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# Forage Yield, Quality and Livestock Production using Saline Drainage Water in the San Joaquin Valley

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## 1 1 INTRODUCTION

In the western San Joaquin Valley of California, many soils are saline and the presence of shallow, saline water tables in low lying areas threatens crop production. Regulations forbid the disposal of saline drainage water in the San Joaquin River and its tributaries. Without a means to dispose of saline drainage water, increasing amounts of farm land will become salt impaired and become unprofitable to farm. The use of underlying groundwater and limited numbers of evaporation basins for disposal of the large volume of drainage water produced is not sustainable or is restricted by regulations. As an alternative disposal strategy, we are testing whether saline-sodic drainage and/or other waste waters can be used in an environmentally sound manner for forage and livestock production. The goal is to use salt tolerant forages to support economic weight gain by cattle or sheep. If economic forage and livestock production can be based on the reuse of drainage water or other waste waters, this unused water will be transformed from an environmental burden into an economic asset. The amount of water that must be disposed to groundwater or in evaporation ponds will be reduced dramatically. Other economic and environmental benefits associated with irrigated pasture also will be realized.

### 1 1.1 *Objectives:*

1. Measure forage biomass accumulation, nutrient and trace element uptake, and the quality of salt tolerant forages produced using saline-sodic drainage water. 2. Monitor the mineral status and general health of cattle and measure their growth rate when grazing forages produced with drainage water. 3. Quantify the effects of saline-sodic drainage water on overall water use, drainage water quantity and quality, salt and trace metal balances, soil organic matter, and soil chemical and physical properties over time. 4. Model changes in important soil chemical, physical and biological properties at the local and field scale.
5. Develop economic models for drainage water reuse on forages.

## 2 2 METHODS

A 30 hectare site near Stratford in Kings County was developed to study the use of drainage and other waste waters for the production of forages and cattle. The site had been abandoned for annual crop production due to salinization and was highly variable. The site was leveled and tile drains were installed at a depth of 4 feet, 120 feet apart. A detailed baseline soil assessment for soil physical and chemical properties was done before the project began in summer 1999. Soils were characterized initially for chemical and physical properties using electromagnetic induction techniques followed by directed soil sampling. All survey work was done with GPS mapping and soil sample site locations were determined using ESAP software (Lesch et al., 2000, 1995). Additional surveys were carried out in March 2003 and November 2004 to assess changes in the same soil properties. Bermuda grass (*Cynodon dactylon (L.*) Pers.) was planted on the site in 1999, and the site was divided into 8 paddocks, each approximately 8 acres in size, to facilitate rotational grazing. In four of the paddocks, the cultivar *Giant* was planted to facilitate hay making, and in the other four, common Bermuda grass was planted. Livestock trials were carried out for three years (2001-2003), but grazing has continued through 2005. Regular forage sampling occurred at soil sample and other locations during each grazing season. Forages were cut to 5 to 7 cm height when sampled. and analyzed for quality and mineral content. Additional samples were collected each year by stratifying samples by height. Samples were divided into three canopy layers and quality parameters compared with canopy average values for the combined sample. Continuous monitoring (water volume) and automated sampling (for $EC_w$) of irrigation and drainage water has been carried out in four of the eight paddocks using automated sampling equipment since irrigation was initiated in 2000. Livestock performance and health were monitored for three years (2001 to 2003) but these data are not reported here.

## 3 3 RESULTS

Selected soil chemical and physical properties were measured at sites chosen using ESAP software (Lesch et al, 2000). Over the 1999 to 2004 period, irrigating with moderately saline water and from 2003 with municipal waste water as well, salinity related properties declined on average in the first two feet of the soil profile, while the lower two feet were largely unchanged. Mo is found at high levels in portions of the site while Se, which is a problem in other parts of the western San Joaquin Valley, is deficient. Details on soil survey are reported by Corwin et al., elsewhere in this proceeding.

Salinity in irrigation water was variable and incorporated drainage water as it became available during the growing season and water from the Kings River. In 2003/4, water from the city of Lemoore’s waste water plant and from a recently opened cheese factory also was used for irrigation as part of the mixture of waste waters applied. The $EC_w$ of irrigation water averaged 3.6 dS $m^{-1}$ and varied from approximately 1 to 10 dS $m^{-1}$ depending on availability. The leaching fraction observed was less than 10%, suggesting that most of the water applied was used by the grass crop. Runoff was negligible, but some loss to groundwater occurred that could not be measured in drain tiles.

Forage biomass and quality were measured at sites selected to reflect soil variation. Pastures were grazed rotationally throughout the 2001-2004 seasons by beef cattle. Grazing intensity varied from year to year. Bermuda grass grew well at moderate salinity levels but failed to produce where salinity ($EC_e$) exceeded 22 dS $m^{-1}$. Standing biomass amounts at the start of grazing during the warm months varied from approximately 1.5 Mg DM $ha^{-1}$ in paddocks with the cultivar *Giant*, to 2.5 Mg DM $ha^{-1}$ in paddocks with common Bermuda grass. Amounts varied with time of year, fertilization, and grazing practices. Intake by cattle was less because cattle are selective and varied depending on stocking rate and management and varied from approximately 40 to 60 % of standing biomass. Average forage quality and mineral contents on a DM basis for 2000 to 2003 are presented in Table 1. For comparison, average values reported by the National Research Council (1989) are included. Differences in quality and mineral content by height in the canopy were observed (fig.1). N (crude protein) in the upper portion of the canopy was 20 to 30 % greater than in overall samples. Trace elements tended to be greater than in the younger leafier material, particularly B, and most minerals as well, with the exception of Na, which was much higher in the lower third of the grass canopy.   At this location, Mo, rather than Se is found in large amounts in some areas of the pastures.  Excess Mo can interfere with Cu metabolism in ruminants and may cause a range of adverse physiological effects.  Generally, Cu:Mo ratios in ruminant diets below 3 or 4 are thought to lead affect cattle health but there is little formal research in this area (Suttle, 1991).  On average, CU:Mo ratios are 5 to 6 or larger.  No Mo toxicity has yet been observed in grazing cattle.  But the tendency for trace elements to be higher in the portion of the canopy selected by cattle when grazing suggests that cattle performance must be monitored for adverse effects when using saline drainage water as an irrigation source.

**Table 1. Bermuda grass forage quality under saline conditions (2000-2003).**

| *Variable* | *n* | *Mean* | *Median* | *SD* | *SE* | *Max* | *Min* | *NRC** |
|---|---|---|---|---|---|---|---|---|
| N (%) | 414 | 1.43 | 1.42 | 0.36 | 0.023 | 2.58 | 0.67 | 1.92 |
| P (%) | 414 | 0.18 | 0.18 | 0.036 | 0.002 | 0.34 | 0.10 | 0.20 |
| K (%) | 414 | 1.63 | 1.60 | 0.40 | 0.020 | 3.41 | 0.76 | 1.70 |
| Ca (%) | 414 | 0.41 | 0.40 | 0.11 | 0.005 | 0.77 | 0.19 | 0.32 |
| S (mg $kg^{-1}$) | 236 | 15430 | 5470 | 1093 | 72.1 | 9450 | 2670 | --- |
| Na (mg $kg^{-1}$) | 414 | 5026 | 4400 | 3210 | 158 | 23920 | 530 | --- |
| Mn(mg $kg^{-1}$) | 414 | 89.6 | 84.0 | 31.0 | 1.52 | 234 | 34.0 | --- |
| Fe (mg $kg^{-1}$) | 414 | 386.5 | 243.5 | 466.0 | 22.9 | 4714 | 78.0 | --- |
| Mg (%) | 414 | 0.193 | 0.180 | 0.60 | 0.003 | 0.56 | 0.10 | 0.16 |
| Zn (mg $kg^{-1}$) | 414 | 27.3 | 26.0 | 8.49 | 0.414 | 58.0 | 12.0 | --- |
| B (mg $kg^{-1}$) | 414 | 245.3 | 209.0 | 131.7 | 6.48 | 1004 | 73.0 | --- |
| Cu (mg $kg^{-1}$) | 414 | 7.34 | 7.10 | 1.79 | 0.088 | 14.4 | 3.4 | --- |
| Mo(mg $kg^{-1}$) | 414 | 1.44 | 1.2 | 0.95 | 0.047 | 5.30 | 0.3 | --- |
| Se (ug $kg^{-1}$) | 129 | 84.9 | 84.0 | 47.3 | 2.31 | 328 | 10.0 | --- |
| Ash (%) | 414 | 10.4 | 9.3 | 3.34 | 0.165 | 24.1 | 5.8 | 10.0 |
| ADF (%) | 414 | 29.6 | 29.4 | 3.03 | 0.149 | 42.3 | 20.7 | 38.0 |
| NDF (%) | 414 | 60.4 | 60.4 | 4.01 | 0.197 | 71.2 | 40.8 | 76.0 |

* hay, sun cured (29-42 days growth)

4 4 CONCLUSIONS

1.  After 5 years of irrigation with moderately saline water, pastures remain are increasingly productive.
2.  Salinity-related properties in soils have declined in the upper profile, indicating that soil reclamation is occurring through the use of moderately saline water.
3.  A large proportion of the irrigation water applied is being used by crops, reducing the amount of saline water for final disposal by 90%.

4. Beef cattle have been grazed on salt-affected pastures without apparent ill effects on livestock health and with acceptable rates of gain. Trace element imbalances in forages and cattle have been managed and did not cause toxicity.

5 5 REFERENCES

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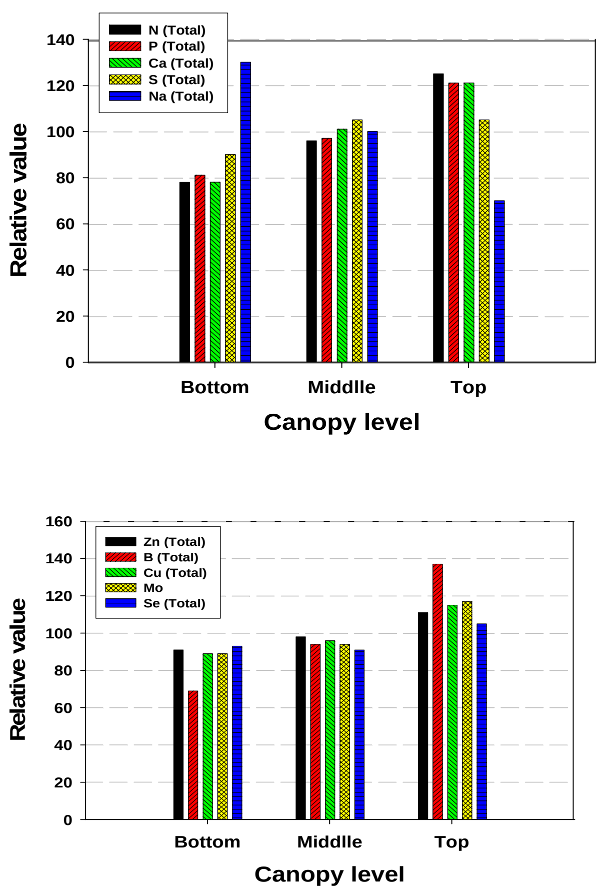


**Figure 1. Relative forage quality values by canopy height**.