IJTA © Serials Publications

National Academy of Agricultural Science (NAAS) Rating : 3.03

Light Interception and Physiological Responses of Hybrid Napier under Varying Shade Levels in Humid Tropics

Savitha Antony* **and C. George Thomas***

ABSTRACT: *A field experiment was conducted for two years during 2013 and 2014 at the Agronomy Research Farm of Kerala Agricultural University, Thrissur to assess the effect of varying shade levels on light interception and important physiological responses of hybrid napier under rainfed ecosystem of the humid tropics. The treatments included were six cultivars (Co-3, Co-4, Suguna, IGFRI-3, DHN-6 and PTH) at three levels of shade (0 per cent, 25 per cent, and 50 per cent) in split plot design. Increasing shade levels had a facilitating effect on leaf-stem ratio, LAI, LAR, FIPAR and chlorophyll b to chlorophyll a ratio. Averaged over the two years, 'Suguna' recorded the highest LAI, FIPAR and leaf–stem ratio at 50 per cent shade level.*

Key words: *hybrid napier, light interception, physiological responses, shade tolerance*

INTRODUCTION

Tropical pastures are efficient in converting solar energy to biomass. Hybrid napier or bajra-napier hybrid is one such tropical fodder crop, which can effectively convert solar energy into plant biomass and animal nutrients. It is the F1 hybrid between bajra (*Pennisetum glaucum* (L.) R.Br.) and napier grass (*Pennisetum purpureum* Schum.). This fodder grass is very popular among dairy farmers because of its high yield potential, quick growth, ease of establishment, palatability, and high nutritive quality. However, major constraints with its cultivation in the humid tropics are limiting land and water resources. In the tropics, where there are constraints on land, fodder production under and near the trees provides an excellent opportunity for expansion. It is a known fact that reduced light penetration affects the growth and quality of pastures. However, the extent of reduction and quality depends on the amount of shade and the degree of shade adaptation of the plant species.

MATERIALS AND METHODS

A field experiment was conducted for two years during 2013 and 2014 at the Agronomy Research Farm of Kerala Agricultural University, Thrissur to assess the effect of varying shade levels on light interception and other physiological responses under rainfed ecosystem of humid tropics. The treatments included were six cultivars (Co-3, Co-4, Suguna, IGFRI-3, DHN-6 and PTH-*Pennisetum* trispecific hybrid) at three levels of shade (0%, 25%, and 50%). The soil of the experiment site is sandy clay loam (Order: Utisol). Shade levels were established using synthetic green shade nets of 25 per cent and 50 per cent by raising wooden poles at 3.0 m above ground level. The experiment was laid out in split plot design with three replications. The cultural operations done were according to the recommended package of practices of Kerala Agricultural University [3]. Rooted slips were planted at a spacing of 60 cm X 60 cm with the onset of South West monsoon during 2013 and the crop was maintained as a perennial crop for two years. The first observations were taken at 75 days after planting and the subsequent observations at 45 days interval.

Above ground herbage from each plot was observed periodically after defoliation. Dry weight of herbage was recorded by randomly selecting five plants from each plot and by drying them at 80 ± 5 °C for 24 hours until constant weight was achieved. Observations on leaf and stem portions were also done separately. From these values, leaf-stem ratio, leaf area index (LAI-cm^2/m^2) and leaf area ratio (LAR-dm^2/g) were calculated. The ratio of leaf area to

* Department of Agronomy, College of Horticulture, Vellanikkara, *E-mail: savithaantony@gmail.com*

ground area gives LAI and that of leaf area to whole plant weight gives the LAR. Representative measurements on chlorophyll a, chlorophyll b, and photosyntetically active radiation (PAR) were taken during the third harvest for the first year and the fourth harvest for the second year. Chlorophyll b to chlorophyll a ratio was also worked out. PAR readings were taken using CI-110 digital plant canopy imager on clear sky day at 12.00 h and 13.00 h at harvest when the canopy was fully developed. PAR measurements at the top of canopy are the incident PAR (PARi) and those below the canopy give the transmitted PAR (PARt). The difference between PARi and PARt gives the intercepted PAR (IPAR). The ratio of IPAR to PARi when multiplied by 100 gives the percentage fraction of IPAR (FIPAR). The ratio of PARt to PARi multiplied by 100 gives the percentage fraction of transmitted PAR (FTPAR).

RESULTS AND DISCUSSION

Shading treatments had significant effects on physiological responses of hybrid napier cultivars. Increasing shade levels had a facilitating effect on leaf-stem ratio, LAI, LAR, FIPAR and chlorophyll b to chlorophyll a ratio (Table 1). Plants showed an increase in LAI of 0.4 -0.6 cm^2/m^2 for every 25 per cent increase in shade level. Over the two years, maximum LAI was attained under 50 per cent shade by 'Suguna', 8.18 and 11.23 cm^2/m^2 in the first and second year (Table 1). According to Reynolds [4], reduced light diminishes the capacity of plants to accumulate carbohydrates and plants try to adjust to low light levels through various mechanisms such as reduced rate of respiration and increased leaf area. These changes improve the competitive ability of plants and thus help to reduce the respiratory load.

The results indicate that in hybrid napier, increasing shade levels has a positive effect on LAR. The results showed strong interaction with cultivars and shade levels. The highest LAR was recorded by 'DHN-6' under all shade levels with its peak value at 50 per cent shade level, 2.03 and 2.32 dm^2/g during first and second year and the least was recorded by 'PTH'.

Leaf to stem ratio is a qualitative character affecting the palatability and consequently animal intake. Increasing shade levels has a positive effect on leaf –stem ratio, because increased partitioning of dry matter to the leaves occurred at the expense of roots [4]. This observation also describes the increasing trend in LAI and LAR with increasing shade levels. The results showed strong interaction with cultivars and shade levels (Table 1). In general, throughout the experiment 'Suguna' recorded higher leaf –stem ratio; it was on par with 'Co 3' and 'IGFRI 3' and the lowest by 'PTH'. During the first year, the highest leaf –stem ratio was recorded by 'Co 3' (2.55) and was on par with 'Suguna' (2.53). In the second year, the highest leaf–stem ratio was recorded by 'Suguna' (2.68), followed by 'Co 3' (2.43).

As suggested by Anderson [1], chlorophyll b to chlorophyll a ratio would be higher for plants grown under shade. Under shade, the leaves function for greater investment of leaf resources in light harvesting rather than energy processing, therefore, it is an adaptive mechanism of plants to produce more of PS II to PS I reaction centres. It means, the plants grown under shade have more of PSII than ATP synthetase; thereby, they have a low rate of photosynthesis [5]. The results showed strong interaction with cultivars and shade levels. The ratio was higher under 50 per cent shade for 'DHN6'— 0.42 and 0.37 in the first and second year. The least ratio was recorded in 'Co 4'.

Over the two years, increasing shade level has a positive effect on PAR interception. PAR interception was maximum under 50 per cent shade level. This trend in increase in FIPAR can be explained by the data on increase in LAI (Fig. 1) with increase in shade levels. As the highest LAI was recorded by 'Suguna' under 50 per cent shade, the highest amount of PAR interception was recorded by 'Suguna', 96.46 and 87.73 per cent in the first and second year. The least LAI was recorded by PTH under open condition; therefore, the least PAR interception was recorded by 'PTH' under open condition, 77.47 and 64.05 per cent in the first and second year.

According to Donald [2], a crop or pasture should have sufficient foliage to intercept the PAR but once the LAI increased beyond the optimum LAI, a stage is reached where the lowest leaves will be shaded and their rate of respiration will exceed the rate of photosynthesis and reaches a negative balance of the rate of dry matter increase. The optimum LAI will vary with the shade levels or the light intensities, as the light intensity increase the optimum LAI also will be greater· As the FTPAR decreased with increasing shade levels lower leaves received reduced amount of transmitted PAR which would have reduced the photosynthesis and yield of crop. Thus, it can be concluded that by optimizing the LAI under varying shade levels we can increase the fodder production under tree canopies.

Table 1
Mean leaf area index (LAI), leaf area ratio (LAR), fraction of intercepted PAR (FPAR) chlorophyll b/a and leaf- stem ratio of selected hybrid napier cultivars under different shade levels

Treatment	*LAI(cm²/m²)*		*LAR(dm²/g)*		*FPAR (%)*		*Chlorophyll b/a*		*Leaf- stem ratio*	
	First year	*Second year*	*First year*	*Second year*	*First year*	*Second year*	*First year*	*Second year*	*First year*	*Second year*
Shade levels										
0	5.59	7.53	1.46	1.43	81.4	75.57	0.33	0.26	1.83	1.71
25	5.96	8.17	1.64	1.75	83.99	77.35	0.34	0.31	2	1.94
50	6.4	8.68	1.82	1.97	91.18	79.8	0.38	0.34	2.16	2.14
LSD 5%	0.04	0.04	0.04	0.02	0.49	0.59	0.002	0.003	0.04	0.01
Cultivars										
Co 3	7.48	9.61	1.73	1.87	89.48	80.39	0.33	0.31	2.32	2.24
Co 4	6.5	10.26	1.83	1.84	86.41	81.89	0.29	0.28	2.24	2.05
Suguna	7.67	10.43	1.72	1.9	89.88	81.38	0.35	0.29	2.37	2.43
IGFRI 3	6.18	7.6	1.53	1.7	85.08	76.98	0.36	0.29	1.91	2.17
DHN 6	4.81	7.29	1.8	2.02	83.2	78.41	0.39	0.33	1.93	1.6
PTH	3.27	3.55	1.21	0.95	79.11	66.39	0.37	0.31	1.19	1.09
LSD 5%	0.06	0.06	0.03	0.01	0.89	0.81	0.001	0.002	0.04	0.04
Open										
Co 3	7.06	8.81	1.53	1.57	85.29	78.92	0.3	0.28	2.14	2.06
Co 4	6.18	9.72	1.65	1.47	81.27	80.8	0.26	0.26	2.07	1.83
Suguna	7.17	9.4	1.51	1.54	84.26	79.8	0.33	0.25	2.15	2.11
IGFRI 3	5.91	7.1	1.42	1.49	80.71	74.79	0.34	0.24	1.8	2.05
DHN 6	4.23	6.9	1.56	1.71	79.42	75.08	0.38	0.28	1.73	1.33
PTH	2.98	3.23	1.08	0.76	77.47	64.05	0.36	0.27	1.06	0.89
25 % shade										
Co 3	7.51	9.52	1.71	1.89	87.68	80.58	0.31	0.28	2.27	2.23
Co 4	6.52	10.38	1.81	1.89	85.08	81.55	0.3	0.29	2.17	2.04
Suguna	7.65	10.67	1.74	2	88.91	80.62	0.35	0.3	2.45	2.51
IGFRI 3	6.18	7.67	1.55	1.7	82.71	77.12	0.35	0.3	1.94	2.15
DHN 6	4.69	7.26	1.81	2.03	80.75	78.41	0.39	0.34	1.97	1.63
PTH	3.24	3.53	1.21	0.96	78.81	65.83	0.37	0.33	1.21	1.07
50 % shade										
Co 3	7.88	10.51	1.96	2.14	95.47	81.68	0.38	0.36	2.55	2.43
Co 4	6.8	10.68	2.03	2.14	92.89	83.32	0.32	0.31	2.47	2.28
Suguna	8.18	11.23	1.9	2.16	96.46	83.73	0.38	0.32	2.53	2.68
IGFRI 3	6.46	8.04	1.63	1.91	91.8	79.04	0.37	0.32	2.01	2.3
DHN 6	5.51	7.7	2.03	2.32	89.43	81.74	0.42	0.37	2.1	1.84
PTH	3.59	3.88	1.35	1.12	81.05	69.29	0.39	0.33	1.31	1.32
LSD 5%	0.08	0.12	0.06	0.03	1.52	1.4	0.009	0.001	0.07	0.08

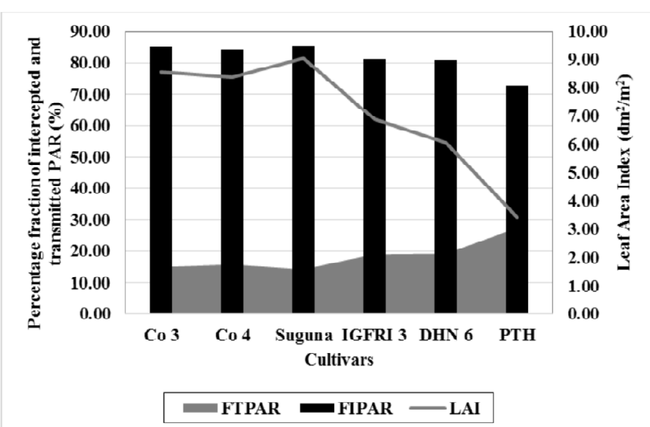

Figure 1: Effect of cultivars on fraction of intercepted PAR (FIPAR), transmitted (FTPAR) and leaf area index (LAI)

REFERENCES

Anderson, J.M. (1986), Photoregulation of the composition, function and structure of thylakoid membranes. *Annu. Rev. Plant. Physiol.*, 37:93-136.

Donald, C.M. (1963), Competition among crop and pasture plants. *Adv. Agron.*, 15: 1-118.

KAU [Kerala Agricultural University]. (2011), *Package of Practices Recommendations Crops* (14th Ed.), Kerala Agricultural University, Thrissur, 360 p.

Reynolds, S.G. (1995), *Pasture- Cattle-Coconut Systems*. FAO-RAPA Publication: 1995/7, FAO-RAPA, Bangkok, Thailand, 668 p.

Sinha, R. K. (2014), *Modern Plant Physiology* (2nd Ed.). Narosa Publishing House, New Delhi, 26:36p.