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RESEARCH PAPER

Morphological factors affecting fresh biomass in guinea grass (*Megathyrsus maximus*) varieties under saline stress condition

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Abstract : Salinity is one of the major constraints for the production and yield of any crop. The guinea grass is perennial and high yielding grass. The present investigation was carried out to know the morphology and yield of six different guinea grass genotypes namely BG-1, BG-2, DGG-1, BG-4, CO-1,and RD under varying saline stress condition *i.e.,* 0, 4. 8, 12 ECe levels. The genotypes CO-1 and RD failed to survive under high stress condition *i.e.,* at 8 and 12 ECe levels respectively. The height, tiller number, tiller regeneration efficiency, leaf and stem fresh weight and fresh biomass was evaluated in six different genotypes of guinea grass. The maximum height was recorded in BG-4 where as minimum height was recorded in CO-1 genotype irrespective of salinity level. It was observed that the genotype DGG-1 recorded highest number of tillers and genotype BG-1, DGG-1 recorded highest tiller regeneration capacity. The DGG-1 genotype recorded highest leaf fresh weight and BG-4 recorded highest stem fresh weight where as the CO-1 recorded minimum leaf and stem fresh weight. The highest fresh biomass was recorded in DGG-1 genotype irrespective of salinity level. This study reveals that the DGG-1 and BG-4 genotypes are relatively more tolerant with high biomass in comparison with the BG-1 and BG-2 genotypes. The CO-1 and RD genotype had better performance under mild stress condition but failed to survive under higher stress condition.

Key words: Biomass, Fodder, Regeneration, Salinity

Introduction

Around the globe, the area under saline soils is increasing as a result of deforestation and unsustainable irrigation practices (Munns and Gilliham, 2015). Using the saline land for pasture production to improve animal husbandry can convert an unproductive saline land to cultivable land (Munns and Gilliham, 2015). The acute shortage of fodder to the tune of 63.5 % (Jitendra, 2016) existing in India and opportunity to use unproductive lands for fodder production is a viable solution for shortage of fodder and changes in land use pattern due to climate change induced salinity,

Guinea grass, *Megathyrsus maximus* (Jacq.) is one of the productive grasses which is valuable for pasture, green fodder and silage and grown in all parts of India. The average yield is about 18-29 tons/ha (Fernandes *et al.,* 2014). Indian Grassland and Fodder Research Institute has >200 accessions of guinea grass. Several varieties like BG-1, BG-2, BG-4, DGG-1 were released for cultivation in India. However, none of these varieties was tested for its potential to yield greenfodder under saline conditions. Hence this study will be conducted to understand the adaptability of guinea grass varieties under saline conditions.

Material and methods

The experiment was conducted under controlled conditions using six guinea grass genotypes namely, BG-1, BG-1, DGG-1, BG-4, CO-1, and RD. As procurement of natural saline soils with varying salinity and natural saline areas near the site of the experiment was unavailable, artificial saline soils were prepared based on Sevanayak *et al.*(2018). The four different levels of salinity *i.e.,* 0 ECe, 4 ECe, 8 ECe, 12 ECe was artificially created using different salts.

Containers without any drainage holes which can hold 60 kg of soil was used for each treatment. The soil salinity created based on a percentage of salt ratio 13:7:1:2, using a combination of salts of NaCl, Na_2SO_4, $MgCl_2$ and $CaSO_4$ respectively was allowed to distribute uniformly in the soil in the container for more than 45 days by subjecting it to repeated cycles of irrigation and evaporation before planting single rooted slips per soil bag.

Plant height (cm) was measured from the base of the plant to the tip of the terminal leaf using meter scale. Number of tillers were counted manually. Tiller regeneration ability was calculated as the difference between the tiller number counted at 90 and 45 days after planting. Leaves and stems were separated after every harvest and the weight of leaf and stem was weighed separately and expressed as g plant^{-1}.The leaves and stems were dried in a hot air oven at 65 °C for a week and the weight of the leaves and stem recorded respectively and expressed as g plant^{-1}. 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}. Statistical analysis was carried for factorial RBD using WASP software

Results and discussion

Plant height is a visually evident morphological parameter. It is apparent from the data presented in the Table 1 that the plant height increased at higher salinity level in comparison with the control treatment in DGG-1, BG-2, CO-1 genotypes but it was in a reverse manner in case of BG-1, BG-4 and RD genotypes. The genotype BG-4 recorded the maximum height (123 cm) and minimum was recorded in CO-1 genotype among all the genotype irrespective of salinity level. At different

Table 1. Effect of salinity levels on plant height (cm) in guinea grass genotypes

Genotypes	Soil salinity levels (ECe)				
	0	4	8	12	Mean
BG-1	93.7	99.0	87.3	121.9	100.4
	(10.1)	(10.4)	(9.8)	(11.5)	(10.4)
BG-2	110.3	89.6	133.8	121.6	113.8
	(10.9)	(9.9)	(12.0)	(11.5)	(11.0)
DGG-1	118.0	120.2	118.4	122.6	119.8
	(11.3)	(11.7)	(11.3)	(11.5)	(11.4)
BG-4	117.5	115.1	137.3	125.2	123.7
	(11.3)	(11.2)	(12.2)	(11.6)	(11.5)
CO-1	85.3	82.3	0.0	0.0	41.9
	(9.7)	(9.5)	(0.7)	(0.7)	(5.1)
RD	72.3	89.6	109.2	0.0	67.7
	(8.9)	(10.3)	(10.9)	(0.7)	(7.7)
Mean	99.5	99.3	97.6	81.8	
	(10.3)	(10.5)	(9.4)	(7.9)	
		S.Em.±		C.D. at 5 %	
Genotypes		0.2		0.7	
Salinity		0.2		0.7	
Genotype x salinity		0.5		1.3	

The figures in parenthesis are square root transformed values

salinity levels the maximum height was recorded in control treatment (99.5 cm) irrespective of the genotypes.

The data concerning the number of tillers is presented in the Table 2. The highest tiller no was noted in DGG-1 and BG-1 followed by BG-4. Among the salinity levels 0 ECe recorded highest number of tillers and the lowest number of tillers were recorded at 12ECe level among four genotypes *i.e.,* BG-1, BG-2, DGG-1, BG-4. The impact of genotypes, salinity and the interaction of genotype into salinity was statistically significant in case of the number of tillers.

Table 2 shows the findings of the regeneration index of the crops. The regeneration is a crucial factor in fodder crops to ensure plant stand to yield sufficient biomass in the succeeding harvest. The maximum tiller regeneration ability recorded at 0 ECe level with respect to treatment mean and DGG-1 recorded highest tiller regeneration ability irrespective of salinity level. DGG-1 and BG-1 recorded high regeneration ability irrespective of salinity levels.

In a fodder crop, fresh leaf weight is an important parameter that contributes towards yield. The data about total leaf fresh weight is presented in Table 3.The fresh leaf weight in all genotypes increased in salinity levels at 12ECe as compared to control. The maximum leaf fresh weight was recorded in DGG-1 variety whereas the minimum leaf fresh weight was recorded in CO-1 variety. There was a significant difference among all genotypes for total leaf fresh weight.

Stem fresh weight also contributes to the total fodder yield in guinea grass. The data on total stem fresh weight recorded is represented in the Table 4. There were genotypic differences in stem fresh weight recorded at 12 ECe and 0 ECe. CO-1 recorded a highest stem fresh weight at the control and 4 ECe (1159.3 $g^{-1)}$ amongst the genotypes. BG-4 recorded the highest stem fresh weight at 8 and 12 ECe. According to the varietal mean the BGG-1 showed maximum stem fresh weight and the minimum was recorded in CO-1 variety. Highest stem fresh weight was recorded at 4 ECe level and the least was recorded at 12 ECe level irrespective of genotypes. DGG-1 and BG-4 varieties showed a significant difference for the fresh stem weight among 8 and 12 ECE level. It was evident from the data that genotypes behaved differently at high saline conditions in fresh stem weight.

The observations recorded on the total fresh biomass is presented in the Table 5.As a fodder crop, the fresh biomass is the economic part used as the feed for the cattle. Compared with controls of all the genotypes except for BG-2, the total fresh biomass increased to 12ECe salinity. The maximum total biomass was recorded at 12ECe levels among DGG-1, BG-4

Table 2. Effect of salinity levels on a number of tillers and tiller regeneration ability in guinea grass genotypes

Genotypes	Number of tillers					Tiller regeneration ability				
	0	4	8	12	Mean	0	4	8	12	Mean
BG-1	41.3	42.6	59.0	54.3	49.3	20.00	16.33	39.33	19.66	23.83
	(6.9)	(7.0)	(8.1)	(7.8)	(7.4)	(4.48)	(3.97)	(6.29)	(4.29)	(4.75)
BG-2	44.3	39.0	39.6	42.0	41.2	18.00	8.33	16.33	15.33	14.49
	(7.1)	(6.7)	(6.7)	(6.9)	(6.8)	(4.27)	(2.94)	(4.07)	(3.97)	(3.81)
DGG-1	47.0	40.0	52.0	51.0	47.5	23.00	18.00	26.67	22.33	22.50
	(7.3)	(6.8)	(7.7)	(7.6)	(7.3)	(4.82)	(4.25)	(5.18)	(4.77)	(4.75)
BG-4	40.3	32.6	47.6	42.6	40.8	16.00	14.00	16.33	10.33	14.16
	(6.8)	(6.2)	(7.3)	(7.0)	(6.8)	(4.00)	(3.74)	(3.95)	(3.25)	(3.73)
CO-1	47.3	28.0	0.0	0.0	18.8	25.67	20.33	0.00	0.00	11.50
	(7.3)	(4.8)	(0.7)	(0.7)	(3.3)	(5.07)	(4.49)	(0.70)	(0.70)	(2.74)
RD	39.3	41.3	35.0	0.0	28.9	16.00	21.33	11.00	0.00	12.08
	(6.7)	(6.9)	(6.4)	(0.7)	(5.1)	(4.02)	(4.64)	(3.37)	(0.70)	(3.18)
Mean	43.2	37.2	38.8	31.6		19.77	16.38	18.27	11.27	
	(7.0)	(6.4)	(6.1)	(5.1)		(4.44)	(4.0)	(3.92)	(2.94)	
		S.Em.±		C.D. at 5 %			S.Em.±		C.D. at 5 %	
Genotypes		0.04		0.19			0.17		0.75	
Salinity		0.05		0.14			0.19		0.45	
Genotype x salinity		0.10		0.29			0.60		1.10	

The figures in parenthesis are square root transformed values

Table 3. Effect of salinity on total leaf fresh weight (g plant $^{-1}$yr^{-1})in guinea grass genotypes

Genotypes	*Salinity Levels (ECe)*				
	0	4	8	12	Mean
BG-1	802.0	826.0	764.0	1013.3	851.3
	(28.2)	(28.7)	(27.5)	(31.8)	(29.6)
BG-2	1172.0	1230.3	1117.6	1176.3	1174.0
	(34.2)	(35.0)	(33.3)	(34.2)	(34.2)
DGG-1	1500.0	1308.3	1578.6	1749.3	1534.0
	(38.6)	(36.1)	(39.5)	(41.6)	(39.0)
BG-4	983.3	1131.3	1078.6	1294.0	1121.8
	(31.3)	(33.6)	(32.8)	(35.9)	(33.4)
CO-1	1493.6	1664.6	0.0	0.0	789.5
	(38.5)	(40.4)	(0.7)	(0.7)	(20.1)
RD	1260.3	1274.0	1021.3	0.0	888.9
	(35.4)	(35.5)	(31.9)	(0.7)	(25.9)
Mean	1201.8	1239.1	926.7	872.1	
	(34.4)	(34.9)	(27.6)	(24.1)	
		S.Em.±		C.D. at 5 %	
Genotypes		0.6		2.1	
Salinity levels		0.7		1.7	
Genotype x salinity levels		1.5		4.3	

The figures in parenthesis are square root transformed values

Table 4. Effect of salinity on total stem fresh weight (g plant $^{-1}$yr^{-1}) in guinea grass genotypes

Genotypes	*Salinity Levels (ECe)*				
	0	4	8	12	Mean
BG-1	692.66	497.0	644.66	717.0	637.83
	(26.24)	(22.28)	(25.39)	(26.75)	(25.16)
BG-2	685.33	722.66	604.0	582.33	648.58
	(26.18)	(26.81)	(24.58)	(24.04)	(25.40)
DGG-1	764.66	694.66	668.33	805.33	733.24
	(27.28)	(26.32)	(25.76)	(28.32)	(26.92)
BG-4	756.0	738.33	709.33	1025.33	807.24
	(27.49)	(27.17)	(26.62)	(31.98)	(28.13)
CO-1	922.0	1159.33	0.0	0.0	520.33
	(30.28)	(33.58)	(0.70)	(0.70)	(16.31)
RD	898.0	992.0	590.66	0.0	620.16
	(29.77)	(31.38)	(24.28)	(0.70)	(21.53)
Mean	786.44	800.66	536.16	521.66	
	(27.87)	(27.92)	(21.22)	(18.71)	
		S.Em.±		C.D. at 5 %	
Genotypes		0.63		0.96	
Salinity levels		0.77		1.17	
Genotype x salinity levels		1.55		2.35	

The figures in parenthesis are square root transformed values

Table 5. Effect of salinity on total fresh biomass (g plant $^{-1}$yr^{-1}) in guinea grass genotype

Genotypes	*Salinity Levels (ECe)*				
	0	4	8	12	Mean
BG-1	1494.66	1323.00	1408.66	1730.33	1489.16
	(38.52)	(36.37)	(37.52)	(41.58)	(38.49)
BG-2	1857.33	1953.00	1721.66	1758.66	1822.66
	(43.08)	(44.14)	(41.46)	(41.91)	(42.64)
DGG-1	2264.66	2003.00	2247.00	2554.66	2267.33
	(47.48)	(44.74)	(47.27)	(50.41)	(47.47)
BG-4	1739.33	1869.66	1788.00	2319.33	1929.08
	(41.69)	(43.22)	(42.27)	(48.16)	(43.83)
CO-1	2415.66	2824.00	0.00	0.00	1309.91
	(49.03)	(52.64)	(0.70)	(0.70)	(25.76)
RD	2158.33	2266.00	1612.00	0.00	1509.08
	(49.03)	(52.64)	(0.70)	(0.70)	(25.76)
Mean	1988.32	2039.77	1462.88	1393.83	
	(44.80)	(45.62)	(28.32)	(30.57)	
			S.Em.±	C.D. at 5 %	
Genotypes			0.74	2.60	
Salinity levels			0.91	2.12	
Genotype x salinity levels			1.83	5.21	

The figures in parenthesis are square root transformed values

and BG-1 variety. The RD and CO-1 variety recorded maximum total biomass at 4ECe level. The DGG-1 recorded highest fresh biomass irrespective of salinity level.

It was observed that CO-1 did not survive above 4 ECe and RD above 8 ECe. When all the varieties had a survival of 100 % at all, the levels of salinity up to 12 ECe, CO -1 and RD had survival rates of 0 % at salinity levels higher than 4 and 8, respectively.

The increase in fresh biomass over control was 12.8 % in DGG-1 compared to BG-4 (Table 5). This increase in total fresh biomass was attributed to 16.6 % over control in fresh leaf weight (Table 3) and in BG-4, it was due to fresh stem biomass (Table 4). The per cent increase in fresh biomass over control was high in BG-4, but it could not surpass DGG-1 in total fresh biomass, mainly due to the tillering capacity of DGG1 (Table 2). The regeneration ability of DGG-1 was very high, at 12 ECe compared to BG-4 (Table 2). Regeneration ability recorded significant correlation with tiller number recorded (0.690*) and leaf fresh weight (0.630*). Some grasses can survive and grow well under salinity stress, whereas some are sensitive to salinity in terms of biomass reduction. The BG-1 and BG-2 were able to survive under high saline conditions but with very low biomass compared to other genotypes. Even though leaf area increase was highest in BG-4, more tillers, high regeneration efficiency and high leaf fresh weight in DGG-1 resulted in higher fresh biomass, which is desirable for a green fodder crop. Fresh biomass was significantly correlated at 5 % level to tiller number (+ 0.690**) and leaf fresh weight (0.916**) .

The findings on morphological observations in this study are in close agreement with those earlier reported by Li *et al.* (2013) in Bermuda grass, Acosta-Motos *et al.* (2017) in *Rosmarinus officinalis* and Courtney *et al.* (2016) in smooth cordgrass. A similar kind of results were reported by Pompeiano *et al.* (2016) in seashore paspalum and Adnan *et al.* (2016) in *Desmostachya bipinnata*.

Conclusion

The over all study reveals that more number of tillers and tiller regeneration capacity in turn more leaf fresh eight is the major factor for high fresh biomass in DGG-1 genotype. The highest stem fresh weight is the responsible factor for the high fresh biomass in BG-4 genotypes. These DGG-1 can be recommended to grow under saline stress condition for the better yield.

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