Regional Soil Tests to Evaluate Coastal Field Salinity

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Soil Tests for Salinity Diagnosis

Saltwater intrusion from sea level rise and tidal flooding is increasing soil salinity risks in coastal farm fields (Figure 1). Soil salinity is related to the presence of soluble salts and cations (positively charged ions) like sodium (Na), calcium (Ca), magnesium (Mg), and to a lesser extent, potassium (K). Excess soil salinity can reduce crop yields, damage soil structure, and disrupt nutrient availability.

Figure 1: Flooding along a coastal tidal wetland into an agricultural field is reducing crop growth on Delmarva.

The **saturated paste (SP)** extraction method is the standard test used for measuring soil salinity. This extraction targets cations in the soil solution that would be immediately available to plants. To classify soils and predict crop response, the electrical conductivity (EC_e) and sodium absorption ratio (SAR) from the SP are used. However, the SP test is not routinely available in the Eastern U.S. This factsheet introduces a practical alternative to the SP to assess soil salinity—using sodium (Na) levels from the **Mehlich-3 (M3)** soil test to estimate salinity and sodicity.

Routine Agronomic Soil Tests in the Mid-Atlantic

Several soil tests, such as M3, Mehlich-1, Bray-1 (for P only), and ammonium acetate (for Ca, K, and Mg) are routinely available to growers in the Mid-Atlantic to assess soil fertility. The M3 is the most common routine agronomic soil test in the region. The M3 test uses a mixture of weak acids, salts, and chelating agents to extract nutrients from the soil. The M3 test is designed to measure nutrients (Ca, Mg, K) present in the soil solution and also nutrients that are bound to soil particles, including those held on the cation exchange capacity (CEC). The M3 test will also extract micronutrients like iron (Fe), boron (B), copper (Cu), and zinc (Zn).

However, determining excess salinity presents a different issue than assessing soils for routine soil fertility—salinity involves a high concentration of soluble salts and cations in the soil pore water and held on exchange sites. Plus, diagnosing soil salinity requires measurement of Na, which is not a required plant nutrient. As previously mentioned, the SP test, which targets cations in the soil solution, is the preferred test for assessing soil salinity. However, the M3 test also targets nutrients bound to soil particles. As such, the M3 test may offer a viable option for identifying salt-affected soils if analysis is expanded to include measurement of Na, especially when Na buildup is the main cause of soil salinity.

Classifying Soil Salinity

Soil salinity classifications are typically based on SP-based **EC_e** and **SAR**, as well as the exchangeable sodium percentage (**ESP**) derived from an ammonium acetate extraction (Table 1). Salinity can be based on an $EC_e > 4$ dS m^{-1}, while sodicity can be observed when SAR > 13 $mmol_c$ L^{-1}. For more information about traditional soil salinity classifications, refer to *Salt Measurements and Soil Classifications* (available at http://www.udel.edu/0013558).

Table 1. Classification of salt-affected soils in the USA saturated paste by electrical conductivity (ECe), sodium absorption ratio (SAR), exchangeable sodium percentage (ESP), and pH.

Class	**ECe (dS cm^{-1})**	**SAR** mmol$_c$ L^{-1}	**ESP (%)**	**pH$_e$**
Non Saline	< 4.0	< 13	< 15	< 8.5
Saline	> 4.0	< 13	< 15	< 8.5
Sodic	< 4.0	> 13	> 15	> 8.5
Saline-Sodic	> 4.0	> 13	> 15	< 8.5

In the absence of SP testing, Mehlich-3 Na can be used to estimate both EC_e and SAR. We can estimate EC_e from M3- Na (ppm or mg kg^{-1}) using the following equation:

$$\mathbf{EC_e} = (0.0048 \times \text{M3-Na}) + 0.068$$

To estimate SAR, we must evaluate how Na concentrations compare to the other cations in the soil. For this we use the sodium cation ration (SCR), which uses extracted elements from M3 extraction in $cmol^+$ kg^{-1} in this equation:

$$\mathbf{SCR\ (\%)} = \left(\frac{\text{Na}}{\text{Ca} + \text{Mg} + \text{K} + \text{Na} + \text{Acidity}}\right) \times 100$$

Then we calculate SAR using the following equation:

$$\mathbf{SAR} = (0.46 \times \mathbf{SCR}) + 0.55$$

The estimated ECe and SAR values can then be used to classify soil salinity issues. Based on the above calculations, an EC_e of 4 corresponds to a M3-Na concentration of 800 mg kg $soil^{-1}$. Similarly, a SCR of 27% corresponds to a SAR of 13. To facilitate salinity classification, we list the M3-Na and SCR values that correspond with soil salinity classifications (Table 2). We have added a transitional classification, where soils may be exhibiting saline or sodic conditions. Keep in mind that this table refers to soil quality and remediation, and that reduced crop growth can occur at lower Na concentrations than 500 mg kg^{-1} Na.

*Table 2. Mehlich-3Na (**ppm or mg kg^{-1}**) and SCR values that correspond to soil salinity classifications.*

Soil Class	**Na (mg kg^{-1})**	**SCR (%)**
Non Saline	< 500	< 17
Transitional	500 – 800	17 – 27
Saline	≥ 800	< 27
Sodic	< 800	≥ 27
Saline-Sodic	≥ 800	≥ 27

Using Mehlich-3 to Convert to EC_e and Predict Crop Response

The EC_e is also used to predict the potential effects of coastal soil salinity on soil quality and crop growth. Table 3 presents M3-Na concentrations (expressed in mg kg^{-1} or ppm) that can be used to estimate crop stress. These values are preliminary based on research using the SP test for salinity interpretation. We offer these interpretations as a guide as they need to be evaluated in the field to determine their accuracy. Site-specific factors like soil texture, drainage, and crop variety will also influence crop response to salinity. Low lying coastal fields may have interactions between flooding and salinity that reduce yields beyond just Na concentrations. However, these can be used as a starting point.

*Table 3. Approximate soil Mehlich-3 sodium (M3-Na - ppm or mg kg^{-1}) concentrations that **may** affect crop growth and yield when based on a threshold ECe.*

Crop	EC_e (dS m^{-1})	M3-Na (mg kg^{-1})
Orchardgrass	1.5	~299
Corn	1.7	~340
Alfalfa	2.0	~402
Tomato	2.5	~507
Asparagus	4.1	~840
Soybean	5.0	~1027
Wheat	6.0	~1,235
Sorghum	6.8	~1,402
Cotton	7.7	~1590
Rye (cereal)	11.4	~2361

Summary

The M3 soil test, commonly used to assess routine soil fertility in the eastern U.S., provides an alternative approach for estimating Na-related salinity issues and crop stress. By using M3-Na and calculated SCR, it is possible to screen soils for salinity and sodicity risk. While these indicators do not replace EC_e or SAR measurements, they offer a practical, field-friendly tool for identifying problem areas and guiding management decisions. Ultimately, soil test interpretations should be verified with field observations and used alongside crop performance and site conditions to inform long-term soil and nutrient management.

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References

Pokhrel, S, Blew, W., Miller, J.O., and Shober, A.L. (2025). Evaluating routine agronomic soil tests for coastal soil salinity detection in the Mid-Atlantic, *Soil Science Society of America Journal*, *89,* e70075. https://doi.org/10.1002/saj2.70075

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