Agricultural Journal 8 (4): 196-203, 2013
ISSN: 1816-9155

Persistency of Common Fodder Grasses under *Melia azedarach* Based Silvipastoral System

[1]S.R. Barsila, [1]Naba R. Devkota and [2]I. Barshila
[1]Agriculture and Forestry University, Rampur, Chitwan, Nepal
[2]Ministry of Agricultural Development (MOAD), Kathmandu, Nepal

Abstract: An experiment was conducted from July, 2004 to October, 2005 at IAAS Livestock Farm, Rampur under 14 years old *Melia azedarach* tree (maintained 1200 stems ha^{-1}) shade to study the dried weight yield potentiality of common fodder grasses, grown with tropical legumes and their persistency. A Split Plot Design (SPD) was employed with three replications with three different canopy levels (trees pruned at 3-5 m from the ground and one open) as main plots and four forage mixtures as subplots. Shade level was maintained by pruning the trees throughout the experiment. The shade level at the initial phase was measured by LUX-101 Lux Meter (Model No. 44147) at August, 2004 and was standardized for low (72% irradiance to open) medium (64% irradiance to open) and heavy (58% irradiance to open). Number of tillers/plant in fodder grasses decreased as the shade level increased in all the harvests whereas blue panic always had the highest number of tillers/plant ($p<0.001$) in all shade levels. Likewise, cumulative dried weight yield of (2004 and 2005 harvests) fodder grasses also decreased as the shade level increased. Nevertheless, the effect of shade was similar ($p>0.05$). Furthermore, highest cumulative dried weight yield was in open condition (63.29 ton ha^{-1}) followed by low shade 26.50 ton ha^{-1} (42% to that of open ton ha^{-1}) whilst the cumulative dried weight yield in medium shade remained 27% and it was only 21% in heavy shade to that of open. It can be concluded that *Panicum antidotale* can be grown in summer under high density plantations at least for two harvests. The selection of forage species is more important criterion of silvipastoral work than the maintenance of shade level.

Key words: Fodder grasses, silvipastoral system, *Melia azedarach*, shade level, canopy closure ratio

INTRODUCTION

Nepal is one of the countries with the highest livestock density in the world (HMG/N, 2002/03) which shares 32% to Agriculture Gross Domestic Product (AGDP) and is expected to increase by 47% by 2015 AD (APROSC and JMA, 1995). However, the associated shortage of feedstuffs to livestock has been considered important reason for the low productivity, thereby causing the poor household income. The estimated feed deficit in the country is 34% on Dry Matter (DM) basis and 54.3% in terms of green roughages, annually, to feed the growing ruminants (Pande, 1997; Raut, 1998). The present feed deficit condition both in terms of quality and quantity has not only aggravated the poor household income but also expected to reduce the trade deficit for livestock and livestock related products (Yadav and Devkota, 2005).

The feed supply from the agricultural land is limited and it hardly further allows going for massive fodder/forage production due to small holdings in nature. Obviously, optimization of the forest related resources in order to satisfy the demand of growing livestock population would be one of the sound alternatives. Development of silvipastoral system is one of them as tree plantings have been common, especially in the terai region. Benefits of integration of pastures with plantations have been well documented (Shelton *et al*., 1987; Reynolds, 1988) which could be inferred as an alternative to the conventional forage production systems (Anderson, 1991) with many ecological benefits (Barsila, 2008) to reduce the competition between increasing ruminants and human population due to the increased demand of forage resources (Blair, 1991) from the same unit of agricultural land. Development of such agroforestry systems has also been aimed in order to produce both quality and quantity forages as envisaged in 20 years of Agriculture Perspective Plan (APROSC and JMA, 1995) and possibilities of growing some leguminous and non-leguminous forage species under different tree species has also addressed by LMP.

Limited information are available on modality of silvipastoral system mainly in case of tree fodder

Corresponding Author: I. Barshila, Ministry of Agricultural Development (MOAD), Kathmandu, Nepal

integration (Shrestha *et al*., 1996; Devkota, 2000) and scientific information with respect to the morphological adaptations and their persistency particularly to that for trees and associated understorey forage crops are scanty. Among many multipurpose tree species found in Southern plains of Nepal, *Melia azedarach* tree is gaining popularity. Hactares of *Melia azedarach* based plantations are established and the area under the trees is still neglected. The available radiation could also be better exploited for better forage production in the shaded barelands (Healy *et al*., 1998), the swards of which not only adds the fresh green matter production but also to the nutritive quality of the forages. This study aims to determine the effects of shade of mature stands of *Melia azedarach* L. mostly on persistency of tiller production and DM yield.

MATERIALS AND METHODS

The experiment was carried out from July, 2004 to October, 2005 at Institute of Agriculture and Animal Science, Livestock Farm, Rampur using 14 years old *Melia azedarach* L. planted with 5×5 m^2 area. The number of stems (trees) in the field were maintained 1200 ha^{-1} with an average height of 8.5 m whereas average girth measured at breast height of trees was recorded 12 inches at the end of this experiment. The soil of the research site was sandy loam with organic matter content found 3.59% whereas soil organic carbon and soil N were 2.1 and 0.1%, respectively when employed with Walkley and Black (1934) method. The experiment was conducted using with Split Plot Design (SPD) with three replications. The main plot was tree shade created by pruning trees to the height upto 3-5 m from the ground with one open condition whereas forage mixture as subplots. Grasses were planted at 1×0.75 m^2 while the legumes were planted in the inter-row of grasses at the rate of 2 kg seed ha^{-1} at 5 cm depth. The combination of grasses and legumes in each subplot were as follows:

T_1 = *Pennisetum purpureum* (Napier)+*Desmodium distortum* (Greenleaf Desmodium)
T_2 = *Pennisetum purpureum* (Napier)+*Neonantia weightii* (Glycine)
T_3 = *Panicum antidotale* (Blue Panic)+*Desmodium distortum* (Greenleaf Desmodium)
T_4 = *Panicum antidotale* (Blue Panic)+*Neonantia weightii* (Glycine)

General agronomic practices were followed without irrigation and fertiization throughout the experiment. The understorey bushes and weeds were cleared once a month while earthing up was done twice a year for fodder grasses. A fairly similar shade level was maintained in each main plot throughout the experiment by pruning the lowermost branches of Melia tree. The shade level at the initial phase was measured by LUX-101 Lux Meter (Model No. 44147) at August, 2004 and was standardized for low (72% irradiance to open) medium (64% irradiance to open) and heavy (58% irradiance to open). The experimental site was also analyzed with respect to canopy closure ratio in the previous year by Timsina (2005) and was having 0.64, 0.54 and 0.43 canopy closure ratio, respectively for heavy medium and low shade.

The first harvest of grssses herbage mass was taken above 20 mm separately at 60 days after plantation. Then the subsequent harvests were taken in the interval of 45 days. The number of tillers/plant was analyzed separately at all harvests. Fresh herbage mass production was sampled on square meter basis whereas only 100 g of the fresh herbage from a plot was used to estimate the dry matter yield. The total dry matter production on hectare basis was calculated.

RESULTS

The data provided hereunder represent the average values across the different shade level. The figures for averages according to the forage mixtures have been given in the texts only.

Number of tillers/plant: Effect of shade was significant ($p<0.05$) to number of tillers/plant for grasses at 30th July, 2004 harvest (Table 1). In general, the number

Table 1: Average number of tillers/plant in non-leguminous forages under different levels of Melia shade at IAAS Livestock Farm, Rampur, 2004/05

	Average number of tillers/plant			
	Herbage harvested at			
Shade level	30th July, 2004	15th Sept, 2005	30th July, 2005	15th Sept, 2004
Heavy	8	16	16	24
Medium	11	19	19	32
Low	17	27	31	50
Open	41	76	48	81
Analysis of variance				
Shade level (df = 2)	p<0.05	NS	p<0.001	p<0.05
SEM	3.23	4.39	1.35	3.53
LSD	11.18	15.18	4.68	12.23
Forage mixture (df = 3)	p<0.001	p<0.001	p<0.001	p<0.001
SEM	4.89	9.12	2.76	6.19
LSD	14.18	26.47	8	17.95
Interaction (df = 6)	NS	NS	NS	NS
SEM	8.01	14.37	4.35	9.93
LSD	23.05	41.43	12.54	28.59

NS = No Significance difference at p<0.05; SEM = Standard Error of Mean; LSD = Least Significant Difference of means at significance level α = 0.05; Na = Napier; BP = Blue Panic; Des. = Desmodium; Gly. = Glycine; df = Degrees of freedom of tillers/plant decreased as the shade level increased. Accordingly, highest number of tillers/plant was obtained for grasses under open condition (41/plant) while it was lowest for heavy shade (8/plant). Among the species, the number of tillers/plant for forage species at medium shade level was in between the open and heavy shade. Blue panic had 77 tillers/plant in open condition, the number was lowest for heavy shade (12 tillers/plant when grown with desmodium. The trend of obtaining highest tillers/plant by blue panic continued in all shade levels in the order of more tillers in low shade followed by at medium and heavy shade.

At 15th September, 2004 harvest, the effect of shade was non-significant ($p>0.05$) to the number of tillers/plant for non-leguminous forages. The number of tillers/plant was increased in all shade levels compared to the number of tillers/plant of 30th July harvest compared to the values of 30th July harvest. Accordingly, the number of tillers/plant was increased by 100% in heavy shade, 73% in medium shade, 59% in low shade and 85% in open. The interactive effect of shade on forage mixture had similar effect ($p>0.05$) to the number of tillers/plant.

At 30th July, 2005 harvest, as well the effect of shade was highly significant ($p<0.001$) to number of tillers/plant for grasses. As in the case of previous harvest, highest number of tillers/plant was recorded for open condition (mean value 48 tillers/plant) which was decreased subsequently at low shade (31 tillers/plant), medium shade (19 tillers/plant) and heavy shade (16 tillers/plant) (Table 1). At this harvest also, blue panic always had the highest number of tillers/plant (87 tillers/plant) under open condition when grown with glycine compared to Napier. Napier had the lowest number of tillers/plant in all shade levels (Table 1, Appendix 1). The detail of average tiller production and dried weight yield across the dates of harvest has been presented in Fig. 1.

Shade effect remained similar ($p>0.05$) to the number of tillers/plant for herbage harvested on different dates (Table 1). In general, number of tillers/plant in non-leguminous forages decreased as the shade level increased from low to heavy shade (Table 1, Appendix 1). Highest number of tillers/plant was obtained in open (81 tillers/plant) and the lowest in heavy shade (24 tillers/plant).

Dried weight yield: At 30th July, 2004 harvest 10.14 ton ha^{-1} dried weight of non leguminous herbage harvested was obtained for open conditions whereas in the case of low shade, the value was recorded as 3.92 ton ha^{-1}. Lowest dried weight yield of herbage

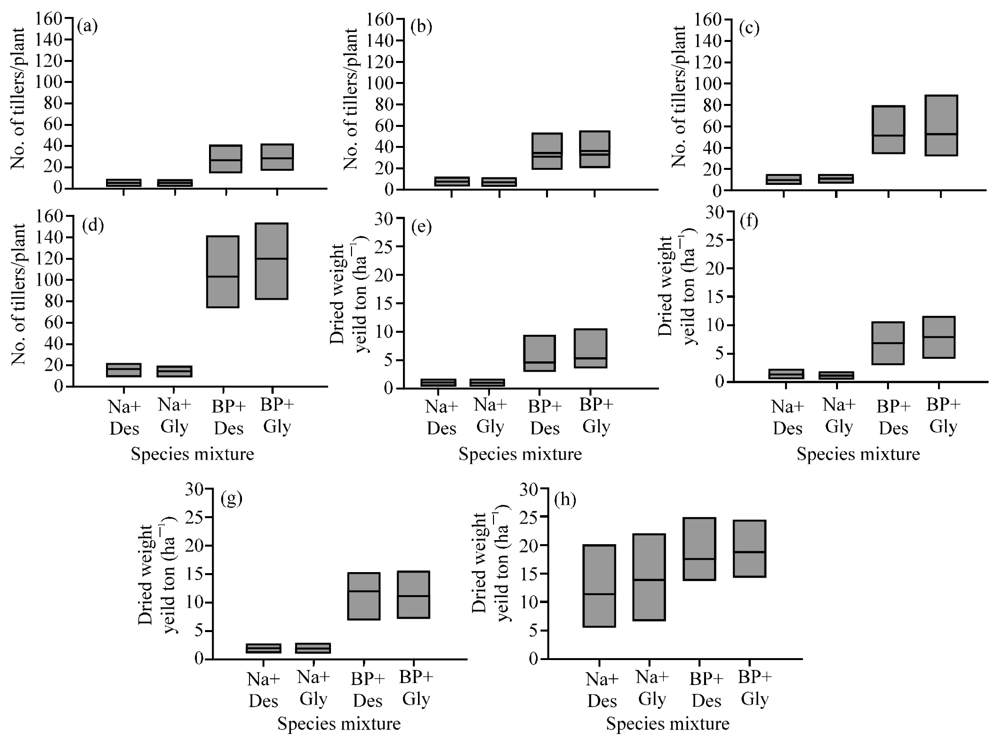

Fig. 1: Average number of tillers and dried weight yield (ton ha^{-1}) of different grass-legume mixture herbage harvested at 30th July and 15th September in 2004 and 2005. Average values across all harvested displayed: a) Heavy shade; b) Medium shade; c) Low shade; d) Open; e) Heavy shade; f) Medium shade; g) Low shade; h) Open

harvested was 1.51 ton ha^{-1} in medium shade. Dried weight harvested of blue panic was always highest in all shade levels whereas the value was 13.98 ton ha^{-1} in case of open conditions when grown with Glycine. Napier, similarly always had the lowest dried weight compared to the blue panic at all shade levels (Table 2).

The dried weight yield of grasses at 15th September, 2004 harvest was obtained highest for open condition (21.67 ton ha^{-1}) and the lowest in heavy shade (3.14 ton ha^{-1}). The dried weight reduced ($p<0.05$) as the shade level increased from low to heavy shade. Accordingly, dried weight yield of blue panic was always highest in all shade levels followed by Napier. The highest dried weight yield in blue panic was found in open conditions (25.82 ton ha^{-1}) when grown with desmodium and remained the lowest in heavy shade (5.19 ton ha^{-1}) (Table 2). At 30th July, 2005 harvest, dried weight trend of non leguminous forages mixture and the effect of shade was similar to that of 2004 harvests. Accordingly, highest dried weight of regrowth was obtained for open which subsequently decreased in case of low, medium and heavy shade. However, the dried weight at all shade levels and also the dried weight value of forage mixture decreased for 30th July harvests to that of 2004 harvests (Table 2). Accordingly, the highest dried weight value was limited to 10.45 ton ha^{-1} for open and 2.16 ton ha^{-1} for heavy shade (Table 2).

The trend of dried weight yield for grasses at 15th September, 2005 harvest was similar to that of previous harvests (Table 2) as well. Highest dried weight yield in open condition was 21.03 ton ha^{-1} whereas the lowest value for low shade was 5.78 ton ha^{-1}. Nevertheless, the effect of shade was similar ($p>0.05$) to all levels of shade. However, the species difference was highly significant ($p<0.001$). The trend of dried weight attained by blue panic remained highest in the order of low shade followed by at medium shade and at low shade, respectively (Table 2).

The dried weight yield total in 2004 was differed according to the shade level ($p<0.05$) which was further dependent on species ($p<0.001$). In overall, the highest dried weight yield attained by blue panic remained in the order of highest in open (31.81 ton ha^{-1}) followed by low (12.23 ton ha^{-1}) and medium shade (6.28 ton ha^{-1}) while it was the lowest for heavy shade (4.77 ton ha^{-1}). Likewise, the trend of dried weight total of 2005 was similar in trend to that of dried weight total of 2004 harvests. Nevertheless, shade effect was similar ($p>0.05$) in 2005 harvests.

The cumulative dried weight of all months (harvests of 2004 and 2005 total) harvests of non-leguminous forages remained in trend similar to that of 2005 harvests. Accordingly, shade effect remained similar ($p>0.05$) across the shade levels but the species difference was highly significant ($p<0.001$). Cumulative dried weight yield was 63.29 ton ha^{-1} in open condition and the lowest was obtained for low shade (12.71 ton ha^{-1}). The dried yield cumulative for non leguminous forages decreased as the shade level increased (Table 2, Appendix 2). The detail of the interactive effect of shade and forages in mixture to the dried weight yield of grasses component in all the harvests has been presented in Table 2.

Table 2: Herbage harvested (above 20 mm regrowth dried weight (ton ha^{-1}) average of common fodder grasses under Melia shade at IAAS, Livestock Farm, Rampur, 2004/05

	Dried weight yield of non-leguminous forages (ton ha^{-1})						
	Herbage harvested at						
Shade level	30th July, 2004	15th Sept, 2004	Total of 2004	30th July, 2005	15th Sept, 2005	Total of 2005	Cumulative*
Heavy	1.63	3.14	4.77	2.14	5.78	7.95	12.71
Medium	1.51	4.77	6.28	3.85	6.8	10.65	16.93
Low	3.92	8.32	12.23	5.05	9.21	14.27	26.50
Open	10.14	21.67	31.81	10.45	21.03	31.48	63.29
Analysis of variance							
Shade level (df = 2)	p<0.05	p<0.05	p<0.05	p<0.05	NS	NS	NS
SEM	0.57	0.81	1.5	0.51	1.36	1.669	2.6
LSD	1.96	2.81	3.67	1.77	4.7	5.776	9.01
Forage mixture (df = 3)	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
SEM	0.53	0.62	1.22	0.57	1.2	1.2	1.4
LSD	1.52	1.81	2.51	1.66	3.48	3.47	4.06
Interaction (df = 6)	NS	p<0.01	p<0.01	NS	NS	NS	p<0.01
SEM	0.97	1.24	2.37	1	2.26	2.45	3.34
LSD	2.81	3.62	4.88	2.88	6.55	7.2	10.08

NS = No Significance difference at $p<0.05$; SEM = Standard Error of Mean; LSD = Least Significant Difference of means at significance level $\alpha = 0.05$; Na = Napier; BP = Blue Panic; Des. = Desmodium; Gly. = Glycine; df = Degrees of freedom; Cumulative* = Cumulative values of all months of 2004 and 2005 harvests

DISCUSSION

Research results based in this study showed that numbers of tillers/plant in grasses was highest ($p<0.001$) in the order for open, followed by low shade. The available results have also well demonstrated that the number of tillers/plant increased for second cut (15th September harvests) in all shade levels as well as to the open condition. Various environmental factors might influence the vegetative growth of forages under shade. The low temperature at shaded condition could slow down the morphological development. The decrease in number of tillers/plant in grasses is possibly due to due to the slower rate of photosynthesis (Bahmani *et al*., 2000; Gautier *et al*., 1999). Low light intensity could render negative effect to the number of tillers/plant (Auda *et al*., 1966; Devkota, 2000). The differences in the shade condition, forage species grown and the time forages species grown are the likely sources of variation in number of tillers/plant in non-leguminous forages. The increase in number of tillers/plant for non leguminous forages in second cut (15th September) might be due to the defoliation effect (Watt and Haggar, 1980; Krans and Beard, 1985). Paez *et al*. (1997) reported the beneficial effect of defoliation to the number of tillers/plant for *Panicum maximum* under *Eucalyptus grandis* shade which was similar to the condition of harvests of this experiment. Result of this experiment also matches to the findings of Timsina (2005).

Generally, forage availability reduces under tree plantations (Robinson, 1991), especially when trees grow older (Mohd Najib, 2003). In contrast to the findings of this experiment to the dried weight Wong and Wilson (1980) on the other hand found increased herbage yields for green panic (*Panicum trichoglume*). Research result showed that dried weight yield, as indicated by dry matter content of non leguminous forages, reduced as the level of shade increased for all the harvests. The main reason for such result could be due to the reduction of photosynthetic rate in shade (Peri *et al*., 2002). When plants experience a change from high to low irradiance, photosynthesis deactivation process occurs due to a reduction in stomatal conductance (Amundson *et al*., 1995) related to an increase in biochemical limitations (Tinoco-Ojanguren and Pearcy, 1993). However, the rate of photosynthesis and stomatal conductance of shade grown forages are not quantified with respect to the dried weight yield in this experiment.

The result of this experiment confirmed the results reported by Timsina (2005) for same species under the same canopy level as dried weight reduced in shade due to reduction in light level (Henderson and Robinson, 1982) would be caused by reduced rate of photosynthesis. The shaded plants attained shorter plant height, tiller number/plant and number of leaves/plant which ultimately reduced the dried weight yield. The dried weight yield increased at 15th September harvests in both years could be related to the residual tillers in the field that might have added effect indeed. In terms of species, blue panic had the highest number of tillers/plant, highest plant height and highest number of leaves per plant which could well contribute to the highest dried weight yield to that of Napier.

CONCLUSION

Results of this experiment revealed the possibilities of growing common perennial fodder grassesunder *Melia azedarach* tree. Blue panic (*Panicum antidotale*) in low shade gave the highest dried weight yield when grown in combination with Greenleaf Desmodium. Summer sowing of blue panic for deciduous based silvipastoral system under high density plantation (heavy shade) at least for 2 harvests can be recommended. Based on the findings of this experiment, it can be concluded that selection of forage species is more important part of silvipastoral study than maintenance of shade as reflected by the changes in tiller density (number of tillers/plant) and dried weight yield.

ACKNOWLEDGEMENT

Researcher would like to express sincere thanks and appreciation to the Heifer Project International Nepal for their financial support for carrying out the field experiment.

APPENDIX

Appendix 1: Number of tillers/plant in non-leguminous forages under different levels of Melia shade at IAAS Livestock Farm, Rampur, 2004/05

	Average number of tillers/plant			
	Herbage harvested at			
Shade level	30th July, 2004	15th Sep, 2004	30th July, 2005	15th Sep, 2005
Heavy				
Na+Des	2	6	3	5
Na+Gly	3	6	3	6
BP+Des	12	26	27	43

Appendix 1: Continue

Shade level	Average number of tillers/plant Herbage harvested at 30th July, 2004	15th Sep, 2004	30th July, 2005	15th Sep, 2005
BP+Gly	15	26	30	44
Mean	8	16	16	24
Medium				
Na+Des	6	10	4	7
Na+Gly	6	9	4	8
BP+Des	16	27	33	56
BP+Gly	17	29	34	57
Mean	11	19	19	32
Low				
Na+Des	6	10	6	9
Na+Gly	6	9	9	12
BP+Des	29	45	52	83
BP+Gly	27	44	56	94
Mean	17	27	31	50
Open				
Na+Des	8	15	17	21
Na+Gly	9	13	15	19
BP+Des	71	128	72	139
BP+Gly	77	149	87	145
Mean	41	76	48	81
Analysis of variance				
Shade level (df = 2)	p<0.05	NS	p<0.001	p<0.05
SEM	3.23	4.39	1.35	3.53
LSD	11.18	15.18	4.68	12.23
Forage mixture (df = 3)	p<0.001	p<0.001	p<0.001	p<0.001
SEM	4.89	9.12	2.76	6.19
LSD	14.18	26.47	8	17.95
Interaction (df = 6)	NS	NS	NS	NS
SEM	8.01	14.37	4.35	9.93
LSD	23.05	41.43	12.54	28.59

NS = No significant difference at p<0.05; SEM = Standard Error of Mean LSD = Least Significance Difference of means at α = 0.05; Na = Napier; BP = Blue Panic; Des = Desmodium; Gly = Glycine; df = Degrees of freedom

Appendix: 2: Herbage harvested (above 20 mm regrowth dried weight, ton ha^{-1}) of common fodder grasses under Melia shade at IAAS, Livestock Farm, Rampur, 2004/05

Shade level	Dried weight yield of non-leguminous forages (ton ha^{-1}) Herbage harvested at 30th July, 2004	15th Sep, 2004	Total of 2004	30th July, 2005	15th Sep, 2005	Total of 2005	Cumulative*
Heavy							
Na+Des	0.37	0.76	1.13	0.24	0.56	0.80	1.93
Na+Gly	0.37	0.71	1.08	0.26	0.56	0.82	1.90
BP+Des	2.77	5.19	7.96	3.70	10.26	13.96	21.92
BP+Gly	3.02	5.89	8.91	4.45	11.75	16.20	25.11
Mean	1.63	3.14	4.77	2.14	5.78	7.95	12.71
Medium							
Na+Des	0.59	1.62	2.21	0.55	1.07	1.61	3.82
Na+Gly	0.51	1.32	1.83	0.58	1.09	1.67	3.50
BP+Des	2.00	7.89	9.89	6.26	11.99	18.25	28.14
BP+Gly	2.95	8.25	11.2	8.03	13.04	21.07	32.27
Mean	1.51	4.77	6.28	3.85	6.80	10.65	16.93
Low							
Na+Des	1.15	1.98	3.13	1.13	2.59	3.72	6.85
Na+Gly	1.13	2.65	3.78	1.19	2.66	3.84	7.62
BP+Des	6.52	15.02	21.54	9.08	15.39	24.47	46.01
BP+Gly	6.87	13.62	20.49	8.82	16.21	25.04	45.53
Mean	3.92	8.32	12.23	5.05	9.21	14.27	26.50
Open							
Na+Des	6.64	15.75	22.39	4.99	20.79	25.78	48.17
Na+Gly	6.56	20.59	27.15	6.83	21.66	28.49	55.64
BP+Des	13.39	25.82	39.21	14.9	19.55	34.45	73.66
BP+Gly	13.98	24.51	38.49	15.08	22.11	37.19	75.68
Mean	10.14	21.67	31.81	10.45	21.03	31.48	63.29

Appendix: 2: Continue

	Dried weight yield of non-leguminous forages (ton ha^{-1})						
	Herbage harvested at						
Shade level	30th July, 2004	15th Sep, 2004	Total of 2004	30th July, 2005	15th Sep, 2005	Total of 2005	Cumulative*
Analysis of variance							
Shadelevel (df = 2)	p<0.05	p<0.05	p<0.05	p<0.05	NS	NS	NS
SEM	0.57	0.81	1.50	0.51	1.36	1.669	2.60
LSD	1.96	2.81	3.67	1.77	4.70	5.776	9.01
Forage mixture (df = 3)	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
SEM	0.53	0.62	1.22	0.57	1.20	1.20	1.40
LSD	1.52	1.81	2.51	1.66	3.48	3.47	4.06
Interaction (df = 6)	NS	p<0.01	p<0.01	NS	NS	NS	p<0.01
SEM	0.97	1.24	2.37	1.00	2.26	2.45	3.34
LSD	2.81	3.62	4.88	2.88	6.55	7.20	10.08

NS = No significance difference at $p<0.05$; SEM = Standard Error of Mean; LSD = Least Significant Difference of means at significance level $\alpha = 0.05$; Na =Napier; BP = Blue panic; Des = Desmodium; Gly = Glycine; df = Degrees of freedom, Cumulative* = Cumulative values of all months of 2004 and 2005 harvests

REFERENCES

APROSC. and JMA., 1995. Nepal: Agricultural Perspective Plan. Agricultural Projects Services Centre and John Mellor Associates, Kathmandu, Nepal.

Amundson, R.G., A.R. Ali and A.J. Belsky, 1995. Stomatal responsiveness to changing light intensity increases rain-use efficiency of below crown vegetation in tropical savannas. J. Arid Environ., 29: 139-153.

Anderson, G., 1991. Benefits, limitations and management of a fully integrated agroforestry system. Agric. Sci., 4: 15-17.

Auda, H., R.E. Blaser and R.H. Brown, 1966. Tillering and carbohydrate contents of orchrdgrass as influenced by environmental factors. Crop Sci., 6: 139-143.

Bahmani, I., C. Varlet-Grancher, L. Hazard, C. Matthew and M. Betin *et al.*, 2000. Post-flowering tillering in contrasting light environments of two New Zealand perennial ryegrass cultivars with different perennation strategies. Grass Forage Sci., 55: 367-371.

Barsila, S.R., 2008. Silvipastoral system: An alternative to sustainable forage production in Nepal. Proceedings of the 14th Annual International Sustainable Development Research Conference, September 21-23, 2008, New Delhi, India -.

Blair, G.J., 1991. The ACIAR Forage Program. In: Forages for Plantation Crops, Shelton, H.M. and W.W. Stur (Eds.). ACIAR, Canberra, pp: 1-4.

Devkota, N.R., 2000. Growth of pasture species in shade in relation to alder silvopastoral systems. Ph.D. Thesis, Massey University, New Zealand.

Gautier, H., C. Varlet-Grancher and L. Hazard, 1999. Tillering responses to the light environment and to defoliation in populations of perennial ryegrass (*Lolium perenne* L.) selected for contrasting leaf length. Ann. Bot., 83: 423-429.

Healy, K.D., K.G. Rickert, G.L. Hammer and M.P. Bange, 1998. Radiation use efficiency increases when the diffusive component of incident radiation is enhanced under shade. Aust. J. Agric. Res., 49: 665-672.

Henderson, M.S. and D.L. Robinson, 1982. Environmental influences on yield and *in vitro* true digestibility of warm-season perennial grasses and the relationships to fiber components. Agron. J., 74: 943-946.

Krans, J.V. and J.B. Beard, 1985. Effects of clipping on growth and physiology of Merion Kentucky bluegrass. Crop Sci., 25: 17-20.

Mohd Najib, M.A., 2003. Growth of native and improved forages under orchard crops. Proceedings of 8th Meeting of the Regional Working Group on Grazing and Feed Resources for Southeast Asia, September 22-28, 2003, Kuala Lumpur, Malaysia, pp: 49-51.

Paez, A., M.E. Gonzalez and J.J. Vilasmil, 1997. Acclimation of *Panicum maximum* to different light regimes. Effect of subsequent defoliation. Revista de la Facultad de Agronomia, 14: 625-639.

Pande, R.S., 1997. Fodder and Pasture Development in Nepal. Udaya Research and Development Services (P.) Ltd., Kathmandu, Nepal.

Peri, P.L., D.L. McNeil, D.J. Moot, A.C. Varella and R.J. Lucas, 2002. Net photosynthetic rate of cocksfoot leaves under continuous and fluctuating shade conditions in the field. Grass Forage Sci., 57: 157-170.

Raut, Y., 1998. A handbook of animal husbandry, Part I: Pasture production. His Majesty's Government, Nepal, Ministry of Agriculture, Department of Livestock Services, Hills Leasehold Forestry and Forage Development Project, Harihar Bhawan, Lalitpur, Nepal.

Reynolds, S.G., 1988. Pastures and Cattle under Coconuts. Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN-13: 9789251027226, Pages: 321.

Robinson, J.B., 1991. The growth of *Chloris gayana* within and adjacent to a plantation of *Eucalyptus grandis*. Trop. Grasslands, 25: 287-298.

Shelton, H.M., L.R. Humphreys and C. Batello, 1987. Pastures in the plantations of Asia and the Pacific: Performance and prospect. Trop. Grasslands, 21: 159-168.

Shrestha, S.R., N.R. Devkota and T.R. Chapagain, 1996. Performance of Napier (*Pennisetum purpureum*) Grass under the Canopy of Sissoo (*Dalbergia sisoo*). In: IAAS Research Reports (1994-1995), Neupane, F.P. and M. Kharel (Eds.). Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal, pp: 237-239.

Timsina, K., 2005. Growth and nutritive value of common forage species under *Melia* based silvipastoral system in Chitwan. M.Sc. Thesis, Institute of Agriculture and Animal Science, Tribhuvan University, Rampur Chitwan, Nepal.

Tinoco-Ojanguren, C. and R.W. Pearcy, 1993. Stomatal dynamics and its importance to carbon gain in two rainforest *Piper* species. Oecologia, 94: 395-402.

Walkley, A. and I.A. Black, 1934. An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29-38.

Watt, T.A. and R.J. Haggar, 1980. The effect of defoliation upon yield, flowering and vegetative spread of *Holcus lanatus* growing with and without *Lolium perenne*. Grass Forage Sci., 35: 227-234.

Wong, C.C. and J.R. Wilson, 1980. Effects of shading on the growth and nitrogen content of green panic and Siratro in pure and mixed swards defoliated at two frequencies. Aust. J. Agric. Res., 31: 269-285.

Yadav, J.L. and N.R. Devkota, 2005. Feeds and feeding situation of livestock in the Terai region of Nepal. Proceedings of the Concluding Workshop and 6th Temperate Asia Pasture and Fodder Research Network Meeting, March 8-11, 2005, Dhulikhel, Kabhre District, Nepal.