United States Department of Agriculture

NRCS

TECHNICAL NOTES

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ECOLOGICAL SCIENCES TECHNICAL REFERENCES FOR IN-SERVICE USE ONLY

AGRONOMY OK-17 August 15, 2006

RE: Crop Tolerances to Soil and Irrigation Water Salinity

This technical note was developed to supplement the Oklahoma NRCS Nutrient Management (590), Waste Utilization (633), Salinity and Sodic Soil Management (610), and Irrigation Water Management (449) standards. It is referenced in each of the standards as it pertains to soil and water salinity and its relationship with plants. This technical note is not intended to be used in lieu of good irrigation water management and agronomic practices. It is meant to supplement existing NRCS information.

Salinity affects crop production when salts buildup in the rooting zone of the soil. The plant's ability to extract water from the soil profile is diminished as excessive soluble salts accumulate in the root zone. Reduced water uptake by the plant can result in slow or reduced growth. This can cause the appearance of a drought condition (i.e., plant wilting) even with relative high soil moisture conditions. High salt concentration in irrigation water can injure plants also. Crops have different salinity tolerance levels and the effects of salinity can vary with plant growth stage. For example, crop tolerance to salinity is lower during germination and small seedling stages but usually increases as the plant grows and matures.

Salinity is generally the measurement of the Total Dissolved Salts (TDS) concentration or Electrical Conductivity (EC) in irrigation water, effluent, or saturated soil extract. EC is determined by measuring how well water conducts electricity. As salt concentrations increase, the EC will increase. EC is normally measured in units of millimhos (mmhos/cm), deciSiemens (dS/m), or micromhos (µmhos/cm) where 1 mmhos (or dS/m) = 1000 µmhos. The µmhos/cm can be converted to parts per million soluble salt concentrations using the following formula: µmhos/cm x 0.65 = ppm or mg/L. Multiplying ppm by 2 = lbs/ac.

The Oklahoma State University Soil, Water, and Forage Analytical Laboratory provides testing for nutrients and salinity levels in soil, water, and effluent. All testing in soils and water should be done just prior to application. Soils receiving repeated applications of effluent or irrigation water high in salts needs to be tested annually and monitored for salinity accumulation.

Tables 1 and 2 provide crop tolerances to salt in soils and irrigation water. The tables should be used together. For example, do not irrigate with effluent when an existing soil EC exceeds the crop tolerance.

Soil Salinity Crop Tolerances

Table 1 displays soil salinity tolerances for selected crops and grasses. Many plants are less tolerant to salinity during germination and early seedling stages but become more tolerant as they mature. Therefore, crops or grasses should not be planted when the Maximum Soil EC Without Yield Loss values are exceeded. If the decision is made to plant crops or grasses when the soil test EC value exceeds the Maximum Soil EC Without Yield Loss value, then substantial stand and yield reductions can be expected.

Irrigating with Effluent Water

Effluent water from waste storage facilities used for irrigation may contain high levels of salts. Crop damage from sprinkler irrigation applications of effluent with high EC levels occurs because salt in the water comes in direct contact with plant leaves. Research and data for using effluent water on crops and forages is limited. When using effluent for sprinkler irrigation, the following guidance is recommended:

- Avoid light, frequent irrigations. Plants are more susceptible to the number of irrigations rather than the duration of irrigation.

- Avoid slow, rotating type sprinklers that allow drying of plant leaves to occur between cycles.

- Avoid applications in hot, dry, windy conditions when evaporation rates are high. This allows water to evaporate on the leaf and leave salt residues. Night applications will help reduce this risk.

- Use good quality water before and particularly after irrigating with effluent. Using good quality water for short periods (five minutes or so) before and after effluent applications will help dilute salt concentrations in the soil and wash salt residues off plant leaves.

- Plants in the germination to seedling stages are generally much less tolerant to salt than plants in more mature stages. Applications on established plants usually have less effect than on young emerging plants.

- To minimize plant damage, test a small area with an application of irrigation effluent and observe for a few days before applying to entire field.

When using effluent to irrigate, follow the guidance in **Figure 11-8**. **Figure 11-8** provides the maximum amount of effluent water application that can be applied annually based on soil texture.

Do not apply effluent if the EC, sodium (Na), or chloride (Cl) values exceeds the plant tolerance listed in **Table 2**. When the EC of the effluent exceeds 5, no more than 1” of effluent water should be applied annually.

Crop Tolerances to Irrigation Water Salinity

Table 2 provides information for irrigation water salinity tolerance on selected crops and grasses. The EC values contained in **Table 2** are compiled from literature that has not been

field tested in Oklahoma. Therefore, extreme care should be exercised when irrigating with water high in salt concentration.

Since plant responses to salt in irrigation water are so varied, it is not recommended that effluent water be used on crops or grasses during germination or seedling stages of plant growth.

Annual crops should be well established and/or near reproductive stages before effluent water is applied. Effluent water that exceeds the values in the Maximum Irrigation Water EC Without Yield Loss column of **Table 2** should not be used for the selected crop.

Effluent water should not be used on perennial grasses during establishment. Effluent used on established grasses should not exceed the values in the Maximum Irrigation Water EC Without Yield Loss column of **Table 2** for the selected grass.

Effluent that exceeds the values in the Maximum Irrigation Water EC Without Yield Loss column may be applied only during fallow periods for annual crops or during dormant seasons for perennial grasses. **Figure 11-8** will be used to determine maximum application amounts of effluent used during fallow or dormant seasons. Applications of effluent should be made as close to plant nutrient uptake as possible to efficiently use the nutrients in the effluent.

Limited information is available for establishing minimum sodium (Na) and chloride (Cl) concentration levels that could cause foliar damage from irrigation water. Those available are listed in **Table 2** and should also be used to determine irrigation water applications.

/s/ Kevin D. Norton

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TABLE 1. General Crop Tolerances to Soil Salinity (EC is in mmho/cm)

Species	Maximum Soil EC Without Yield Loss [1/ 2/]	Percent of Normal Yield as EC Increases [1/ 2/]				
		EC 4	EC 8	EC 12	EC 16	EC 20
Field Crops						
Barley [3/]	8.0	100%	100%	80%	60%	40%
Cotton	7.7	100%	98%	78%	57%	36%
Sunflower	4.8	100%	84%	64%	44%	24%
Rye	11.4	100%	100%	93%	50%	7%
Canola	11.0 [5/]	100%	100%	87%	35%	-
Wheat [3/]	6.0	100%	86%	57%	29%	-
Grain Sorghum	4.0	100%	71%	42%	14%	-
Sudangrass	2.8	95%	78%	61%	43%	-
Cowpea	1.3	63%	8%	-	-	-
Corn	1.8	84%	54%	24%	-	-
Alfalfa	2.0	85%	56%	27%	-	-
Soybean	5.0	100%	40%	-	-	-
Peanut	3.2	77%	-	-	-	-
Grasses						
Alkali Sacaton	14 [4/]	100%	**	**	**	**
Tall Wheatgrass	7.5	100%	96%	79%	62%	46%
Bermudagrass	6.9	100%	93%	67%	42%	16%
Western Wheatgrass	6.0 [4/]	100%	**	**	**	**
Tall Fescue	3.9	99%	78%	57%	35%	14%
Perennial Ryegrass	5.6	100%	82%	52%	21%	-
Orchardgrass	1.5	98%	73%	48%	24%	-
Lovegrass	2.0	83%	50%	16%	-	-
Native grass	5.0**	**	**	**	**	**

**No data available or NRCS Estimation
[1/] NRCS National Irrigation Guide, Chapter 13, Table 13-3 (Salt Tolerance of Selected Crops)
[2/] Western Fertilizer Handbook 8th Edition, Table 2-6
[3/] Wheat and Barley are less salt tolerant at germination and seedling stage. EC values should not exceed 4 to 5 at this stage.
[4/] Montana Plant Materials Technical Note No. 26 – 1981 and revised 1996
[5/] Francois, 1994a

TABLE 2. Crop Tolerances to Irrigation Water Salinity (EC is in mmho/cm)

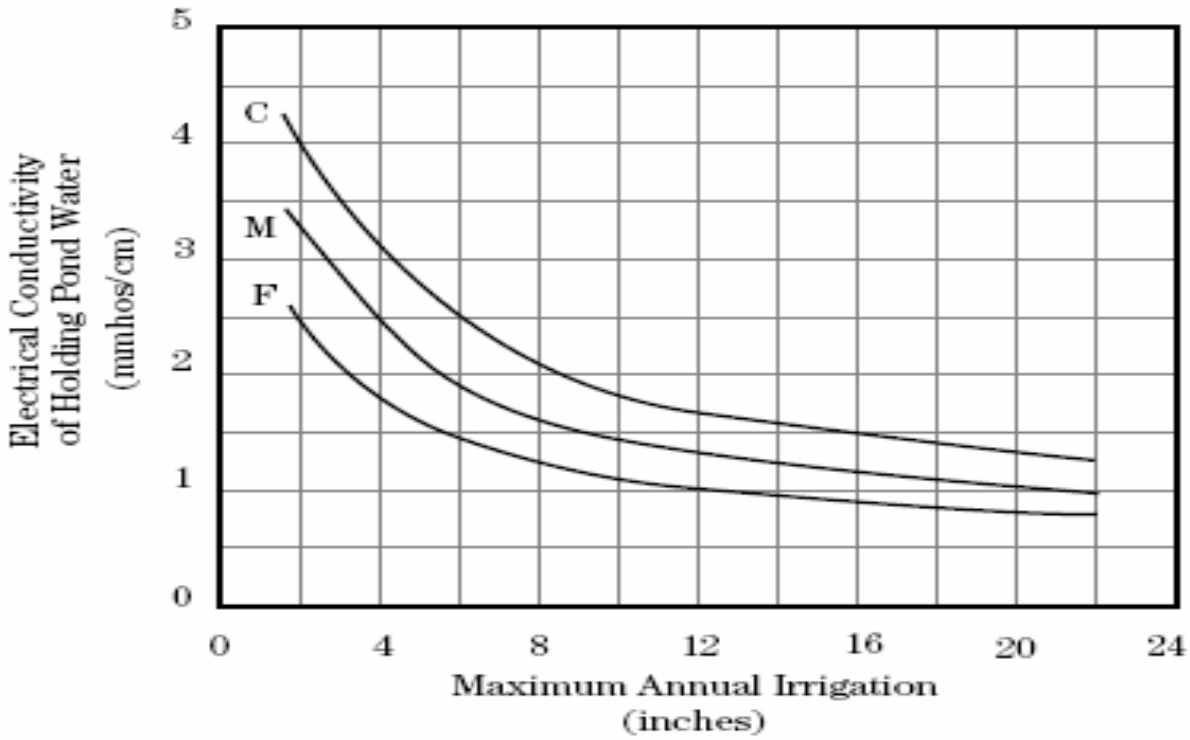
Species	Maximum Irrigation Water EC Without Yield Loss [1/]	Minimum Sodium (Na) Concentration Causing Foliar Damage (mg/L) [2/]	Minimum Chloride (Cl) Concentration Causing Foliar Damage (mg/L) [2/]
Field Crops			
Barley	5.3	231	351
Cotton	5.1	460	700
Canola	7.0 **	**	**
Rye	7.5 **	**	**
Sunflower	3.0	**	**
Sudangrass	1.9	**	**
Wheat	4.0	**	**
Grain Sorghum	2.7	231	351
Cowpea	0.9	**	**
Corn	1.1	231	351
Soybean	3.3	**	**
Alfalfa	1.3	231	351
Peanut	2.0**	**	**
Grasses			
Alkali Sacaton	9.0**	**	**
Tall Wheatgrass	5.0	**	**
Bermudagrass	4.6	**	**
Western Wheatgrass	5.0	**	**
Tall Fescue	2.6	**	**
Perennial Ryegrass	3.7	**	**
Orchardgrass	1.0	**	**
Lovegrass	1.3**	**	**
Native Mixture	3.0**	**	**

**No data available or NRCS Estimation

[1/] Western Fertilizer Handbook 8th Edition, Table 2-7 through 2-10

[2/] Western Fertilizer Handbook 8th Edition, Table 2-14

Figure 11–8 Maximum annual amount of undiluted waste storage pond water that can be added to a coarse (C), medium (M), or fine textured (F) soil



- Figure 11-8 – NRCS Agricultural Waste Management Field Handbook, Chapter 11
- Do not apply effluent if the EC, Sodium (Na), or Chloride (Cl) values exceeds the plant tolerance listed in **Table 2**.
- When the EC of the effluent exceeds 5, apply no more than 1” of effluent water annually for all soil textures.