Currently Used Salt Index Tables are Misleading

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Abstract

In the 1940s, fertilizer materials that were available at that time were evaluated for changes that occurred in the soil solution osmotic pressure upon application. The term “Salt Index” was then used to compare the increase in osmotic pressure for 45 fertilizer materials against the same weight of sodium nitrate. During the 1950s a simplified laboratory method was developed where salt index was measured by electrical conductance rather than by osmotic pressure. Data derived from the laboratory method does not correlate with the earlier soil applied application, with the laboratory evaluation giving a significantly higher Salt Index number. Fertilizer materials, especially liquids like UAN (urea ammonia nitrate solution), APP (ammonium polyphosphate), ATS (ammonium thiosulfate), KTS (potassium thiosulfate) and CN-9 (calcium nitrate solution) were not available until after the original study. However, data from these materials have been added to the data from the original study in fertilizer Salt Index reference tables being used today. Industry claims for fertilizer materials related to a low Salt Index for seedling safety or foliar application are inappropriate. Soil, weather and crop condition like soil type, moisture and temperature, as well as rate of application and method of application, have more to do with safety than the Salt Index number.

Introduction

The current salt index tables in some major fertilizer reference publications are misleading. These tables have combined data from an original study conducted in the 1940s based on osmotic pressure with a method now used by some laboratories to measure salt index based on electrical conductivity.

Rader et al. (1943) reported salt index values for 45 fertilizer materials based on the osmotic pressure of the soil solution when applied to Norfolk sand. This method involved mixing fertilizer materials with air-dried soil and then spraying with water to bring the moisture content to 75% of its moisture equivalent. After 5 days, the soil solution was removed and evaluated for conductivity and freezing point. The freezing-point lowering values were then converted to osmotic pressure by tables developed for vegetable saps. A salt index value was then expressed relative to the increase in osmotic pressure as compared with that obtained with the same weight of sodium nitrate.

Fertilizer materials evaluated in this original study primarily involved dry materials available in the 1940s. Three nitrogen (N) solutions were evaluated, but these were not UAN (urea ammonium nitrate solution) because the N content ranged from 37% to 40.8%. Fertilizer materials developed after the 1940s, like UAN, ATS (ammonium thiosulfate), APP (ammonium polyphosphate), KTS (potassium thiosulfate), CaTs (calcium thiosulfate), CN-9 (calcium nitrate solution), etc., were not available for evaluation.

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A laboratory method was later published by Jackson (1958) where salt index of a fertilizer was measured by electrical conductance relative to sodium nitrate. Several laboratories have used this method in recent years to evaluate new materials.

Many references, such as the *Crop Protection Handbook*, and *Western Fertilizer Handbook* now publish salt index tables that combine values from both methods.

Comparisons of Methods

Murray and Clapp (2004) compared several potassium sources for salt index values as determined by the Jackson method with the original data published by Rader.

As noted in Table 1, salt index values from the two methods do not correlate. Some minor differences are noted in the K_2O concentration because Rader used chemically pure material for potassium sulfate and potassium nitrate. In this study, a soluble grade of potassium chloride (62% K_2O) was used, whereas, Rader evaluated 60% K_2O grade. Values from the Jackson method are higher than those from the Rader study. These higher values range from 28.6% for potassium chloride to 141.2% for potassium sulfate. Potassium thiosulfate was not available when the Rader study was conducted.

Table 1. Salt Index values for some K Sources from the Jackson and Rader methods and those being reported in *Crop Protection Handbook* (CPH) and *Western Fertilizer Handbook* (WFH).

K source	Rader	Jackson*	CPH	WFH
K chloride	116.3	149.6	116.2	116.3
K sulfate	46.1	111.2	42.6	46.1
K nitrate	73.6	97.6	69.5	73.6
S of Potash-magnesia	43.2	64.8	43.4	43.4
K thiosulfate	-	63.2	68.0	64.0

* Determined by Southern Environmental Testing, Florence, Alabama

Seedling Safety

Some references have been made using the salt index value of a fertilizer to indicate seedling safety, especially for direct placement with the seed. However, other factors like crop and soil type, soil moisture and temperature, and fertilizer rate and placement have a greater influence on seedling safety than the salt index value.

Data from a recent three-year study in Minnesota illustrates that soil temperature has a major influence on seedling survival and yield in a starter fertilizer placement study for corn (Randall and Vetsch 2005-2007). Placement of a starter NPKS fertilizer in the seed zone resulted in no significant reduction in plant populations for two of the three years of the study when soil temperatures were in the 56^0F to 60^0F range, but reduced the population by 32.5 percent when the temperature was 48^{0}F (Table 2).

Table 2. Influence of a starter NPKS fertilizer on corn stands and yield.

	N-P_2O_5-K_2O-S (lbs/A)	2004	2005	2006
Soil temperature-^{0}F		56	48	60
Days to Emergence		8	15	-
Plant Population-10^3/A	0-0-0-0	33.6	33.5	34.1
	6-20-6-4	33.3	22.6	32.9
Yield-bu/A	0-0-0-0	181.7	166.5	209.2
	6-20-6-4	198.9	145.1	215.4

New Method for Evaluation

Salt index values have been used to indicate the safety of a fertilizer material to crop foliage. For example, in the CPH the salt index of UAN-28 is lower (63.1) than Urea (74.4), but when applied to crop foliage a urea solution is much safer than UAN.

Recently, Murray et al. (2007) published information on a new method to evaluate fertilizer materials for potential foliage injury. The laboratory method involves vapor pressure osmometry where values are expressed as mmol kg^{-1} with lower values indicating lower potential injury. Osmolality values as compared to the Rader salt index value for some fertilizer materials are noted in Table 3. These values do not correlate with the salt index values, but were found to correlate with potential turf injury as summarized in Table 4.

Table 3. Osmolality values in comparison to Salt Index values for select fertilizer materials.

Material	SI*	Os (mmol kg^{-1}) **
Ammonium nitrate	104.0	1804
Sodium nitrate	100.0	4092
Urea	74.4	1018
UAN-28	64.6	1439
Potassium nitrate	69.5	3434
Ammonium sulfate	68.3	2314

Diammonium phosphate	29.2	2054

*Salt Index values from *Crop Protection Handbook*, ** Osmolality values determined by Southern Environmental Testing, Florence, Alabama .

Table 4. Osmolality value for select N fertilizers and potential turf injury.

N Source	Os (mmol kg^{-1})*	Burn Rating**
N-SURE	568	8.5
NBN	715	7.2
Nitro-30	796	7.3
Urea	1032	6.3
UAN-32	1423	5.7
Ammonium nitrate	1450	4.4
	R^2 – 0.865	

*Osmolality values determined by Southern Environmental Testing, Florence, Alabama. **Rating scale 1 to 9 with 6 or below being unacceptable injury level.

Summary

Current salt index reference tables are not accurate because values expressed for new fertilizer materials, especially liquids developed after 1943 were evaluated by a different method (Jackson) than the original study (Rader). The two methods are not compatible since the Jackson method gives a significantly higher value than the Rader method. When salt index values from the two methods are combined in the same reference table, new materials are at a disadvantage in relation to the older materials because of the higher index value.

A new system such as Vapor Pressure Osmometry has potential for use in predicting injury for a foliar application of fertilizer materials. At the very least, materials should be evaluated under the same conditions, such as the Jackson method.

References

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