Biomass Production & Nutritional Value of Forages Irrigated with Saline-sodic Drainage Water in a Greenhouse Study

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1 INTRODUCTION

The westside San Joaquin Valley (SJV) has been one of the most productive farming regions in the United States and in the world. In recent years, productivity has declined in some fields due to increasing soil salinity which is primarily a result of shallow water tables and the marine parent material of the soil. Subsurface drainage systems are needed to reduce salt and boron accumulation in the root zone, but regulations on the disposal of the saline drainage water (DW) have curtailed their use. The reuse of saline DW for salt-tolerant forage production has been proposed not only to reduce the volume of drainage effluent requiring disposal (San Joaquin Valley Drainage Implementation Program, 2000), but also to produce nutritional and safe forage material for cattle and sheep (Grattan et al., 2004; Kaffka et al., 2004). Objectives of this approach are to manage salt and DW on the farm (called IFDM) or on a regional scale, and at the same time to minimize environmental impacts such as salt loading into rivers and wildlife hazards due to selenium or other trace elements present in the DW. In addition, the demand for forage feeds continues to increase because of the expanding dairy and beef industry in this region. Cultivation of salt-tolerant forages would not only increase forage supplies, but it could play a key role in drainage water management in SJV (Qadir & Oster, 2004).

Several salt tolerant forages were tested under DW irrigation in a sand tank study at the USDA Salinity Laboratory in Riverside, CA (USSL) (Grattan et al., 2004). In this study, tall wheatgrass, bermudagrass and paspalum had high dry matter production and forage quality under saline irrigation (ECiw = 15 and 25 dSm^{-1}). Some of the same forages were evaluated for two years in large field plots at Red Rock Ranch (RRR) in Five Points, CA in soils that received DW irrigation for four to five years and were in very poor physical condition. Creeping wildrye grew well in moderately saline fields at RRR (ECe = 13 dSm^{-1}) and had high dry matter production and acceptable forage quality (Suyama et al., 2005). Tall wheatgrass variety '*Jose*' also performed well due to its ability to maintain adequate biomass production and good forage quality in very saline soils (17 – 20 dSm^{-1} ECe). In the Riverside sand tank study, the '*salado*' and '*SW9720*' alfalfa varieties were categorized as "salt-sensitive" because of the large difference in biomass production between the 15 and 25 dSm^{-1} ECiw treatments (Grattan et al., 2004). However, in fields with relatively low soil salinity (ECe < 5 dSm^{-1}) at RRR, '*salado*' alfalfa had very high dry matter production (17 - 20 MT DM/ ha) and excellent forage quality (Suyama et al., 2005). However, there was large variation in soil salinity amongst the forage stands at RRR, we also conducted a greenhouse study to evaluate the more promising forages in a field soil: sand mix under uniform and controlled soil conditions. The objectives of this research are to evaluate the suitability of five forages for IFDM system based on their productivity, nutritional value, and safety for feeding to animals.

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2 MATERIALS AND METHODS

Because of the large variability in soil salinity amongst the field plots at RRR, five salt-tolerant forages were selected to be evaluated in a greenhouse experiment utilizing field soil rather than sand culture. The experiment ran from from January 2004 to December 2004. The forages were tall wheatgrass (*Thinopyrum ponticum* var. *'Jose'*, formally classified as *Agropyron elongatum* var. *'Jose'*), creeping wildrye (*Leymus triticoides* var. *'Rio'*), alfalfa (*Medicago sativum* var. *'salado'*), paspalum (*Paspalum vaginatum* var. *'Sealsle 1'*), and bermudagrass (*Cynodon dactylum* var. *'Giant'*). The treatments consisted of three irrigation water qualities: non-saline (NS; 0.5 – 0.9 dSm^{-1}), low saline (LS; 8 – 10 dSm^{-1}), and high saline (HS; 18 – 20 dSm^{-1}) that were applied in a randomized complete block experimental design. Saline treatments began at half strength and were increased to full strength within 25 days. Tap water was used for the NS treatment and concentrated DW from RRR was diluted for the LS and HS treatments. Fertilizers were added to the irrigation waters to bring the final concentrations to approximately 107 mg/L (ppm) K, 15.5 mg/L P, 31 mg/L Ca, and 20 uM Fe. Nitrogen was added only to the NS treatment to balance its N level with that of the LS treatment (64 mg/L NO3-N, entirely from the DW). The N level in the HS treatment was 115 mg/L NO3-N. The nitrogen levels of the NS and LS treatments were not increased to that of the HS treatment to avoid overly succulent growth that would not be representative of these conditions.

Pre-germinated forage seedlings were transplanted into pots 25 cm (10 in.) in diameter × 30 cm (12 in.) in depth. The pots were filled with a soil mixture consisting of 60 % clay soil and 40 % sand. The clay soil was collected from a fresh water-irrigated field at RRR, and was sieved through a 2.5 cm (1 in.) diameter screen. The grass forages were cut just prior to heading and alfalfa was cut at 10 % bloom. Dry matter accumulation was measured as the sum of all the cuts taken over the one year period. Relative yields were calculated as the ratio between the dry matter of LS or HS and the dry matter of the NS treatment. Organic forage quality was measured as metabolizable energy (ME) using a rumen fluid gas test (Robinson & Getachew, 2002); and as crude protein (CP), neutral detergent fiber (NDF), and ash using standard laboratory procedures. Mineral analyses (Ca, Mg, P, S, Na, Cl, B, Se, and NO3) were performed at the UC-DANR Analytical Lab, Davis, CA.

3 RESULTS AND DISCUSSION

All forages had the highest dry matter production under non-saline (NS) irrigation followed by low-saline (LS) and high saline (HS) irrigation (Fig. 1.). Under LS and HS treatments, bermudagrass had the highest biomass accumulation of all the forages, but under high saline (HS) irrigation, its relative yield (RY) was less than 44 % (Fig. 2). This result contrasts slightly with that of Kaffka et al. (2004) in which bermudagrass grew well under relatively high soil salinity (average ECe, 0 to 30 cm, = 11.4 dS/m). *'Salado'* alfalfa also had high biomass production under NS irrigation, but under both LS and HS irrigation, its dry matter production and RY were the lowest of the forages.

Paspalum, on the other hand, had very low biomass production under NS irrigation, but it had medium to high salt tolerance because under both LS and HS irrigation its RY was second only to that of tall wheatgrass. The RY of creeping wildrye under LS condition was above 83 %, but under HS irrigation, its RY dropped to 59 %. Tall wheatgrass was judged to be the most salt tolerant because under HS irrigation it had the highest biomass production and its RYs under both LS and HS irrigation were the highest (94% and 87 %). Forage quality and ion composition data will also be presented in the poster.

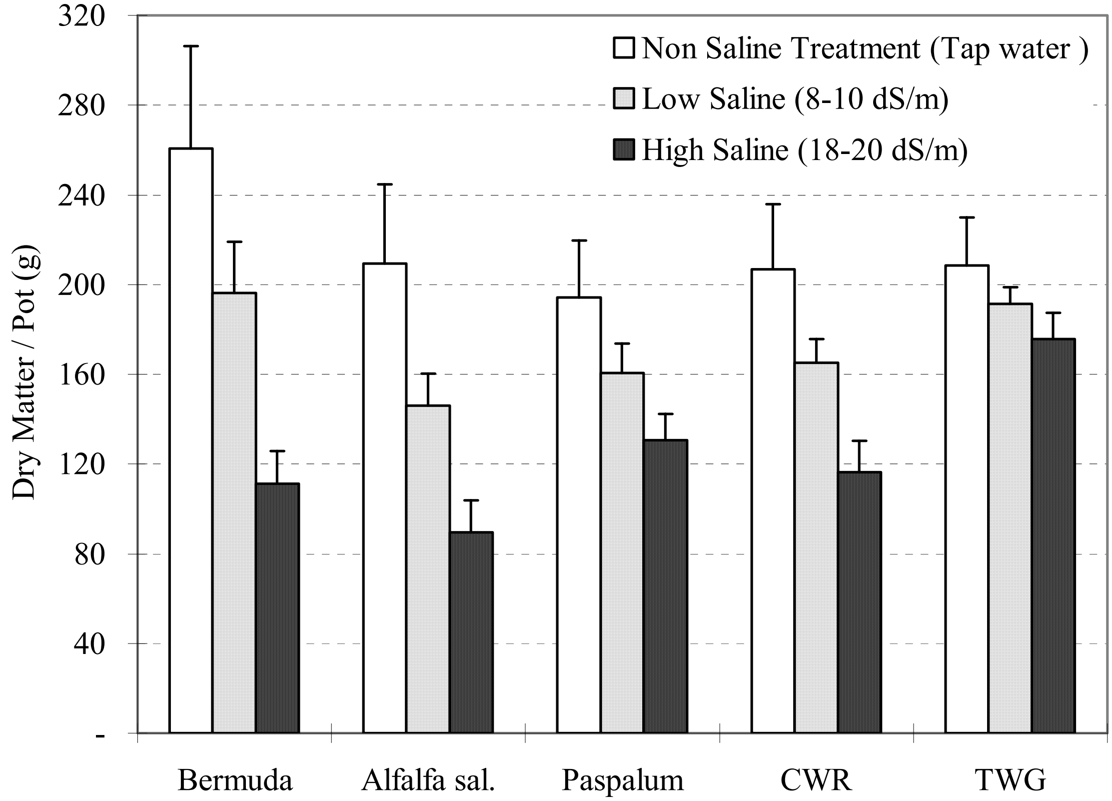

Figure 1. Forage dry matter accumulation from January 2003 to December 2004.

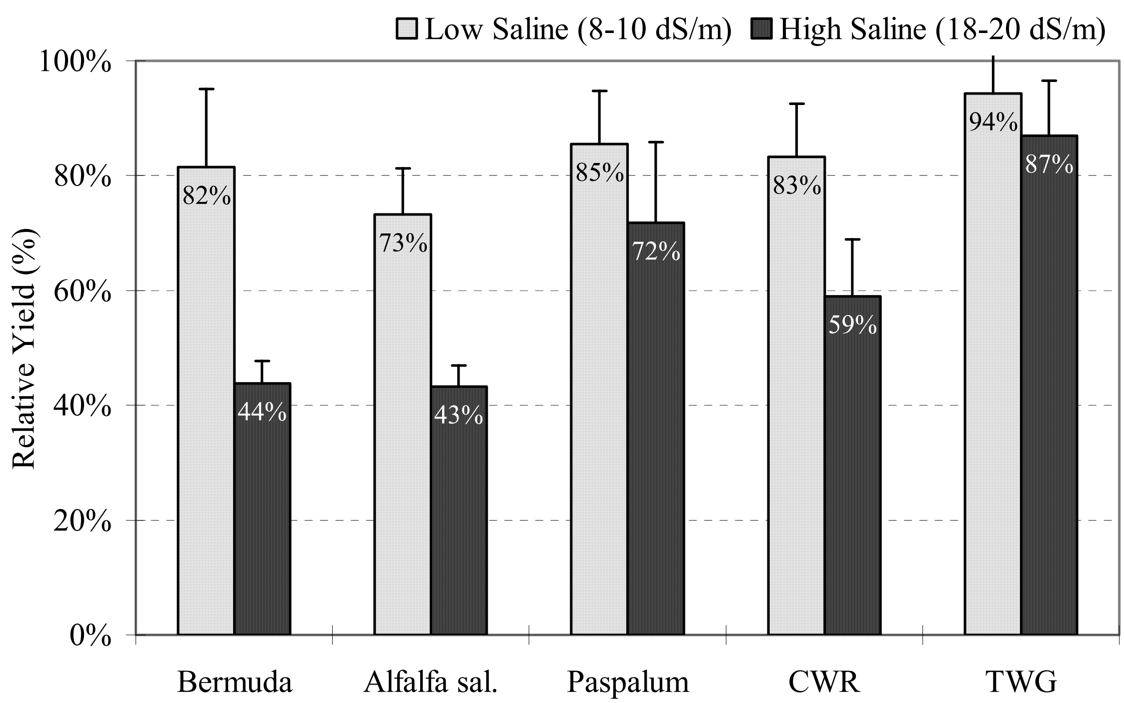

Figure 2. Salt-tolerance (relative forage yield).

4 CONCLUSIONS

Based on the biomass production in three studies (sand tank, field, and greenhouse) tall wheatgrass (TWG) is a top candidate for DW re-use systems in which the irrigation water salinity is very high (ECiw > 12 dSm^{-1}) and/or the soil salinity is very high (ECe > 15 dSm^{-1}). Although results are not yet available from this greenhouse study, the forage quality of TWG was very high in both the sand tank and field studies (Grattan et al., 2004; Suyama et al., 2005). Based on our results and those of Kaffka et al. (2004), bermudagrass has good biomass production and forage quality under irrigation with moderately saline DW. Furthermore, in the study by Kaffka et al. (2004), beef cattle grazing on DW-irrigated bermudagrass had acceptable weight gains and no apparent health impairments. However, in our greenhouse study bermudagrass production was greatly reduced when DW salinities were 18-20 dS/m and Kaffka et al. (2004) also reported that bermudagrass could not grow where the soil salinity was above 22 dSm^{-1} ECe.

Paspalum and Creeping wildrye (CWR) were intermediate in salt tolerance. In fields at RRR that were less saline than those where TWG was growing, CWR produced 13 MT DM/ ha (Suyama et al., 2005). In this greenhouse experiment where the two forages could be evaluated under similar salinities, TWG produced more biomass than did CWR under both the 8-10 and 18-20 dSm^{-1} irrigation water salinities. *'Salado'* alfalfa was the most salt sensitive forage. Productivity was greatly reduced by saline conditions, but it was observed in the greenhouse that conditions of water lodging resulting from poor infiltration due to the sodic soil conditions hindered the root development. Tolerance to both salinity and water-logged soil conditions are important criteria for forage evaluation under saline-sodic irrigation (Qadir & Oster, 2004). Comparisons of forage quality and ion composition will be discussed in more detail in the poster.

5 ACKNOWLEDGMENTS

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