Salt tolerance of corn in the Delta

Glenn J. Hoffman  ◀  Eugene V. Maas  ◀  Terry L. Prichard
Jewell L. Meyer  ◀  Robert Roberts

The salt tolerance of corn has not been well established, and published studies, none of which were done on organic soils, were thought to be site-specific. Published information indicates that corn production is not reduced until soil salinity, expressed as the average electrical conductivity of the soil water in the root zone, exceeds 3.4 dS/m (about 2,200 ppm salt). For each dS/m increase in salinity above this threshold, production decreases at a rate of 6 percent. Because corn is more sensitive to salinity than are other crops, such as wheat, barley, and asparagus, water quality standards and management practices (including irrigation timing, irrigation amount, and leaching) must prevent soil water salinity from exceeding 3.7 dS/m, on the average, during the growing season. Neither the climate nor the organic soils of the Delta significantly altered the salt tolerance threshold of corn from the published value for mineral soils.

Experimental procedure

The soil on the experimental site on Terminous Tract, San Joaquin County, is Rindge muck. The soil profile changes from muck (45 percent organic matter) to peat (59 percent organic matter) at a depth of 60 to 90 cm and then to mineral soil at 2 meters. We established sprinkler-irrigated treatments, each replicated six times, on the eastern portion of the site, and four subirrigated treatments, each replicated twice with two subplots per replicate, on the west side. All areas surrounding the experiment were also planted to corn and served as borders. (See experimental design, fig. 1)

In 1979, the first year of the study, the five sprinkler treatments were irrigated with waters having electrical conductivities of 0.2, 0.6, 1, 2, and 3 dS/m. Water for the 0.2 dS/m (control) treatment was taken directly from the South Fork of Mokelumne River. Saline well water with electrical conductivity of 7.4 to 8.4 dS/m, was mixed with river water for the other treatments. Salinity levels of the water for the four subirrigated treatments were 0.2, 0.6, 1, and 2 dS/m in 1979.

Because no significant yield reductions occurred in 1979, the salinity levels in 1980 and 1981 were increased to 0.2, 2, 4, 6, and 8 dS/m for the sprinkler treatments and 0.2, 2, 4, and 6 for the subirrigated treatments.

Rows of corn (Zea mays L. cv. DeKalb XL75), spaced 76 cm apart, were planted in the spring in an east-west direction in one continuous operation for all plots and borders. Six rows, each 7.6 meters

![Fig. 1. Four subirrigated salinity treatments were each replicated twice with two subplots per replicate. Five sprinkler-irrigated treatments were each replicated six times.](image-url)
long, were harvested from the center of each replicate early in October each year.

In sprinkled plots, mini-sprinklers applied an average depth of 16 mm over the entire plot area in one hour (see table). Water was applied in the sprinkled plots at about twice the expected rate of evapotranspiration (ET) to keep the salinity profile in the root zone as uniform as possible. Sprinkler irrigations were applied weekly except for a few brief periods early in the season when light, frequent irrigations were applied for plant stand establishment.

Irrigation water for the subirrigated plots was blended directly in the pipelines by manually adjusting gate valves, so that all four treatments could be irrigated simultaneously to minimize soil water movement among plots. Each subirrigation plot was irrigated by filling two ditches spaced every 16 rows of corn. In 1980 and 1981, the rate of flow entering and leaving each ditch was monitored with orifice plates.

The subirrigated treatments were similar to irrigation practices of the area. Two or three subirrigations were applied during each season. Each subirrigation continued for several days and ended when the water table rose to within about 15 cm of the soil surface midway between the irrigation ditches.

**Results**

Statistical analysis of grain yield in relation to soil salinity in the root zone for each treatment during each year showed very little difference between irrigation methods in either threshold or slope (rate of yield reduction at salinity values larger than the threshold) (fig. 2). Based on the results, the salt tolerance of corn harvested as grain has a threshold of 3.7 dS/m and a slope of 14. The threshold is close to the value of 3.4 calculated from previously published tolerance data, but the rate of yield reduction is considerably greater than the value of 6 obtained in other areas.

Significant concentrations of soluble salts are not normally found in organic soils. Organic soils, differentiated from mineral soils by an organic matter content greater than 20 percent, are formed from partially decayed plant remains that accumulated originally in shallow bodies of fresh water or in poorly drained areas where anaerobic conditions persisted. In contrast, saline soils usually occur in regions where water is lacking. The Sacramento-San Joaquin Delta is an important example of an agricultural area with organic soils that are threatened by salinity.

The objective of this study was to establish the general relation between salinity of the irrigation water and soil water salinity for the organic soils of the Delta, based on results from the three-year field experiment to establish the salt tolerance of corn. An initial step was to standardize procedures of measuring soil salinity in organic soils. Previous work indicated that the method of sample preparation influenced the measurement of electrical conductivity (EC) in organic soils, particularly in subsoil samples.

**Salinity measurements**

Soil salinity is determined routinely by measuring the electrical conductivity of a soil saturation extract. The soil sample is either dried, ground, and passed through a 2-mm round-hole sieve or passed through a sieve with drying or grinding. Water is then added while mixing until the soil is saturated. The mixture is allowed to stand overnight, and additional water is added if required to saturate the sample. The soil solution extracted by vacuum from the saturated soil is then measured for electrical conductivity.

In September 1979, we took soil samples from each experimental plot and divided them into three subsamples before analysis. One set of subsamples was allowed to dry at room temperature and then ground (dry, ground). A second set was dried at room temperature but was not ground (dry, unground). The third was brought to saturation without drying or grinding (wet, unground).

The influence of sample preparation on the measurement of salinity is illustrated in figure 1 for samples taken from the treatments with applied waters having an electrical conductivity of 2 dS/m (about 1300 ppm) in the two methods tested: subirrigation and mini-sprinklers. Sample preparation had no significant influence on the measurement from samples collected above a depth of

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**Fig. 2.** Salt tolerance as indicated by yield showed little difference between irrigation methods in either threshold or slope.

**Fig. 1.** Sample preparation technique influenced electrical conductivity of soil saturation extract (EC,) below 30 cm.

**Fig. 2.** Measurements (1981) from wet, unground soil samples agree closely with other measures of salinity.