# Salt Damage to Soybean

- Toxic elements in water and soil can significantly hamper soybean productivity.
- Excessive levels of chloride (Cl) and sodium (Na), which make up salt, in irrigation water are considered toxic ions and have the ability to damage soybean plants.
- Plant toxicity normally occurs when certain ions in irrigation water are absorbed and accumulated at high concentrations in the leaves.

## Salt Damage

Almost all water contains dissolved salts (Cl and Na) and other trace elements which can impact water quality.[1] Salinity levels are a main concern for most irrigation water, as high salt levels can harm plants and reduce yield potential. Salt begins to accumulate as water evaporates from the surface and the crops remove water from the soil.

Figure 1. Salt damage to soybean from irrigation. Source: Dr. Gordon Johnson, University of Delaware.

Symptoms of salt injury are similar to drought as plants wilt and the leaf area can decrease.[2] Salt injury symptoms first appear on older leaves, turning them light green to yellow followed by necrosis (Figure 1). The under canopy of the soybean crop must be evaluated to catch salt injury early on. Leaves may also appear scorched shortly after irrigation. If salinity levels are high enough, a plant may die prematurely.

Furrow irrigated soybean fields may experience worse salt injury in areas that receive higher rates of low-quality water. These areas may be the first one-third of the field nearest the water source or any low-lying areas where irrigation water may stagnate.

## Chloride Toxicity Testing

If excessive salt is suspected in an irrigated field, a water sample should be sent in for analysis. From the analysis, two types of salt problems can be diagnosed, a problem with total salinity (too much Cl) or a problem associated with the combination of total salinity and sodium (Cl and Na), sodicity. Soil testing may not be of much help in working with chloride, as chloride ions move rapidly in the soil when water is added or removed.

Irrigation, high water tables, manure, fertilizer applications, or soil parent material may be sources for high Cl or Na levels. Knowing the source of the salt is important to apply effective management practices. When submitting water samples, remember that water from a source can vary in quality with time. It is good to always test during potential irrigation periods.

## Saline Soils—Chloride Toxicity

Soils with high Cl levels are called saline soils and water uptake to a plant can be reduced. Saline soils normally have a pH value below 8.5 and are low in sodium (Table 1).[3] Additional facts about saline soils:

- Water salinity can be measured by electric conductivity (EC) (Table 1).
- Symptoms occur initially at the soybean leaf tip. Chemical analysis of plant tissue can be used to confirm Cl toxicity.
- In irrigated field, Cl uptake depends not only on the water quality, but also on soil Cl levels from leaching and the ability of the soybean product to exclude Cl.
- Chloride toxicity can occur in regions where the water table or irrigation water is high in Cl. Excessive fertilizer use can also increase Cl toxicity.
- Geographies include the coastal/tidal region and hard clay pan soils with poor drainage in areas of Kansas, Southern Missouri, Southern Illinois, and parts of Arkansas and the Mississippi Delta.

**Table 1. Classification of salt-affected soils.**

| Classification | EC (dS/m)[1] | Soil pH | SAR[2] | Soil physical condition |
|---|---|---|---|---|
| **Slightly Saline** | 2 - 4 | <8.5 | <13 | normal |
| **Saline** | >4.0 | <8.5 | <13 | normal |
| **Sodic** | <4.0 | >8.5 | >13 | poor |
| **Saline-Sodic** | >4.0 | <8.5 | >13 | varies |
| **High pH** | <4.0 | >7.8 | <13 | varies |

[1] Electrical conductivity dS/m = mmho/cm.; [2] Na adsorption ratio, if reported as exchangeable sodium percentage (ESP) use 15% as threshold value.
Source: Colorado State University Extension.[3]

# Salt Damage to Soybean

## Sodic Soils—Sodium Toxicity

Soils are considered sodic when they contain high amounts of Na. High Na levels can lead to the breakdown of soil structure causing the soil to not compact when dry and impervious to water penetration.[1] Sodic soils can appear to be dark and smooth.

- High Na concentration can cause ion imbalance of potassium (K), calcium (Ca), and magnesium (Mg) in the plant.
- Na toxicity is not as easily diagnosed as Cl toxicity, but damage to plant tissues has been correlated to high Na concentrations in irrigated water.
- Soils with high Na levels are expressed by the Sodium Adsorption Ratio (SAR). This is calculated from the ratio of Na to Ca and Mg (Table 1).[1] To determine if a soil is sodic or just has high pH the SAR should be determined.
- Symptoms of high Na are leaf burn, scorch, and dead tissue along the leaf edges. A combination of plant tissue, irrigation water, and soil analyses increases the probability of a correct diagnosis.
- Na toxicity can occur in regions where soils have high levels of exchangeable Na, irrigation water is high in Na, and rainfall is limited.

## Management

Leaching may be used as a basic management tool for controlling salinity in soil. To leach the soluble salts, water is applied in excess and then is lost to evaporation. This technique is used to keep the salts in solution until they leach below the plant root zone. This technique may be accomplished during any irrigation and as much as needed. In some areas normal amounts of rainfall may provide enough additional water to allow for salt leaching. Preplant irrigation can also help reduce salt levels as salts can accumulate near the soil surface when fields are fallow.

In fields with saline soils, salt tolerance can be improved when the soybean plant has the ability to regulate the absorbed Cl ion within the plant. Soybean products absorb Cl from the soil at the same rate, but are differentiated into two genotype groups based on their ability to regulate the absorbed Cl (Table 2). The two genotype groups are:

Excluder plants that store Cl in the root while Na will still be translocated to the shoot tips and leaves.

Includer plants take in the chloride and move it to the top of the plant where toxic levels can accumulate and kill the plant.

It is important to note that soybean excluder products planted in areas where both Na and Cl are at the toxic levels will not provide tolerance due to the Na toxicity effect on the plant. Soybean excluders are more common in soybean products planted in the Southern regions and less common in Northern regions.[1] Both includer and excluder soybean products are affected by high salt levels, but includers may experience more damage.

**Table 2. Soybean chloride sensitivity product rating.**

| Product | Description |
|---|---|
| Includer (I) | Products accumulate chloride throughout the plant. They are considered sensitive to high levels of soil chloride and should not be planted on those soils. Plant carries the recessive form of the gene. |
| Excluder (E) | Products accumulate chloride and restrict it to the roots. Plant characteristic is controlled by one dominant gene. |
| Segregating (SEG) | Products have both includer and excluder plants. |

## Selecting Salt Tolerant Soybean Products

Salt tolerance may be a key agronomic characteristic to consider in fields where high levels of Cl limit yield potential. Symptoms and causes of Cl and Na toxicity are frequently confused. Effective management of these problems varies and requires proper diagnosis. Excluder soybean products can be an effective management tool to minimize the impact of Cl toxicity.

Your seed representative can help you identify essential agronomic characteristics needed and match the right products to your fields. Refer to your seed guide or product characteristic sheet for the chloride sensitivity of your soybean products. The abbreviations Inc. = Includer and Exc.= Excluder.

**Sources:**
[1]Fipps, G. Irrigation water quality standards and salinity management strategies. Texas Cooperative Extension. B-1667; [2] Lofton, J. Dangers of irrigating with low-quality water. Soybean South. Louisiana AgCenter Macon Ridge Research Station. (verified 9/9/2014); [3]Waskom, R.M. et al. 2014. Diagnosing saline and sodic soil problems. Colorado State University Extension, No. 521; Davis, J.G. et al. 2013. Managing sodic soils. Colorado State University Extension, No. 504; Holifield, S. et al. Environmental stress and adaptation to stress. University of Arkansas, http://abstracts.aspb.org (verified 9/23/14); Rupe, J.C. et al. 2000. Effect of chloride and soybean cultivar on yield and the development of sudden death syndrome, soybean cyst nematode, and southern blight. The American Phytopathological Society, Volume 84, Number 6. http://www.apsnet.org; Dunn, J.M. et al. 2006. Effects of chloride irrigation water on soybean Excluder and Includer cultivars. http://crops.confex.com (verified 4/2/13); Korth, K.L. and C. Pengyin. 2011. Annual soybean progress reports. University of Arkansas Research and Extension.

For additional agronomic information, please contact your local seed representative.