Saving fresh water resources through cultivation of salt-tolerant forage grasses: seasonal and genotypic variations

Salt-tolerant forage grasses, Cenchrus ciliaris L., experiment at ICBA

Perennial grasses are one of the most important components of the farming system in the Gulf region. Traditionally, grasses meet a large percentage of the demand for green feed in the region. Rhodes grass (*Chloris gayana*) is the most common perennial forage grass in the region. However, due to their high water requirements and reduced yields caused by increases in soil and irrigation water salinity, perennial grasses are targeted by governments and international research authorities to be replaced by less water-demanding forage grasses. Alternative perennial forages that require less water for irrigation (even low quality saline water) are being recommended as an alternative to the dominant Rhodes grass. Buffel grass (*Cenchrus ciliaris* L.) is an important perennial forage grass which belongs to the family Poaceae. It produces rhizomes and is native to the Arabian Peninsula. It has sufficient salt tolerance potential and can be grown on marginal soils and in water-scare conditions.

Cenchrus ciliaris L. is a very good pasture grass for hot and dry regions in the tropics and sub-tropics and is mainly cultivated for permanent pastures in Africa, Australia and Asia (Arshadullah et al. 2011). It is the most drought-tolerant of the commonly sown grasses in arid areas and can be found in environments with annual rainfall as low as 100 mm. In such places, it gives the best results under irrigation, if it is available, since it has high water use efficiency (Osman et al. 2008). Buffel grass, C_4 species, is nutritious and valued for its production of palatable forage and intermittent grazing. Yield of some genotypes makes it a good forage for the summer and winter cropping season. The grass is fed green and can also be turned into silage. The present work is part of an extensive screening and selection program targeting the identification and evaluation of salt-tolerant *C. ciliaris* accessions (160 accessions were evaluated in a pot trial for salinity tolerance potential; they were screened and selected previously from a global collection of 800 accessions received from the United States Department of Agriculture, local landraces and commercial varieties). An improved salinity tolerance trait of a particular genotype permits the conservation of fresh water and its use for higher value purposes, providing both ecological and economic benefits essential for sustainable agriculture in dry lands (Keating et al. 2010).

The initial step in the development of salt-tolerant cultivars is to identify salinity tolerance potential within the crop and, when available, within its wild relatives. ICBA's program aims to identify superior genotypes for both food and forage production under arid conditions. These genotypes should be characterized by high productivity under saline conditions, thereby improving agricultural productivity and sustainability in marginal environments. Forty genotypes of *Cenchrus ciliaris* L. were evaluated in a field trial laid out in a split-plot design with three replications. The irrigation treatments consisted of three salinity levels with EC_w 5, 10 and 15 dS/m and supplied to the field plots through a drip irrigation system. The plots measuring 0.5 m x 4 m, (for a plot area of 2 m²) were established and planted manually with a row spacing of 0.5 m to enable manual weeding. The standard agronomic procedure was used to collect growth and yield data from two middle rows within each plot (Al-Dakheel et al. 2015). The plots were harvested at the heading stage and fresh (FW) and dry biomass (DW) yield were obtained and expressed as t/ha. The experiment was carried out for five consecutive years and the average five harvests were achieved per year. Analysis of variance and General Linear Model (GLM) was used to assess the effect of salinity with the limit of statistical significance set as p = 0.05 using the SPSS 17.0 statistical program.

Genotypic performance and yield range: The average total annual yield in *C. ciliaris* genotypes ranged from 98.0 - 353.0 t/ha at low salinity (5 dS/m), 78.0 - 269.0 t/ha at medium (10 dS/m) and 73.5 - 225.5 t/ha at high salinity levels (15 dS/m). The annual DW yield was in the range of 34.5 - 106 t/ha at 5 dS/m salinity level, 26.5 - 90.5 t/ha at medium salinity (10 dS/m) and 24.5 - 73.0 t/ha at high salinity (15 dS/m). Nawazish et al. (2006) found that shoot dry weight was severely affected in the *C. ciliaris* ecotype from Faisalabad, where it decreased from 29.83 to 8.02 g. The ecotype from the Salt Range region showed a considerable increase in its root fresh and dry weights accompanied by much less reduction in shoot fresh and dry weights as compared to that from the Faisalabad region.

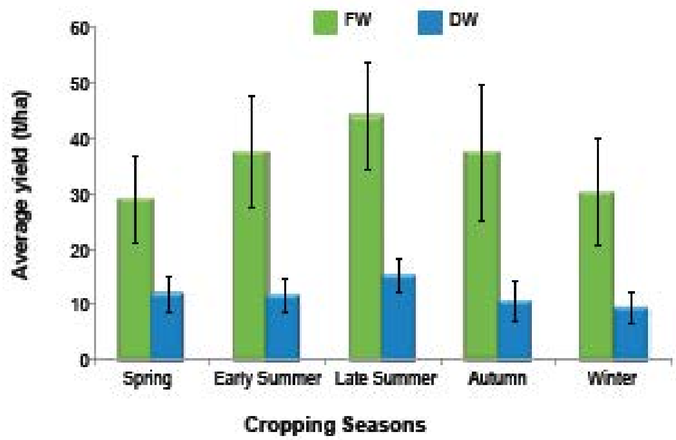

Figure 1: Relationship between season and average yield/harvest (fresh and dry weight, FW, DW) (t/ha) in Cenchrus ciliaris L. (average yield over all the years at all salinity levels).

Seasonal variation: The mean fresh and dry weights in the highest production season (late summer harvest) were 44.06 and 15.20 t/ha respectively, followed by early summer (37.49 and 11.59 t/ha) and autumn harvest (37.41 and 10.53 t/ha) (Figure 1). Higher fresh and dry biomass yields in the summer season are due to a prolonged growth period and more optimum growth conditions. In winter the biomass production was lowest with mean FW 30.23 t/ha and DW 9.31 t/ha. However, the dry matter percentage in the winter growth (spring harvest), on average, for all genotypes was higher than other seasons (28-34% vs. 41%) (Figure 1). Such high dry matter percentage compensated for the lower total fresh biomass production. Shinde et al. (1998) found that dry matter yield of pasture was highest during winter and lowest during monsoon: the annual mean was 2,276 kg/ha and *Cenchrus ciliaris* constituted 73%, 87% and 36% of the vegetation cover during monsoon, winter and summer respectively. Moreover, Kaleem et al. (2010) reported better capture and utilization of temperature, light, photoperiod and soil moisture during spring than in autumn for crop growth and yield attributes.

Stable and high yield genotypes: The average DW yield in the top 5 best-performing and lower 5 genotypes was 98.9 t/ha and 41.7 t/ha (5 dS/m), 82.5 t/ha and 30.8 t/ha (10 dS/m), 66.8 t/ha and 26.3 t/ha (15 dS/m), respectively (Figure 2b). Within each salinity level, there is a good chance of selecting the genotypes, based on their relative performance (DW). Several accessions from the top 5 selection with high FW yield potential are of particular

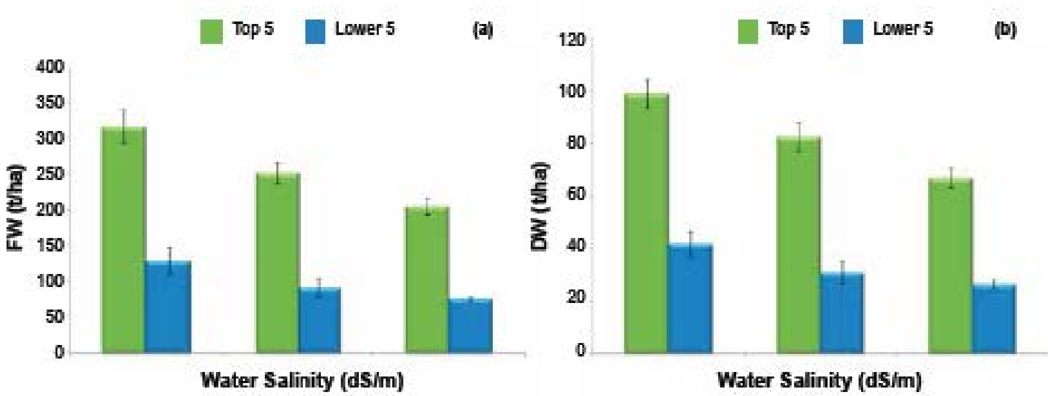

*Figure 2: Impact of saline water (5, 10, 15, dS/m) on average annual yield performance (FW, DW) (t/ha) of top 5 and lower 5 performing Cenchrus ciliaris L. genotypes. *Data is average of top 5 and lower 5 genotypes at each salinity level.*

Harvesting of Cenchrus ciliaris L. at ICBA research station

interest as a forage resource in irrigated salt-affected agro-ecosystems for livestock and are highly suitable for arid and semi-arid regions. Genotype 37 (Grif 1619 from Pakistan) was the high DW producing accession at all salinity levels. Other genotypes like 38 was high dry biomass producing at low (103.5 t/ha) and medium (76.5 t/ha) salinity but at high salinity, it was less stable and its dry biomass declined by more than 56% (45.5 t/ha). Another accession "17" was among the top ten genotypes at low salinity (5 dS/m) but its DW yield decreased at medium and high salinity displaying a classical pattern of a salinity sensitive genotype. Contrary to such pattern, genotype 12 was ranked 16 among the forty genotypes at low salinity, while at medium and high salinity it ranked among the top 5 highest genotypes in dry biomass yield displaying better salt-tolerance (data not shown).

In conclusion, the study showed the existence of a wide genetic diversity among the Cenchrus accessions. Among the forty accessions (Accession No 37, 38, 2, 12) were identified as salt-tolerant, high-yielding and stable genotypes at various salinity levels. These genotypes hold good salt tolerance potential and can be grown to enhance farm productivity in saline conditions in arid and semi-arid environments.

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