1.0 SCOPE

1.1 The Mehlich 3 soil test was developed by Mehlich in 1984 as an improved multi-element extractant for P, K, Ca, Mg, B, Na, Mn, Cu, Fe, and Zn (Mehlich, 1984). The Mehlich 3 test is used throughout the United States and Canada because it is well suited to a wide range of soils, both acidic and basic in reaction. The Mehlich 3 is similar in principle to the Bray and Kurtz P-1 test because it is an acidic solution that contains ammonium fluoride. Acetic acid in the extractant also contributes to the release of available P in most soils. A Mehlich 3 value of 45-50 mg P/kg soil is generally considered to be optimum for plant growth and crop yields, higher than the critical values used for other standard soil P tests such as the Bray and Kurtz P-1, Mehlich 1, and Olsen P.

2.0 DEFINITIONS

2.1 Laboratory Control Sample: The laboratory control sample is an intralaboratory developed sample whose true Mehlich 3 value is approximated by the average of repeated measures.

2.2 Duplicate Samples: A duplicate test involves splitting a sample to sub-samples and processing each through the same sample preparation procedure in order to determine the precision of the method.

2.3 Preparation Blank: The Preparation Blank is a sample that contains only the reagents used in the extraction procedure. The preparation blank undergoes the same procedure as other samples and therefore gives an indication of any contamination picked up during the sample preparation process.

2.4 ICP-AES: Inductively Coupled Plasma-Atomic Emission Spectrometry.

3.0 EQUIPMENT AND SUPPLIES

3.1 Automatic extractant dispenser, 10 mL capability

3.2 pH Meter accurate to 0.05 units

3.3 Laboratory Balance: Any laboratory balance accurate to within ± 0.01 grams may be used (all weight measurements are to be within ± 0.01 grams)

3.4 Extraction vessels, 50ml disposable cups

3.5 ≥18 MΩ deionized water (DI).
Standard Operating Procedure
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Version 13

3.6 Rotating shaker with a capability of 150 excursions per minute (epm)

3.7 12 ml syringes equipped with 0.45um nylon filters.

3.8 15ml Falcon tubes.

3.9 ACS grade Ammonium fluoride (NH4F)

3.10 EDTA [(HOOCCH2)2NCH2CH2N (CH2COOH)2]

3.11 ACS grade Ammonium nitrate (NH4NO3)

3.12 Glacial acetic acid

3.13 Trace metal grade HNO3

4.0 PROCEDURE

4.1 Mehlich 3 Extracting Solution Preparation: (0.2 M CH3COOH, 0.25 M NH4NO3, 0.015 M NH4F, 0.013 M HNO3, 0.001 M EDTA [(HOOCCH2)2NCH2CH2N (CH2COOH)2].
   4.1.1 Add 1000mL of distilled water to a 2 L volumetric flask.
   4.1.2 Add 40 g of ammonium nitrate (NH4NO3) in the distilled water.
   4.1.3 Add 1.11g of ammonium fluoride (NH4F).
   4.1.4 Add 0.585g EDTA.
   4.1.5 Add 23 mL glacial acetic acid (99.5%, 17.4 M).
   4.1.6 Add 1.6 mL of concentrated nitric acid (HNO3, 68 to 70 %, 15.5 M).
   4.1.7 Add distilled water to 2 L final volume and mix well (enough extractant for 200 samples), final pH should be 2.5 ± 0.1.
   4.1.8 Check blank and blank filtered solution on ICP prior to analysis. P concentration should be < 0.05 mg/L.

4.2 Weigh 1.00g of soil into extraction cup.

4.3 Calibrate pH meter and record result in Appendix.

4.4 Check extraction solution pH at time of extraction and record in Appendix.

4.5 Check bottle top dispenser calibration with DI water and record results in Appendix.

4.6 Add 10ml of extraction fluid in batches of six samples.
4.7 Shake at 150 or more⁸ epm for five minutes at a room temperature at 24 to 27 °C.
Standard Operating Procedure
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4.7.1 The rotation speed should be maintained at an rpm that provides vigorous swirling.

4.8 Remove from shaker and immediately 0.45um glass filter (nylon) at least 5ml into falcon tubes.
4.8.1 Rapid filtration is required to limit the extraction time to 5 minutes.

5.0 Estimated CEC for soils with pH <7.2 per Sikora and More 2014
5.1 CEC is estimated by summation of cations extracted by Mehlich 3.

6.0 Base Saturation per Sikora and Moore 2014
6.1 Base saturation (%) = (Ca + Mg + K + Na) ÷ CEC x 100
   6.1.1 Exchangeable Ca (cmolc kg⁻¹) = Extractable Ca (mg kg⁻¹) ÷ 200
   6.1.2 Exchangeable Mg (cmolc kg⁻¹) = Extractable Mg (mg kg⁻¹) ÷ 120
   6.1.3 Exchangeable K (cmolc kg⁻¹) = Extractable K (mg kg⁻¹) ÷ 390
   6.1.4 Exchangeable Na (cmolc kg⁻¹) = Extractable Na (mg kg⁻¹) ÷ 230

7.0 QUALITY CONTROL

7.1 Laboratory Control Sample (LCS): The laboratory control sample must fall within ± 20% of the known value.

7.2 Sample Duplicates: The relative percent difference (RPD) must be no more than ±20%.

\[ RPD = 100 \times \frac{(S - D)}{Avg. (S,D)} \]

7.3 Preparation Blank: If any analyte concentration is above the detection limit in the preparation blank, the lowest concentration of the analyte reported in associated samples must be ≥ 10 times the preparation blank concentration.

8.0 REFERENCES


9.0 APPENDIX

Extraction Solution pH day of extraction

Batches completed

Initials/Date

<table>
<thead>
<tr>
<th>Bottletop Dispenser</th>
<th>Calibration</th>
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<tbody>
<tr>
<td>Volume</td>
<td>g DI</td>
</tr>
<tr>
<td>g DI</td>
<td>g DI</td>
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<tr>
<td>g DI</td>
<td>date</td>
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<tr>
<td>initials</td>
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</tbody>
</table>

| Volume              | g DI        |
| g DI                | g DI        |
| g DI                | g DI        |
| g DI                | g DI        |
| date                | initials    |

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<thead>
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<tr>
<td>pH 2 Buffer</td>
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<tr>
<td>pH 4 Buffer</td>
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<tr>
<td>%Slope</td>
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</table>

10.0 INTERPRETATION

10.1 The Mehlich3 extraction was developed for P, K, Mg, Ca, Mn, Fe, Cu, Zn, B, and Na from acid soils, but is applicable to other metals, including Cd, Cu, Ni, and Pb (Mehlich, 1984, Amacher, 1996, Maynard and Kalra, 1993). The Mehlich3 extraction is commonly used to evaluate plant available nutrients. Table 1 shows critical soil test values for several elements (Vitosh, Johnson, and Mengel, 1995).
Table 1. Mehlich3 critical soil test levels for macronutrients P, K, Ca, and Mg, for corn, soybean, wheat, and alfalfa.

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>Soybean</th>
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<tbody>
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