Potential of indigenous desert grasses for forage production in a water-scarce region

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Abstract. Indigenous perennial grasses are widely distributed in the Arabian Peninsula. Their survival under limited rainfall and grazing suggests a potential role as grassland species and for rehabilitation of degraded rangelands. Forage productivity and water-use efficiency (WUE) was determined over 2 years for four indigenous grasses: buffel grass (*Cenchrus ciliaris* L.), dakhna (*Coelachyrum piercei* Benth.), da'ay (*Lasiurus scindicus* Henr.) and tuman (*Panicum turgidum* Forssk.) together with one exotic species, rhodes grass (*Chloris gayana* Kunth) in the central region of the United Arab Emirates. Three irrigation treatments were used: **R1** (1858–6758 m^3 ha^{-1} $year^{-1}$, **R2** (929–3379 m^3 ha^{-1} $year^{-1}$) and **R3** (464–1689 m^3 ha^{-1} $year^{-1}$). Buffel grass had the highest dry matter (DM) yield under all irrigation treatments. The average DM yield of buffel grass was14.6 and 15.1 t ha^{-1} in the 2 years which was significantly higher than that for the other grasses with dakhna having the lowest DM yields. The WUE of 0.7 and 0.8 kg DM m^3 in the 2 years for buffel grass was significantly greater than for the other grasses. Buffel grass showed the largest increase in WUE in both years when the irrigation was reduced from treatment R1 to R3. The results suggest that the desert grasses of the Arabian Peninsula, such as buffel grass, could be useful grass species in reducing the use of scarce irrigation water provided that seed production can be increased.

Introduction

Rangeland degradation in the Arabian Peninsula over the past 50 years has resulted in severe feed shortages for livestock and resulted in increase use of rhodes grass and alfalfa. Both species are produced under irrigation, estimated at 48,000 m^3 ha^{-1} $year^{-1}$ (Peacock *et al.* 2003). Pumping of groundwater for irrigation has resulted in a falling water table in many countries of Arabian Peninsula, increased salinity and, in many cases, abandonment of farms. In all countries of the Arabian Peninsula, water is scarce and the consumption is high, which has put negative pressure on land resources, agricultural production and public health. Agriculture consumes the majority of water (76%), mostly for forage and timber production.

The native plant biodiversity of the Arabian Peninsula, which comprise over 3500 species (Ghazanfar and Fisher, 1998), represent a possible source of nutrients for livestock under appropriate management in the harsh environment of the Arabian Peninsula. These native species are well adapted to the low rainfall, high evaporation rates and high temperatures that prevail in the region (Ghazanfar and Fisher, 1998). The variation existing among these species in relation to stresses, including grazing/browsing by camels, sheep and goats, could be utilized for forage production.

Materials and methods

The research was conducted at Dhaid Research Station of the Ministry of Environment and Water, United Arab Emirates (25º16'N, 55º55'E, elevation 135 m above sea level). We tested four native species: buffel (lebid) grass (*C. ciliaris* L.), dakhna (*C. piercei* Benth.) Bor, da'ay (*L. scindicus* Henr.) and tuman (*P. turgidum* Forssk.), together with one introduced species for comparison: rhodes grass (*C. gayana* Kunth). Rhodes grass is widely used in tropical and arid zones of the world under irrigation. The native grasses were originally collected from the Sharjah Natural History Museum, 30 km from Sharjah City on the main highway to Dhaid City. The seeds of native species used for the study were multiplied at Dhaid Research Station while seed of the rhodes grass (var.

Katambora) were obtain from the local market at Dhaid City.

Treatments

A maximum irrigation treatment (**R1**) was based on ET_0 records and EC_e values at the station, both of which vary according to the season. Two more irrigation levels (**R2 and R3**), representing 0.50 and 0.25 of R1 respectively, were included (Table 1). The irrigation water was supplied by four wells, with EC_e values ranging between 1.2 and 2.0 dS m^{-1}, which are collected into one reservoir from which irrigation was provided. Drip irrigation was applied daily and time of application was measured to the nearest minute (Table 1). The amounts of water delivered by the system were calculated from equation (1):

$$Y_{Rn} = (C_m DNT)(6P)^{-1}$$

where Y is the amount of water in m^3 ha^{-1}, R is the irrigation treatment and n is 1, 2 or 3, C is the number of days to each harvest, D is the nozzle discharge rate in L h^{-1} (4), N is the number of nozzles per experimental plot (33), T is the irrigation period in minutes, based on irrigation treatment and month of the year (Table 1), m is month of the year and P is the plot size (6.25 m^2). Equation 1 was abbreviated to Equation (2):

$$Y_{Rn} = 3.52\,(CT)_m$$

Total amounts of water applied during the 2 years ranged between 1858 and 6758 m^3 ha^{-1} under treatment **R1**, depending on the month of the year. The values for treatment **R2** were between 929 and 3379 and for treatment **R3** between 464 and 1689 m^3 ha^{-1}. The three irrigation treatments were assigned as main plots (2.5 m x 16.5 m), and the five grass species as sub- plots (2.5m x 2.5m) within each main plot. The experiment was replicated three times.

All grasses were sown in Jiffy pots and transplanted in April 2002 with three seedlings in alternating holes 50 cm apart along drip lines and with 50 cm between lines. There were ninety-nine plants per plot for each grass species tested. All grasses were harvested to 5 cm above ground level in May 2002, marking the beginning of the study. Thereafter, herbage was harvested at 32–47 days intervals after the previous harvest.

Measurements

Herbage was harvested when approximately 10% of the tillers carried flower heads. Yield of herbage was measured in 1m x 1m quadrats permanently located in the centre of each plot. The rest of the plot was cut and material discarded after each harvest. Herbage samples were oven-dried (70°C) and weighed.

Table 1. Drip irrigation periods (min d^{-1}) at different months of the year for treatment R1 (1858–6758 m3 ha^{-1} $year^{-1}$), R2 (929–3379 m3 ha^{-1} $year^{-1}$) and R3 (464–1689 m3 ha^{-1} $year_{-1}$).

Irrigation treatment	Months		
	November, December, January, February	May, June, July, August	March, April, September, October
R1	16	48	32
R2	8	24	16
R3	4	12	8

Results and discussion

Dry-matter yield

Total DM yield, representing the sum of the DM yield of ten harvests in the first year and nine in the second year, of buffel grass was greater than that of the other grasses (Table 2). There were also significant interactions between grass species and irrigation treatments. The total DM yield of rhodes grass declined the most as irrigation level reduced from treatment R1 to treatment R3. Total DM yields were reduced by 14.1 kg ha^{-1} (proportionately by 0.73) in the first season and 11 kg ha^{-1} (0.58) in the second season. Corresponding values for buffel grass were 11.5 kg (0.57) and 9.2 kg ha-^{1} (0.48). Similarly, the other indigenous grasses suffered less reduction in DM yield than rhodes grass, ranging between 9.4 kg ha^{-1} (0.70) and 10.2 kg ha^{-1} (0.71) in the first year and 1.9 kg ha^{-1} (0.37) and 5.4 kg ha^{-1} (0.53) in the second year.

Table 2. Total dry-matter yield (t ha^{-1}) of five grasses as affected by three irrigation treatments [R1 (1858–6758 m^3 ha^{-1} year^{-1}), R2 (929–3379 m^3 ha^{-1} year^{-1}) and R3 (464–1689 m^3 ha^{-1} year^{-1})] in the 2 years. Data represent ten harvests in year 1 and nine cuts in year 2.

	Total Dry Matter Yield (t.ha^{-1})							
	Treatment R1		Treatment R2		Treatment R3		Mean	
Grass species	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Buffel grass	20.3	19.0	14.8	16.5	8.8	9.8	14.6	15.1
Rhodes grass	19.3	19.1	11.1	12.2	5.2	8.1	11.9	13.1
Tuman	15.6	9.1	14.4	7.8	6.0	5.5	12.0	7.4
Da'ay	14.3	10.2	10.0	6.1	4.0	4.8	9.4	7.0
Dakhna	13.4	5.2	8.9	4.1	4.1	3.3	8.8	4.2
Mean	16.6	12.5	11.8	9.3	5.6	6.3		
s.e. of mean of grass species	0.74	0.70						
s.e. of mean of treatments	0.57	0.54						
s.e. of mean of species within treatments	1.27	1.22						

Water-use efficiency

Buffel grass had significantly greater WUE than the other grass species with average values of 0.7 and 0.83 kg DM m^{-3} in years 1 and 2 respectively (Table 3). As the amount of irrigation dropped from treatment R1 to R3, the grasses showed increased WUE values but the magnitude was different among the species. The increases for buffel grass were 0.4 kg DM m^{-3} (080) and 0.6 kg DM m^{-3} (1.20) in the 2 years compared with rhodes grass which showed no change in the first season and only 0.4 kg DM in the second season.

Table 3. Water-use efficiency (kg DM m^{-3} of water) in five grasses as affected by three irrigation treatment [R1 (1858– 6758 m^3 ha^{-1} year^{-1}), R2 (929–3379 m^3 ha^{-1} year^{-1}) and R3 (464–1689 m^3 ha^{-1} year^{-1})] in the 2 years.

	Treatment R1		**Treatment R2**		**Treatment R3**		**Mean**	
Grass species	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year1	Year 2
Buffel grass	0.50	0.52	0.74	0.90	0.87	1.07	0.70	0.83
Rhodes grass	0.48	0.52	0.55	0.67	0.52	0.88	0.52	0.69
Tumana	0.39	0.25	0.71	0.43	0.60	0.60	0.57	0.42
Da'ay	0.35	0.28	0.50	0.33	0.41	0.52	0.42	0.38
Dakhna	0.33	0.14	0.44	0.22	0.40	0.36	0.39	0.24
Mean	0.41	0.34	0.59	0.51	0.56	0.69		
s.e. of mean of grass species	0.040	0.040						
s.e. of mean of treatments	0.031	0.031						
s.e. of mean of species within treatments	0.069	0.069						

Data of each grass was first computed for mean DM yield (ten harvests in year 1 and nine harvests in year 2) and then divided by the mean irrigation water in each treatment in each to compute water-use efficiency for each treatment.

Buffel grass in the present study produced the highest DM yields throughout the year. This agrees with previous results suggesting that irrigated buffel grass is well adapted to frequent defoliation (Osman, 1979; Osman and Abu Deik, 1982). Humphreys (1967) indicated that buffel grass produces more leaf and tiller growth than rhodes grass following defoliation because of the higher

accumulation of carbohydrates in stem bases and roots of the former species.).
Buffel grass had the highest WUE values of all the grasses in the period from June to December, a feature extremely important in dry areas of the Arabian Peninsula because of the shortage of water in that period.

Conclusions

The results suggest that the desert grasses of the Arabian Peninsula, such as buffel grass, could be useful grass species in reducing the use of scarce irrigation water provided that seed production can be increased.

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