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NUTRIENT CONTENT AND BIOMASS PRODUCTION IN TROPICAL RANGE GRASSES AND LEGUMES UNDER DIFFERENT LIGHT INTENSITIES

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Abstract

Seventeen promising tropical range grasses and two legumes were studied for nutrient content and biomass production under different light intensities in semi arid region under rain fed conditions. In most of the grasses and legumes, maximum biomass production was recorded under 75% light intensity. Tri specific hybrid produced higher green and dry matter yield (DMY) followed by *Pennisetum polystachyon, Panicum maximum, Cenchrus ciliaris* and *Setaria sphacelata* under high shading conditions i.e. 50% and 25% light intensities indicating their shade adaptation compared to other grass species tested. The higher accumulation of nitrogen in leaves and crude protein under moderate shading shows that these grasses are able to maintain their quality even under shading environment. Magnesium content increased with decreasing light intensity. Higher potassium content was estimated in *Brachiaria brizantha, Pennisetum polystachyon, Brachiaria decombens, Bothriochloa bladhii, Panicum antidotale* and Tri specific hybrid under moderate shading environment. In most of the species maximum phosphorus content in leaves was estimated under 50% and 25% shading condition and it was higher under high shading conditions compared to the open grown grasses and legumes. In general the calcium content in leaves decreased with decreasing light intensity. The biomass production in term of DMY appears to be more closely related with the nutrient accumulation in leaves. In leaves of most of the grasses maximum sugar content accumulated under 75% light intensity, whereas, starch accumulation was maximum under 75% and 50% light intensities.

Key words : Range grasses, legumes, nutrients, light intensity, shading environment.

Introduction

The concentration of nutrients in the plant tissue is of great ecological significance. The availability of nutrients indirectly affects the pattern of nutrient distribution in the various components of a plant. Nitrogen is mostly required by grasses and legumes for enhanced biomass yield. As compared to grasses, legumes require relatively high phosphorus. Potassium plays significant role for crops grown in rain fed conditions. Some of the nutrients (N, P and K) have been reported to be associated with various physiological processes.

Naidu and Swamy (1994) observed that concentration of N, P and K in several tropical tree species varied from month to month. The concentration of N, P and K are higher in the young leaves and

decreased progressively with age (James and Smith, 1978; Ralhan and Singh, 1987; Verma and Mishra, 1989). Light intensities indirectly influence the nutritional uptake of plants up to some extent. The process of nitrogen metabolism is greatly affected unless the plant receives enough light for rapid photosynthesis. In the deficiency of light, nitrogen is not rapidly utilized which in term affects effective utilization of carbohydrates. Therefore, the present investigation was undertaken to work out the effect of different light intensities on biomass, nutrient and sugar content in range grasses and legumes (RGL).

Materials and Methods

Seedlings of seventeen grass species, viz. *Bothriochloa bladhii, Brachiaria mutica, B. decombens, B. brizantha , Cenchrus ciliaris, C. setigerus, Chloris gayana, Chrysopogon fulvus, Dichanthum annulatum, Heteropogon contortus, Panicum maximum, Paspalum notatum, Panicum antidotale, Pennisetum polystachyon, Setaria sphacelata,* Tri specific hybrid (TSH) were raised in the nursery at Indian Grassland and Fodder Research Institute, Jhansi (25°, 25'N, 78°, 35'E and 275 msl), India. Uniform seedlings of all the grasses were transplanted in the field at the spacing of 50 x 50 cm under optimum nutrient (60 kg N and 30 kg P_2O_5 per ha) in July 1996. The soil of the experimental field was sandy clay, neutral; medium textured and contained 0.34% organic carbon, 0.06% nitrogen and 23 kg per ha available phosphorus. The seeds of two species of range legumes were sown at the time of transplanting of grasses. The plant material were raised as per agronomic practices under rain fed condition. After establishment of grasses and germination of range legumes the plots were covered by shading net (Agro shade net) allowing different light intensities (25, 50 and 75 percent) and one treatment was kept in open (100% light intensity) as control under natural environment in three replication. The light intensity under shading net was measured by using Quantum/ Radiometer/Photometer (Model LI-188, LICOR, USA) and required light intensities were obtained by adjusting the height of shading net. The experiment was maintained for three years. In the first year the grasses were established for uniform growth. The observation of biomass production and nutrient content (N, P, K, Ca and Mg) in leaves were recorded during third year of growth at 50% flowering stage after regeneration in July.

Total nitrogen in oven dried plant samples were estimated by Microkjeldal method (AOAC, 1960). The crude protein (CP) was calculated from the estimated nitrogen. Total phosphorus content in dry samples was estimated as suggested by Kitson and Mellon (1944). Potassium and calcium contents were analyzed in dried material by the Digital Flame Photometer. Magnesium content in leaves was determined by thizole yellow described by Johnson and Ulrich (1959) and modified by Yadava *et al.*, (1969). Sugar and starch contents in dry samples of leaves were estimated by Anthrone method (Fong *et al.*, 1953).

Results and Discussion

Biomass production

In most of the grasses and legumes maximum biomass production was recorded under 75% light intensity. *C. ciliaris, S. sphacelata, P. maximum, P. polystachyon,* TSH and *B. mutica* maintained maximum dry matter yield even after third year of growth under shade, exhibiting their adaptability to shade over the years as compared to other grass species and therefore, may be suitable for shading environment under silvo pastoral system (Table1). *S. hamata* produced more biomass than *M. atropurpureum* which may be due to good seed germination under shade. Dry matter yield was positively correlated with photo synthetically active radiation (r = 0.3038).

Nutrient content

Leaves had maximum nitrogen content under 75% light intensity followed by 50% light intensity in some grasses, whereas nitrogen content was higher in some open grown grasses (Figure 1). The higher accumulation of nitrogen under moderate shading by leaves exhibited that these grasses are able to maintain their quality even under shading condition and can be grown under tree canopies in silvo pastoral system.

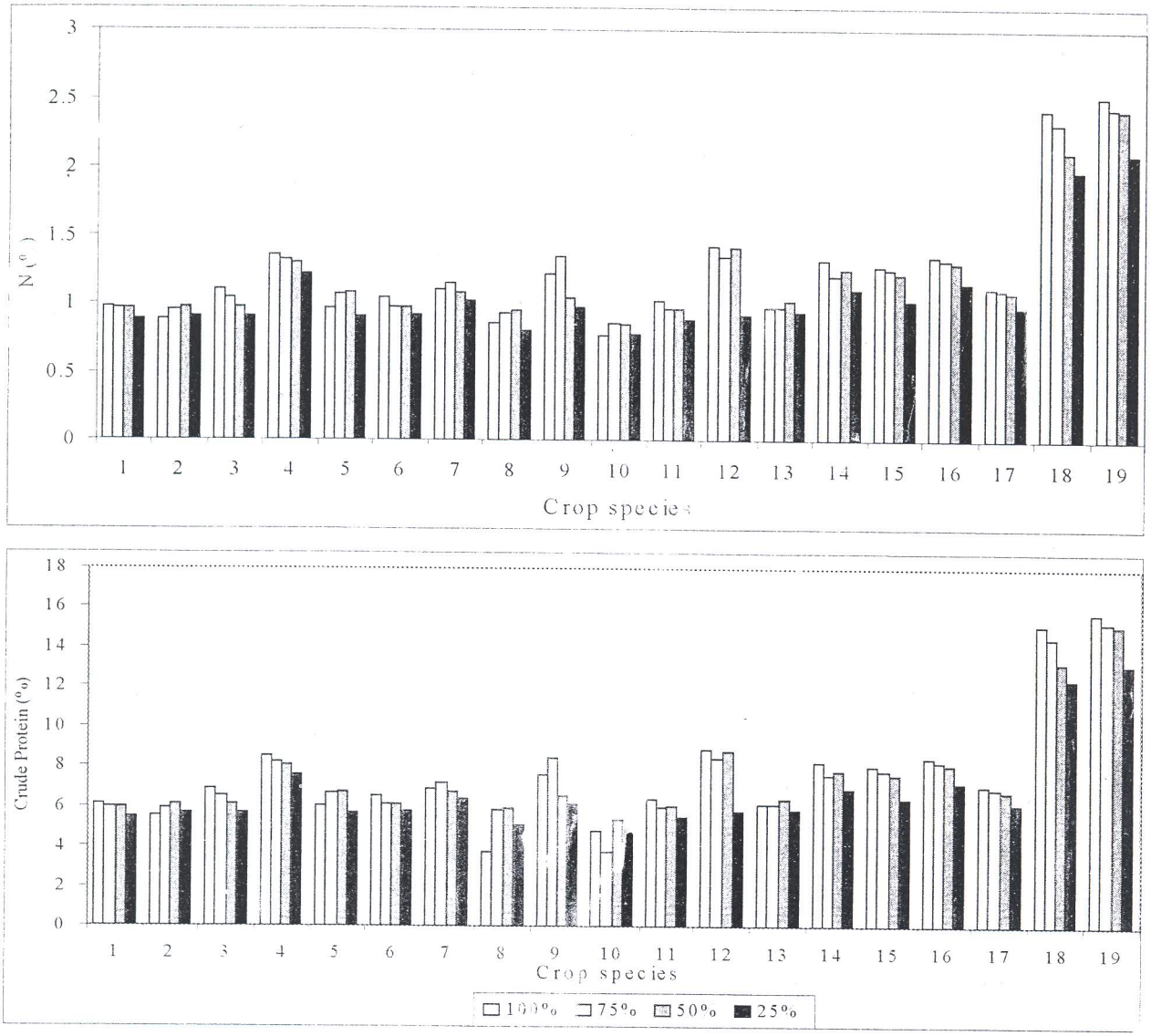

Figure 1. Nitrogen (%) and crude protein in leaves of range grasses and legumes under different light intensities.

(1. *B. bladhii* 2. B. *brizantha* 3. *B. decombens* 4. *B. mutica* 5. *C. ciliaris* 6. *C. setiger* 7. *C. gayana* 8. *C. fulvus* 9. D. *annulatum* 10 *H. contortus* 11. *P. antidotale* 12. *P. maximum* (IGFRI) 13. *P. notatum* 14. *P. maximum* (PGG) 15. *P. polystachyon* 16. *S. sphacelata* 17. Tri specific hybrid (TSH) 18. *M.atropurpureum* 19. *S.hamata*)

Magnesium content increased with increasing shading environment. However, in *S. hamata, S. sphacelata, C. setigerus, C. ciliaris P. maximum,* TSH and *B. mutica* higher magnesium was estimated under 50% and 75% light intensities (Figure 2). The variation in accumulation of magnesium under different light intensities might be due to specific difference irrespective of shading treatments and adaptation of leaves to the various degree of shading. In most of the grass species maximum phosphorus content in leaves was estimated under 50% and 25% shading environment (Figure 2). In *B. bladhii, C. ciliaris, C. setigerus, C. gayana, P. antidotale, P. notatum, S. sphacelata* and TSH it was higher under high shading conditions as compared to the open grown plants. In range legumes the maximum phosphorus content was estimated under 50% light intensity in *M. atropurpureum* and 75% in *S. hamata.*

No trend was observed in K accumulation in leaves however, it was higher in low light intensities in

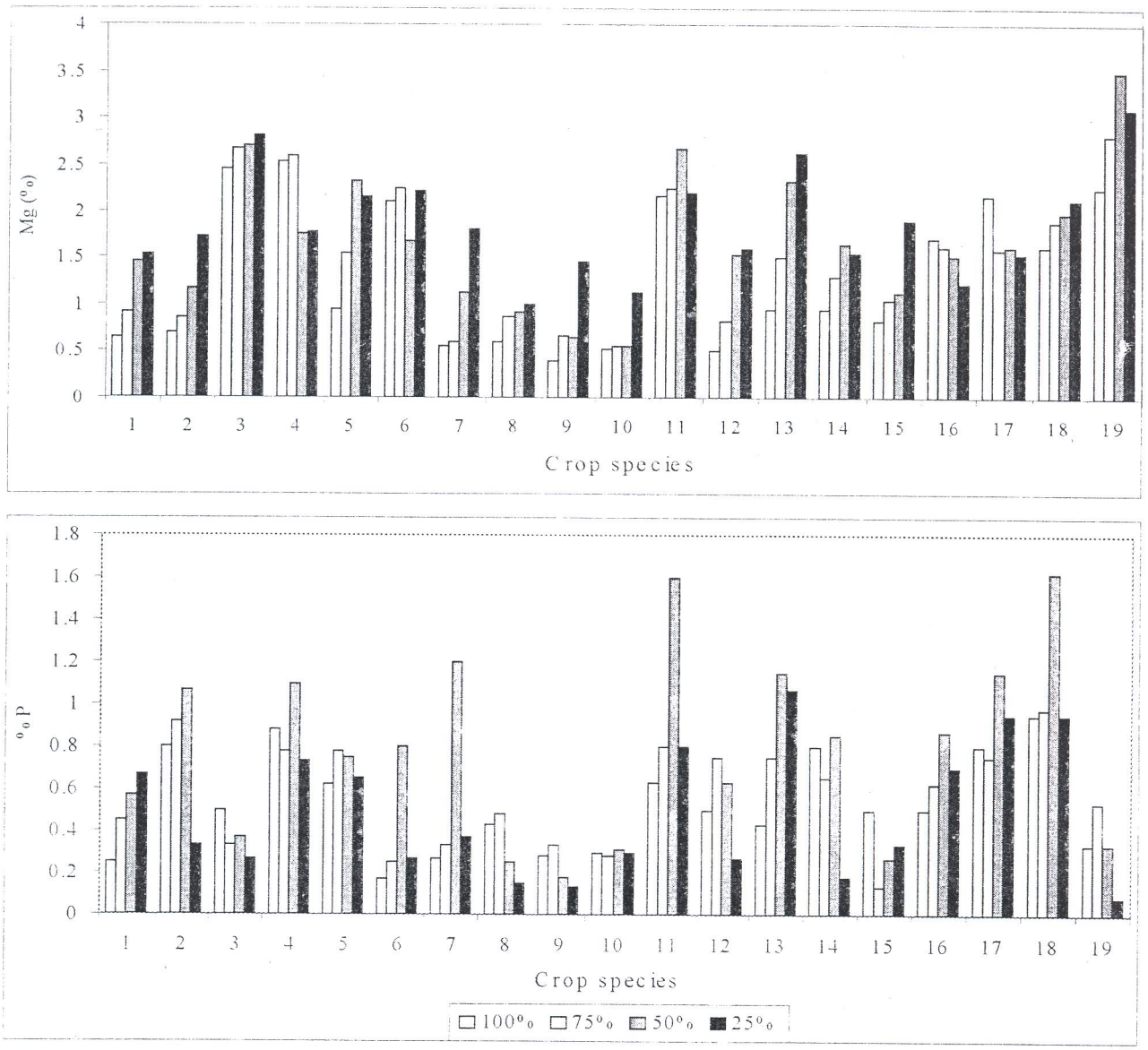

Figure 2. Magnesium and phosphorus content (%) in leaves of range grasses and legumes under different light intensities.

(1. *B. bladhii* 2. B. *brizantha* 3. *B. decombens* 4. *B. mutica* 5. *C. ciliaris* 6. *C. setigerus* 7. *C. gayana* 8. *C. fulvus* 9. D. *annulatum* 10 *H. contortus* 11. *P. antidotale* 12. *P. maximum* (IGFRI) 13. *P. notatum* 14. P. maximum (PGG) 15. *P. polystachyon* 16. *S. sphacelata* 17. Tri specific hybrid (TSH) 18. *M. atropurpureum* 19. *S. hamata*)

most of the grasses except in *C. fulvus, H. contortus, S. sphacelata, C. setigerus* and *B. mutica* in which opposite trend was observed. In *B. brizantha, P. polystachyon, B. decumbens, C. ciliaris, P. notatum, S. sphacelata* and TSH, potassium content was higher under moderate shading environment i.e. 50% light intensity. In legumes the potassium content decreased with decreasing light intensities (Figure 3). The maximum calcium content in leaves was estimated in the grass and legume species grown under open sunlight followed by 75% light intensity (Figure 3). The decrease in calcium content under high shading might be due to lower accumulation of calcium .

Sugar and starch

Maximum accumulation of sugar in leaves of grasses and legumes was observed under 75% light intensities in most of the grass species (Table 2). The

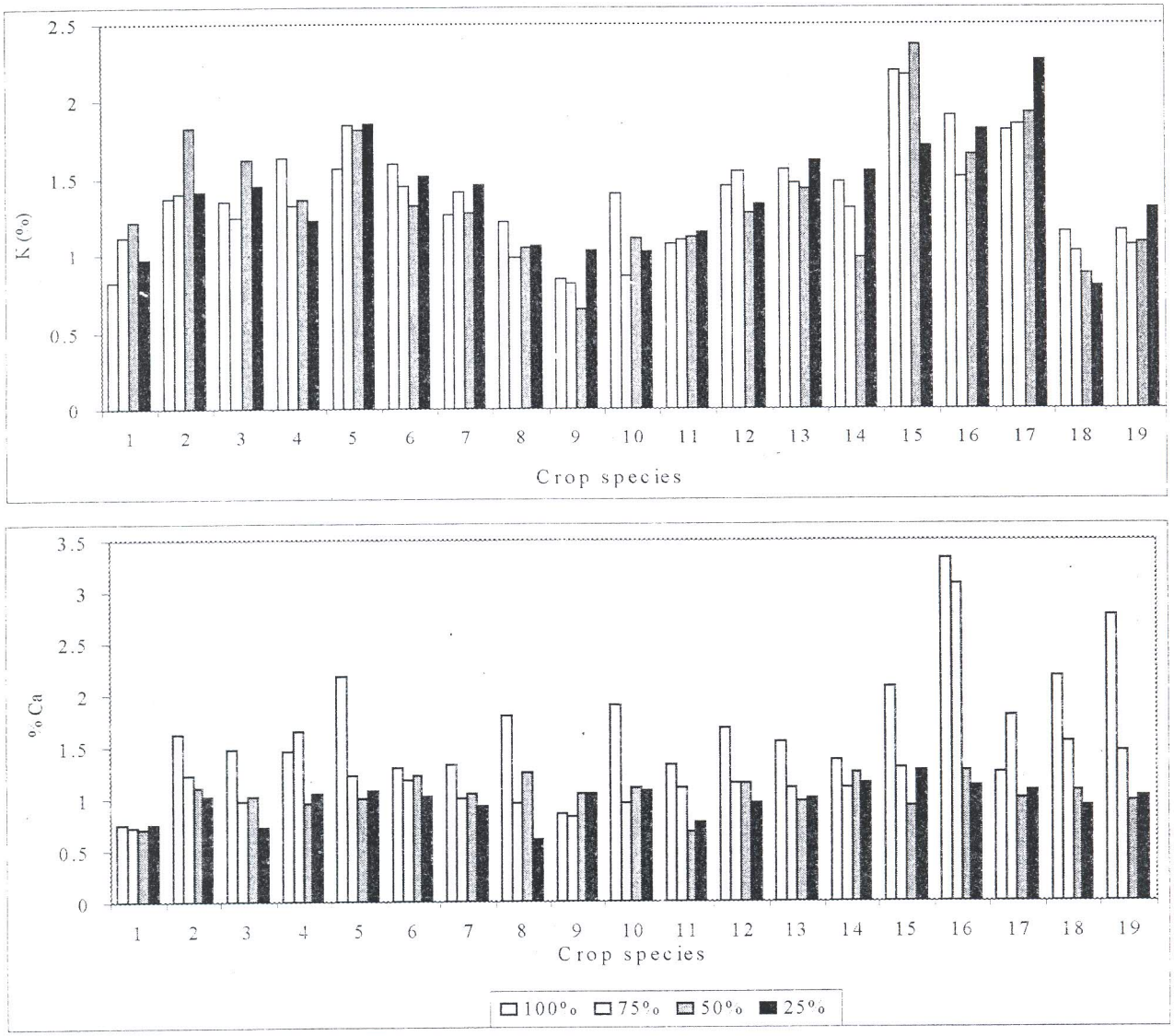

Figure 3. Potassium and calcium content (%) in leaves of range grasses and legumes under different light intensities.

(1. *B. bladhii* 2. B. *brizantha* 3. *B. decombens* 4. *B. mutica* 5. *C. ciliaris* 6. *C.setiger* 7. *C.gayana* 8. *C.fulvus* 9. *D. annulatum* 10 *H. contortus* 11. *P. antidotale* 12. *P.maximum* (IGFRI) 13. *P. notatum* 14. P.maximum (PGG) 15. *P. polystachyon* 16. *S.sphacelata* 17. Tri specific hybrid (TSH) 18. *M.atropurpureum* 19. *S.hamata*)

increased sugar content under shading treatments might be due to lower translocation of sugar to other parts under shade. Starch accumulation in leaves was maximum under 75% and 50% light intensities in all the grasses and legumes, which further decreased under high shading condition.

Crude protein

Crude protein was maximum in leaves at 75% light intensity followed by 50% light intensity in some grasses, however, higher protein content was also estimated in other grasses under full sunlight. Goodchild *et al.* (1972), Naidu and Swamy (1993) and Givinish (1988) reported lower nitrogen, Rubisco and soluble protein contents in shaded plants than the sun grown plants. Vandana and Bhatt (1999) also reported that the total protein content was higher in plants grown under full sunlight than those grown under shading environment. The difference in protein content was insignificant under shade and open environment. The

Table 1: Dry matter yield and crop growth rate in grasses and legumes under various light intensities

Crop species	Total dry weight (q/ha)			
	Light intensities (%)			
	100	75	50	25
Range grasses				
Borthrochloa bladhii	69.3	58.8	50.7	24.7
Brachiaria brizantha	73.8	70.5	41.0	39.0
Brachiaria decumbens	62.8	64.2	48.9	24.7
Brachiaria mutica	56.1	57.9	42.7	41.5
Cenchrus ciliaris	70.9	77.0	70.8	56.3
Cenchrus setigerus	67.4	65.4	50.5	29.8
Chloris gayana	81.7	62.8	51.1	43.3
Chrysopogon fulvus	70.9	58.5	52.0	34.4
Dichanthium annulatum	38.6	48.9	42.6	33.9
Heteropogon contortus	60.5	58.9	39.8	36.8
Panicum antidotale	36.1	35.4	28.7	23.9
Panicum maximum (IGFRI)	99.6	75.2	55.9	42.9
Paspalum notatum	67.0	59.5	56.5	38.5
Panicum maximum (PGG)	83.9	88.6	68.8	63.1
Pennisetum polystachyon	94.3	97.8	89.6	67.7
Setaria sphacelata	56.0	103.8	82.7	62.9
Trispecific hybrid (TSH)	178.0	3.6	118.0	106.0
Range legumes				
Macroptilium atropurpureum	20.4	28.8	26.3	21.0
Stylosanthes hamata	40.1	49.0	26.6	24.4
CD at 5%				
Species	1.564			
Treatment	3.410			
Species x treatment	1.355			

accumulation of higher protein in leaves under moderate shading exhibited that these grasses are able to maintain their quality even under moderate shading situation in silvo pastoral system.

Therefore, on the basis of present investigation *P. maximum, P polystachyon, S. sphacelata*, TSH and *B. mutica* are suitable species for high shading environment and *B. decombens, C. setigerus, C. ciliaris, C. fulvus, D. annulatum, P. notatum* and *S. hamata, M. atropurpureum* for moderate shading (40-60% shading) and therefore, these grasses and legumes are recommended for shading environment under silvo-pastoral system in semi-arid tropical region.

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References

A.O.A.C. 1960. *Official methods of analysis* (Association of Official Agricultural Chemists) Washington D.C. 9th Edn. : 643.

Table 2 : Sugar and starch content in range grasses and legumes as influenced by different light intensities

Crops species	Sugar (% in leaf)				Starch (% in leaf)			
	Light intensities (%)							
	100	75	50	25	100	75	50	25
Range grasses								
Borthrochloa bladhii	1.25	1.48	1.05	1.50	4.40	8.20	8.40	8.60
Brachiaria brizantha	1.22	1.40	1.05	0.98	3.30	6.20	6.40	4.60
Brachiaria decumbens	1.80	1.69	1.55	1.48	5.60	4.60	5.20	4.60
Brachiaria mutica	1.48	1.55	1.25	1.05	3.10	5.20	6.60	6.40
Cenchrus ciliaris	1.89	1.69	1.44	1.38	3.80	6.60	4.50	3.20
Cenchrus setigerus	1.51	2.12	1.65	1.15	4.46	6.60	6.40	7.20
Chloris gayana	1.25	2.52	1.55	1.22	3.40	7.50	7.40	5.80
Chrysopogon fulvus	1.50	1.05	1.02	1.25	3.00	5.60	4.80	5.20
Dichanthium annulatum	2.12	2.50	1.65	1.69	3.50	5.80	4.20	3.00
Heteropogon contortus	1.25	2.50	1.55	1.02	3.20	7.50	7.00	4.40
Panicum antidotale	1.55	2.20	1.40	1.10	2.40	3.60	3.50	6.40
Panicum maximum (IGFRI)	1.62	1.69	1.35	1.25	6.80	9.50	8.20	8.60
Paspalum notatum	1.65	1.45	1.25	1.10	3.40	5.80	4.40	4.46
Panicum maximum (PGG)	1.42	1.25	1.50	1.05	4.40	4.50	5.50	5.60
Pennisetum polystachyon	2.25	1.66	1.65	1.44	5.90	6.60	6.40	8.60
Setaria sphacelata	1.48	1.26	1.20	1.43	4.46	6.80	6.40	8.20
Trispecific hybrid (TSH)	1.65	1.40	1.32	1.40	4.46	7.50	7.40	8.60
Range legumes								
Macroptilium atropurpureum	2.50	2.50	2.50	1.89	4.80	6.80	4.60	4.20
Stylosanthes hamata	1.65	2.50	1.25	2.20	5.50	7.40	5.80	7.00
CD at 5%								
Species		0.040				0.085		
Treatment		0.088				0.186		
Species x treatment		0.035				0.074		

Fong, J., F.L. Shaffer and P.K. Kirk. 1953. *Arch. Biochem. Biophys.*, 45: 319.

Givinish, T.J. 1988. Adaptation of sun and shade; a whole plant perspective. In J.R. Evans, S. Von Coemmer and W.E. Adams III (eds.) Ecology of photosynthesis in Sun and Shade. *SIRO*, Melbourne, pp 63-92.

Goodchild, O.J., O. Bjorkman and N.A. Phyliotis. 1972. Chloroplast ultra structure, leaf anatomy and content of chlorophyll and soluble protein in rainforest species. *Carnegic Inst. Wash*. Year Book, 71: 120.

James, T.D.W. and D.W. Smith. 1978. Seasonal changes in the major ash constituents of leaves and some woody components of trembling aspen and red osier dogwood. *Can J. Bot.*, 56: 1798-1803.

Johnson, C.M. and A. Ulrich. 1959. Analytical methods for use in plant analysis. *Cal. Agric.Exp. Stat. Bull.* 766: 33-45. 38-39 45-47.

Kitson, R.E and M.G. Mellon. 1944. Colorimetric determination of phosphorus as molybdovandate phosphoric acid. *Eugng. Chem. Analyst. Edn.* 16: 379-82.

Naidu, C.V. and P.M. Swamy. 1993. Effect of shade on growth, biomass production and associated physiological parameters in *Pongamia pinnata* (Linn.) Pierre. *Indian J. Plant Physiol.*, 35 (4): 212-214.

Naidu, C.V. and P.M. Swamy. 1994. Seasonal variation in N,P and K content of different plant parts in tropical deciduous tree species. *Indian J. Plant Physiol.*, 37(4): 224-228.

Ralhan, P.K. and S.P. Singh. 1987. Dynamics of nutrients and leaf mass in central Himalayan forest trees and shrubs. *Ecology*, 68 (2): 1974-1983.

Vandana and R.K. Bhatt. 1999. Physiological changes in *Sesbania* species to reducing light intensities. *J. Agronomy & Crop Science*, 182: 43-47.

Verma, K.S. and V.K. Mishra. 1989. Nutrient dynamics studies in agroforestry species of western Himalya I. Macronutrient in *Robinia pseudoacacia* and *Grewia optiva*. *Indian J. For.*, 12(2): 96-100.

Yadava, R.B.R., C.K. Mathai and K. Vellaichamy. 1969. Modification in the colorimetric estimation of magnesium. *Andhra Agric J.* 16: 166.