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RESEARCH PAPER

Effect of salinity stress on morphological characters of Bajra napier hybrid grass [*Pennisetum glaucum* (L.) R. Br.]x [*Pennisetum purpureum* (K.) Schm] varieties

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Abstract: Salinity is a significant constraint in expressing thecrop's full potential. Bajra Napier Hybrid grass is a high-yielding,good-quality fodder grass with palatability grown across different climatic zones of India. A field experiment was conducted at the Indian Grassland and Fodder Research Institute, Dharwad, during 2020-21 to evaluate the effect of salinity stress tolerance in seven established BN Hybrid genotypes,*viz.,*DHN 6, DHN 15, COBN 5, CO 6, BNH 10, IGFRI 7and PHULE YASHWANT at 0 and 12 ECe. The morphological characters like plant height, the number of tillers, the number of green leaves per tiller, regeneration index, and total fresh weight were recorded in these seven genotypes under salinity and control conditions. The maximum height was observed in Phule Yashwant, whereas the minimum height was recorded in genotype DHN 6. BNH 10 recorded the highest regeneration index. The highest total fresh biomass was recorded in the Phule Yashwant genotype, irrespective of salinity levels. This study revealedthat Phule Yashwant displayed the highest fresh biomass among all the genotypes, and the biomass of BNH 10 was on par.Whereas CO 6 and DHN 6 were the poor performers. Higher tiller number, regeneration index, and low leaf-to-stem ratio were the strategies adopted by the tolerant varieties under higher salt levels.

Key words: Bajra napier hybrid, *Pennisetum glaucum, Pennisetum purpureum,* Salinity stress

Introduction

Of 121 million ha of degraded land in India, about 6.75 million ha is classified as salt-affected (Dagar, 2017). The rehabilitation of salty lands is progressing at a prolonged rate. In arid and semi-arid regions, the aquifers turned saline. Groundwater surveys indicate that 25-84% of ground water in different states is poor-quality water (Minhas, 1998). Preferably, using crops that tolerate the high salinity level in the soils would be a practical contribution towards addressing the problem. Plants require physiologically adapted mechanisms to grow under saline conditions. Halophytes are naturally grown under saline environments, and other crops tolerate or resist salinity through morphological, physiological, and molecular means. Salinity mainly affects plants by causing osmotic stress, ion-specific toxicity, oxidative stress, and nutrient imbalance.Understanding the plant salt tolerance mechanisms is critical for maintaining or improving crop yield under adverse saline environmental conditions.

Bajra Napier Hybrid is an interspecific hybrid between bajra and Napier grass. It has the high quality and faster growth of bajra with the deep root system and multi-cut habit of Napier grass. It yields an average of 380 to 400 tons/ha. It produces more tillers with soft and juicy stems, free from pests, diseases,and non-lodging. It can be cultivated throughout the year under irrigated conditions. The forage quality of these hybrids was superior to their parents (Narayanan and Dabadghao, 1972). These hybrids produced more tillers and leaves with the bulk of fodder and grew faster than their parents (Gupta and Mhere,1997).

Material and methods

The experiment was conducted at ICAR-IGFRI, SRRS, Dharwad, from February 2020 to March 2021 to assess the salinity tolerance in seven Bajra Napier (BN.) Hybrid genotypes. DHN 6, DHN 15, COBN 5, CO 6, BNH 10, IGFRI 7and PHULE YASHWANT were grown in containers that can hold 60 kg of soil without any drainage holes to ensure retention of salts and not to be washed away due to irrigation. Artificial salinity in the soils of pots was developed as per the method of Dheeravathu *et al*., 2018.

The natural field saline conditions were emulated by inducing salinity after the monsoon and winter rains receded. The salinity was developed in February, seven months after planting. Before application,the initial soil ECe was 2 ECe. A combination of salts of NaCl, Na_2SO_4, $MgCl_2$, and $CaSO_4$ in the 13:7:1:2 ratio were used to induce salinity 12 ECe. The existing soil ECe was subtracted from the desired treatment ECe and used to calculate the salt required for creating salinity. The percentage of salt required to create the required salinity in ECe for 1260 kg soil was calculated after converting the ECe into ppm and then from ppm to percentage. (21 containers contained 60 kg of soil each for 12 ECe treatments (seven varieties and three replications, 7 x 3 =21). The soil required for 21 containers is 1260 kg).

The quantity of salts (kg) required for 1260 kg soil (A)

$= (\{[(ECe \times 640)/10000] \times 1260kg\} / 100)$

The percentage of salts for desired ECe in the ratio of 13:7:1:2 was calculated, % of salts = [(salt ratio x kg of salt (A)) / (total salt ratio)]

The soil salinity was created based on a percentage of salt ratio and uniformly distributed in the soil in the container by dissolving the salts in water. The salts were added and dispersed in the soil by repeated irrigation and drying.

The individual salt weight for 1260 kg of soil used in this experiment is given below:

Initial ECe of soil (dS/m)	ECe created (ds/m)	kg of salt /1260 kg soil NaCl	Na_2SO_4	$MgCl_2$	$CaSO_4$	Final salinity (ECe)
0-1	0 (control)	0	0	0	0	0
3	7	3.18	1.71	0.24	0.49	10-12

The biomass difference between the two harvests calculated the absolute growth rate and estimated the growth in grams per day.Plant height was measured from the plant's base to the terminal leaf's tip using a meter scale. The number of tillers per plant was counted manually. Tiller regeneration ability was calculated as the difference between the tiller number counted before the 9th and 4th harvest (*i.e.,* first cut after salinity application). The fresh weight of leaves and stem of the individual plants were added to get the total fresh biomass respectively and expressed as g plant^{-1}.The leaf-to-stem ratio was calculated using the dry leaf and stem weights obtained in each harvest. Statistical and correlation analysis was carried out for factorial RBD using WASP software (www.ccari.icar.gov.in/ wasp2.2)

Results and discussion

The biomass yield of the Bajra Napier Hybrid varies significantly depending on variety, age, season, location, and management approaches (Xie *et al*., 2011; Rengsirikul *et al*., 2011; Ogoshi *et al*., 2010). Fresh biomass is crucial in determining the yield, as it is a fodder crop's biological and economic yield. All the genotypes survived in polybags well before applying salinity. At 12ECe, all seven genotypes were established well in polybags, and only DHN 6 and CO 6 failed to emerge in one of the replications. This observation proves that BN hybrids are sensitive to salinity, and sensitivity depends on the genotypes. Another understanding from this observation was that, when planting a tolerant genotype in salinity-affected

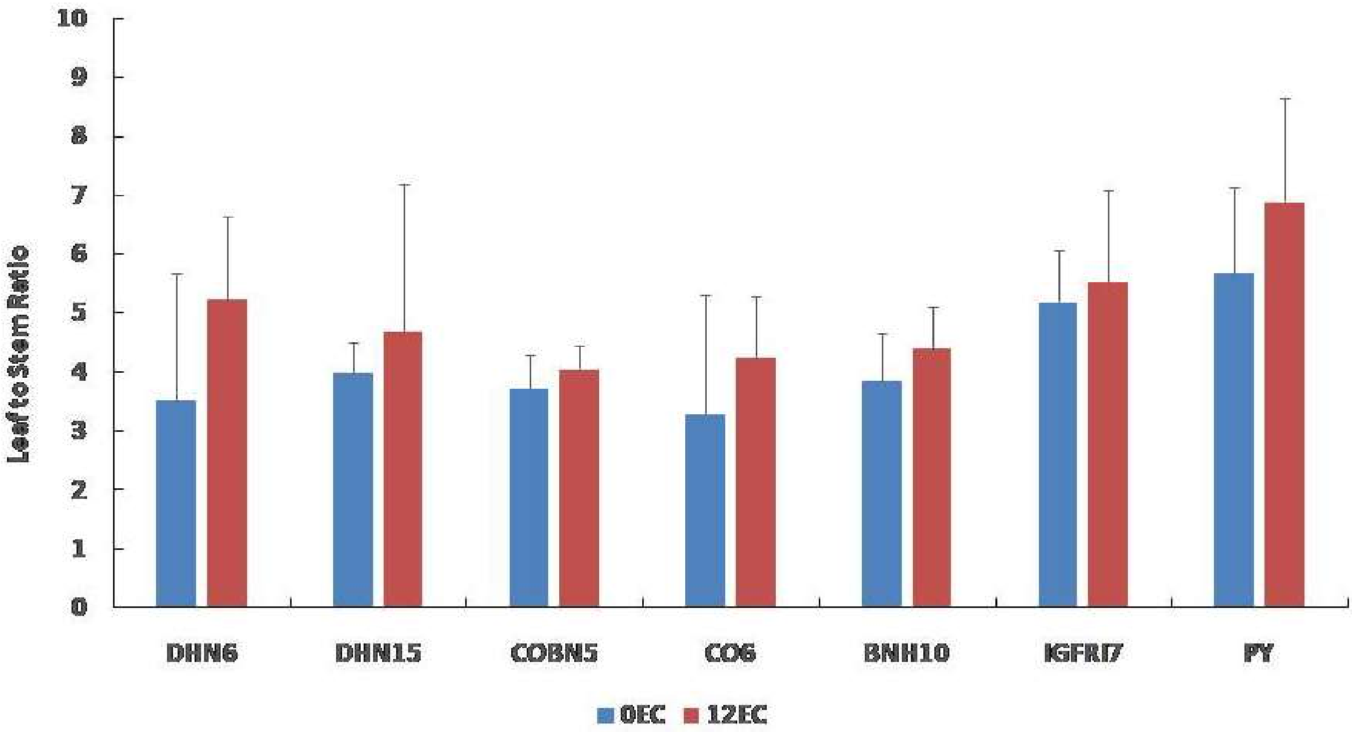

Fig 1. Effect of salinity on the leaf-to-stem ratio in BN hybrid genotypes

Table1. Absolute Growth Rate of BN Hybrid genotypes during different seasons under 0 and 12 ECe

Genotypes	Absolute Growth Rate (g day^{-1}) Summer		Rainy		Winter	
	0ECe	12ECe	0ECe	12ECe	0ECe	12ECe
DHN 6	1.48±4.14	9.26±2.74	-5.03±1.07	-1.70±1.00	-1.57±1.62	0.27±0.63
DHN 15	7.89±2.95	10.54±1.98	-5.85±2.06	-18.49±25.77	-1.07±0.32	2.79±0.33
COBN 5	5.77±2.26	8.20±2.53	-1.03±1.70	6.73±6.93	-0.70±1.97	-0.35±3.71
CO 6	11.57±2.20	7.10±3.28	-3.65±1.16	-1.33±0.86	-0.88±1.22	-6.60±4.63
BNH 10	10.24±6.54	14.58±14.66	-7.01±2.36	-0.90±8.23	1.32±0.79	0.50±2.75
IGFRI7	.9.81±1.24	11.83±4.51	-4.20±3.80	-4.56±0.89	-0.05±0.33	2.02±1.64
Phule Yashwant	19.33±9.12	17.76±4.56	-14.07±10.7	-7.76±0.58	-2.86±4.18	-1.13±1.64

Table 2. Effect of salinity on plant height (cm), number of tillers, and number of green leaves per tillerin BN hybrid genotypes

Genotypes	Plant height (cm)			Number of tillers			Number of green leaves per tiller		
	Salinity levels		Increase/ decrease(%)	Salinity levels		Increase/ decrease(%)	Salinity levels		Increase/ decrease(%)
	0ECe	12ECe		0ECe	12ECe		0ECe	12ECe	
DHN 6	92.83[b]	87.83[c]	-5.39	28.72	17.58	-38.78	7.16[a]	6.25[d]	-12.70
DHN 15	111.11[a]	121.31[ab]	9.18	29.61	30.66	3.54	6.33[a]	6.50[d]	2.68
COBN 5	116.10[a]	121.74[a]	4.86	31.72	36.66	15.57	7.11[a]	8.05[bc]	13.22
CO 6	110.32[a]	112.12[b]	1.63	25.05	25.25	0.79	7.50[a]	8.00[bc]	6.66
BNH 10	119.37[a]	126.86[a]	6.27	27.83	33.44	20.15	7.77[a]	8.33[ab]	7.20
IGFRI 7	116.75[a]	122.37[a]	4.81	29.88	33.00	10.44	6.72[a]	7.38[c]	9.82
PHULE YASHWANT	112.37[a]	123.42[a]	9.83	37.55	41.11	9.48	8.00[a]	8.83[a]	10.37
MEAN	111.26	116.58		30.05	31.10		7.23	7.62	
		S.Em ±	C.D. at 5%		S.Em ±	C.D. at 5%		S.Em ±	C.D. at 5%
Genotypes		2.11	8.7		3.95	11.51		0.20	0.61
Salinity levels		1.59	4.65		2.11	6.15		0.11	0.32
Genotype x Salinity levels		4.23	12.30		5.59	16.27		0.29	0.86

soils, a high population density should be maintained to ensure a minimum persisting plant population.

Season-wise green fodder analysis showed that the summer season recorded the highest green fodder yield, followed by the *Kharif* (rainy) and *Rabi* (winter) seasons (Krishnaveni., 2019). The absolute growth rate was highest during summer under irrigated conditions, followed by rainy and winter (Table 1). The trend was the same in 0 and 12 ECe. The growth rate during the rainy season was negative,probably because of excess water conditions in the polybags without holes.Winter had the lowest growth rate, owing to the winter dormancy. Under control conditions, all the genotypes except BNH 10 showed a negative growth rate during winter. BNH 10 had a positive growth rate in both control and 12ECe, indicating it has no winter dormancy and thus may be suitable for growing under cold conditions.

Table 2 shows the data related to changes in plant height (cm), number of tillers, and number of green leaves per tiller with increased salinity.

Plant height is the visual evidence to understand the plant's growth under control and stress conditions. It is evident from the data in Table 2 that average plant height increased with salinity in all the genotypes except DHN 6. Among all the genotypes, irrespective of the salinity level, DHN 15 showed the maximum average plant height, and the minimum plant height was recorded by DHN 6. The non-significant correlation of fresh biomass with plant height at 0 ECe showed that plant height was a trait expressed due to salinity for the tolerance mechanism. Increased plant height can be considered an essential trait for selecting genotypes for tolerance against salinity.

The data of the number of tillers per plant indicates an increase in tiller number under salinity in all the genotypes, except DHN 6. Under saline conditions, the highest and lowest number of tillers was recorded by Phule Yashwant and DHN 6, respectively. The effect of salinity on the number of tillers produced was statistically significant. Along with these, the number of green leaves per tiller increased in all the genotypes except DHN 6 under salinity. At the genotype level, Phule Yashwant recorded the highest number of leaves per tiller, and DHN 15 showed the least. At 12, ECe recorded the highest number of leaves per tiller.

Table 3 shows the data related to the regeneration index of the crop. Regeneration plays a vital role in these grasses owing to their perennial nature. At different salinity levels, 0ECe was

Table 3. Effect of salinity on regeneration index in BNHybrid genotypes

Genotypes	Salinity levels		Mean
	0ECe	12ECe	
DHN 6	3.00	10.00	6.50
DHN 15	18.33	4.33	11.33
COBN 5	37.66	2.00	19.83
CO 6	9.66	10.00	9.83
BNH 10	8.66	39.66	24.16
IGFRI 7	6.66	4.66	5.66
PHULE YASHWANT	21.00	11.66	16.33
MEAN	15.00	11.76	
	S.Em ±	C.D at 5%	
Genotypes	4.88	20.10	
Salinity levels	3.69	10.74	
Genotype x Salinity levels	9.77	28.43	

Table 4. Effect of salinity on total fresh weight (kg plant^{-1} year^{-1}) in BN hybrid genotypes

Genotypes	Salinity levels		Increase/ decrease(%)
	0ECe	12ECe	
DHN 6	1.99[a]	1.01[c]	-49.24
DHN 15	3.33[a]	4.51[ab]	35.43
COBN 5	4.33[a]	5.18[ab]	19.63
CO 6	3.43[a]	2.93[bc]	-14.57
BNH 10	3.99[a]	5.24[ab]	31.32
IGFRI 7	3.52[a]	3.60[bc]	2.27
PHULE YASHWANT	6.41[a]	6.44[a]	0.46
MEAN	3.86	4.13	
	S.Em ±	C.D at 5%	
Genotypes	0.81	2.36	
Salinity levels	0.43	1.26	
Genotype x Salinity levels	1.14	3.33	

found to have the highest regeneration, while 12ECe showed the least. The regeneration index showcases the loss in the number of tillers as the plant continues to grow.

The observations concerning the total fresh weight are presented in Table 4. The highest total fresh weight was observed in Phule Yashwant at 12 ECe, and the lowest was observed in DHN 6 at 12 ECe. Under different salinity levels,the lowest total fresh weight was recorded at different salinity levels at 0 ECe, while the highest was recorded at 12 ECe.

In Figure 1, the leaf-to-stem ratio under salinity decreased in all the genotypes except CO 6. The highest ratio was observed in Phule Yashwant and the lowest in COBN 5 at 12ECe.The results imply that under salinity, tolerant varieties tend to increase the stem weight as a means toincrease the number of cells to sequester salts and to prevent salts from reaching leaves, which are the green photosynthesizing part of the plant.The critical morphological traitsfor grass are plant height, number of leaves, number of tillers, total fresh biomass, and total dry biomass. The total fresh biomass was positively correlated with morphological traits like plant height (r=0.87**), tillers (r=0.95**), the number of green leaves (0.75**), the fresh and drystem weight (r = 0.96**,0.97**) and fresh and dry leaf weight (r =0.96**,0.95**) at 12 ECe. A similar correlation was observed in guinea grass genotypes under salinity (Kawadikai and Antony, 2020). The yield attributes like plant height, tillers, green leaves, and total fresh weight determine BN hybrid genotypes yield under salinity. The significant correlation coefficients of fresh biomass at 0 ECe were with only the tiller number (0.78*), leaf weights (0.97**) and stem weights (0.98**). This observation implies that an increase in plant height was a trait expressed in the genotypes for the salinity tolerance mechanism.

The height increase can be attributed to increased internodal length and higher hormonal activity at the growing tip. Stems are the primary site of salt accumulation away from photosynthetic tissue. Stems protect the green leaves by storing the salt and protecting the photosynthetic machinery from the deleterious effects of salt. The observation at 12 ECe further strengthens the role of stem biomass. The increased height facilitates storing salt away from the growing parts.

Conclusion

The study showed that higher fresh biomass is a significant indicator of salinity tolerance in BN Hybrids. Phule Yashwant displayed the highest fresh biomass among all the genotypes, and BNH 10 was on par. Based on the results of fresh biomass obtained in this study, genotypes were ranked for their performance under salinity as Phule Yashwant > BNH 10 > COBN 5 > DHN 15 > IGFRI 7 > CO 6 > DHN 6. Phule Yashwant and BNH 10 noticed the maximum biomass-yielding genotypes, whereas CO 6 and DHN 6 were the poor performers.Thus, Phule Yashwanth and BNH 10 can be recommended for growing under salt-affected areas.

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