Salt Tolerance of Soybean Varieties (Glycine max L. Merrill) During Germination and Later Growth

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ACCUMULATION of salts in the irrigated soils of western United States often results in reduction of seed germination and plant growth. Plant genera and species may differ widely in salt tolerance, but, for most crops, varietal differences in salt tolerance are very small. Approximately a third of the soils of the Imperial Valley of southern California are excessively saline and are usually cropped to the more salt tolerant crop species.

Ogasa (12) found that seed germination of soybean variety 'KO 561' was inhibited by a 0.2% NaCl solution at 30 °C, but it was necessary to increase the concentration to 0.3% NaCl to cause inhibition at 15 °C. The data of Uhvits (15) show that at osmotic pressures greater than 7 atmospheres, alfalfa seed germination in solution cultures was retarded considerably more by concentrations of NaCl than by mannitol presumably because of the toxic effect of the salt.

Rudolfs (13) found that seed water absorption in 15 hours was decreased 9% when the osmotic pressure of the germinating solution was increased from 0 to 7 atmospheres with addition of NaCl. Ayers and Hayward (2) showed that salt tolerance during seed germination is not always positively correlated with that of the crop during later growth.

The first physiological reaction of plants immediately after an increase in soil salinity is reduced entry of water in roots (3, 9). Reduced growth, which is not yet clearly understood, follows. Reduced growth is evident in reduced height and development of smaller, darker green leaves (6, 8, 10). The characteristic chloride toxicity symptoms for peach, citrus, and a number of other trees are incipient chlorosis accompanied by drying and browning of the leaf beginning at the margin of the apex. The minimal levels of chloride accumulation associated with leaf burn of several fruit trees ranged from 5,000 ppm to 18,000 ppm chloride (4). Leaves of field, vegetable, and forage crops which usually showed no specific chloride injury in salinized soil ranged from 17,750 ppm to 53,000 ppm chlorides.

Bernstein and Ayers (3) found no relation between chloride content and salt tolerance in green beans. In their studies, 6 varieties of green beans all accumulated large amounts of chloride. Although barley (1) and cotton (11) were considered highly salt tolerant, varietal differences in salinity effects on seed yield were reported. Salt decreased the vegetative portions of barley and wheat relatively more than that of the grain (1). The 'Lee' soybean variety was rated moderately salt tolerant in studies at the U.S. Salinity Laboratory at Riverside, California, in 1955. In this study, seed yields were reduced 50% when the electrical conductivity of the saturation extract of the soil, (ECe) was 9 millimhos/cm. Oil percentage decreased and protein percentage increased slightly.

Preliminary studies with 50 soybean strains adapted to soils of low salinity indicated a wide variation in salt tolerance during seed germination and plant growth. In 1961, salt tolerance of 6 soybean varieties during germination and later growth were critically evaluated at the Southwestern Irrigation Field Station at Brawley, Calif. The results are reported herein.

MATERIALS AND METHODS

Seed Germination

Effects of 6 salinity levels on germination of 6 soybean varieties were determined in successive duplicate 20-day experiments in a controlled-temperature (28° C ± 1°) room. The varieties were N53-509, B34-842, 'Improved Pelican', 'Jackson', N53-505, and Lee.

The salinized substrates were prepared according to the technique described by Ayers and Hayward (2) by adding enough NaCl solution to air-dry coarse-textured, gypsicous soils of low salinity to provide a moisture content sufficient for seed germination (16%). Salt was added at 0%, 0.05%, 0.10%, 0.15%, 0.20%, and 0.25% on a dry-soil basis. Soil salinity was determined by measuring the electrical conductivity of saturation extracts (ECe) as described in the U.S. Salinity Laboratory Agriculture Handbook No. 60 (16). The mean ECe values were 3.1, 6.0, 13.7, 15.3, 11.8, and 8.5 millimhos/cm, respectively. The 0% added salt sample served as the control. Each culture consisted of 2070 grams of prepared soil in a 4-quart can covered with a polyethylene sheet to prevent moisture loss and to transmit light during germination.

Fifty thiram-treated, hand-threshed seeds of each variety were planted 1 inch deep in 3 replications of each salt level. The cans were randomized in a split-plot design with varieties as whole plots and salt concentrations as split-plots. Emergence occurred when cotyledons were above the soil surface. Stands were counted at 5, 7, 11, 15, and 20 days after planting. Seedling tags were cut off at the soil surface at each counting date to minimize changes in salt concentration around the remaining seeds. Analysis of variance of the data was made for each experiment and for the combined experiments.

Plant Growth

The salt tolerances of the 6 soybean varieties used in the germination study were evaluated during growth in the field. The soybeans were grown in 20 × 10-foot basins in an area of rhizobic clover in Holtville saline clay. In each basin, seeds of each variety were planted in rows 2½ feet long on preirrigated ridged seedbeds spaced 30 inches apart in 6 replications. The ECe of the soil around the seed at planting in all basins was 4.0 ± 1 millihoms/cm.

Differential salinity levels were maintained throughout the growing season by salt added to Colorado River irrigation water containing approximately 1,000 ppm salt. The first differential saline irrigation waters, applied 3 weeks after planting, contained 0, 1500, 3000, 4500, 6000, and 7500 ppm added salt with equal parts of sodium and calcium chlorides. The amount of salt added in each of 12 subsequent irrigations was based on the salinity of the soil before each irrigation. Irrigations of 3 acre inches of river water were scheduled according to the time required to deplete the soil moisture in the control plot (0 ppm) to a soil suction of 1 bar at the 8-inch depth. Irrigation frequencies were approximately 10 days. The seasonal mean ECe in the first foot of soil of 7.5, 0.5, and 0.20% on a dry-soil basis was 5.73, 8.1, 9.6, and 10.2 millimhos/cm. The salinity increased slightly with time, but the range of salinity throughout the season was given a basin width less than 1 millihom/cm. Salt in the control was due to indigenous soil gypsum and other salts plus salt added by irrigation water. All basins received calcium nitrate fertilizer at rates of 80 and 20 pounds of N per acre in June and October, respectively.

Stand after emergence and numbers of seed-bearing plants at maturity were recorded. On the 15th of June, July, August, and September, plants in each plot were evaluated for height, leaf size, leaf color, and necrosis. Height was measured from the...