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Calculating Salt Index

Salt content is one of the most critical characteristics of fertilizers that should be considered when fertilizers are applied, especially with seed-row or "in furrow" placement.

Summary: Salt index (SI) of a fertilizer is a measure of the salt concentration that fertilizer induces in the soil solution. SI does not predict the exact amount of a fertilizer material or formulation that could produce crop injury on a particular soil, but it does allow comparisons of fluid formulations regarding their potential salt effects. As we all know, placement of some formulations in or near the seed may decrease seed germination or result in seedling injury.

Fluid fertilizers containing potassium phosphate as the source of K have lower SI values than those containing KCl. When applied near the seed, fertilizers with lower SI values generally cause fewer problems in seed germination or seedling injury. SI of any fluid formulation can be calculated using the SI values of the most common fertilizer sources. Dealers or growers then can select those formulations with lower SI values that best fit their needs.

Banding of nutrients has received much attention over the years. Usually, the fertilizer is placed at a depth greater than that of the seed to allow root interception of the fertilizer band as roots grow outward and downward in the soil.

Band vs broadcast

Regions showing the greatest improvement in efficiency from banding over broadcasting lie in the northern U.S. and Canada, where colder soil conditions are experienced during spring seeding of row crops and small grains. Higher P rates are generally recommended if growers broadcast instead of band their fertilizers.

Banded P tends to be more efficient on very acid soils, highly calcareous soils, and those soils with very low levels of available soil P. Band applications also are usually more efficient when low P application rates are used.

Early planting dates, large amounts of crop residues on the soil surface, and soil compaction may subject plants to more stress. Banded nutrients are usually more effective for crops under these stress conditions. Vegetables respond well to banded fertilizers because they require a relatively large percentage of their total nutrients early in their growth period, and their rooting volume in the soil usually is restricted.

As extra equipment has been installed on planters over the years, it has become more difficult to have enough room to include the coulters required to open the soil for fertilizer placement below and to the side of the seed row. Some growers have quit applying starters because of this limitation and also because of the weight of openers for very large planters. Others have applied starters directly to the seed furrow, which does not require extra openers.

Other considerations. Banding away from the seed row is recommended over seed-row application under most conditions when applying higher nutrient rates, especially N, K, and S. Plants can efficiently use nutrients banded away from the seed row without adversely affecting seed germination or seedling emergence.

Recommendations for fertilizer placement in direct seed contact vary with crop. For many years maximum recommendations ranged from 10-20 lbs/A of N + K_2O in direct seed contact with corn and sorghum. These applied to formulations using KCl as the K source and would not be accurate if potassium phosphate was used as the source of K instead of KCl. This is because of the lower SI value of potassium phosphate compared with KCl (Table 1).

Crop tolerance to increased osmotic pressures (salt content) of the soil solution in the vicinity of the seed varies considerably. For example, wheat is more tolerant of high salt conditions than is grain sorghum, while corn is intermediate. Tolerance of most oil-seed crops (soybeans and cotton) to seed-row application of nutrients is very low, and seed-row application of fertilizer for these crops should be viewed with caution.

Fluid fertilizers may produce a lower osmotic pressure in the soil solution than granular products of a similar grade. Fewer problems generally are encountered using fluids as seed-row fertilizers when compared to granular, since less soil water is required and salts are mainly dissolved in fluid formulations.

Seed-row application

This method refers to placement of relatively lower rates of nutrients in direct seed contact, usually for row crops. It also has been called "pop-up" or "in-furrow" application, but "seed-row" is more descriptive. Seed-row placement increases the possibility of early root interception by nutrients.

Problems. Major concern of this practice is decreased seed germination or seedling injury caused by high salt concentrations in the soil solutions around germinating seeds.

Also, some starter components such as urea, UAN, or ammonium thiosulfate can produce free ammonia (NH_3) under certain soil conditions. Direct seed contact by NH_3 could result in poor germination or seedling death. Selection of the proper starter fertilizer is the way to minimize this occurrence.

Fertilizers best suited for seed-row application have 1) low salt index, 2) high water solubility, 3) contain N, P, K and S, with relatively high P content, 4) contain both urea and ammonium-nitrogen, 5) minimize content of compounds that liberate NH_3, and 6) use potassium phosphate instead of KCl as the K source.

Salt index

Salt content is one of the most critical characteristics of fertilizers used for row-seed placement. The SI is a measure of the salt concentration that fertilizer induces in the soil solution.

The SI of a material is expressed as the ratio of the increase in osmotic pressure of the salt solution produced by a specific fertilizer to the osmotic pressure of the same weight of $NaNO_3$, which is based on a relative value of 100. Sodium nitrate was chosen as the standard because it was 100 percent water soluble and it was a commonly used nitrogen fertilizer when the SI concept was first proposed in 1943. Higher analysis fertilizers usually have a lower SI because fewer ions of salts are placed in the soil solution per unit of plant nutrient when they dissolve.

Note that the N and K materials of commonly used fertilizers (Table 1) have higher SI values than those of P materials. The SI of a mixed formulation containing N, P, and/or K is the sum of the SI values of its components. Although the total SI for a high-analysis NPK mixture may be greater than that for a low-analysis NPK mixture, the SI per unit of plant nutrients may be lower in the high-analyses product. Therefore, the lower fertilizer rate needed to supply the same amount of plant nutrients subjects the germinating seeds to less potentially adverse salt effects.

It should be noted that the SI *does not* predict the exact amount of fertilizer material or a fertilizer formulation that could produce crop injury on a particular soil. However, it does compare one fertilizer formulation with others regarding the osmotic (salt) effects. It also shows which fertilizers (those with a higher SI) will be most likely to cause injury to germinating seeds or seedlings if placed close to or in the seed row.

Calculating salt index

The SI of a mixed fertilizer (NPKS) is the sum of the SI of each component per unit of plant nutrient times the number of units in that component. See Table 2 for SI calculations of 7-21-7.

To calculate SI of any formulation:

1. List the material, grade, and weight for each component in columns 1-3.
2. Determine nutrient units in columns 4-6 by multiplying the weight of each component by its nutrient content and dividing each result by 20.
3. List SI per plant nutrient unit in each component in column 7.
4. Determine the SI due each component by multiplying the sum of the nutrient units in columns 4-6 times the corresponding SI value in column 7.

Table 1. Salt index values of fertilizer materials.

	———Salt Index———	
	Per equal wts of materials	Per unit of nutrients*
Material and analysis		
Nitrogen/Sulfur		
Ammonia, 82%N	47.1	0.572
Ammonium nitrate, 34%N	104.0	3.059
Ammonium sulfate, 21%N, 24%S	68.3	3.252
Ammonium thiosulfate, 12%N, 26%S	90.4	7.533
Urea, 46%N	74.4	1.618
UAN, 28%N (39% a. nitrate, 31% urea)	63.0	2.250
32%N (44% a. nitrate, 35% urea)	71.1	2.221
Phosphorus		
APP, 10%N, 34%P_2O_5	20.0	0.455
DAP, 18%N, 46%P_2O_5	29.2	0.456
MAP, 11%N, 52%P_2O_5	26.7	0.405
Phosphoric acid, 54%P_2O_5		1.613[a]
72%P_2O_5		1.754[a]
Potassium		
Monopotassium phosphate, 52%P_2O_5, 35%K_2O	8.4	0.097
Potassium chloride, 62%K_2O	120.1	1.936
Potassium sulfate, 50%K_2O, 18%S	42.6	0.852
Potassium thiosulfate, 25%K_2O, 17%S	68.0	2.720

[a] Salt index per 100 lbs of H_3PO_4 *One unit equals 20 lb.

Table 2. Calculating salt index of 7-21-7.

						—Salt index—	
	%			Nutrient units		per unit	in for-
Material	Nutrient	lbs/ton	N	P_2O_5	K_2O	(20 lb)[a]	mulation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10-34-0	10%N, 34%P_2O_5	1,235	6.2	21.0	—	0.455	12.4
UAN	28%N	57	0.8	—	—	2.250	1.8
KCl	62%K_2O	226	—	—	7.0	1.936	13.6
Water		482	—	—	—	—	—
		2,000	7.0	21.0	7.0		27.8[b]

[a] Salt index per unit (20 lb) of plant nutrients, listed Table 1, also called the partial salt index.
[b] 0.79 SI/unit plant nutrient

5. Total individual SI values of all components in column 8.

SI values for a 6-24-6 formulation containing potassium phosphate are shown in Table 3. Phosphoric acid is first ammoniated to a 1-3-0 ratio, which results in an approximate 50-50 mixture of MAP and DAP at about pH 6.8. Potassium phosphate is then added to provide all of the K and remainder of the P. Resulting SI of this grade and SI per unit of plant nutrients are much lower than those for 7-21-7, which contained KCl.

Other points to consider are:

When K_2SO_4 is used instead of KCl, the SI is somewhat lower. However, the solubility of K_2SO_4 is lower than that of KCl, so this must be considered in producing formulations relatively high in K_2O.

SI values of acids are given as values per 100 lbs of acid rather than a unit of 20 lbs. Also, the SI of H_3PO_4 varies with P concentration of the acid.

SI values calculated differ for formulations when ammoniated phosphate solutions are prepared. SI per unit of N due to the ammoniating solution is not included because its contribution has already been accounted for in the SI per 100 lbs of H_3PO_4, since it has been converted to ammonium phosphate. The same method is used for calculating the SI of ammoniated H_2SO_4 formulations.

SI values and SI per plant nutrient of some commonly used liquid formulations are listed in Table 4. Note that all formulations containing potassium phosphate have relatively low SI values. The two formulations containing KCl (7-21-7 and 4-10-4) have much higher SI values and are not suggested for use in seed-row placement. These results show that SI of fluid fertilizers varies significantly, depending on the grade and components in the formulation.

Table 3. Calculating salt index of 6-24-6.

Material	% Nutrient	lbs/ton	Nutrient units N	Nutrient units P_2O_5	Nutrient units K_2O	—Salt index— per unit (20 lb)[a]	—Salt index— in formulation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NH_3	82%N	146	6.0	—	—	—[b]	—
H_3PO_4	54%P_2O_5	666	—	18.0	—	1.613	10.7
Potassium phosphate	22%K_2O, 22%P_2O_5	546	—	6.0	6.0	0.097	1.2
Water		642	—	—	—	—	—
		2,000	6.0	24.0	6.0		11.9[c]

[a] Salt index per unit (20 lb) of plant nutrients, listed in Table 1, also called the partial salt index.
[b] Ammoniation of phosphoric acid to a 1-3-0 ratio forms a mixture of MAP and DAP.
[c] 0.32 SI/unit plant nutrient.

Table 4. Salt index of some common liquid formulations.

Formulation	Salt index	Salt index per unit of plant nutrient (20 lb)
2-20-20[a]	7.2	0.17
3-18-18[a]	8.5	0.22
6-24-6[a]	11.5	0.32
6-30-10[a]	13.8	0.30
9-18-9[a]	16.7	0.48
10-34-0[b]	20.0	0.45
7-21-7[c]	27.8	0.79
4-10-10[c]	27.5	1.18
28%UAN[c]	63.0	2.25

[a] These grades are formulated using potassium phosphate as the K source.
[b] Use in seed-row placement with caution.
[c] Not suggested for use in seed-row placement.

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