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GROWTH AND PRODUCTIVITY OF TROPICAL RANGE GRASSES AND LEGUMES

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Abstract

Seventeen grasses and two legumes were studied for growth, productivity, photosynthesis and light use efficiency at 50% flowering stage under semiarid tropical conditions to identify appropriate species for inclusion in silvopastoral systems. Maximum dry matter yield, leaf area index (LAI), crop growth rate (CGR) and light use efficiency (LUE) were observed in Tri specific hybrid (TSH) followed by *Pennisetum polystachyon, Panicum maximum, Cenchrus ciliaris and Chrysopogon fulvus* indicating their potential for maximization of productivity under semi arid tropical environment. Significantly high positive relationship was found between DMY and LAI; CGR and LUE. Rate of photosynthesis was highest in TSH followed by *C. setigerus* indicating the intrinsic potential of these species for higher CO_2 assimilation. *S. hamata* showed higher productivity over *M. atropurpureum* and thus can be rated as the most potential range legume for semiarid tropics.

Key words : Range grasses, Legumes, Crop growth rate, Leaf area index, Dry matter yield, Photosynthesis, Transpiration

Introduction

It is often stated that a plant type should be selected which can capture more solar energy, convert it into structural carbohydrates and other substances. The adaptability and productivity of plant is mainly related to its functional responsiveness under natural environmental condition. In many environments plant productivity is determined at least by the rate of net photosynthesis and light use efficiency and is, therefore, subject to selection of promising types. The productivity of grass communities dominated by *Panicum, Sehima, Cenchrus, Chrysopogon, Heteropogon, Bothriochloa, Brachiaria,* and *Dichanthium* is decreasing day by day. Many of these grasses have been confined in isolated patches and the grazing lands are infested by weeds, bushes and other undesirable plants. Most of these grasses are perennial and have a broad ecological amplitude, which depends on the acclimatization of various physiological processes. Marked differences have been reported in dry matter production, specific leaf weight and net assimilation rate in different genotypes of plant species and these characters can be used to identify the elite plant types (Murthy *et al.*, 1986). Understating the capacity of different range grasses and legumes for photosynthesis, transpiration and light use efficiency is essential for incorporation in the silvopastoral systems for maximization of productivity. Therefore, the dominant tropical grasses and legumes were studied for their physiological attributes.

Materials and Methods

Seedlings of seventeen grass species [viz. *Bothriochloa bladhii* (Retz.) S.T. Blake, *Brachiaria mutica* (Forsk.) Stapf, *Brachiaria decumbens* Stapf, *Brachiaria brizantha* (Hochst ex A. Rich) Stapf, *Cenchrus ciliaris* Linn, *Cenchrus setigerus* Vahl, *Chloris gayana* Kunth, *Chrysopogon fulvus* (Spreng) Choiv, *Dichanthium annulatum* (Forsk.) Stapf, *Heteropogon contortus* (Linn.) P. Beauv. Ex R. & S., *Panicum maximum (cv.* IGFRI*)* Jacq, *Panicum maximum (cv.* PGG 289*)* Jacq, *Paspalum notatum* Fluegge, *Panicum antidotale* Retz., *Pennisetum polystachyon* L, *Setaria sphacelata* Stapf. Ex Hubb, Tri Specific Hybrid (TSH) [(*Pennisetum americanum* X *P. purpureeum*) X *P. squamulatum*] were raised in the nursery at IGFRI, Jhansi (25° 25'N, 78° 35'E; and 275 msl). Uniform seedlings of all grasses were transplanted in the field at 50 X 50 cm spacing. The sward was fertilized with 60 kg N and 30 kg P_2O_5/ha in July 1996. The soil of the experimental field was sandy clay in texture and neutral in reaction. It contained 0.34% organic carbon, 0.06% total N and 23.0 kg/ha available P_2O_5. The seeds of two range legumes [*Stylosanthes hamata* (L.) Taub. and *Macroptelium atropurpureum* (DC.) Urb.] were sown at the time of transplanting of grasses. In the first year, grasses were established for uniform growth and observations were recorded during the second and third years at 50% flowering stage after monsoon initiated growth in July. The samples were dried at 80 °C for 48 hours. Observations were recorded for LAI, SLW and dry matter production. CGR was calculated by using the formula of Evans (1972). Observation on photosynthesis (PN), transpiration (TR) and stomatal conductance (CS) in leaves were recorded with the help of LI 6200 Portable Photosynthesis System (LICOR, USA) during the noon hours on sunny days. PN/TR and PN/CINT were also calculated. LUE was determined by the methods described by Bhatt and Misra (1990).

Results and Discussion

Plant height in range grasses varied from 70 to 182 cm. The maximum growth in term of main tiller height was recorded in TSH, followed by *B. mutica*, *P. maximum* (IGFRI), *P. polystachyon*, *C. gayana* and *B. bladhii*. In legumes, *M. atropurpureum* attained maximum plant height as compared to *S. hamata* (Table 1). The total above ground dry matter production varied from 261 to 1780 g /m². The maximum dry matter production and crop growth rate (CGR) were found in

Table 1: Morphophysiological variation in tropical range grasses and legumes

Plant Species	Tiller height (cm)	Total dry weight (g/m²)	CGR	SLW (g /m² /d)	LAI (mg /cm²)	CS (cm s⁻¹)	PN/TR	PN/CINT	LUE (%)
Range grasses									
Bothriochloa bladhii	124	511	4.44	6.24	2.74	0.59	2.62	0.105	0.77
Brachiaria brizantha	100	640	5.56	4.45	6.68	0.98	2.00	0.155	0.89
Brachiaria decumbens	60	754	6.55	6.66	4.85	0.72	2.20	0.096	1.14
Brachiaria mutica	180	561	4.87	5.05	4.60	0.58	3.00	0.214	0.80
Cenchrus ciliaris	120	709	6.16	6.12	4.80	0.15	2.65	0.143	0.89
Cenchrus setigerus	82	674	5.86	5.15	4.88	0.64	4.50	0.217	1.23
Chloris gayana	140	631	5.48	5.92	4.71	0.68	3.29	0.155	0.88
Chrysopogon fulvus	125	709	6.16	4.22	7.26	0.75	2.20	0.091	1.21
Dichanthium annulatum	95	386	3.35	4.08	3.95	1.10	2.89	0.173	0.57
Heteropogon contortus	70	577	5.01	4.36	4.04	0.92	3.00	0.136	0.79
Panicum antidotale	125	261	2.27	4.36	3.88	0.52	4.86	0.220	0.49
Panicum maximum (IGFRI)	170	646	5.61	6.88	6.57	0.61	2.66	0.152	0.84
Paspalum notatum	100	443	3.85	5.15	4.26	0.64	4.12	0.206	0.65
Panicum maximum (PGG)	136	839	7.29	6.10	7.54	0.78	2.54	0.220	1.26
Pennisetum polystachyon	142	943	8.20	7.12	7.87	1.00	2.32	0.149	1.37
Setaria sphacelata	110	560	4.87	6.13	4.39	0.52	4.67	0.137	0.78
Tri specific hybrid (TSH)	182	1780	15.47	6.32	10.66	0.81	3.27	0.295	2.50
Range legumes									
Macroptelium atropurpureum	90	204	1.77	4.60	4.75	0.48	1.31	0.049	0.33
Stylosanthes hamata	50	401	3.48	6.60	2.91	0.36	2.18	0.051	0.71
C.D. at 5% level -	3.017	3.410	0.139	0.100	0.206	0.0338	0.2025	0.0101	-

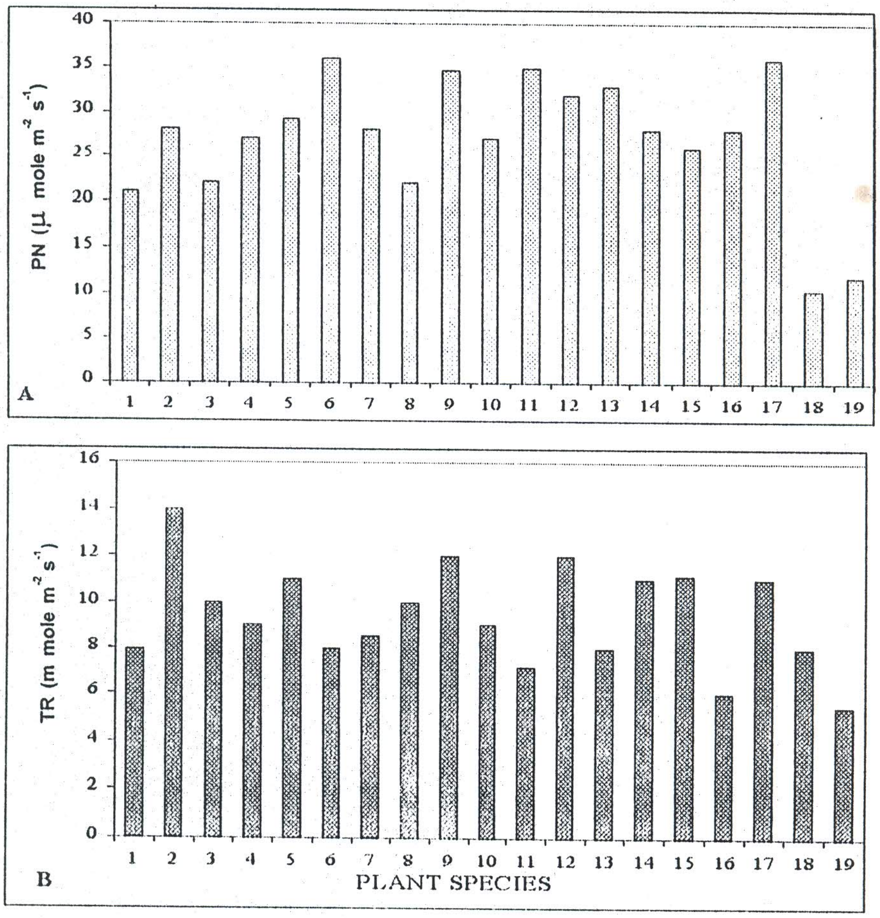

Fig. 1 (A & B). Rate of photosynthesis (PN) and rate of transpiration (TR) in tropical range grasses and legumes. (1. *B. bladhii* 2. *B. brizantha* 3. *B. decumbens* 4. *B. mutica* 5. *C. ciliaris* 6. C. setigerus 7. *C. gayana* 8. *C. fulvus* 9. *D. annulatum* 10 *H. contortus* 11. *P. antidotale* 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*)

TSH followed by *P. polystachyon* and *P. maximum* (PGG), *C. fulvus*, *C. ciliaris* and *B. decumbens*. In *S. hamata* dry matter yield and CGR were much higher to that of *M. atropurpureum* (Table 1).

The dry matter accumulation per unit of leaf area which reflect the specific leaf weight (SLW) was recorded maximum in *P. polystachyon*, followed by *B. decumbens* and *P. maximum* (IGFRI), *S. sphacelata*, *B. bladhii*, *P. maximum* (PGG) and *C. ciliaris* and ranged from 4.08 to 7.12 mg $/cm^2$ indicating their productivity and adaptability in the semi arid tropical environment. In *S. hamata*, SLW was recorded maximum as compared to *M. atropurpureum*. The leaf area production in term of (LAI) was recorded maximum in TSH, *P. polystachyon*, *P. maximum* (PGG) and *C. fulvus*. Minimum value of LAI (2.74) in *B. bladhii* and maximum LAI (10.66) was recorded in TSH. In *M. atropurpureum* LAI was higher as compared of *S. hamata* (Table 1). A liner relationship between DMY and LAI (r= 0.8389) predicting the maximum biomass accumulation per unit leaf area was observed, which intern reflected the higher values of SLW & CGR.

Rate of photosynthesis varied from 21.00 to 36.11 µ mole $CO_2/m^2/s$. The PN value was highest in TSH and *C. setigerus* followed by *P. antidotale* and *D. annulatum*, *P. notatum*, *C. ciliaris*, *S. sphacelata*, *P. maximum* (PGG), *C. gayana* and *B. brizantha* (Fig.1A) exhibiting high photosynthetic efficiency. In *S. hamata* the rate of CO_2 assimilation was higher as compared to *M. atropurpureum*. The maximum transpiration rate

(TR) was observed in *B. brizantha* followed by *D. annulatum, P. maximum* (IGFRI), *C. ciliaris, P. maximum* (PGG), *P. polystachyon* and TSH respectively and minimum transpiration was recorded in *S. sphacelata, P. antidotale, B. bladhii, C. setigerus* and *P. notatum* (Fig.1B). In *M. atropurpurem*, transpiration rate was higher than *S. hamata*. Stomatal conductance varied from 0.15 to 1.10 and it was maximum in *D. annulatum* whereas *P. polystachyon, B. brizantha, H. contortus* and *P. maximum* (PGG) were at par (Table 1). PN/TR ratio indicated that the moles of water transpired for the fixation of one mole of CO_2 termed as water use efficiency varied from 4.86 to 8.0. The maximum PN/TR values were found in *P. antidotale* followed by *S. sphacelata, C. setigerus, P notatum* and TSH. In legumes maximum water use efficiency was measured in *S. hamata* (Table 1). The PN/CINT ratio, which represents the carboxylation efficiency (Farquhar and Sharkey, 1982), was maximum in TSH (0.295) followed by *P. maximum* (PGG), *P. antidotale, C. setigerus, B. mutica* and *D. annulatum* (Table1).

On the basis of calorific value of these grasses, the light use efficiency (LUE) varied from (0.49 to 2.50) and maximum value was found in TSH followed by *P. polystachyon, P. maximum* (PGG), *C. setigerus, C. fulvus* and *B. decumbens*. In *S. hamata* LUE was higher than *M. atropurpureum* (Table 1). The forage species, viz. TSH, *P. polystachyon, P. maximum, C. setigerus, C. fulvus, B. deucumbens* and *S. hamata* having high LUE may be adopted for maximization of productivity under semiarid tropical conditions. The amount of radiation absorbed by crops is often found proportionate to the rate of dry matter production (Biscoe and Gallagher, 1977)

The correlation coefficient among selected parameters are presented in Table 2. TDMY showed high positive relationship with LUE, CGR, LAI and SLW indicating its interdependence on these characters. Therefore, the grass species having high SLW, CGR and LAI should be selected for maximization of productivity.

Table 2 : Correlation coefficient among various morpho-physiological parameters in range grasses and legumes

	Height	TDM	CGR	SLW	LAI	PN	TR	CS	PN/TR	PN/CINT	LUE
Height	1.0000										
TDM	0.4877	1.0000									
CGR	0.4876	0.9988	1.0000								
SLW	0.2186	0.4286	0.4287	1.0000							
LAI	0.5670	0.8389	0.8390	0.2195	1.0000						
PN	0.4038	0.3479	0.3482	-0.1249	0.2904	1.0000					
TR	0.3342	0.4102	0.4099	-0.0334	0.5972	0.3370	1.0000				
CS	0.0473	0.2748	0.2748	-0.2507	0.3920	0.3016	0.5542	1.0000			
PN/TR	0.1017	-0.0278	-0.0273	-0.1161	-0.1842	0.6853	-0.4295	-0.1226	1.0000		
PN/CINT	0.5647	0.5241	0.5243	-0.0583	0.4603	0.8576	0.2533	0.2547	0.5847	1.0000	
LUE	0.4220	0.9802	0.9803	0.3845	0.8288	0.3275	0.3405	0.2864	0.0046	0.5152	1.0000

Critical value (1-TAIL, 0.05) = + Or - 0.38958
Critical value (2-TAIL, 0.05) = + Or - 0.45429

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