FACT SHEET

SALT INDEX & FERTILIZER BURN

SUL4R-PLUS

Virtually all fertilizer materials are salts.

When they dissolve in the soil, they increase the salt concentration of the soil solution. An increase in salt concentration increases the osmotic potential of the soil solution. The higher the osmotic potential of a solution, the more difficult it is for seeds or plants to extract soil water they need for normal growth.[1]

The salt index does not predict the amount of material that will produce injury to crops in particular soil. It classifies fertilizer material relative to each other and shows which is most likely to cause injury. It is possible to formulate similar grades of mixed fertilizers from different materials that have significantly different salt indices.[1]

Understanding Salt Index

Original Salt Index (SI) is a numerical comparison between fertilizer materials in use since 1943. Sodium nitrate (NaNO3) was used as the standard since it was a commonly used, 100% water-soluble source of nitrogen at the time. Its SI was set at 100 and other fertilizers are then expressed as a percent of the standard.[2]

(Osmotic Pressure $_{\text{Fertilizer Material}}$ / Osmotic Pressure $_{\text{NaNO3}}$) x 100 = SI

SI measures the electrical conductivity of a 1% fertilizer solution. Solutions with a high SI have a higher conductivity, an indication of the amount of salt in the solution.[2]

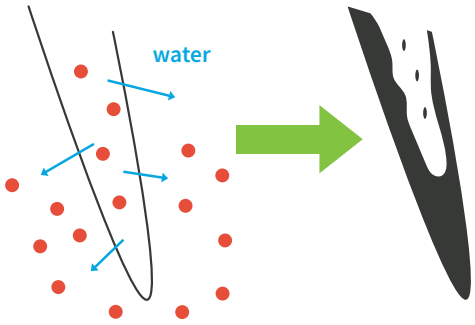

Fig 1: Understanding Salt Impact on Root Burn[3]

Impact of Salt Content on Plant Cells

When a solution with a high salt content is separated from a solution with a low salt content by a semi-permeable membrane, such as a cell wall, water will move through the membrane from the low concentration to the high concentration, seeking a balance. If this water movement is from within the plant cell to outside of the cell, plant injury may occur. **Traditionally, SI has been utilized as an indication of seedling safety for furrow applied starter fertilizers.** Cells in plant seeding have higher water content than mature plant tissue, therefore they are more vulnerable to movement of water out of the cell.[3]

Fig 2: Healthy Root[4]

Factors Affectioning Fertilizer Burn

CROP Sensitivity

Crop tolerances to increased osmotic potential from fertilizer near the seeds varies widely. Wheat is moderately tolerant of high-salt conditions while soybeans are very sensitive. Corn is intermediate intolerance.[1]

Dry soil conditions, as well as fertilizers that produce free ammonia (urea, UAN, DAP), will significantly increase seed and seedling stress, leading to injury or possible death. Be aware of the salt index of your starter fertilizer and don't overstress your young crop.[1]

Soil Conditions[3]

- Soil moisture
  - Moist soils – fertilizer salts diffuse away from band
  - Dry soil – minimal diffusion
- Low CEC (sandy, low OM soils)
  - Less reaction of soil and fertilizer
  - Salt concentration remains high
- Temperature
  - Roots grow slowly in cold soil

Concentration of fertilizer salts

- Broadcast
  - Fertilizer is dispersed, rarely causes injury
- Banded (2" x 2")
  - Fertilizer is more concentrated closer to seed
  - At typical application rates injury unlikely
- In furrow/seed placed/pop-up
  - Extremely close proximity to seed
  - Reduced rates, but can still cause problems

Crop	Relative sensitivity
Wheat	Least sensitive†
Corn	
Forage legumes	
Soybean and Edible bean (dry or snap)	
Vegetables including sweet corn	Most sensitive

* Reproduced from Reid (2006).
† Least sensitive does not mean that the crop is not sensitive to salt.

Don't place fertilizer with seed of super sweet hybrids of sweet corn, soybean, dry bean, & pea (Reid 2006)

Fig 3: Crop Sensitivity[3]

WHEAT DEVELOPMENT TEST

Fig 4: Wheat Trials Root Damage by Urea (loss of root hairs)[4]

Why are fertilizer salts a problem for Nitrogen containing fertilizers?[3]

- Sometimes more injury than estimate based on salt content alone
  - NH_3 – Toxic to plant tissue, moves freely through cell walls
- Urea, UAN, ammonium thiosulfate and DAP can cause more damage from NH_3 toxicity than MAP, ammonium sulfate, and ammonium nitrate
- Moderate alkaline soil conditions promote NH_3 production
  - In bulk soil
  - Caused by reaction of the fertilizer

How does Ammonia harm the seeds?

Nitrogen fertilizers that contain or convert to the NH4+ form can convert to ammonia gas in pores of the soil under certain conditions. Lower soil pH and dry conditions can increase the risk of root damage due to ammonia.

SALT INDEX - N FERTILIZERS

Material and Analysis (N-P_2O_5-K_2O-S)	Salt Index per equal weights of materials	Salt Index per unit of nutrients†
Ammonia, 82-0-0-0	47.1	0.572
Ammonium nitrate, 34-0-0-0	104.0	3.059
Ammonium sulfate, 21-0-0-24	68.3	3.252
Ammonium thiosulfate, 12-0-0-26	90.4	7.533
Urea, 46-0-0-0	74.4	1.618
UAN, 28-0-0-0 (39% AN, 31% urea) 32-0-0-0 (44% AN, 35% urea)	63.0 71.1	2.250 2.221

* Reproduced from Mortvedt (2001).
† One unit equals 20 lb.

Table 1: SI for N Fertilizers[3]

Salinity is of greatest concern in soils that are:

- Irrigated with water high in salts
- Poorly drained, allowing for too much evaporation from the soil surface
- Naturally high in salts because very little salt leaches out
- In areas where the water table (the level or depth to free-flowable water in the soil) is shallow
- In seepage zones, which are areas where water from other locations (normally up slope) seep out.[7]

WATER MOVEMENT INFLUENCED BY SALT CONTENT

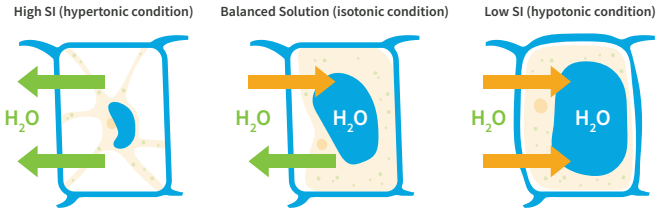

Fig. 5: Water will exit across the cell membrane when a solution placed on it has a higher salt concentration than that within the cell. The resulting shrinkage may damage the cell. [6]

Fig. 6: When in equilibrium, water will move in both directions across the cell membrane. [6]

Fig. 7: Water will enter across the cell membrane when a solution placed on it has a lower salt concentration than that within the cell. The resulting swelling may damage the cell. [6]

Toxic Effects of Salts: The Plant Guy

For answers, we have to go back to osmosis. The key to osmosis is the presence of a semipermeable membrane, which allows water to pass through it, but NOT dissolved solutes, especially salts. All living cells, including plant cells, are surrounded by semipermeable membranes.

Salts absorb and bind tightly with water, preventing roots from absorbing water. The salt can even pull water from the plant, creating a drought-like condition. At higher concentrations, sodium will compromise the absorption of essential nutrients such as calcium, magnesium, and potassium.

In addition to the osmotic effects on plants, the second problem when most plants are exposed to high salinity conditions (e.g., saline soils) is that sodium, and certain other ions, are toxic to plants when their concentrations are relatively high.

Despite the semipermeable membranes, under high salinity conditions, sodium chloride and other dissolved salts can leak into the cells.

Abnormally high amounts of Na+ and high concentrations of total salts can inactivate some enzymes and inhibit protein synthesis.

At a high concentration, Na+ may displace calcium ions (ca++) from the cell membranes, causing them to become “leaky,” that is, to lose their semipermeable nature. This can have disastrous, even lethal, effects on plant cells. Photosynthesis is also inhibited when high concentrations of Na+ and/or Cl- accumulate in chloroplasts.[8]

How does SUL4R-PLUS® fertilizer interact with roots?

With a salt index of 5 to 8, the direct root contact with calcium sulfate is safe and makes the plant thrive. There is no root burn as indicated in the picture to the right.

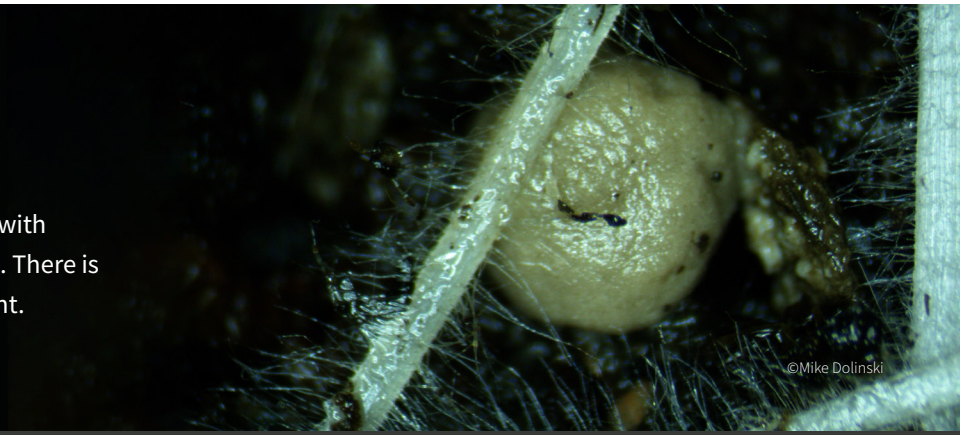

Fig. 8: SUL4R-PLUS® with Wheat 7 Days[4]

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Sources and Excerpts

1. Fertilizer Salt Index, Fact Sheet No. 15, (05/2002) A&L Great Lakes Laboratories
2. Fluid Journal, Vol. 9, No. 2, Issue 33. Calculating Salt Index. John Mortvedt.
3. Understanding Salt Index of Fertilizers. Carrie Laboski, Department of Soil Science, University of Wisconsin-Madison
4. © by Mike Dolinski, Taurus Ag (March 2019)
5. The effect of ammonia on germination and development of seedlings in soil. (1970) Martin David Openshaw, Iowa State University
6. Diagram from Wikipedia
7. Texas A&M Agilife Extension, Managing Soil Salinity, E-60 3-12. Tonu Provin and J.L. Pitt, Texas A&M University. http://soiltesting.tamu.edu/publications/E-60.pdf
8. How Salt Stresses Plants (Or Not), The Plant Guy https://www.howplantswork.com/2013/01/31/how-salt-stresses-plants-or-not/

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