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Yield and quality of bajra napier hybrid as influenced by magnesium and boron nutrition in humid tropics of Kerala

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Abstract
A field experiment was conducted at AICRP on Forage Crops and Utilization, Vellayani for consecutive three years during *Kharif* 2015-17 to assess the influence of Mg and B nutrition on the performance of bajra napier hybrid. Treatments consisted of two field conditions (open and coconut garden) and five nutrient levels- N_1: recommended POP + $MgSO_4$ 80 kg/ha+ Borax 10 kg/ha, N_2: POP + $MgSO_4$, 80 kg/ha, N_3: POP + Borax, 10 kg/ha, N_4: POP alone and N_5: POP without FYM. Application of 200:50:50 kg NPK/ha and 25 t/ha of farm yard manure (FYM) was taken as recommended package of practice (POP). Pooled analysis of three years data showed that field condition and nutrient levels had significant effect on plant height, number of tillers/hill, GFY and DFY of bajra napier hybrid. Higher (58%) GFY was recorded in open field compared to the crop raised in coconut garden with 25-30% shade. Among the nutrient levels, highest GFY and DFY was recorded in POP alone (200:50:50 kg NPK/ha and 25 t/ha of FYM). Interaction effect of treatments showed significantly superior GFY, DFY and crude protein content in T_2 (200:50:50 kg NPK/ha and 25 t/ha of FYM + $MgSO_4$, 80kg/ha).

Keywords: Bajra napier hybrid, Boron, Coconut garden, DFY, GFY, Magnesium

Introduction
Hybrid napier grass, an interspecific cross between napier grass (*Pennisetum purpureum* Schum.) and bajra (*Pennisetum glaucum* L.), is a popular fodder grass grown in many parts of Kerala. As the per capita land availability is very less in Kerala (GOK, 2019) expansion of area for fodder cultivation is not possible. Coconut gardens offer good opportunity for fodder production in Kerala. Moreover, coconut occupies a major area in the state and the suitability of fodder crops as intercrops under coconut gardens is well established (Lakshmi, 1998). On an average, up to 70 per cent solar radiation is available for inter crops in coconut gardens (Reynolds, 1995), which can be utilized for growing fodder crops such as hybrid napier. Perennial fodder grasses like hybrid napier and guinea grass are widely accepted by the dairy farmers all over Kerala as these grasses are well adapted to tropical conditions with potential for higher yields per unit area and shade tolerance (Posler *et al.,* 1993).

The availability of magnesium (Mg) is very low in soils of Kerala due to leaching under heavy rainfall. The reserve of this nutrient is also very low in the soil. Eighty percent of soils are deficient in Mg and application of $MgSO_4$ @ 80 kg/ha, is recommended to solve the problem of Mg deficiency (KAU, 2011). Mg deficiency is increasingly becoming an important limiting factor in intensive crop production systems, especially in soils fertilized only with N, P, and K. Due to its potential for leaching in highly weathered, low activity soils and the interaction with Al, Mg deficiency is a critical concern in acid soils. One of the well-documented plant adaptation mechanisms in acid soils is the release of organic acid anions from roots. Organic acid anions released from roots will chelate toxic Al ions and form Al-organic acid complexes that are no longer phytotoxic. Magnesium is required for effective release of organic acid anions from roots to modify Al-toxic rhizospheres. Magnesium thus imparts very specific benefits in protecting crops against Al toxicity (Keltjens and Tan, 1993).

Magnesium plays an important role in photosynthesis. Mg also plays an important role in the cell energy balance, interacting with the pyrophosphate structure of nucleotide tri and di-phosphates (Igamberdiev and Kleczkowski, 2003). Magnesium deficiency in plants often results in ultra-structural changes especially in chloroplast, well before visible foliage symptoms are obvious. This is accompanied by impairment of photosynthesis (Sun and Payn, 1999). Magnesium is also an important component of the chlorophyll molecule and is associated with rapid growth, cell division, carbohydrate metabolism, synthesis of amino acids and cell proteins, uptake and migration of P in plants, providing resistance to unfavourable factors like drought. It is an essential mineral element for plants and microbes, can have both direct and indirect effect on disease. But the total magnesium reserves in soils are poor and thus magnesium is considered as a critical element in the acid soils of Kerala. Magnesium application is required for crops grown in soils with magnesium content below the critical limit of 120 mg/kg.

Similarly boron(B) has a primary role in cell wall biosynthesis, cell division, lignification of cell wall, membrane function, RNA metabolism, indole acetic acid (IAA) production, phenol metabolism, carbohydrate metabolism, sugar transport, nucleotide synthesis and respiration (Sims and Jhonson, 2003). Boron plays an important role in carbohydrate-borate complex, which controls carbohydrate transport and cell wall protein metabolism, cell wall permeability and metabolism of phenolics and lignin synthesis. B has an essential role in carbohydrate transport through phloem. Though boron is required in very minute quantities, but it plays a vital role in physiology of plants. Indeed, application of B is essential for crops grown in soils with available B below the critical limit of 0.5 mg/kg. About 65% of Kerala soils is deficient in available B. Application of 10 kg borax/ ha or foliar application of 0.2% borax solution can supply enough B to meet plant needs (KAU, 2011).

At present the nutrient recommendation for bajra napier hybrid in Kerala includes only NPK fertilizers @ 200:50:50 kg/ha and 25 t/ha of farm yard manure. Hence, it was felt appropriate to study the role of Mg and B in the nutrition and production of bajra napier hybrid so as to seek the possibility of including these nutrients in the fertilizer schedule of the crop with the aim to increase its productivity. In the light of the above facts, the present study was undertaken to assess the impact of nutritional influence of Mg and B on the growth, yield and quality attributes of bajra napier hybrid.

Materials and Methods

***Location of the study*:** Field experiment was conducted at AICRP on Forage Crops and Utilization, College of Agriculture, Vellayani, Kerala for three consecutive years during *Kharif* 2015-2017. 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) with EC-0.053 dSm^{-1} (normal), organic carbon- 1.0 %, available K_2O- 98.7 kg/ ha, available Mg- 14.80 mg/kg and available B- 0.30 mg/ kg.

***Crop establishment*:** The experiment was laid out in factorial RBD with three replications. The treatments included two factors *viz.* growing conditions (2) and nutrient levels (5). The growing conditions were open (S_1) and coconut garden (S_2) and nutrient levels were- N_1: POP recommendation + $MgSO_4$ 80 kg/ha+ Borax 10 kg/ha, N_2: POP + $MgSO_4$ 80 kg/ha, N_3: POP +Borax 10 kg/ ha, N_4: POP alone and N_5: POP without FYM. Application of 200:50:50 kg NPK/ha and 25 t/ha of farm yard manure was taken as recommended package of practices (POP).

The hybrid napier variety Suguna, released from Kerala Agricultural University was used for the study. It has high tillering capacity (40 tillers/plant), better quality with crude protein content of 9.4% and crude fibre content of 24.0%. Average yield of the variety is 280-300 t/ha. The crop was established in *Kharif* 2015.Three nodded stem cuttings of BN hybrid was planted in the channels @ 1 sett per hill at a spacing of 60 cm x 60 cm. FYM @ 25 t/ha and chemical fertilizers like urea (46% N), rajphos (20% P_2O_5) and muriate of potash (60% K_2O) were applied to supply NPK @ 200: 50: 50 kg/ha. Entire dose of phosphorus and potassium were applied as basal. Nitrogen was applied in equal split doses after all the harvests. Entire dose of magnesium and boron were applied as single dose as per the treatments. Irrigation was provided to the crop as and when required. The first harvest was taken 75 days after planting and subsequent harvests at an interval of 45 days.

***Biometric observations and chemical analysis*:** Observations were recorded on growth parameters (plant height, number of tillers, leaf stem ratio), yield parameters (green fodder yield and dry fodder yield) and quality parameter (crude protein and crude fibre). The samples of whole fresh biomass samples of grass in each harvest was oven dried at 70^0C for 48 hours for dry matter (DM) determination. For the calculation of leaf stem ratio, the sample plants collected at each harvest were separated into leaves and stem and dried to a constant weight in hot air oven at 70°C. Dry weight of stem and leaves were recorded separately for each plant and ratio was worked out. The fresh fodder yields from each harvest were multiplied with the DM content and summed up to get annual dry fodder yield per hectare. Total nitrogen (N) of oven dried samples from each harvest was determined by the micro Kjeldahl procedure 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 fibre content was also determined by following standard method (AOAC, 1975).

***Statistical analysis*:** Data generated from the experiment was subjected to statistical analysis by applying ANOVA for RBD and significance was tested by 'F' test (Snedecor and Cochran, 1967). Pooled analysis of the data for three years was also done.

Results and Discussion

***Growth and yield*:** Pooled analysis of three years data showed that field condition and nutrient levels had significant effect on plant height, number of tillers/hill, GFY and DFY of bajra napier hybrid. Interaction effect was also found to be significant. Bajra napier hybrid grown in open condition recorded highest values for plant height, number of tillers/hill, GFY and DFY. Hybrid napier being shade sensitive produced lower number of tillers under coconut garden. It is a common fact that in most fodder crops tiller production is higher under higher intensity of sunlight. According to Reynolds (1995), 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. Under coconut shade, bajra napier hybrid recorded minimum leaf length and tiller number of 149.48 cm and 17.8, respectively (Table 1). Tiller number was 60% higher in open situation than under coconut shade. Similar result was reported earlier by Baruch and Guenni (2007) in three *Brachiaria* sp. viz., *B. decumbens, B. brizantha* and *B. dicyoneura* . Higher tiller production might be due to the greater availability of sunlight in open condition, which resulted in more carbohydrate assimilation. The increased tiller production in full sunlight in the present study was also in agreement with the findings of Guenni *et al*. (2008) in *Brachiaria brizantha.* Anita *et.al*. (2018) reported that specific leaf area of fodder cowpea varieties were higher in partial shade compared to open condition and this response can be attributed to the development of relatively large and thin leaves due to decreased number of mesophyll cells per unit area, increased internal air space and reduced cell size (Kephart *et.al*., 1992).

Under open field conditions 58% higher GFY was recorded compared to the crop raised in coconut garden with 25-30% shade. The increased number of tillers and higher leaf stem ratio in open condition might have resulted in the higher green fodder yield in open condition. The yield reduction observed under shaded situation can be explained by the data on relative reduction in tiller number under coconut shade. The rate of fodder production is a function of tiller production and leaf growth (Selvi and Subramanian, 1993). Usually yield of forage crops are linearly related to the amount of light available. At low light intensity, spongy tissues are developed in plants which might be responsible for lesser dry matter accumulation. Negative effects of shade on fodder yield of hybrid napier under coconut was also reported by Pandey *et al.* (2011).Wong (1993) reported that shade depressed total dry matter production in two tropical grasses *Paspalum malacophyllum* and *Paspalum wettsteinii*, and the depression was proportional to the quantum of photosynthetically active radiation reduction. Kephart and Buxton (1996) reported that increasing shade levels significantly decreased the growth rates and herbage yield of forages.

Application of varying nutrient levels also had significant influence on plant height, number of tillers/hill, GFY and DFY (Table 1-2). Among the five nutrient levels, highest GFY and DFY was recorded in POP alone (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure). GFY was found significantly superior to all the other treatments, but DFY was at par with N_2 (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure + $MgSO_4$, 80 kg/ha) and N_3 (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure + borax, 10 kg/ha). Interaction effect of treatments (Table 2) showed significantly superior GFY, DFY and tiller number in N_2 (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure + $MgSO_4$, 80 kg/ha). Magnesium being an important component of chlorophyll molecule was associated with rapid growth, cell division, protein synthesis, carbohydrate assimilation and played a major role in many metabolic activities of the plant and that probably contributed to significant increase in tiller number and higher green fodder yield. This increase in yield due to increase in levels of magnesium might also be due to the enhanced nutrient uptake and positive interaction of nutrients. An increasing trend in green and dry fodder yield of bajra napier hybrid upto a level of 80 kg of $MgSO_4$ was reported earlier by Akhila and Thomas (2018). Positive impact of magnesium and boron application on green fodder yield of guinea grass in coconut based fodder production system was also observed by Lakshmi *et al.* (2007). However, grasses did not respond to B, even when plant B levels were very low (Sherrell, 1983).

Table 1. Effect of Mg and B on growth and yield of bajra napier hybrid (pooled data over three years)

Treatments	Plant height (cm)	Number of tillers/hill	L: S	GFY* (q/ha/ year)	DFY* (q/ha/ year)
A. Field condition					
Open situation	168.76	28.76	1.90	1982.05	429.18
Coconut garden	149.48	17.80	1.99	1248.94	269.87
CD (P<0.05)	4.28	1.98	NS	29.61	23.05
B. Nutrient levels					
N_1: POP + $MgSO_4$ 80 kg/ha+ borax 10 kg/ha	161.07	21.39	1.99	1519.41	332.90
N_2: POP+ $MgSO_4$ 80 kg/ha	157.07	32.89	1.89	1618.87	354.46
N_3: POP + borax, 10 kg/ha	154.65	20.33	1.99	1666.99	369.42
N_4: POP	163.07	21.61	1.98	1736.13	374.21
N_5: POP without FYM	159.70	20.17	1.90	1536.09	316.66
CD (P<0.05)	6.76	3.13	NS	46.82	36.45
SEm	1.05	1.05		2.10	1.05

Table 2. Interaction effect of field situation and nutrient levels on growth and yield of bajra napier hybrid (pooled data of three years)

Treatments	Plant height (cm)	Number of tillers/hill	L: S	GFY* (q/ha/ year)	DFY* (q/ha/ year)
Open situation + POP + $MgSO_4$ 80 kg/ha + borax 10 kg/ha	170.48	25.44	1.94	1882.12	385.05
Open situation + POP + $MgSO_4$ 80 kg/ha	167.09	37.11	1.84	2106.98	505.37
Open situation + POP + borax, 10 kg/ha	168.0	25.0	1.90	1987.02	441.24
Open situation + POP	169.82	29.0	2.04	1999.18	397.71
Open situation + POP without FYM	168.40	27.11	1.78	1934.95	416.54
Coconut garden + POP + $MgSO_4$ 80 kg/ha + borax 10 kg/ha	151.67	17.33	2.03	1156.69	280.74
Coconut garden + POP + $MgSO_4$ 80 kg/ha	147.06	13.11	1.94	1130.75	203.54
Coconut garden + POP + borax, 10 kg/ha	141.32	15.67	2.08	1346.96	297.61
Coconut garden+ POP	156.34	14.22	1.92	1473.08	350.71
Coconut garden+ POP without FYM	151.0	28.67	2.03	1137.26	216.78
CD (P<0.05)	4.20	1.98	NS	26.15	26.5
SEm	1.05	1.05		2.02	2.02

*1 ton = 10 quintals (q); POP=Recommended package of practices (200:50:50 kg NPK/ha + 25 t/ha FYM); L: S= Leaf to stem ratio; GFY=Green fodder yield; DFY= Dry fodder yield; NS: Non-significant

Table 3. Effect of Mg and B on quality characters of bajra napier hybrid (pooled data over three years)

Treatments	Crude protein content (%)	Crude protein yield*(q/ha)	Crude fibre content (%)
A. Field condition			
Open situation	10.42	46.24	38.50
Coconut garden	9.14	16.25	39.03
CD (P<0.05)	0.62	1.01	NS
B. Nutrient levels			
N_1: POP + $MgSO_4$ 80 kg/ha + borax 10 kg/ha	8.70	25.44	36.90
N_2: POP + $MgSO_4$, 80 kg/ha	11.55	36.74	38.78
N_3: POP + borax, 10 kg/ha	9.55	30.75	38.50
N_4: POP	9.10	31.75	38.98
N_5: POP without FYM	10.0	31.56	40.65
CD (P<0.05)	0.98	1.59	0.96
SEm	4.077	1.57	1.06

Table 4. Interaction effect of field situation and nutrient levels on quality characters of bajra napier hybrid (pooled data over three years)

Treatments	Crude protein content (%)	Crude protein yield *(q/ha)	Crude fibre content (%)
Open situation + POP + $MgSO_4$, 80 kg/ha + borax 10 kg/ha	8.70	35.23	37.80
Open situation + POP + $MgSO_4$, 80 kg/ha	13.0	57.60	39.20
Open situation + POP + borax, 10 kg/ha	8.70	42.27	37.0
Open situation + POP	9.50	46.36	39.50
Open situation + POP without FYM	12.20	49.74	39.0
Coconut garden + POP + $MgSO_4$, 80 kg/ha + borax 10 kg/ha	8.70	15.65	36.0
Coconut garden + POP + $MgSO_4$, 80 kg/ha	10.10	15.87	38.37
Coconut garden + POP + borax, 10 kg/ha	10.40	19.23	40.0
Coconut garden+ POP	8.70	17.14	38.47
Coconut garden+ POP without FYM	7.80	13.37	42.30
CD (P<0.05)	1.38	2.26	1.36
SEm	0.69	1.13	1.18

*1 ton = 10 quintals (q); POP=Recommended package of practices (200:50:50 kg NPK/ha + 25 t/ha FYM); L: S= Leaf to stem ratio; GFY=Green fodder yield; DFY= Dry fodder yield; NS: Non-significant

Fodder quality: Highest crude protein content, crude protein yield and crude fibre content were recorded in open condition than under coconut shade (Table 3-4). Among the nutrient levels, highest crude protein content and CPY was recorded in N_2 (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure + $MgSO_4$, 80 kg/ha**).** Highest crude fibre content was observed in the crop raised with POP without FYM (200:50:50 kg NPK/ha). This might be due to the mineralization of $MgSO_4$ by microorganisms in soil and its mobilization thereby enhancing magnesium and sulphur uptake and translocation of phosphorus, all of which particularly sulphur played important role in protein synthesis. Availability of sufficient quantity of magnesium at comparatively higher levels of magnesium application would have increased the uptake of N, resulting in a consequent increase in crude protein synthesis. The role of Mg in chlorophyll formation would have influenced the development of higher N content in leaves in the above treatment. Similar results were also reported by Hosseini *et al*. (2007). Magnesium fertilization facilitates an increase in protein content in plants; higher protein content is an important factor in production of forage grain crops and grasses (Mayland and Wilkinson, 1989; Roemheld and Kirkby, 2007). Magnesium is associated with the synthesis of amino acids and cell proteins. According to Saad and El-Kholy (2000) foliar application of magnesium sulphate increased crude protein content of plants. Similar findings were observed by Fajemilehin *et al*. (2008) in guinea grass and by Staugaitis and Rutkauskienė (2012) in Italian ryegrass.

The interaction effect was significant on quality aspects, and highest crude protein content and crude protein yield was recorded in open condition + 200:50:50 kg NPK/ha and 25 t/ha of farm yard manure + $MgSO_4$, 80 kg/ha and was at par with open situation + POP without FYM (200:50:50 kg NPK/ha). Lowest crude fibre was also recorded in open situation + POP recommendation (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure) + $MgSO_4$, 80 kg/ha + borax, 10 kg/ha and was at par with open situation+ POP (200:50:50 kg NPK/ha and 25 t/ha of farm yard manure) + borax, 10 kg/ha. Fajemilehin *et al*. (2008) observed that crude fibre content was significantly reduced due to magnesium application in guinea grass (*Panicum maximum*) and also reported that magnesium fertilization reduced the rapidity of lignification in forage crops. This was probably due to the fact that magnesium acts as an activator or co-factor of many enzymes and metabolic processes in plants (Cowan, 2002).

Conclusion

Based on the three years experimentation it was inferred that higher yields and better quality in bajra napier hybrid could be fetched under open condition with application of $MgSO_4$ at 80 kg/ha in addition to recommended package of practices of 200:50:50 kg NPK/ha and 25 t/ha of farm yard manure.

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