Light Dependent Morpho-Physiological Changes and Yield Response of Hybrid Napier Cultivars under Rainfed System

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Introduction

For small dairy farmers in the tropics, open land for fodder cultivation is often limited because of the predominance of tree crops and paddies. Probably because of this limitation, to offset fodder supply for the livestock, growing fodder crops under tree crops such as coconut is a widely prevalent practice in the tropics. However, successful establishment and growth of most fodder crops especially high yielding types such as hybrid napier under shade depends on the amount of light available and the consequent morpho-physiological responses of the crops.

Materials and Methods

To develop a suitable adaptive agronomic management to grow hybrid napier under varying shade levels and to study its morpho-physiological responses, a field experiment was conducted for two years during 2013 and 2014 at the Agronomy Research Farm of Kerala Agricultural University, Thrissur. The experiment consisted of six popular cultivars of hybrid napier (Co-3, Co-4, Suguna, IGFRI-3, DHN-6 and PTH) at three levels of light intensities (0%, 25 % and 50 %), laid in split plot design. Rooted slips were planted with the onset of South West Monsoon during 2013 and the crop was raised without irrigation relying only on rainfall. The first harvest was taken at 75 days after planting (DAP). Subsequently, harvesting was done at 45 days interval. Accordingly, four harvests were made in the first year and five in the second year. Because of non-receipt of rains, no harvesting was done during summer months. Observations on growth parameters were recorded at each harvest and dry weight of herbages were recorded. Observations on growth parameters such as number of tillers and leaf area were recorded at each harvest and dry weight of herbage was recorded. Chlorophyll a, chlorophyll b, total chlorophyll, percentage fraction of light intercepted and percentage fraction of transmitted PAR (photosynthetically active radiation) were recorded before the third and ninth harvest on clear sunny days. Analysis of variance was performed on all data collected using standard procedures. Where the F-test was significant (at 5 per cent level of significance), the least significant differences (LSD) was used to compare means at P = 0.05.

Results and Discussion

The study showed that shading reduced the number of tillers, dry fodder yield and fraction of transmitted PAR in hybrid napier and had a facilitating effect on leaf area index (LAI), chlorophyll content, and light interception. As observed by Gautier *et al*., (1999) shading reduced tillering by delaying the tiller buds development to tillers (Fig. 1A). The frequent defoliation in multicut fodder crops like hybrid napier under shaded situation will reduce the organic reserve for regrowth, and in turn, the total dry fodder yield. During the initial stages of experiment, tiller production was less and then gradually increased, but decreased after the fourth harvest due to non receipt of rains. Subsequently, a gradual increase was noticed with the receipt of rains in the second year. The average relative percent reduction in tiller number was 13.85 and 23.08, as the shade levels were raised to 25 and 50 percent, for every 25 percent increase in shade level 10 percent reduction in tiller number was noticed.

Shading had a facilitating effect on LAI (Fig. 1B). Shading stimulates the synthesis of axing and gibberellins and leaves may become etiolated under intense shade, because these hormones promote cell division and elongation (Keuskamp *et al.*, 2010). The highest LAI was recorded under 50 percent shade during the sixth harvest (12.85cm^2/m^2). Moisture availability affected LAI and the peak LAI coincided with the periods of South West and North East monsoon showers. The above trend in increase in LAI with increasing shade levels helped in maximum light interception by plants under 50 percent shade, eventually decreasing the percentage fraction of PAR transmittance to the lower layers (Fig. 1D). The percentage fraction of intercepted light was more than 80 per cent under 50 per cent shade as the crop recorded maximum LAI under corresponding shade level. Hence the percentage fraction of PAR transmittance was less than 20 per cent under 50 per cent shade.

Shading had significant facilitating effects on the content of total chlorophyll, chlorophyll a and chlorophyll b (Fig.1C). The highest content of chlorophyll a, chlorophyll b and total chlorophyll was observed under 50 per cent shade (1.57, 0.56, 3.46 mg/g respectively).The results showed that chlorophyll a, chlorophyll b and total chlorophyll increased at the rate of 0.2, 0.1 and 0.3 mg/g respectively for every 25 per cent increase in shade level. Increasing chlorophyll b content is an adaptive mechanism of plants to harvest more light under shade by facilitating more production of PSII reaction centers, thereby reducing the synthesis of ATP syntetase causing low rate of photosynthesis (Anderson, 1986).

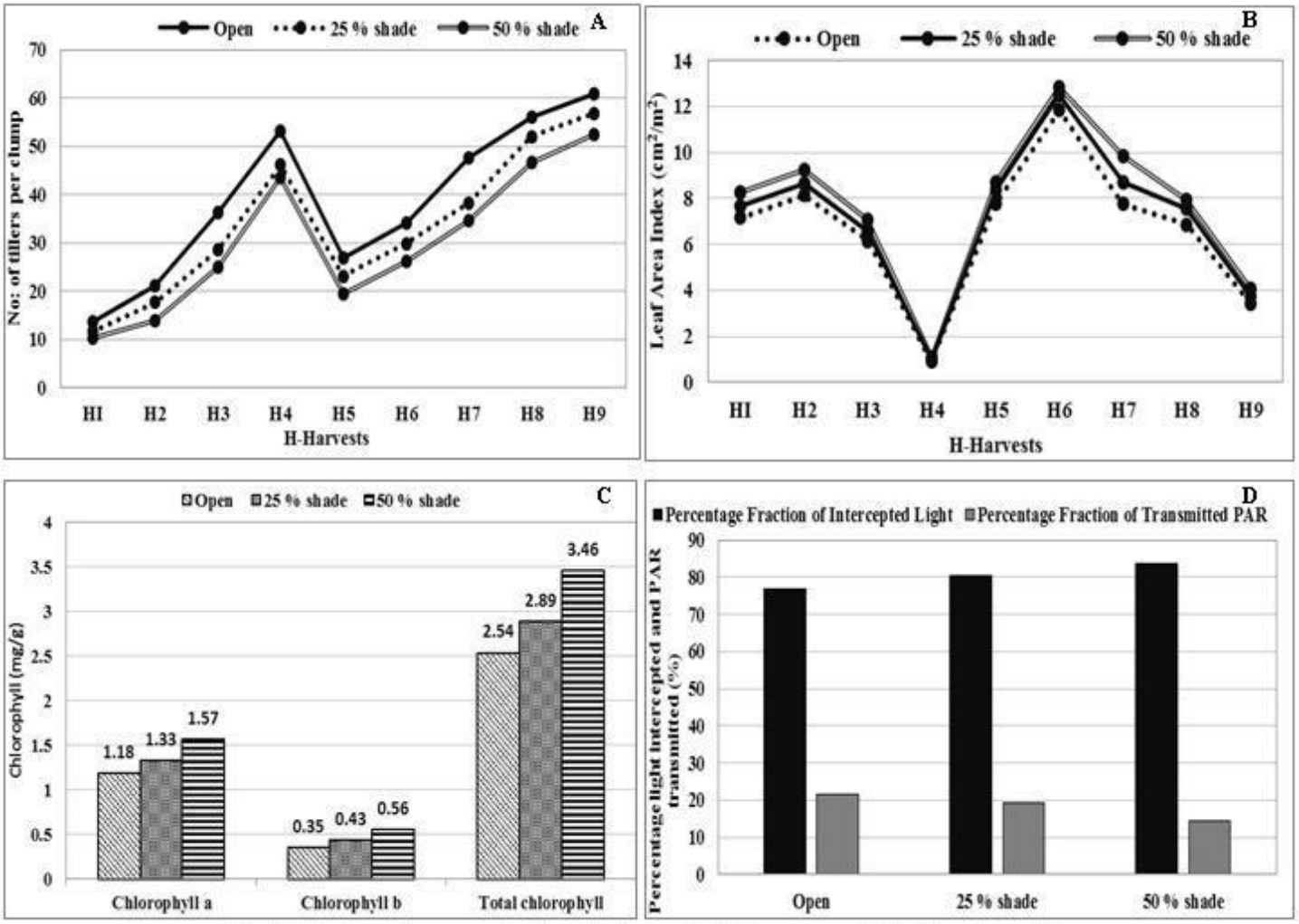

Fig. 1: Light dependent morpho-pysiological changes of hybrid Napier cultivars

The results showed that dry fodder yield decreased towards the summer months and the peaks in dry fodder yield coincided with the periods of South West and North East monsoon showers. In the first year, the highest dry fodder yield was reported in the first harvest as the harvesting was done at 75 days after planting while in the second year during the sixth harvest (second harvest of second year) compared to fifth harvest (first harvest of second year) as the fertilizer application was done after the fifth harvest. Shading, in general, reduced the fodder yield of hybrid Napier. Over a period of two years, the highest total dry fodder yield was recorded under full sunlight, 15.88 Mg/ha and 25.05 Mg/ha in the first and second year respectively. The relative dry fodder yield under 25 and 50 per cent shade levels was 83.34 per cent and 73.27 per cent of the dry fodder yield under full sunlight. A decrease of 10 per cent in dry fodder yield was observed with 25 per cent increase in shade level and the mean relative per cent reduction in dry fodder yield was 16.07 and 26.22 per cent as the shade levels were raised to 25 and 50 per cent respectively.

The decrease in fodder yield with increasing shade levels can be attributed to the tendency of decrease in number of tillers and PAR transmittance in tune with the increase in LAI and chlorophyll b content. Increasing LAI with increased shade caused mutual shading of lower leaves which reduced the PAR transmittance to the lower layers. This ultimately reduced the rate of plant photosynthesis and dry matter accumulation. Over the two years, the highest dry fodder yield was recorded by 'Suguna' under all the shade levels, followed by 'Co-3' and 'Co-4' (Table 1). Under open condition, the cultivar 'Suguna' recorded the highest dry fodder yield (20.93mg/ha/yr) during the first year, but in the second year the cultivar 'Co-4'recorded the highest dry fodder yield (31.88mg/ha/yr), followed by 'Suguna'(29.06mg/ha/yr) and they were on par.

Table 1: Yield response of hybrid Napier cultivars due to shade

Cultivars	Total dry fodder yield (Mg/ha/yr)					
	Open		25 % shade		50 % shade	
	First year	Second year	First year	Second year	First year	Second year
Co 3	19.72	26.16	17.64	23.73	14.23	21.92
Co 4	16.07	31.88	14.01	22.34	12.32	20.57
Suguna	20.93	29.06	18.26	24.99	17.52	23.50
IGFRI 3	16.53	23.57	14.70	19.48	13.04	16.33
DHN 6	11.36	19.67	9.26	13.83	7.91	12.09
PTH	10.65	19.97	8.64	17.78	7.46	13.06
LSD (5%) for the first year = 0.69; LSD (5%) for the second year = 1.01						

Conclusion

The study showed that shading reduced the number of tillers, dry fodder yield and fraction of transmitted PAR in hybrid Napier and had a facilitating effect on leaf area index (LAI), chlorophyll content, and light interception. It is expected that adoption of suitable agronomic practices such as selection of suitable cultivars, optimizing the LAI by adjusting the spacing and standardization of cutting frequency will help to reduce the extent of fodder yield reduction when grown under tree crops having varying shade levels.

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