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Research article

Yield and quality of promising fodder grass varieties under varying shade levels in Kerala

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Abstract

An experiment was laid out at AICRP on Forage Crops and Utilization at the College of Agriculture, Vellayani, Kerala, to assess the performance of different fodder grass varieties under varying shade levels. The experiment was laid out in a split-plot design with three replications. Treatments comprised of 3 shade levels (0, 25 and 50% shade) and five fodder varieties [bajra napier (BN) hybrid varieties Suguna, Susthira, CO-3, CO-5 and Guinea grass var. Suparna]. Among the shade levels, highest L:S ratio was recorded under open (1.53) and the highest leaf area was recorded under both 25 and 50% shade levels. Among the varieties, the highest tiller number was recorded in guinea grass var. Suparna (31.7), highest LSR in BN hybrid varieties CO-3 and CO-5 and highest leaf area in BN hybrid variety Susthira. The highest GFY (2418.7 q/ha) and DFY (604.7 q/ha) were recorded by CO-5 under open conditions. Under 25 and 50% shade levels, the highest GFY and DFY were recorded in guinea grass var. Suparna. The highest chlorophyll content was recorded in all four BN hybrid varieties under 50% shade than the other two shade levels. The interaction effect was nonsignificant on quality characteristics like crude protein and fiber contents. Among the shade levels, highest protein content was recorded under 50% shade level (11.7%). Among varieties, BN hybrid var. Suguna recorded the highest protein content (11.33%) and guinea grass var. Suparna had the lowest fiber content (23.84%). Considering the yield and quality of different BN hybrid varieties under varying shade levels, it was concluded that CO-5 is best suited for cultivation under open and Suparna for 25 and 50% shaded fields.

Keywords: BN hybrid varieties, Fodder quality, Fodder yield, Guinea grass, Shade levels

Introduction

Livestock, being a key source of supplementary income and livelihood, especially for small landholders and landless rural poor, plays an important role in the rural economy of the country. The total livestock population in the country was 536.7 million during 2018-19 and this is 4.6% more than the previous livestock census held in 2012 (GOI, 2019). Even though there is an increase in the cattle population, productivity is very low. Ensuring an adequate supply of reasonable quality feed and fodder is one of the major challenges which Indian livestock sector is currently facing (Mahanta *et al*., 2020; Kumar *et al.*, 2023). In 2019, the total green fodder demand was 827.19 million tons (mt) and the supply was 734.2 mt. The projected green fodder requirement for 2050 is 1012.70 mt and availability is 826.05 mt, so demand and the deficit gap is 11.24 and 18.43% in 2019 and 2050, respectively (IGFRI, 2013). Considering the fodder crop production scenario in Kerala, the fodder requirement in the state is 232.0 mt, whereas the availability is only 94.5 mt, with a deficit of approximately 60% (137.5 mt) (GOK, 2020). The above mentioned data indicates that there is a wide gap between demand and supply of fodder crops in the country as well as in Kerala. In Kerala, the scope for using arable land for fodder production is limited as the per capita land availability is very less. Incorporating fodder crops in the existing cropping system is the best alternative to increase the area under fodder crops (Ghosh *et al.,* 2022), especially in coconut-based cropping systems. However, the response of fodder crops to shade is a matter of concern when intercropped with coconut and tree crops. Intensive fodder production based on grasses has become more important among the farmers of Kerala as it is easy to maintain and has less cost of cultivation. Hybrid napier grass is a popular perennial grass grown in many parts of India, as it is very well suited for tropical conditions. It is a high-yielding, highly nutritious and palatable perennial grass. Guinea grass is also a popular perennial fodder grass in Kerala because of its high-yielding, palatable and shade-tolerant nature. BN hybrid and guinea grass are popular perennial grass fodders because of their fast-growing nature and higher productivity from a limited land area (Pradeep Behari *et al*., 2015; Thomas *et al*., 2021). Nutritional parameters, including crude protein, crude fiber, total ash and mineral content (Antony and Thomas, 2014) and physiological parameters like leaf area index, leaf-stem ratio and chlorophyll content (Antony and Thomas, 2015) differ significantly among the different fodder grass varieties. Antony and Thomas (2015) reported that CO-3 produced a higher number of tillers under 25% and 50% shade levels. The control of tillering in grasses is the contribution of genetic and physiological factors and their interaction with environmental factors (Assuero and Tognetti, 2010). Malaviya *et al.* (2020) reported that in guinea grass, an increasing trend in chlorophyll content was observed with an increase in shade intensity and maximum chlorophyll content was noted in 75% shade. There was a significant reduction in herbage accumulation of pasture with an increase in shade intensity (Dodd *et al*., 2005). Thomas *et al*. (2020) observed an increase in green fodder yield of hybrid napier (58%) in open areas than those grown in coconut gardens with 25 to 30% shade.

Knowledge about the shade tolerance of different fodder grass varieties will help the farmers to cultivate this crop in coconut gardens as well as in homesteads with different tree species, which offers a good opportunity to increase the area under fodder production in the state and thereby provide quality fodder throughout the year. Considering the above mentioned factors, this study was formulated to generate information about the response of promising varieties of different fodder grasses to varying shade levels in comparison with open.

Materials and Methods

***Location of the study*:** A field experiment was conducted under the All India Coordinated Research Project on Forage Crops and Utilization at the College of Agriculture, Vellayani, Kerala, India, during 2020-2021 to assess the performance of different fodder grass varieties under varying shade levels. The site experienced a warm humid tropical climate, with a mean rainfall of 1807 mm, most of which was received during the south-west monsoon (June-August). The soil of the experimental site was sandy clay loam which belongs to the order oxisols, Vellayani series. The soil in the experimental site was strongly acidic (pH 4.8), EC (0.22 dS m^{-1}) was normal and medium in organic carbon (0.96%), available phosphorus (68.2 kg ha^{-1}) and available potassium (178 kg ha^{-1}).

Experimental design: The experiment was laid out in a split-plot design with 15 treatment combinations in 3 replications, main plot treatments were different shade levels (0, 25 and 50% shade) and subplot treatments were four BN hybrid varieties (Suguna, Susthira, CO-3, CO-5) and one guinea grass variety (Suparna). Suguna and Susthira are the BN hybrid varieties. Suparna is the guinea grass variety from Kerala Agricultural University, and CO-3 and C0-5 are the high-yielding BN hybrid varieties from Tamil Nadu Agricultural University. Different shade levels were imposed by using a shade net with 25 and 50% shades. Three nodded stem cuttings of BN hybrid grass were planted in the channels @ 1 sett per hill and slips of guinea grass were planted in the channels @ 2 slips per hill with 60 X 60 cm spacing. Farmyard manure @ 25 t ha^{-1} for BN hybrid and guinea grass was applied in trenches taken for the planting of grasses and the entire dose of P and K each @ 50 kg ha^{-1} was given as basal, N @ 200 kg ha^{-1} was given in equal splits after each cut for BN hybrid and guinea grass. Harvesting was done at 45-day intervals.

Biometric observations and chemical analysis: Observations were recorded during each harvest on growth (plant height, number of tillers, leaf stem ratio, leaf area), yield (green fodder yield and dry fodder yield) and quality parameters were recorded annually (crude protein yield, fiber content and oxalate content). The samples of whole fresh biomass samples of grasses in each harvest were oven-dried at 70°C for 48 hours for dry matter (DM) determination. The fresh fodder yields from each harvest were multiplied with DM content and summed up to get the annual dry fodder yield per hectare. The micro Kjeldahl procedure determined the total nitrogen (N) of oven-dried samples from each harvest and crude protein (CP) was calculated by multiplying N content with 6.25 (AOAC, 1995). CP content was multiplied with DM yield from each harvest and summed up to get annual CP yields per hectare. The crude fiber content was determined by the AOAC method (AOAC, 1995).

Economics and statistical analysis: The economics of cultivation was worked out based on the cost of cultivation and the prevailing market price of the fodder. Data generated from the experiment were subjected to statistical analysis by applying ANOVA for split-plot design and significance was tested by 'F' test (Snedecor and Cochran, 1967).

Results and Discussion

Growth parameters: Experimental results revealed that different shade levels had a significant effect on the growth parameters of different fodder grass varieties (Table 1). The highest plant height was observed at 50% shade level (1.72 m) and among varieties, the BN hybrid variety Suguna recorded the highest plant height (1.79

m). Among different treatment combinations, Suguna under 50% shade level had maximum plant height (2.13 m). Since shading enhances the synthesis of auxin and gibberellins, which promote cell division, cell elongation, apical dominance, and inter nodal elongation. Plants exhibited shade avoidance mechanisms such as increased plant height and etiolated leaves (Keuskamp *et al*., 2010). Increased plant height under shade might be due to increased intermodal length under shaded situations than under open conditions (Blanche, 1999). The number of tillers varied significantly with shade levels and varieties but the interaction effect was nonsignificant. Among different shade levels, open conditions recorded a maximum number of tillers (24.27) and among different fodder grass varieties, the Guinea grass variety Suparna recorded a maximum number of tillers (31.78). It is a common fact that in most fodder crops tiller production is higher under higher intensity of sunlight (Thomas *et al*., 2020). A higher number of tillers under open conditions might be due to more carbohydrate assimilation. A higher number of tillers under non-shaded areas could also be due to the enhanced illumination at the base of grasses since this will activate basal buds for new tiller production (Morais *et al*., 2006).

Table 1. Growth characters of different fodder grass varieties under varying shade levels

Treatment	Plant height (m)	No. of tillers	L: S ratio	Leaf area (cm^2)
Shade levels				
S_1 (25%)	1.56 ab	19.80 b	1.40	358.8 a
S_2 (50%)	1.72 a	19.07 b	1.32	355.5 a
S_3 (Open)	1.44 b	24.27 a	1.53	307.1 b
SEM	0.0413	1.0442	0.0435	5.7638
CD (p <0.05)	0.162	4.1001	NS	22.6315
Varieties				
V_1 (Suguna)	1.79 a	16.33 c	1.21	362.1 b
V_2 (Susthira)	1.59 b	15.44 c	1.22	485.6 a
V_3 (CO 3)	1.41 c	20.89 b	1.65	288.4 c
V_4 (CO 5)	1.37 c	20.78 b	1.51	292.2c
V_5 (Suparna)	1.72 ab	31.78 a	1.49	273.9 c
SEM	0.0558	0.9356	0.1006	12.8006
CD (p <0.05)	0.1628	2.7308	0.2936	37.3623
Interaction effect				
S_1V_1	1.58	15.00	1.43	380.7
S_1V_2	1.49	14.33	1.23	485.0
S_1V_3	1.62	20.67	1.42	324.7
S_1V_4	1.43	19.00	1.47	316.7
S_1V_5	1.70	30.00	1.43	287.0
S_2V_1	2.13	16.33	1.21	380.7
S_2V_2	1.71	14.00	1.18	531.0
S_2V_3	1.43	16.67	1.35	292.0
S_2V_4	1.47	19.00	1.43	281.3
S_2V_5	1.86	29.33	1.43	292.3
S_3V_1	1.65	17.67	0.99	325.0
S_3V_2	1.65	18.00	1.24	440.7
S_3V_3	1.18	25.33	2.17	248.7
S_3V_4	1.20	24.33	1.63	278.7
S_3V_5	1.60	36.00	1.60	242.33
SEM	0.0966	1.6205	0.1742	22.1713
CD (p <0.05)	0.282	NS	NS	NS

The effect of shade on the leaf-stem ratio was nonsignificant but varied significantly with different grass varieties. Maximum leaf stem ratio was recorded for BN hybrid variety CO-3(1.65). Maximum leaf area was recorded under 25% shade level and among varieties BN hybrid variety Susthira recorded maximum leaf area (485.6 cm^2). Under limited illumination increased LAI is an adaptation to expose more photosynthetic area by increasing leaf area (Attridge, 1990). Plants grown under shaded situations deposit higher photosynthetic products in leaves to enhance light harvesting ability and increase photosynthetic area (Lambers *et al*., 1998).

Yield parameters: Shade had a significant effect on green and dry fodder yields of different fodder grass varieties (Table 2). Maximum green fodder yield was recorded under open conditions (2088.2 qha^{-1}) and among varieties, the Guinea grass variety suparna had maximum green fodder yield (2009.8 qha^{-1}). Among different treatment combinations CO-5 under open conditions produced maximum green fodder (2418.7 qha^{-1}). Maximum dry fodder yield was recorded under open conditions (522.1 qha^{-1}) and among varieties, the Guinea grass variety suparna had maximum dry fodder yield (502.7 qha^{-1}). Among different treatment combinations, CO-5 under open conditions produced maximum dry fodder yield (604.7 qha^{-1}). Decreased solar radiation might have reduced the photosynthetic productivity and carbohydrate assimilation (Senevirathna *et al.,* 2003) which reduced the yield under a shaded situation. A higher number of tillers and photosynthetic rate under open conditions also might have been attributed to increased fodder yield under open conditions. Selvi and Subramanian (1993) stated that fodder yield is a function of tiller production. At reduced light, spongy tissues might have developed in plants which led to lesser dry matter accumulation. Shade reduced the dry fodder yield in two tropical grasses, *Paspalum malacophyllum* and *Paspalum wettsteinii* and this reduction was proportional to the reduction of photosynthetic active radiation (Wong,

Table 2. Yield and quality of different fodder grass varieties under varying shade conditions

Treatment	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Chlorophyll content (mg/g)	Protein content (%)	Fibre content (%)
Shade levels					
S_1 (25%)	1865.9 b	466.7 b	2.6 b	11.0 b	27.29
S_2 (50%)	1674.1 c	418.7 c	3.2 a	11.7 a	26.34
S_3 (Open)	2088.2 a	522.1 a	2.4 c	10.1 c	28.73
SEM	8.5169	7.9948	0.0143	0.0553	0.7935
CD (p <0.05)	33.4414	31.395	0.0563	0.2163	NS
Varieties					
V_1 (Suguna)	1844.3 c	461.3bc	2.99 ab	11.33 b	28.32
V_2 (Susthira)	1796.3 d	449.1 c	2.89 b	10.32 c	27.86
V_3 (CO 3)	1808.8 cd	452.4 c	3.14 a	9.87 e	28.83
V_4 (CO 5)	1921.00 b	480.33 ab	3.12 a	10.79 c	28.40
V_5 (Suparna)	2009.8 a	502.7 a	1.51 c	12.35 a	23.84
SEM	13.248	8.7105	0.0566	0.1222	0.5044
CD (p <0.05)	38.6683	25.4241	0.1625	0.3567	1.4721
Interaction effect					
S_1V_1	1907.3	477.3	2.83	11.43	28.63
S_1V_2	1840.7	460.3	2.75	10.25	27.68
S_1V_3	1781.7	446.0	2.99	9.64	28.43
S_1V_4	1744.3	436.0	2.94	11.09	28.33
S_1V_5	2055.3	514.0	1.52	12.63	23.36
S_2V_1	1474.0	368.7	3.60	12.32	27.44
S_2V_2	1500.0	375.0	3.45	11.00	26.42
S_2V_3	1589.0	397.3	3.54	10.73	27.53
S_2V_4	1600.0	400.3	3.78	11.24	27.70
S_2V_5	2207.3	552.0	1.61	13.30	22.58
S_3V_1	2151.7	538.0	2.56	10.25	28.89
S_3V_2	2048.3	512.0	2.49	9.72	29.48
S_3V_3	2055.7	514.0	2.87	9.23	30.52
S_3V_4	2418.7	604.7	2.65	10.14	29.18
S_3V_5	1766.7	442.00	1.39	11.13	25.57
SEM	22.9463	15.087	0.0981	0.2117	0.8736
CD (p <0.05)	66.9754	44.0357	0.2862	NS	NS

1993). Yields of fodder crops were directly related to light availability and similar results were reported by Antony and Thomas (2015) in different BN hybrid varieties.

Quality parameters: The highest chlorophyll content was recorded in all four BN hybrid varieties under 50% shade than the other two shade levels (Table 2). Among varieties, CO-3 recorded the highest chlorophyll content and among different treatment combinations CO-5 under 50% shade level recorded maximum chlorophyll content. When plants were grown under the shaded situation, they produced a lesser number of mesophyll cells with larger grana and with higher concentration of chlorophyll content (Lambers *et al*., 1998). Attridge (1990) stated that increased chlorophyll content under shaded conditions than open conditions is an adaptive mechanism of plants to maintain photosynthetic efficiency under limited illumination. Under full sunlight, the rate of destruction of chlorophyll will be faster (Eriksen and Whitney, 1981) and this could be attributed to the minimum chlorophyll content under open conditions. The highest protein content was recorded under 50% shade level (11.7%) and among varieties, Suguna recorded maximum protein content (11.33%). Among different treatment combinations, guinea grass var. Suparna under 50% shade level produced maximum protein content (13.30%). Crude protein content was more affected by shade than other quality characters since nitrogen accumulation was higher in all green plants grown under shade (Kephart and Buxton, 1993). In fodder grasses crude protein content increased with an increase in shade level (Wilson, 1996).

Conclusion

Based on the growth, yield and quality attributes of promising fodder grasses studied, it was inferred that BN hybrid variety CO-5 is best suited for cultivation under open conditions in Kerala, India. Under 25 and 50% shade levels, the guinea grass variety Suparna is best suited for cultivation and, hence, could be recommended for cultivation in coconut gardens.

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