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 water management techniques acceptable for corn grown on organic soils should be suitable for more tolerant crops.

The objective of this study was to determine the salt tolerance of corn grown on a typical muck soil in the Delta. Tolerance was compared under two methods of irrigation: subirrigation, which is the usual local method, and mini-sprinklers to achieve uniform water applications. (We present details of the experimental procedures and complete results in "Salt tolerance of corn in the Sacramento-San Joaquin Delta of California," *Irrigation Science*, Vol. IV, pp. 31-44, 1983).

In this three-year field experiment, the largest value of soil water salinity without a yield reduction was at a threshold of 3.7 dS/m (approximately 2,400 ppm salt). At lower salinities, grain yield was equivalent statistically to nonsaline conditions. For each dS/m increase in soil water salinity above the threshold, grain yield was reduced at the rate of 14 percent. An almost identical threshold was found for total shoot growth. Thus, to prevent loss in corn yield, the salinity of the applied water 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 sprinkled 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

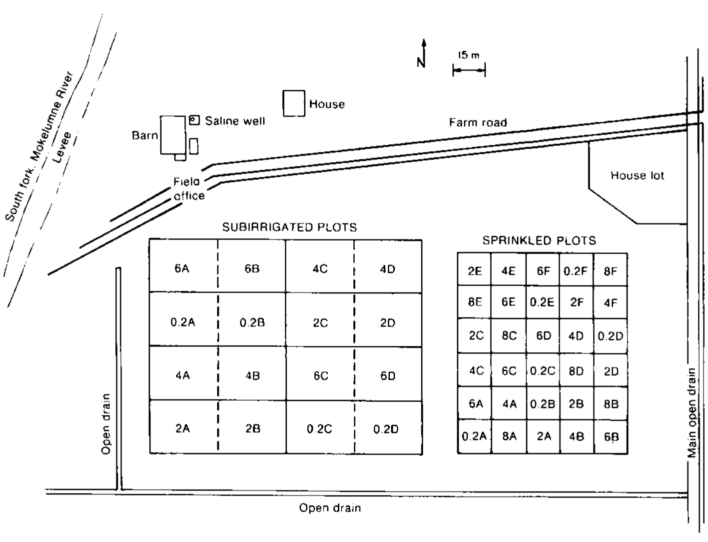

Fig. 1. Four subirrigated salinity treatments were each replicated twice with two subplots per replicate. Five sprinkler-irrigated treatments were each replicated six times.

Water balance for sprinkled and subirrigated treatments*

Water	May	June	July	Aug.	Sept.	Total
			mm			
1979						
Pan evaporation	195	252	236	199	167	1,049
Evapotranspiration†	22	82	197	188	111	600
Sprinkler application	0	234	458	273	173	1,138
Rainfall	2	0	5	0	0	7
1980						
Pan evaporation	187	186	240	233	154	1,000
Evapotranspiration†	23	61	215	209	75	583
Sprinkler application	168	319	332	367	216	1,402
Subsurface Irrigation						
Total applied	...	1,110	...	1,510	...	2,620
Net applied	...	370	...	690	...	1,060
Rainfall	9	0	16	0	0	25
1981						
Pan evaporation	179	274	288	221	183	1,145
Evapotranspiration†	23	94	254	202	121	690
Sprinkler application	86	300	500	397	87	1,370
Subsurface irrigation						
Total applied	...	690	710	850	...	2,250
Net applied	...	420	340	350	...	1,110
Rainfall	0	0	0	0	0	0

* Values are presented as the depth of water applied uniformly over the entire area.
† In nonsaline treatments.

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. □

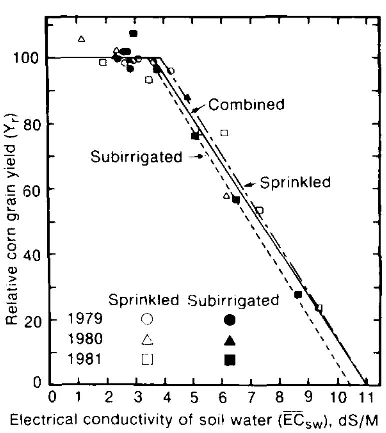

Fig. 2. Salt tolerance as indicated by yield showed little difference between irrigation methods in either threshold or slope.

Relationship of irrigation water salinity and soil water salinity

Terry L. Prichard □ Jewell L. Meyer □ Glenn J. Hoffman
Franz R. Kegel □ Robert Roberts

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 without 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

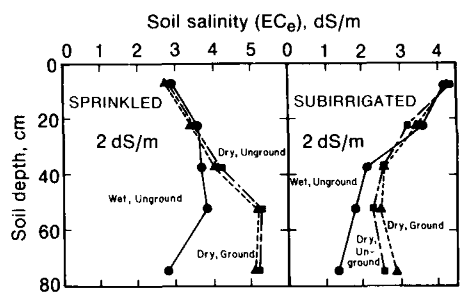

Fig. 1. Sample preparation technique influenced electrical conductivity of soil saturation extract (EC_e) below 30 cm.

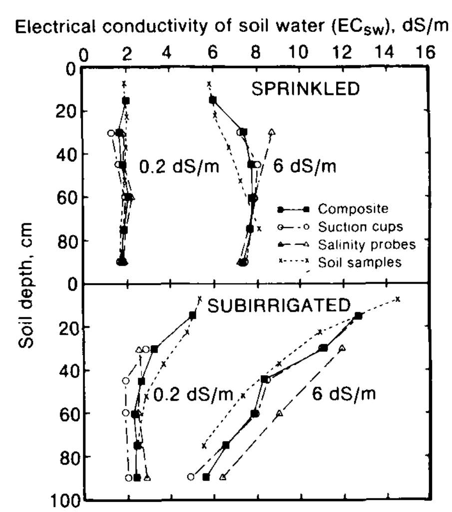

Fig. 2. Measurements (1981) from wet, unground soil samples agree closely with other measures of salinity.