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GROWTH OF *CENCHRUS PENNISETIFORMIS* HOCHST. & STEUD. UNDER AMENDED SEAWATER IRRIGATION IN POT CULTURE EXPERIMENT

D. Khan[1] and R. Ahmad[2]

[1] *Department of Botany, Govt. National College, Karachi.- 74800, Pakistan.*
[2] *Department of Botany, University of Karachi, Karachi-75270, Pakistan.*

ABSTRACT

Growth of *Cenchrus pennisetiformis* Hochst. & Sterud. was investigated under 10-30% amended seawater (ECiw: 4.5-14.0 $dS.m^{-1}$) irrigation in pot culture experiment. The data for monthly harvested phytomass around an year indicated extreme reduction of growth during dry and winter months. The salinity and seasonality interacted significantly. The cumulative forage biomass harvested per annum under 30% amended seawater (14.0 $dS.m^{-1}$) irrigation was 281.4 ± 22.3 $g.pot^{-1}$ (FW) as compared to 1025.2 ± 15.9 $g.pot^{-1}$ (FW) in control (1.2 $dS.m^{-1}$). Fifty per cent reduction in total harvested biomass corresponded with irrigation medium of EC_{iw} : 7.04 $dS.m^{-1}$. and SAR: 6.29. TL50 values for monthly harvests varied widely with season and were lowest for the month of May (TL50 ECiw : 3. 24 $dS.m^{-1}$, TL50 SAR: 3.51). The reduction in total forage production in 10 and 20 % seawater was c. 38.5 and c. 63.2% of the control, respectively. The plant showed flowering throughout the year.

Key Words: *Cenchrus pennisetiformis*, amended seawater irrigation, biomass productivity.

INTRODUCTION

Cenchrus pennisetiformis Hochst. & Steud. is an annual or short-lived perennial graminoid of arid and semi-arid areas and remain green during dry period of the year. It is a good fodder grass and cattle and other animals graze this plant (Cope, 1984). It may sometimes be observed invading moderately saline soils in Karachi University campus, particularly after summer or winter rains (Khan *et al.,* 1999). The present investigation undertakes to evaluate growth of this species under saline conditions (amended seawater irrigation) for its possible utilization in biosaline agriculture.

MATERIALS AND METHODS

(i) Preparation of irrigation media:

Different dilutions of seawater (10-30%), in order to reduce Na toxicity, were amended with fertilizer-mixture using Calcium Ammonium Nitrate (CAN), Single Super Phosphate (SSP) and Sulphate of Potash (SOP) in amounts appropriate to provide N: P: K ratio of 170:41:156. Magnesium was provided as magnesium sulphate. Micronutrients and Fe-EDTA each corresponding to half strength Hoagland's solution were added at the rate of 100ml /100 liters of culture solution to complete its composition. Control culture solution was prepared in tap water. The chemical analysis of the irrigation media appears in Table 1.

Table 1. Analysis of different dilutions of seawater after chemical amendments (data is a mean of 5 replicates).

Irrigation Medium	pH	EC_{iw}: $dS.m^{-1}$	Na (meq/l)	K (meq/L)	Ca + Mg (meq/L)	SAR
Control	7.35	1.2	3.26	1.27	32.43	0.80
10% SW + amendments	7.55	4.5	27.17	1.27	54.89	5.19
20% SW + amendments	7.45	9.5	52.60	3.19	69.86	7.37
30% Sw + amendments	7.45	14.0	131.52	3.83	109.78	17.75
Seawater (Arabian sea)	7.50	40.0	328.00	8.00	162.17	36.48

(ii) Growth:

Preconditioning and pot culture

The equal number of tiller of more or less equal vigour (with roots) of *C. pennisetiformis* were grown in 30 cm diameter China pots with efficient drainage system and containing 5 Kg sandy soil (collected from Sonmiani beach), provided with a basal perforation. The rooting medium was initially half strength Hoagland's solution and later tap water at the alternate days. To avoid shock effects of saline irrigation, the plants, after one month, were pre-conditioned by irrigating them initially with 5% amended seawater and gradually increasing the concentration up to a level in which the plants were to be finally grown.

Pots were kept in slightly slanting position on a cemented platform so as to ensure rapid drainage of saline water from the basal outlet. Over irrigation was practiced to avoid accumulation of salts in the root zone. Each pot was irrigated with 2 liters of irrigation medium at weekly interval, irrespective of any rains. Three replicates were kept for each treatment and the control. The pots were arranged in complete random fashion. The experiment was continued for one-year period.

The foliage biomass in terms of fresh weight was taken as criterion of growth. Foliage was clipped at monthly interval at 10 cm. height from the soil surface. A limit of salinity (EC_{iw}) and sodicity (Na - meq/l and SAR) at which growth reduced by 50% was computed by using formula proposed by Davis *et al.* (1972) – $TL_{50} = C_1 + [(C_2 – C_1)(50 – P_1)] / (P_2 – P_1)$.

RESULTS AND DISCUSSION

The monthly variation of harvests of *C. pennisetiformis* under saline irrigation are presented in Table 2. Increase of salts concentration in irrigation medium decreased shoot biomass throughout the year. In control plants there were clearly two spurts of growth – after summer rains (111.3 mm) and post winter rains in the month of April (47.6 mm). The second spurt of growth in treated plants tended to mitigate progressively with salinity of the irrigation medium. ANOVA for the experimental design (Randomized Block Design) indicated that both harvest ($F = 158.56$, $p < 0.001$) and salinity ($F = 460.9$, $p < 0.001$) have significant effect on plant growth and there is also a significant interaction between treatment (salinity) and harvest ($F = 32.8$, $p < 0.001$). The adverse effects of salinity which couldn't develop in initial months developed gradually with time and salinity status of the irrigation medium. Biomass production was significantly low in winter months. Although plant showed flowering for the whole span of year, salinity appeared to induce flowering little earlier in 30% seawater irrigation. Salinity inhibited vegetative growth substantially and under 30% seawater irrigation the winter harvest mostly composed of spikes with little amount of leaves. The toxic effects were highly adverse in 30% seawater where one plant died in the month of March (after six months of saline irrigation continuation). The reduction in total forage production in 10 and 20 % seawater was c. 38.5 and c. 63.2% of the control, respectively, amounting to 630.5 ± 18.5g and 377.8 ± 12.1g as against 1025.2 ± 15.9g in control (Table 2).Growth inhibition was maximum for the month of May under 30% seawater irrigation (reduction amounting to 93.6 % of the control) – these plants even couldn't recover after April rains. The relationship between salinity (EC_{iw}) and total harvest (g per year - FW) was curvilinear (Fig. 1) as given by the following equation:

$$\text{Total Harvested Biomass (g) FW / year} = 1168.55 - 135.6988\,(EC_{iw}) + 5.2159\,(EC_{iw})^2 \pm 39.71$$

$t = 38.0 \quad t = 13.1 \quad t = 7.9$

$p < 0.001 \quad p < 0.001 \quad p < 0.001$

$R^2 = 0.9859$; Adj. $R^2 = 0.9827$; $F = 314.86$

The TL50 values for salinity of irrigation medium (EC_{iw}) and its sodium content and sodicity in terms of SAR (corresponding to 50% reduction), varied with season substantially (Table 3). Such values were higher for initial two months of the experiment followed by the values for months receiving rains. TL50 values for water salinity, sodium content and the SAR corresponding to 50% decline in growth were minimum for dry and summer month of May (3.24, 18.05 and 3.51, respectively). Our data indicates that unlike *Cenchrus setigerus* which is reported to be a salinity tolerant species within a range of 8-16 $dS.m^{-1}$ (CAZRI, 1987), *Cenchrus pennisetiformis* is much sensitive to salinity. Its regeneration is greatly inhibited with salinity. It is a low biomass producing plant as compared to such grasses as *Sporobolus arabicus, Panicum turgidum, Pennisetum divisum and Leptochloa fusca* grown under similar cultural conditions (Khan, 1987; Ahmad *et. al*, 1987; Khan and Ahmad, 2002). The data suggest that it may only be grown successfully with water of salinity below 4 $dS.m^{-1}$. It has little potential in biosaline agriculture.

It also follows from the results that occurrence of *C. pennisetiformis* in moderately saline soils after summer rains could a phenomenon related to lowering of salt content in upper layer of soil as a result of leaching of salts to deeper soil layer due to rains (cf. Heurteaux, 1970) reducing the danger of salinity during early stages of plant life. The occurrence of some nominal glycophytes in diverse habitats of littoral salt marsh of Red Sea coast of Egypt (Kassas and Zahran, 1967) and in highly saline waterlogged inland areas of Hyderabad district., Sindh, Pakistan (Khan *et. al*, 2003) have already been reported.

Table. 2. Fresh weight of biomass (g) harvested from *C. pennisetiformis* as affected with seasonal variation and irrigation with chemically amended seawater dilutions.

Treatments / Months	**BIOMASS HARVESTED (g per pot)**			
	Control	**10% Seawater**	**20% Seawater**	**30% Seawater**
September (4.00 mm) **	88.0 ± 0.8	89.36 ± 5.66 *(+1.54)	75.0 ± 6.32 (-14.8)	64.10 ± 2.58 (-27.2)
October (Zero)	113.83 ±8.85	129.17 ± 8.77 (+13.5)	99.00 ± 3.47 (-13.3)	92.17 ± 7.04 (-19.03)
November (Zero)	115.80 ± 9.72	60.80 ± 4.72 (-42.5)	49.33 ± 0.33 (-53.4)	42.00 ± 2.08 (-60.3)
December (Zero)	44.33 ± 6.17	33.33 ± 1.76 (-24.8)	15.33 ± 1.76 (-65.4)	10.20 ± 0.12 (-76.99)
January (Zero)	67.0 ± 1.53	41.20 ± 1.20 (-38.5)	12.33 ± 2.33 (-81.6)	11.00 ± 1.00 (-83.6)
February (Zero)	46.67 ± 3.33	41.0 ± 2.08 (- 12.1)	6.67 ± 2.40 (-85.7)	5.83 ± 1.17 (-87.5)
March (Zero)	43.67 ± 1.86	28.33 ± 1.77 (-35.1)	14.67 ± 2.40 (-66.4)	8.67 ± 4.67 (-80.1) ***
April (47.6 mm)	45.0 ± 1.73	26.67 ± 0.88 (-40.7)	12.00 ± 1.15 (-73.3)	8.00 ± 4.62 (-82.2)
May (Zero)	186.33 ± 8.57	35.67 ± 2.97 (-80.8)	19.67 ± 3.48 (-89.5)	12.00 ± 2.00 (-93.6))
June (0.50 mm)	172.33 ± 10.11	80.33± 10.84 (-53.4)	24.16 ± 3.49 (-86.0)	13.25 ±5.10 (- 92. 3)
July (81.80 mm)	59.0 ± 6.66	46.0 ± 3.06 (-22.0)	24.00 ± 2.65 (-59.3)	11.67 ± 6.00 (-80.2)
August (25.0 mm)	56.00 ± 7.02	43.33 ± 2.73 (-22.6)	25.00 ± 2.52 (-55.4)	12.33 ± 6.49 (-78.0)
Annual (158.9 mm)	**1025.2 ± 15.9**	**630.50 ± 18.4 (- 38.5)**	**377.83 ± 12.1 (- 63.2)**	**281.43 ± 22.34 (-72.6)**

*, Promotion or reduction in growth over control within an observation; **, Figures denote amount of rain in the month ***, One plant of the treatment died in March. LSD (salinity) $_{0.05}$: 3.57 and LSD (seasonality) $_{0.05}$: 6.18.

Table 3. TL 50 values for various months of growth based on EC, Na content and SAR of the irrigation water.

Month of Growth	TL_{50} – ECiw	TL_{50}–Na (meq/L)	TL_{50} – SAR
September	c 14.0	c 131.50	c 17.75
October	c 14.0	c 131.50	c 17.75
November	7.95	44.72	6.69
December	7.63	42.95	6.54
January	5.84	33.98	5.77
February	7.07	40.25	6.31
March	7.34	41.61	6.43
April	8.65	34.40	5.72
May	3.24	18.05	3.51
June	4.29	25.65	4.91
July	8.25	46.12	6.82
August	8.68	48.44	7.01

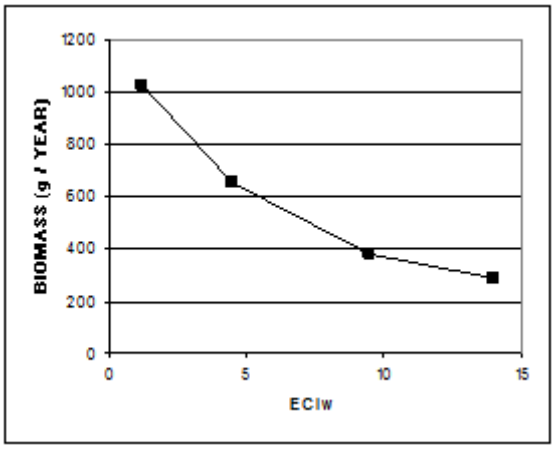

Fig. 1. Relationship between salinity and total biomass of *C. pennisetiformis* harvested per pot per year. TL_{50} (EC_{iw}) = 7.04, TL_{50} (Na) = 40.09 meq/L and TL_{50} (SAR) = 6.29.

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