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Growth and Yield Response of Bajra Napier Hybrid under Different Irrigation Regimes with Fertigation Levels and Sources

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ABSTRACT

Background: Livestock plays a significant role in Indian economy. Cattle population in India is higher (192.6 million), whereas the productivity is not. Quality fodder has to be supplied rather than costly concentrate feeds to reduce cost of production. Water being the important input of agriculture, its per capita availability (1829 m^3) is reducing gradually. To improve the use efficiency drip irrigation is preferable rather than flood irrigation. Fertigation improves nutrient delivery and uptake in plants. Bajra Napier hybrid is a multicut perennial fodder grass grown in arid and semiarid region with high biomass yield.

Methods: Experiment was conducted at college farm of Agricultural College and Research Institute, Madurai to study the growth and yield response of Bajra Napier under different irrigation regimes and fertigation levels. The treatments were laid out in split plot design, with three irrigation regimes in main plot and six fertigation treatments in sub plot.

Result: The combination of 100% ET_c with 100% RDF of NPK applied as water soluble fertilizer recorded higher morpho-physiological characters such as plant height, number of tillers and leaves per clump, leaf area index and green fodder yield, during the first two harvests. This might be due to more water availability at 100% ET_c which lead to more water and nutrient uptake from the soil, In addition to that water soluble fertilizer at 100% RDF has more nutrient ratio and solubility. Positive correlation was observed between the growth parameters and green fodder yield, As the source and sink are the same in fodder crops.

Key words: Green fodder yield, Irrigation regimes, Morpho-physiological characters, Water soluble fertilizer.

INTRODUCTION

Livestock plays a significant role in the Indian economy. According to the basic animal husbandry statistics 2021, it contributes 4.4 per cent of our GDP and 25.5 per cent of agricultural GDP. It provides livelihood in the form of alternate income for our rural population. India holds a larger population of cattle, 192.49 million in numbers (Indiastat, 2019). Stable production of milk and meat is maintained, whereas the productivity is deteriorating. On the other hand its consumption is increasing at a pace of 2.8 and 3 per cent per annum. The productivity of livestock can be enhanced by providing with quality fodder. In India 6.6 million hectares are under fodder cultivation (4 % of total cultivated area). With the rising human population and demand for food crops, it is not possible to demarcate separate land for fodder cultivation. Focus should be given to improve the productivity of the fodder crops.

Bajra Napier hybrid is a cross between fodder pearl millet IP 20594 (*Pennisetum glaucum*) and Napier grass FD 437 (*Pennisetum purpureum Schumach*). It is perennial in nature has a lush growth with succulent leaves, quicker regeneration capacity and less oxalate content. It is a multi-cut perennial grass with profuse tillering and yield a very good tonnage throughout the year among the other grass species (Panday and Roy 2011) . In addition, it also supplies green fodder at least for five years once established (Rahman and Talukder 2015).

Water is the most significant input in agriculture. The per capita availability of water is decreasing day by day due to the growing population. The lack of water remains as a barrier for the development of irrigated agriculture in the world. Micro irrigation is convenient and is an effective means of applying water directly to soil surface and nearer to the plant root zone without much loss of water leading to higher water productivity. Implementing micro irrigation practices for Bajra Napier grass will improve the water use efficiency of the fodder there by increase the water conservation. So optimum use of water may allow for prolonged supply of water to subsequent cuttings.

Fertigation is the process in which nutrients are applied along with irrigation water. Drip fertigation has proved its superiority over other methods due to the direct application of water and nutrients in the vicinity of root zone. Drip fertigation also enables accurate adjustment of water and

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nutrient supplies to meet the actual crop requirements based on its growth stages and thus, minimizing the loss of expensive nutrients which ultimately helps in improving productivity and quality of farm produce (Bar-Yosef 1999). Water soluble fertilizers are more efficient than commercial fertilizers and delivers more nutrient use efficiency. These fertilizers are highly soluble in water with low salt index. With the increase in adaption of drip irrigation by farmers water soluble fertilizers can be deployed for better delivery in drip and uptake by plants.

There are scanty information on comparison of fertilizer sources on drip fertigation and irrigation on a deficit basis in Bajra Napier hybrid. Therefore the present investigation was carried out.

MATERIALS AND METHODS

The experiment was conducted in the central farm of Agricultural College and Research Institute, Madurai. It was situated in Periyar-Vaigai Command area (PVC) of the southern agro-climatic zone of Tamil Nadu state. The coordinates of the experimental site are 9°54' North latitude and 78°54' East longitude at an altitude of 147 meters above mean sea level. The experiment was laid in a split plot design, with 3 levels in main plot, 6 levels in sub plot and replicated thrice. The treatments are as follows

I_1-100 % ET_C	I_2-80 % ET_C	I_3-60 % ET_C
F_1-100% RDF N and K commercial fertilizer	F_2-75% RDF N and K commercial fertilizer	F_3-100% RDF N and K water soluble fertilizer
F_4-75% N and K water soluble fertilizer	F_5-100% RDF NPK water soluble fertilizer	F_6-75% RDF NPK water soluble fertilizer

RDF-150: 50: 40 kg ha^{-1} of NPK.

Sources: K-MOP (0: 0: 60); Water soluble-polyfeed (19: 19: 19); SOP (0: 0: 50) and urea.

Irrigation regimes

Irrigation was scheduled using the formula of Doorenbos and Pruitt (1977). Quantity of water to be applied was calculated daily by using the data of class A pan evaporimeter, pan coefficient and appropriate crop coefficient values at different crop stages. The reference evapotranspiration and crop evapotranspiration were calculated. Irrigation was given at 3 days once and fertigation was given at 6 days once. The irrigation water requirement was calculated by subtracting the effective rainfall from crop evapotranspiration. ER was calculated by water balance method suggested by Dastane (1967). Irrigation was given in three levels of 100, 80 and 60 per cent ET_c.

Data collection

Morphological characters

Morphological characters such as plant height, number of tillers per clump and number of leaves per clump were measured. Plant height was taken during the harvest stage, measuring from the soil surface to the fully expanded top leaf, the number of tillers and the number of expanded leaves in a clump were counted. Five random samples were measured in each plot and mean values were calculated plant height was expressed in cm.

Leaf areaindex (LAI)

LAI was worked out by observing the length and width of the broad portion of the fourth leaf from the top and total number of leaves were calculated. The measurements were observed during the harvest stage and leaf area index was worked out using the following formulae (Shanmugasundaram 1980).

$$\text{Leaf area index} = \frac{L \times B \times 0.75 \times N}{S}$$

Where

L- Length of the fourth leaf from top (cm), B-Max width of the fourth leaf from top (cm).

N- Number of leaves/plant, S- Space occupied/plant (cm^2).

Green fodder yield

First harvest was carried out 75 days after planting and subsequent harvests after 45 days. The plants in the plot were cut 15 cm above from the ground level. Fresh herbage yield was measured by using field sensitive spring balance immediately after harvesting. The total weight of forage per plot was converted to per hectare yield and expressed in tonnes.

Statistical analysis

The data on various parameters studied during the course of investigation were subjected to statistical analysis in split plot design with the statistical package “R” software. The treatment means were compared by using Duncan’s multiple range test (DMRT posthoc) at $P \leq 0.05$ probability level.

Correlation analysis

Pearson correlation (r) was analysed to elucidate the relationship between the growth parameters and yield. Whereas in fodder crops the growth attributes may be considered as yield attributes. Being the vegetative portion as the economic part.

RESULTS AND DISCUSSION

Plant height

The plant height was significantly affected by irrigation regimes and fertigation in both the cuttings. Table 1 The treatment I_1 recorded more height of 309.8 and 232.0 cm in both cuttings. Under fertigation treatments F_5 gave out taller plants of 273.6, 205.2 cm in both cuttings. The interaction of irrigation and fertigation was significant for plant height. The treatment combination of I_1F_5 exhibited higher plant height of 334.8 and 251.1 cm in both cuttings. Lower plant height was recorded in I_3F_2, (183.3, 137.5 cm). The water requirement was met continuously in I_1F_5 along with split application of NPK based on the crop stage leads to better nutrient uptake along with water intake. Optimum moisture

provided a conducive environment root growth and in turn to better shoot growth. In I_3F_2 less moisture availability leads to poor growth and comparatively decreased nutrient uptake by plants. This results were confirmed by Sathiyaraj (2017) in sugarcane, where 125 % ET_c and 100 % RDF of NPK as water soluble fertilizer showed higher plant height.

Number of tillers per clump

The results of number of tillers per clump under different irrigation regimes with fertigation sources and levels are given in Table 2. The number of tillers was significantly influenced by irrigation regimes. I_1 recorded more number of tillers (30.6, 36.1) in both cuttings. Different fertigation sources and levels showed significant results on number of tillers in both the cuttings. F_5 recorded more number of tillers 25.4 and 31.4 in both cuttings. I_1F_5 showed significantly high number of tillers in combination during both cuttings, (34.2 and 39.3). In adequate soil moisture, wetting area and better nutrient uptake was observed which leads to vigorous growth compared to less water and nutrient available treatments. This was proved by Soni *et al.,* (1991) where adequate supply of water and nutrients in surface drip fertigation lead to better root and shoot establishment. This promoted more axillary bud development and in turn more tillers. This was in concordance with Oberoi *et al.,* (2022).

Number of leaves per clump

Number of leaves per clump showed significant response to irrigation regimes Table 3. More number of leaves was recorded in I_1 (374.4, 364.6) in both cuttings. Among the fertigation treatments, F_5 showed higher number of leaves per clump 326.3 and 317.5 in both cuttings. The interaction effect was significant between irrigation regimes and fertigation. I_1F_5 exhibited more leaves per clump, 408 and 397 in two cuttings. Under optimum moisture in the rhizosphere region better nutrient absorption also takes place. In addition to that translocation of assimilates takes place. This was confirmed by Farahmandfar *et al.,* (2018) and have observed more growth and yield of fodder maize underfrequent irrigation and higher level of potassium sulphate fertilizer.

Leaf area index

Leaf area index is significantly affected by irrigation regimes Table 4. I_1 had higher LAI such as 24.5 and 24.2 in both cuttings. F_5 showed more LAI in both cuttings (21.4, 21.8). The combination of I_1F_5 recorded higher LAI (27.8, 28.4) in both cuttings. Optimum water application and higher dose of nutrients improved the growth attributes like number of tillers and leaves per clump leading to increased LAI.

Table 1: Influence of irrigation levels and fertigation on plant height (cm) of Bajra Napier hybrid.

Treatments	1st cutting				2nd cutting			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	310.7±4.1c	250.0±6.3h	202.8±3.6k	254.5±35.2c	233.0±2.1c	187.5±1.3g	152.1±1.2j	190.9±23.4c
F_2	290.9±2.2e	235.7±4.0i	183.3±2.2l	236.6±32.0e	218.2±0.9d	176.8±6.5h	137.5±2.3k	177.5±23.2e
F_3	323.1±4.7b	258.6±4.7g	203.4±5.3k	261.7±37.7b	242.3±2.4b	194.0±6.2f	152.5±1.7ij	196.3±25.7b
F_4	296.5±7.4d	241.7±4.8h	200.2±5.2k	246.1±31.8d	222.4±5.3d	181.3±5.6gh	148.4±2.6j	184.0±21.0d
F_5	334.8±10.2a	273.3±4.6f	212.7±5.0j	273.6±37.9a	251.1±4.0a	205.0±7.5e	159.6±0.7i	205.2±25.8a
F_6	302.8±2.8d	245.6±6.5h	198.5±6.9k	249.0±32.6d	225.1±1.1d	184.2±4.1gh	149.2±3.1j	186.2±21.6d
Mean	309.8±7.9a	250.8±6.1b	200.1±4.3c		232.0±5.0a	188.1±4.1b	149.9±3.0c	

The values are Mean±Standard error SE. The same letter in each column are not significantly different from each other based on DMRT P≤0.05. Treatment details: I_1-100% ET_C; I_2-80% ET_C; I_3-60% ET_C; F_1-100% RDF N and K commercial fertilizer; F_2-75% RDF N and K commercial fertilizer; F_3-100% RDF N and K water soluble fertilizer; F_4-75% N and K water soluble fertilizer; F_5-100% RDF NPK water soluble fertilizer; F_6-75% RDF NPK water soluble fertilizer.

Table 2: Influence of irrigation levels and fertigation on number of tillers per clump of Bajra Napier hybrid.

Treatments	1st cutting				2nd cutting			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	31.0±0.4c	21.9±0.6h	15.0± 0.3k	22.7±4.6c	36.5±0.5c	28.4±0.5h	22.3±0.6k	29.0±4.1c
F_2	27.3±0.7e	19.3±0.1i	12.8±0.2l	19.8±4.2e	33.2±0.5e	25.9±0.4i	20.2±0.4l	26.4±3.7e
F_3	32.6±0.8b	23.4±0.6g	15.4±0.4k	23.8±5.0b	37.9±0.1b	29.7±0.4g	22.6±0.3k	30.1±4.4b
F_4	28.8±0.5d	20.9±0.6h	14.3±0.6k	21.4±4.2d	34.5±0.5d	27.5±0.2h	21.6±0.4k	27.9 ±3.7d
F_5	34.2±0.4a	24.9 ±0.9f	16.9±0.3j	25.4±5.0a	39.3±0.4a	31.1±0.7f	23.9±0.4j	31.4±4.4a
F_6	29.5±0.7d	21.5±0.6h	14.7±0.3k	21.9±4.3d	35.2±0.1d	28.0±0.2h	21.9±0.5k	28.3±3.8d
Mean	30.6±1.0a	22.0±0.8b	14.9±0.6c		36.1±0.9a	28.4±0.7b	22.1±0.5c	

The values are Mean±Standard error SE. The same letter in each column are not significantly different from each other based on DMRT P≤0.05. Treatment details: I_1-100% ET_C; I_2-80% ET_C; I_3-60% ET_C; F_1-100% RDF N and K commercial fertilizer; F_2-75% RDF N and K commercial fertilizer; F_3-100% RDF N and K water soluble fertilizer; F_4-75% N and K water soluble fertilizer; F_5-100% RDF NPK water soluble fertilizer; F_6-75% RDF NPK water soluble fertilizer.

Similarly, in fodder sorghum number of irrigation and nitrogen levels had a significant impact on the LAI (Pradhan *et al.,* 2015).

Green fodder yield

The results of green fodder yield are depicted in Table 5. Irrigation levels had significant difference on fresh yield. Higher herbage yield was harvested from I_1 (48.3, 64.4 t ha^{-1}) in both cuttings. Fertigation with F_5 treatment gave out more green fodder yield of 42.1, 56.1 t ha^{-1} in both cuttings. The interaction between irrigation regimes and fertigation showed significant differences. More herbage yield was harvested in I_1F_5 in both cuttings (70.1, 52.6 t ha^{-1}). Supplying irrigation based on crop requirement and fertigation with water soluble fertilizers lead to better vegetative growth, this in turn produced more herbage yield. In fodder crops both

Table 3: Influence of irrigation levels and fertigation on number of leaves per clump of Bajra Napier hybrid.

Treatments	1st cutting				2nd cutting			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	378.9±3.6c	297.4±8.5h	231.1±7.8k	302.5±42.7c	368.7±2.9c	286.6±7.4h	224.8±7.2k	293.4±41.6c
F_2	342.8±11.4e	268.9±1.5i	207.2±6.2l	273.0±39.2e	335.3±6.9e	261.6±6.0i	204.4±5.4l	267.1±37.9e
F_3	393.4±4.2b	309.6±3.3g	234.6±7.7k	312.5±45.8b	382.8±3.3b	300.2±6.8g	228.2±4.6k	303.7±44.6b
F_4	358.5±6.2d	289.3±1.9h	224.7±3.9k	290.8±38.6d	348.9±7.8d	277.3±2.6h	218.6±5.7k	281.6±37.7d
F_5	408.0±11.2a	322.4±3.6f	248.5±2.6j	326.3±46.1a	397.0±4.8a	313.7±7.0f	241.8±5.9j	317.5±44.8a
F_6	364.9±4.2d	293.3±4.3h	227.6±5.3k	295.3±39.6d	355.1±2.0d	282.6±4.4h	221.4±6.1k	286.4±38.6d
Mean	374.4±9.7a	296.8±7.5b	228.9±5.5c		364.6±9.3a	287.0±7.4b	223.2±5.0c	

The values are Mean±Standard error SE. The same letter in each column are not significantly different from each other based on DMRT P≤0.05. Treatment details: I_1-100% ET_C; I_2-80% ET_C; I_3-60% ET_C; F_1-100% RDF N and K commercial fertilizer; F_2-75% RDF N and K Commercial fertilizer; F_3-100% RDF N and K water soluble fertilizer; F_4-75% N and K water soluble fertilizer;F_5-100% RDF NPK water soluble fertilizer; F_6-75% RDF NPK water soluble fertilizer.

Table 4: Influence of irrigation levels and fertigation on LAI of Bajra Napier hybrid.

Treatments	1st cutting				2nd cutting			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	25.8±0.3c	20.1±0.6h	15.7±0.6k	20.5±2.9c	22.1±0.2c	17.2±0.5h	13.5±0.4k	17.6±2.5c
F_2	23.5±0.8e	18.4±0.1i	14.3±0.4l	18.7±2.7e	20.1±0.4e	15.7±0.4i	12.3±0.3l	16.0±2.3e
F_3	26.8±0.3b	21.0±0.2g	16.0±0.6k	21.3±3.1b	23.0±0.2b	18.0±0.4g	13.7±0.3k	18.2±2.7b
F_4	24.4±0.5d	19.4 ±0.1h	15.3±0.3k	19.7±2.6d	20.9±0.5d	16.6±0.2h	13.1±0.4k	16.9±2.3d
F_5	27.8±0.8a	22.0±0.3f	16.9±0.2j	22.2±3.1a	23.8±0.3a	18.8±0.4f	14.5±0.4j	19.0±2.7a
F_6	24.9±0.3d	19.8±0.3h	15.5±0.4k	20.1±2.7d	21.3±0.1d	16.9±0.3h	13.3±0.4k	17.2±2.3d
Mean	25.5±0.7a	20.1±0.5b	15.6±0.3c		21.9±0.6a	17.2±0.4b	13.4±0.3c	

The values are Mean±Standard error SE. The same letter in each column are not significantly different from each other based on DMRT P≤0.05. Treatment details: I_1-100% ET_C; I_2-80% ET_C; I_3-60% ET_C; F_1-100% RDF N and K commercial fertilizer; F_2-75% RDF N and K commercial fertilizer; F_3-100% RDF N and K water soluble fertilizer; F_4-75% N and K water soluble fertilizer; F_5-100% RDF NPK water soluble fertilizer; F_6-75% RDF NPK water soluble fertilizer.

Table 5: Influence of irrigation levels and fertigation on green fodder yield (t ha^{-1}) of Bajra Napier hybrid.

Treatments	1st cutting				2nd cutting			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
F_1	65.1±1.0c	50.6±1.6h	39.7±1.5k	51.8±7.3c	48.8±0.7c	38.0±0.7h	29.8±0.7k	38.9±5.5c
F_2	59.2±2.2e	46.5±0.4i	36.1±1.2l	47.3±6.7e	44.4±0.6e	34.7±0.6i	27.1±0.5l	35.4±5.0e
F_3	67.6±1.1b	53.0±0.6g	40.3±1.5k	53.6±7.9b	50.7±0.1b	39.8±0.6g	30.2±0.4k	40.2±5.9b
F_4	61.6±1.4d	49.0±0.4h	38.6±0.9k	49.7±6.6d	46.2±0.7d	36.7±0.3h	29.0±0.6k	37.3±5.0d
F_5	70.1±2.3a	55.4±0.7f	42.7±0.7j	56.1±7.9a	52.6±0.5a	41.6±0.9f	32.0±0.6j	42.1±5.9a
F_6	62.7±1.0d	49.9±0.8h	39.1±1.1k	50.6±6.8d	47.0±0.2d	37.4±0.3h	29.3±0.6k	37.9±5.1d
Mean	64.4±1.7a	50.7±1.3b	39.4±0.9c		48.3±1.2a	38.0±1.0b	29.6±0.7c	

The values are Mean±Standard error SE. The same letter in each column are not significantly different from each other based on DMRT P≤0.05. Treatment details: I_1-100 % ET_C; I_2-80 % ET_C; I_3-60 % ET_C; F_1-100% RDF N and K commercial fertilizer; F_2-75% RDF N and K commercial fertilizer; F_3-100% RDF N and K water soluble fertilizer; F_4-75% N and K water soluble fertilizer; F_5-100% RDF NPK water soluble fertilizer; F_6-75% RDF NPK water soluble fertilizer.

Table 6: Correlation between green fodder yield and growth parameters during 1st cutting of Bajra Napier hybrid.

	GFY	PH	NTPC	NLPC	LAI
GFY	1				
PH	0.999**	1			
NTPC	1.000**	0.999**	1		
NLPC	1.000**	0.998**	1.000**	1	
LAI	0.992**	0.988**	0.991**	0.992**	1

**Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlation between green fodder yield and growth parameters during 2nd cutting of Bajra Napier hybrid.

	GFY	PH	NTPC	NLPC	LAI
GFY	1				
PH	0.999 **	1			
NTPC	1.000 **	0.999 **	1		
NLPC	1.000 **	0.999 **	1.000 **	1	
LAI	0.972 **	0.968 **	0.972 **	0.972 **	1

**Correlation is significant at the 0.01 level (2-tailed).

GFY: Green fodder yield; NLPC: Number of leaves per clump; PH: Plant height; LAI: Leaf area index; NTPC: Number of tillers per clump.

source and sink are the same. This was in conformity with Brar (2021). Dharaiya *et al.,* (2022) also reported similar result and observed that in sweet sorghum 1.0 PEF irrigation level and 125 % .RDF of N gave more yield.

Correlation analysis

Correlation was carried out at 1 per cent probability level. Under which positive correlation was observed between the growth parameters like plant height, number of tillers and leaves per clump and leaf area index with the green fodder yield of Bajra Napier hybrid in both the cuttings. The correlation results are depicted in Tables 6 and 7. Similar correlations were found in Bajra Napier hybrid by Zhang *et al.,* (2010). Singh *et al.,* (2020) also reported same results and observed that in Bajra Napier Hybrid varieties under different salinity stress levels positive correlation was between morpho-physiological characters (plant height, number of leaves and leaf area) with green fodder yield.

CONCLUSION

Based on the above study, it can be concluded that irrigation regimes had a greater impact on the vegetative growth and yield of Bajra Napier hybrid. Lower water availability upto 60 per cent crop evapotranspiration reduces the succulence and yield of the crop. Under fertigation, water soluble fertilizer produced better growth than commercial fertilizers for drip irrigation. The combination of optimum irrigation and fertigation levels gave out better morpho-physiological characters and green fodder yield. Fertigation in low irrigation regimes with commercial fertilizers had poor leaf growth and yield. Positive correlation was observed between growth parameters and forage yield. Therefore under 100 per cent Et_c and 100 per cent RDF of water soluble fertilizer higher herbage yields can be achieved. Whereas in low water availability conditions, 80 per cent Et_c with 100 per cent RDF of water soluble fertilizer can be followed for achieving optimum yield.

Conflict of interest: None.

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