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Performance of Guinea grass (*Panicum maximum*) as influenced by row proportion under different tree species in north-eastern hilly region of India

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Abstract

Growth and yield performance of Guinea grass (*Panicum maximum*) was compared under different row proportions and four tree species predominantly found in North Eastern Region. The growth and yield were higher with *Morus alba* followed by *Terminalia myriocarpa*. Plant height increased with increasing row proportions, whereas, number of tillers/plant, clump circumference, leaf length and leaf width were significantly decreased. Plant height, clump circumference and number of leaves/plant were significantly ($P \leq 0.05$) higher in three row proportions. Guinea grass harvested under *Morus alba* showed higher fodder yield (34.7%), actual fodder sticks (50.0%) and above ground biomass (38.6%) than other tree species. Similarly, three row proportions had 120.5, 149.4 and 127.9% respectively higher yield than one row. Correspondingly, *Morus alba* had higher soil moisture during both the season, but *Michelia oblonga* registered higher solar radiation transmission.

Key words: Fodder, Guinea grass, Intercropping, *Michelia oblonga*, *Morus alba, Panicum maximum*, *Parkia roxburghi,* Row proportions, Shade, Soil moisture, Solar radiation transmission, *Terminalia myriocarpa*

Abbreviations: **LAI:** leaf area index, **LSD:** least significant difference, **MA*:*** *Morus alba*, **MO*:*** *Michelia oblonga*, **PR:** *Parkia roxburghi,* **SMC:** Soil moisture contents, **SRT:** Solar radiation transmission, **TDM:** total dry matter production, **TM*:*** *Terminalia myriocarpa*

Introduction

India possesses nearly 15 per cent of the world's human population and 16 per cent of world's livestock population with just 2.5 per cent of the geographical area of the world. Due to this huge human and livestock population, natural resources are over exploited, resulting in land degradation and environmental insecurities (Narendra *et al.*, 2011). In Arunachal Pradesh, commercial production of fodder is hardly available. Silvopastoral land use has been identified as a holistic approach to rehabilitate the degraded lands and wastelands for meeting the demand and supply of multitude of commodities by rural masses and conservation of natural resources.

In most tropical grasses, the varying response in yield under shade has been reported. Malaviya *et al.* (2006) reported that the response of guinea grass vary with its morphotypes, whereas, Lowry *et al.* (1988) reported 250% higher guinea grass under the shade of the canopy of *Albizia lebbek* trees as compared with that of outside the canopy. Wilson *et al.* (1990) reported 35% greater growth of *bahia* grass (*Paspalum notalum*) under approximately 55% light transmission as compared to open condition within a plantation of *Eucalyptus firandis* trees. These beneficial tree canopy effects are commonly believed to be due to leaf drop, better nutrient cycling, higher soil organic matter and improved soil physical structure (Young, 1989), and nitrogen fixation in the case of 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 Mani, 2005).

Present study was designed with the objectives to evaluate the growth and yield of guinea grass (*Panicum maximum*) and soil moisture content 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'N, 94°76'E and 660 m above MSL) during 2010 and 2011 crop seasons.

The tree species were planted at 3.0 m row intervals in 1997-98. Guinea grass was intercropped during second week of April, 2009 with four tree species *viz. Terminalia myriocarpa* (TM), *Michelia oblonga* (MO), *Parkia roxburghi* (PR) and *Morus alba* (MA). TM and MO have been included in study because of large scale plantation by the stakeholders in the state, PR was included due to its ability to restore wasteland and improve soil by N_2-fixation. Similarly, MA was selected as it provides additional returns through sericulture intervention (Table 1). The observations and data measurements are recorded during 2010 and 2011. The experiment was laid out in a split plot design with three replications. Care was taken during the planting and guinea grass was intercropped at least 1.0 m away from the tree trunks on both the sides and gross plot size of main plot was 33.0 m x 12.0 m and sub plot was 9.0 m x 3.0 m. The guinea grass was planted with spacing of 0.5 m x 0.5 m of plant geometry in two and three row proportion (1.25 m away in two row and 1 m away in three row from tree trunk), and one row were planted at 1.5 m away 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, leaf area, leaf area index (LAI), total dry matter production (TDM) and yield were taken. Leaf area was measured by the equation (Sf = 0.6058 (C*L), with the coefficient of determination R = 0.8586) proposed by Bianco *et al.* (2001). Where, Sf is the real leaf area, C is the main vein leaf length and L is the maximum leaf width. Yield was recorded, only after harvesting of the crop at 15 cm above the ground level from predetermined 1.5 m x 1.0 m quadrates, three cuttings were made during month of January, June and September. The cumulative of all the cuttings were sown as total yield.

Soil moisture contents were recorded by gravimetric method during January and June. 0-20 cm depths of soil samples were drawn from the each plot of the experiment unit with the help of soil auger and moisture content was measured.

SMC= $[(è_1 - è_2)/ è_2]$* 100, Where, $è_1$ is soil moisture content of wet sample, $è_2$ is soil moisture content of dry sample.

Solar radiation transmission (SRT) 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 guinea grass and the radiation transmission on open field. The area having no tree species in an around are considered as cent percent transmission and compared with recorded data from different tree species.

SRT= (q_1/ q_0)*100, Where, q_1 is solar radiation transmitted to canopy of guinea grass and q_0 solar radiation transmitted to pure stand.

The different parameters were statistically analyzed by SAS 9.2 programme. The significance of treatment effects was determined by *F*-test. The significance of the difference between means of two treatments was tested using least significant difference (LSD) at 5% probability level.

Results and Discussion

Growth parameters: Growth parameters *viz.* plant height, number of tillers/clump, clump circumference, number of leaves, leaf length and leaf width of guinea grass varied significantly ($P \leq 0.05$) with different tree species and row proportions (Table 2). The highest growth parameters were recorded with MA (118.4 cm, 29.9, 1324.6 cm, 4.97, 80.4 cm and 17.7 mm, respectively) followed by TM and lowest with MO.

Among the row proportions, growth attributes differed significantly ($P \leq 0.05$) with number of tillers/plant, clump circumference, leaf length and leaf width were higher on one row proportion (31.5, 1318.4 cm, 81.2 cm and 17.7 mm, respectively) followed by two row proportion. However, plant height and number of leaves/plant were higher with three row proportions (121.3 cm and 5.21, respectively). It was noticed that as plant height increased, there were fewer tillers, less circumference, and in contrary to these, number of leaves/plant, leaf length and leaf width were higher. Lowry *et al.*, 1988 had also registered the similar findings in guinea grass. The interaction between tree species and row proportions were statistically similar.

The crop growth parameters *viz.* leaf area, LAI and dry matter/plant varied significantly ($P \leq 0.05$) with tree species (Table 3). Highest crop growth values were found with MA (12531.7 cm^2/plant, 5.01 and 250.4 g/m^2, respectively) followed by TM. But TM and PR were statistically similar at $P \leq 0.05$.

Table 1. Description of land use characteristics

Treatment	Vegetation cover	Approximate age (yrs)	Surface area (m^2)	Density (tree/ha)	No. of rows	No. of trees/row	Basal area (m^2/ha)
MA	Pure stand	15	360	32	4	8	0.20
TM	Pure stand	15	810	86	9	9.5	2.09
PR	Pure stand	15	450	50	5	10	0.71
MO	Pure stand	15	810	88	9	9.8	2.49

MA: *Morus alba,* TM*: Terminalia myriocarpa,* PR*: Parkia roxburghi* and MO*: Michelia oblonga*

Table 2. Growth performance of guinea grass under different tree species

Treatment	Plant height (cm)	Number of tillers/clump	Clump circumference (cm)	Number of leaves/plant	Leaf length (cm)	Leaf breadth (mm)
Tree species						
MA	118.4^{a}	29.9^{a}	1324.6^{a}	4.97^{a}	80.4^{a}	17.7^{a}
TM	105.8^{b}	25.6^{b}	1061.8^{b}	4.37^{b}	76.9^{b}	16.7^{b}
PR	100.8^{c}	23.9^{bc}	963.8^{bc}	4.22^{b}	74.7^{b}	16.5^{bc}
MO	94.8^{c}	21.9^{c}	877.8^{c}	3.86^{c}	71.4^{c}	16.1^{c}
LSD	4.44	2.61	112.01	0.34	2.51	0.46
Pr>f	**	**	**	**	**	**
Row proportion						
One	87.3^{c}	31.5^{a}	1318.4^{a}	3.43^{c}	81.2^{a}	17.7^{a}
Two	106.3^{b}	25.8^{b}	1114.1^{b}	4.41^{b}	77.8^{a}	17.0^{b}
Three	121.3^{a}	18.7^{c}	753.5^{c}	5.21^{a}	66.7^{b}	15.5^{c}
LSD	8.85	3.10	167.71	0.47	3.64	0.63
Pr>f	**	**	**	**	**	**
TS x RP	0.062	0.739	0.189	0.031	0.336	0.312

* and ** are significant at 5% and 1% respectively, Means followed by the same letter are not different at 0.05 probability level

Table 3. Crop growth parameters and dry matter yield of guinea grass under different tree species

Treatment	Leaf area (cm^2/plant)	Leaf area index	Total dry matter (g/m^2)	Actual fodder yield (kg/ha)	Actual fodder sticks (kg/ha)	Above ground biomass (kg/ha)
Tree species						
MA	12531.7^{a}	5.01^{a}	250.4^{a}	4463.8^{a}	1692.0^{a}	6155.7^{a}
TM	8539.7^{b}	3.42^{b}	224.6^{b}	3962.7^{b}	1473.2^{b}	5435.8^{b}
PR	7406.1^{b}	2.96^{b}	217.9^{b}	3829.6^{b}	1382.3^{b}	5212.0^{b}
MO	5836.6^{c}	2.33^{c}	189.1^{c}	3313.9^{c}	1127.7^{c}	4441.5^{c}
LSD	1213.90	0.49	19.42	336.71	115.03	451.69
Pr>f	**	**	**	**	**	**
Row proportion						
One	9605.0^{a}	3.84^{a}	137.4^{c}	2382.9^{c}	808.7^{c}	3191.6^{c}
Two	9609.0^{a}	3.84^{a}	294.8^{a}	4039.0^{b}	1431.0^{b}	5470.0^{b}
Three	6522.0^{b}	2.61^{b}	229.3^{b}	5255.5^{a}	2016.7^{a}	7272.2^{a}
LSD	2404.90	0.96	24.33	445.47	202.19	645.32
Pr>f	**	**	**	**	**	**
TS x RP	0.034	0.034	0.456	0.374	0.107	0.293

* and ** are significant at 5% and 1% respectively, Means followed by the same letter are not different at 0.05 probability level

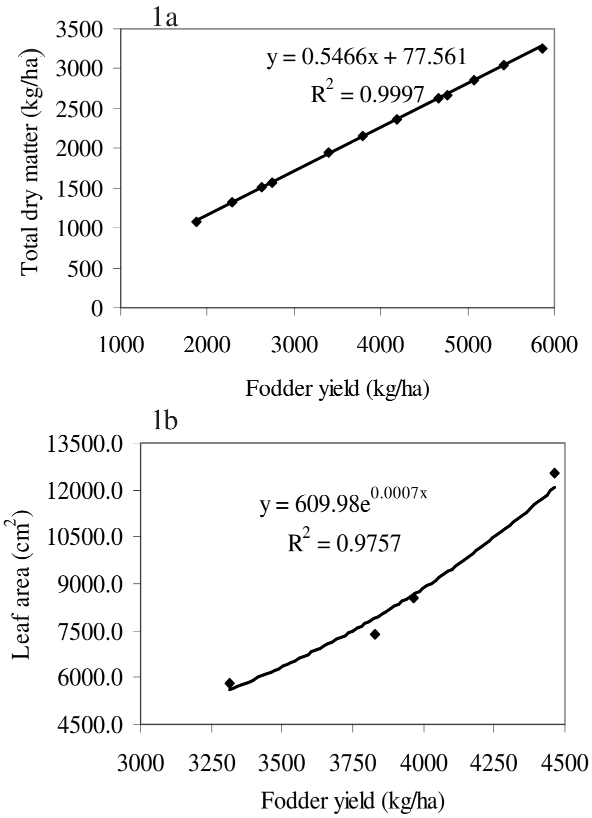

Figure 1. Relation between fodder yield in respect to different tree species and row proportions of guinea grass with a) total dry matter (linear) and b) leaf area (exponential)

The lowest crop growth values were obtained with MO (5836.6 cm^2/plant, 2.33 and 189.1 g/m^2, respectively). The crop growth values largely depends on growth parameters, as growth parameters increased these values also increased gradually.

Among the row proportions, the highest leaf area and LAI was obtained with one row proportion (9605.0 cm^2/plant and 3.84, respectively) followed by two row and three row proportions. However, highest dry matter/plant (294.8 g/m^2) was recorded with three row proportions followed by two row proportions and least from one row proportion (137.4 g/m^2).

Yield: Fodder yield, actual fodder sticks and above ground biomass were significantly ($P \leq 0.05$) influenced by tree species and row proportions of guinea grass. Highest fodder yield, actual fodder sticks and above ground biomass were recorded with MA (34.7, 50.0 and 38.6% respectively) followed by TM (19.6, 30.6 and 22.4% respectively) (Table 3). However, lowest yield were obtained from the MO.

Fodder yield is largely depends on total dry matter accumulation, both the parameters shows positive linear relation with R^2= 0.99 (Figure 1a). Similarly, leaf area could explain the relation with fodder yield in exponential relation with R^2= 0.98 (Fig. 1b). Similar finding was also reported by Kubota *et al.* (1994) and Seresinhe and Pathirana (2000) in different tree-grass combinations.

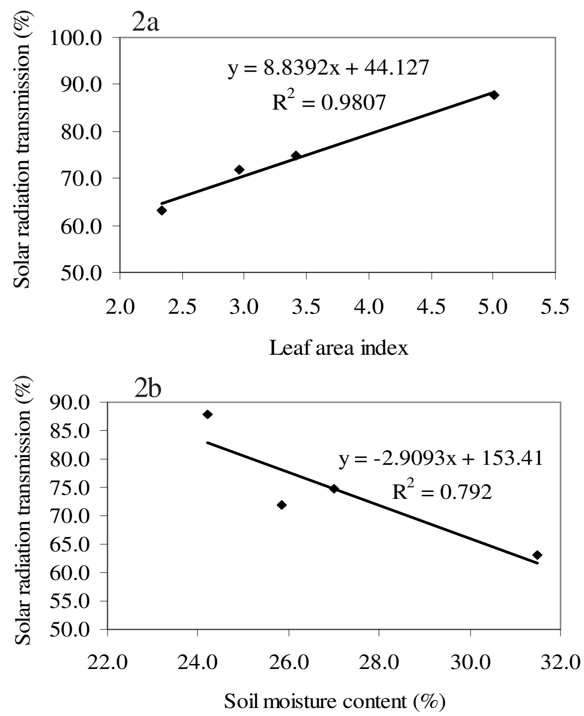

Figure 2. Relation between solar radiation interception in respect to tree species with a) leaf area index and b) soil moisture content (linear)

Table 4. Soil moisture content up to 30cm soil depths

Treatment	January	June
Tree species		
MA	20.7[c]	27.8[b]
TM	21.6[c]	29.4[b]
PR	24.6[b]	30.1[b]
MO	27.9[a]	35.1[a]
LSD	1.92	2.56
Pr>f	**	*
Intercropping		
One	25.5[a]	32.7[a]
Two	24.0[ab]	30.3[ab]
Three	21.5[b]	28.8[b]
LSD	2.77	2.89
Pr>f	*	*
TS x IC	0.835	0.907

* and ** are significant at 5% and 1% respectively, Means followed by the same letter are not different at 0.05 probability level

Among the row proportions, the highest fodder yield, actual fodder sticks and above ground biomass were obtained from three row proportions followed by two and the lowest with one row proportion. Three row proportions had 120.5, 149.4 and 127.9% respectively higher followed by two row proportions (69.5, 77.0 and 71.4% respectively) over one row proportion (Table 3).

Soil moisture content: Soil moisture content varied significantly with different tree species and row proportions of guinea grass (Table 4). Highest soil moisture content was recorded with MO followed by PR. However, lowest soil moisture content was obtained from MA during both the observation periods. MO had registered 37.8 and 26.3% higher soil moisture during January and June respectively followed by 18.8 and 8.2% respectively in PR. Among the row proportions, the higher soil moisture content was measured with one row proportion followed by two row proportions. However, the lowest soil moisture content was recorded with three row proportions. It is evident from the findings that as row proportion increased soil moisture content decreased significantly during both the sampling time. Fodder yield has followed the polynomial relation with soil moisture content (R^2=0.49). This clearly depicts that soil moisture could explain up to 49.0% of variation and has relationship with each other.

Solar radiation transmission: Solar radiation transmission (SRT) largely depends on tree species but not with intercrop row proportions. Highest solar radiation was transmitted to intercrop in MA followed by TM, being lowest in MO. This might be due to the canopy coverage of tree species. As canopy is dense, the transmission is less and vice versa with thin canopy coverage. Solar radiation transmission and leaf area index showed the positive linear relation with coefficient of determination of R^2= 0.98 (Figure 2a). It is apparent that MA had only 12.2% light intercepted in canopy and rest was transmitted. However, MO had 36.8% light interception. Similarly, TM and PR had 25.2 and 28.0% respectively light interception. Soil moisture content and solar radiation transmission showed the negative linear relation with R^2= 0.79 (Figure 2b). The reverse relationship between solar radiation transmission and soil moisture content were observed. Solar radiation transmission of intercropping was similar for all, but radiation transmission to grounds were varied significantly (three<two<one row). Soil moisture content during January and June followed the trend of three <two<one row. The above findings might be due to difference in vertical arrangement of foliage and canopy architecture of intercrop components, which may lead to less SRT by intercropping compared with no tree stand (Keating and Carberry, 1993).

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