure 3. Relationship between fodder yield and numbers of broom (irrespective of tree species and row proportions) a. 2nd year, b. 3rd year

Table 2: Yield analysis of broom unit grass intercropped with multipurpose tree species

Tree species	No. of inflorescence bearing clump (x 10^3)		% of inflorescence bearing tiller		Inflorescence length (cm)		Dry matter production (Mg/ha)	
Years	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**
Tree species								
Alnus nepalensis	69.0^{a}	258.8^{a}	74.4^{a}	78.5^{a}	86.2^{a}	117.7^{a}	8.52^{a}	9.68^{a}
Grevillea robusta	63.3^{b}	234.4^{b}	71.3^{ab}	76.9^{a}	84.8^{a}	113.67^{ab}	7.93^{ab}	9.22^{ab}
Terminalia myriocarpa	57.4^{c}	203.5^{c}	70.6^{ab}	73.4^{ab}	83.1^{a}	107.8^{ab}	7.43^{bc}	8.68^{bc}
Morus alba	56.4^{c}	201.6^{c}	68.2^{b}	70.9^{b}	79.7^{a}	104.5^{b}	6.95^{c}	8.17^{c}
LSD (P=0.05)	2.94	4.18	5.18	5.92	7.62 (NS)	11.40	0.75	0.79
Row proportion								
One	54.6^{b}	189.6^{b}	73.8^{a}	77.5^{a}	89.0^{a}	117.6^{a}	6.98^{b}	8.00^{b}
Two	68.5^{a}	259.5^{a}	68.4^{b}	72.3^{b}	77.8^{b}	104.3^{b}	8.44^{a}	9.87^{a}
LSD (P=0.05)	4.72	21.51	3.07	3.73	3.95	6.93	0.62	0.61

Means followed by the same letter in column are not different at 0.05 probability level using least significant difference

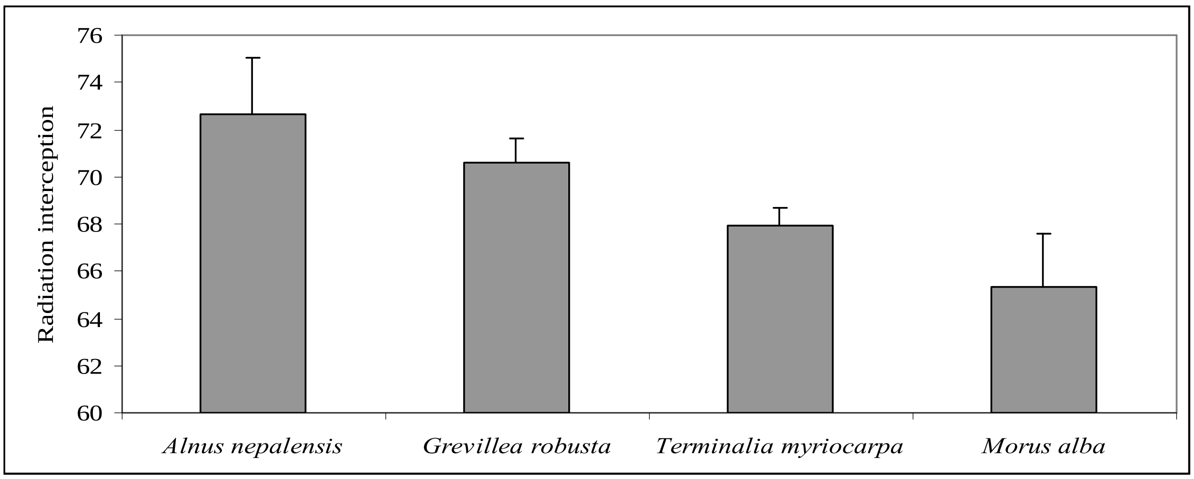

Figure 4. Solar radiation interception (%) as influenced by multipurpose tree (mean± 1, SE, n=5)

Table 3: Yield analysis of broom grass intercropped with multipurpose tree species

Tree species	Total culm yield/ tussock		Total no. of broom		Fodder yield (Mg/ha)	
Years	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**
Tree species						
Alnus nepalensis	58.3^{a}	206.0^{a}	1971^{a}	7394^{a}	8.53^{a}	11.95^{a}
Grevillea robusta	53.7^{ab}	191.3^{ab}	1808^{b}	6698^{b}	7.83^{ab}	11.07^{ab}
Terminalia myriocarpa	50.4^{b}	177.8^{bc}	1641^{c}	5814^{c}	7.43^{bc}	10.45^{bc}
Morus alba	47.2^{b}	168.2^{c}	1613^{c}	5759^{c}	6.67^{c}	9.45^{c}
LSD (P=0.05)	7.20	19.40	84.16	119.32	0.82	1.26
Row proportion						
One	44.58^{b}	147.3^{b}	1559^{b}	5418^{b}	6.28^{b}	8.82^{b}
Two	60.24^{a}	224.4^{a}	1958^{a}	7414^{a}	8.85^{a}	12.64^{a}
LSD (P=0.05)	5.03	15.61	134.87	614.62	0.70	0.98

Means followed by the same letter in column are not different at 0.05 probability level using least significant difference

Table 4: Economic analysis in Rs/ha of broom grass intercropped with multipurpose tree species

Tree species	Cost of cultivation		Gross return (x 10^3)		Net return (x 10^3)		B:C	
Years	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**	**2nd**	**3rd**
Tree species								
Alnus nepalensis	12000	25000	23.98[a]	79.92[a]	11.98[a]	54.92[a]	1.00[a]	2.20[a]
Grevillea robusta	12000	25000	22.00[b]	72.51[b]	10.00[b]	47.51[b]	0.83[b]	1.90[b]
Terminalia myriocarpa	12000	25000	20.13[c]	63.36[c]	8.12[c]	38.36[c]	0.68[c]	1.54[c]
Morus alba	12000	25000	19.46[c]	62.32[c]	7.46[c]	37.32[c]	0.62[c]	1.49[c]
LSD (P=0.05)			0.83	1.32	0.83	1.32	0.069	0.053
Row proportion								
One	12000	25000	18.78b	58.59b	6.78b	33.59b	0.56b	1.34b
Two	12000	25000	24.00a	80.46a	12.00a	55.46a	1.00a	2.22a
LSD (P=0.05)			1.62	6.52	1.62	6.52	0.14	0.261

Means followed by the same letter in column are not different at 0.05 probability level using least significant difference

***Economic analysis*:** Cost of cultivation of broom under different tree species were similar but during third year cultivation cost was considerably higher than the second year (Table 4). Higher costs were mainly because of higher maintenance, and also increase of labour cost. Gross and net return, and B: C ratio differed significantly and followed the trend of *Alnus nepalensis* > *Grevillea robusta* >*Terminalia myriocarpa*>*Morus alba*. Return and B: C ratio were higher during 3rd year over 2nd year. This might be due to higher yield obtained during the 3rd year as compared to 2nd year. This directly leads to higher return.

Among the row proportions, broom at two row proportions gave comparatively higher gross and net return (Table 4). Similarly, B: C ratio was higher with two rows than the one row. In 3rd year, the return and B: C ratio was significantly higher than the 2nd year.

It can be recommended that farmers of the state who are actively involved in growing of trees and keeping the livestock, should plant at least two row of broom in between trees. It will provide the fodder, broom stick, which they use as fuel, additional income from broom and various produces from the trees.

References

Bhatt, B. P., L. B. Singh, K. K. Satapathy, Y. P. Sharma and K. M. Bujarbaruah. 2010. Rehabilitation of shifting cultivation areas through agroforestry: A case study in Eastern Himalaya, India. *Journal of Tropical Forestry Science* 22(1): 13-20.

Bisht, N.S. 1998. *Broom grass*. SFRI Information bulletin no. 6 State Forest Research Institute.

Ibrahim, M. and F. Sinclair. 2005. The history of future of agroforestry research and development: Policy impacts and needs. In: *Forests in the global balance- changing paradigms* (Eds. G. Mery, R. Alfaro, M. Kanninen, M. Lobovikov). IUFRO World Series Vol. 17, pp. 151-160.

John, S. A. and C. Mini. 2005. Biological efficiency of intercropping in okra (*Abelmoschus esculentus* (L.) Moench). *Journal of Tropical Agriculture* 43(1-2): 33-36.

Nautiyal, S., R. K. Maikhuri, K. S. Rao, R. L. Semwal and K. G. Saxena. 2003. Agro-ecosystem functions around a Himalayan Biosphere Reserve. *Journal of Environmental Systems* 29:71-100.

Ramakrishna, P. 1984. The science behind rotational bush fallow agricultural system (jhum): *Proc. Indian Acad. Sci. (Plant Science)* 93(3): 379-400.

Semwal, R. L., R. K. Maikhuri, K. K. Rao, K. K. Sen and K. G. Saxena. 2003. Leaf litter decomposition and nutrient release patterns of six multipurpose tree species of central Himalaya, India. *Biomass and Bioenergy* 24(1): 3-11.

Sharma, G. and L. Liang. 2006. The role of traditional ecological knowledge systems in conservation of agrobiodiversity: A case study in the Eastern Himalayas. *Proceedings of International Policy Consultation for Learning from Grassroots Initiatives and Institutional Interventions*, 27-29 May 2006. Indian Institute of Management, Ahmedabad, India.

Sharma, G., L. Lian and Koji Tanaka. 2006. On-farm agrobiodiversity management in mountain marginal farms in the Sikkim Himalaya. *Proceedings of the International Workshop on Shifting Agriculture, Environment Conservation and Sustainable Livelihood of Marginal Mountain Societies*, Guwahati, 23-25 September 2006.

Young, A. 1989. Ten hypotheses for soil - agroforestry research. *Agroforestry Today* 1(1): 13-16.