SOIL TEST METHODS ACCURACY AND PRECISION COMPARISON: HISTORICAL NORTH AMERICAN PROFICIENCY TESTING (NAPT) PROGRAM RESULTS

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ABSTRACT

The SSSA-NAPT Program provides open access to soil, water, and plant laboratory data. This data is collected quarterly from about 150 participating laboratories. For soil data, five samples are sent to participant laboratories for them to submit data for any or all of the 99 accepted methods. Our objective was to evaluate data precision from 43 soil samples (2019-2021). A measure of precision was made by dividing the Median Absolute Deviation (MAD) by the Median for each of the 43 samples evaluated for each analyte. The average precision score across all data was 8.3%, with a range from <1% to 34% (21% was the upper end if only including analyses with the minimum of eight laboratories submitting data). Precision for pH was exceptionally good and, in general, carbon and the primary macronutrients had relatively better precision than the secondary macronutrients, micronutrients, etc. These and other data presented aid in understanding precision across laboratories and show that these participating laboratories, on average, are capable of precise analysis; although some methods are inherently better than others. The NAPT database is an excellent open resource for evaluating the quality of data generated by agricultural laboratories.

INTRODUCTION

Soil test data precision helps us understand the value and limitations of this data (https://acsess.onlinelibrary.wiley.com/doi/pdf/10.1002/crso.20048). The Soil Science Society of America (SSSA) has a vast expertise from its over 6,000 member scientists. The North American Proficiency Testing (NAPT) Program is operated as an activity of the SSSA and governed by an oversight committee comprised of some of these experts as representatives of Regional Soil and Plant Analysis Workgroups; Scientific Organizations; State/Provincial Departments of Agriculture; and private and public laboratories (https://www.naptprogram.org/). The NAPT program furnishes laboratories with quality control and quality assurance tools through quarterly statistical evaluation of soil, plant, and water samples. These tools assist laboratories in generating accurate and precise analyses, as well as leveraging their participation in assuring clientele and other consumers that their data meets high standards.

This valuable program, with the collective wisdom and expertise found in the credibility of SSSA, not only provides resources to laboratories, but also to consumers of the data they generate. The aggregated soil, water, and plant data generated by these laboratories is openly available at https://www.naptprogram.org/content/laboratory-results. We have open access to the collective data provided by the lab community, such as that previously explored for plant tissue (https://acsess.onlinelibrary.wiley.com/doi/abs/10.1002/crso.20113). Herein, we provide an assessment for soil analyses.

MATERIALS AND METHODS

From the database described above, a subsample (43 soil samples) from the library of soil data available from various quarters of 2019-2021. A measure of precision for each method was made by dividing the Median Absolute Deviation (MAD) by the Median for each of the 43 samples for each analyte.

RESULTS

These precision scores had an: average = 8.4%, median = 7.3%, standard deviation = 5.5%, and minimum = 0.6% and maximum = 34% (if only including analytes with at least 8 laboratories submitting data, the maximum value is 20%). The median data is shown in Figures 1-4. These values give a sense of the precision of the data generated collectively across labs (note: these are not measures of correlation to any measure of plant response). There is much data to parse in this analysis, which will be the subject of a future, in-depth publication. However, there are some important preliminary points to glean for those using soil analysis in their management.

The combined pH methods were relatively the most precise methods with a median of 1.0% for pH and 0.7% for buffer pH (Fig. 1-top). In general, the measures for nitrogen (N) were reasonably precise (Fig. 1-bottom), with both methods of total N at 5% and all but the saturated paste method for nitrate-N at ~7%. Ammonium-N and the saturated paste nitrate method were relatively imprecise when evaluated across laboratories in this analysis. When evaluating the commonly used (those with $\geq$8 laboratories submitting data) phosphorus (P) methods (Fig. 2-top), the precision scores were again relatively precise with an average score of 7%. All of the potassium (K) methods were relatively precise (Fig. 2-bottom), with an average score of 6%.

With exception of the saturated paste extraction data and the phosphate based sulfur (S) extractant, the secondary macronutrients had reasonable precision at 6% for calcium (Ca) and magnesium (Mg) and 7% for S (Fig. 3-top). The beneficial nutrient sodium (Na) and its measures for sodicity were disappointingly imprecise—ranging from 11-15% (Fig. 3-top). Another non-essential, but important component of soil chemistry, aluminum (Al) had good precision with Mehlich 3 extraction, which is the primarily used method (Fig. 3-top). For the micronutrients (Fig. 3-bottom), the precision was relatively poor with the exception of zinc (Zn) and the Mehlich extractions for iron (Fe), manganese (Mn), and copper (Cu) with a range of 6-8% for these analytes. The DTPA extraction had poorer precision than the Mehlich extractions in every case. The measures for boron (B) and chloride (Cl) were poor, with average precision scores of 14-15%.

The measures for total carbon (C) and its derived "organic matter (OM)" were relatively precise with an average of 4% (Fig. 4-top). The relatively new Solvita soil health test, with an aim of evaluating microbial use of carbon—measuring respiration of carbon dioxide, had very poor precision (Fig. 4-top). The remaining soil tests of cation exchange capacity (CEC), carbonates, salts, and texture were relatively imprecise with scores that were generally in the double digit percentages, although the pipette method of texture had good precision for silt and clay (Fig. 4-bottom).

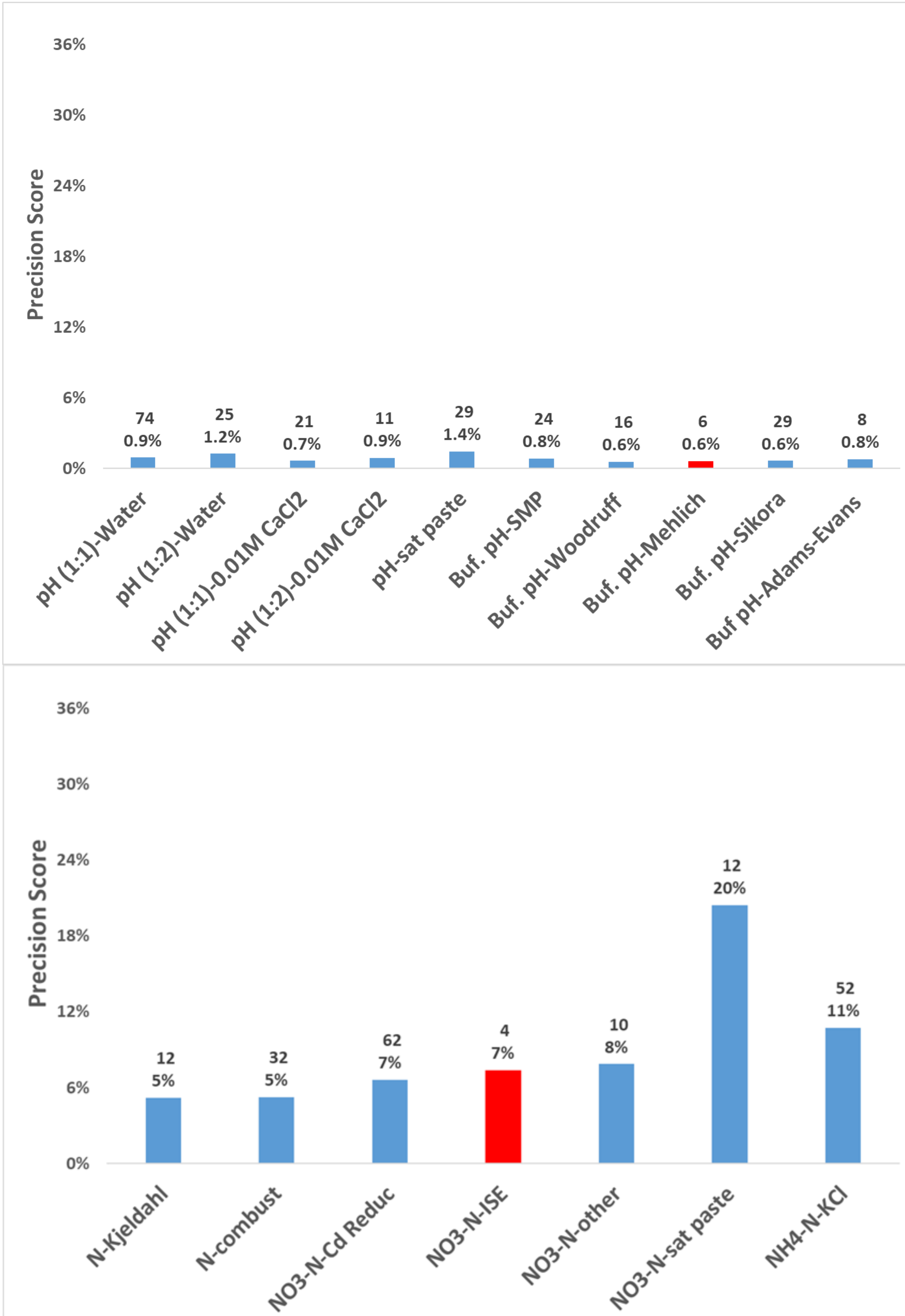

Fig. 1. Precision scores for various soil pH (top) and nitrogen (N) (bottom) analyses calculated from 43 samples tested by participating NAPT laboratories with the median absolute deviation (MAD) divided by the median for each and then averaged for each analyte. Value above the percentage listed at the top of each bar is the number of labs that submitted data for each analyte (those in red signify too few labs to generate statistics within the NAPT program).

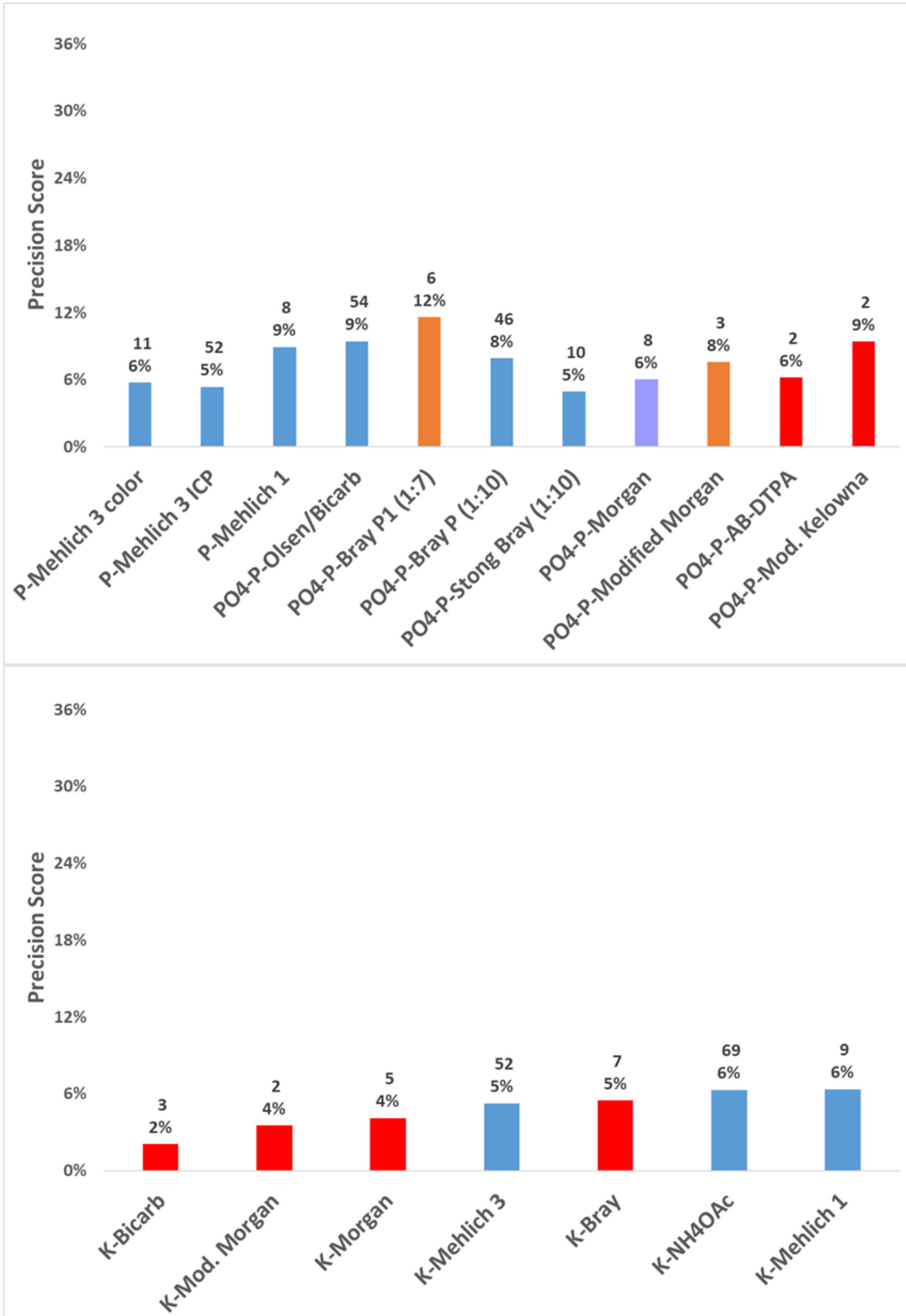

Fig. 2. Precision scores for various soil phosphorus (P) (top) and potassium (K) (bottom) analyses calculated from 43 samples tested by participating NAPT laboratories with the median absolute deviation (MAD) divided by the median for each and then averaged for each analyte. Value above the percentage listed at the top of each bar is the number of labs that submitted data for each analyte (those in red signify too few labs to generate statistics within the NAPT program).

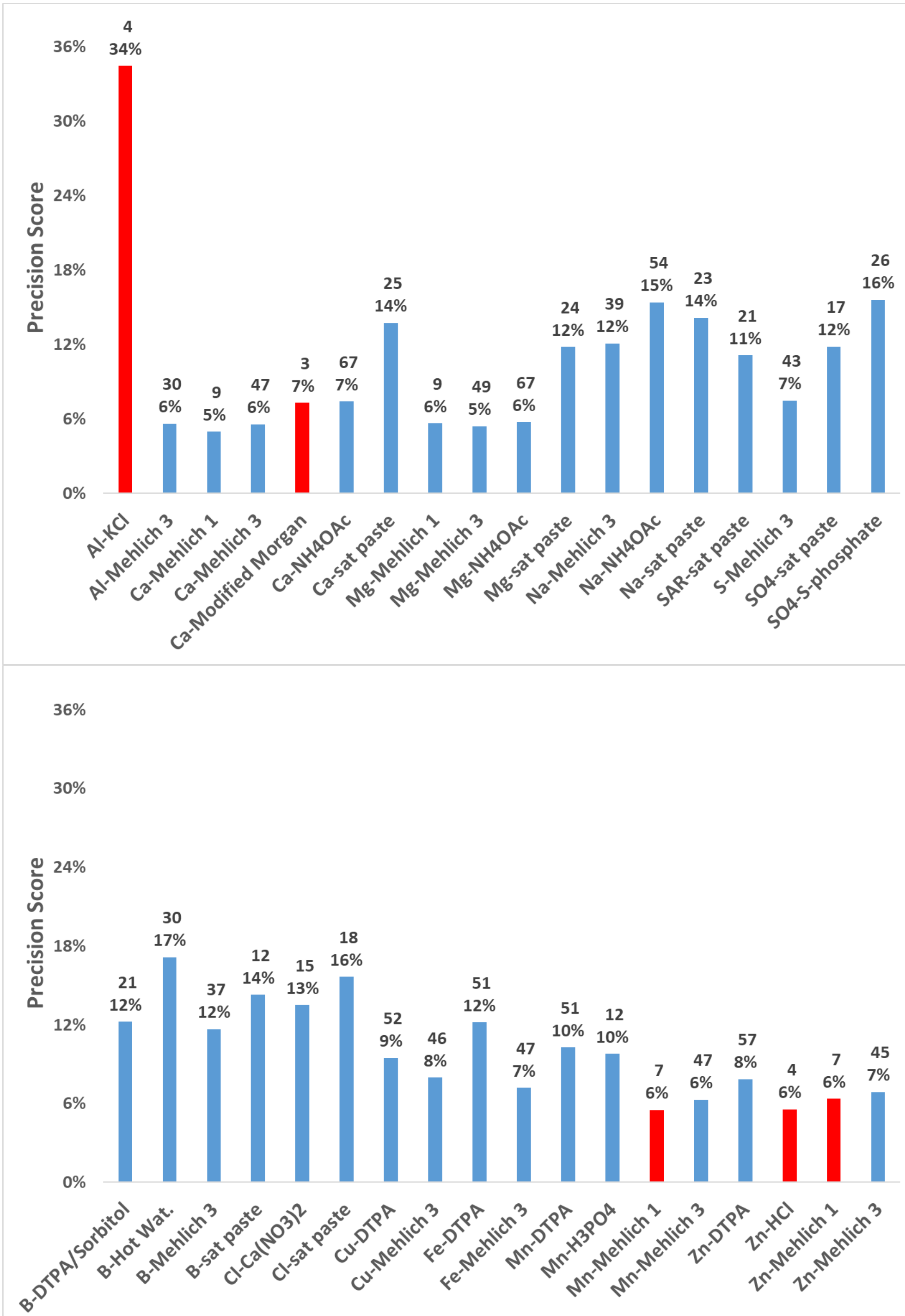

Fig. 3. Precision scores for various soil secondary macronutrients and aluminum (Al) (top) and micronutrients (bottom) analyses calculated from 43 samples tested by participating NAPT laboratories with the median absolute deviation (MAD) divided by the median for each and then averaged for each analyte. Value above the percentage listed at the top of each bar is the number of labs that submitted data for each analyte (those in red signify too few labs to generate statistics within the NAPT program).

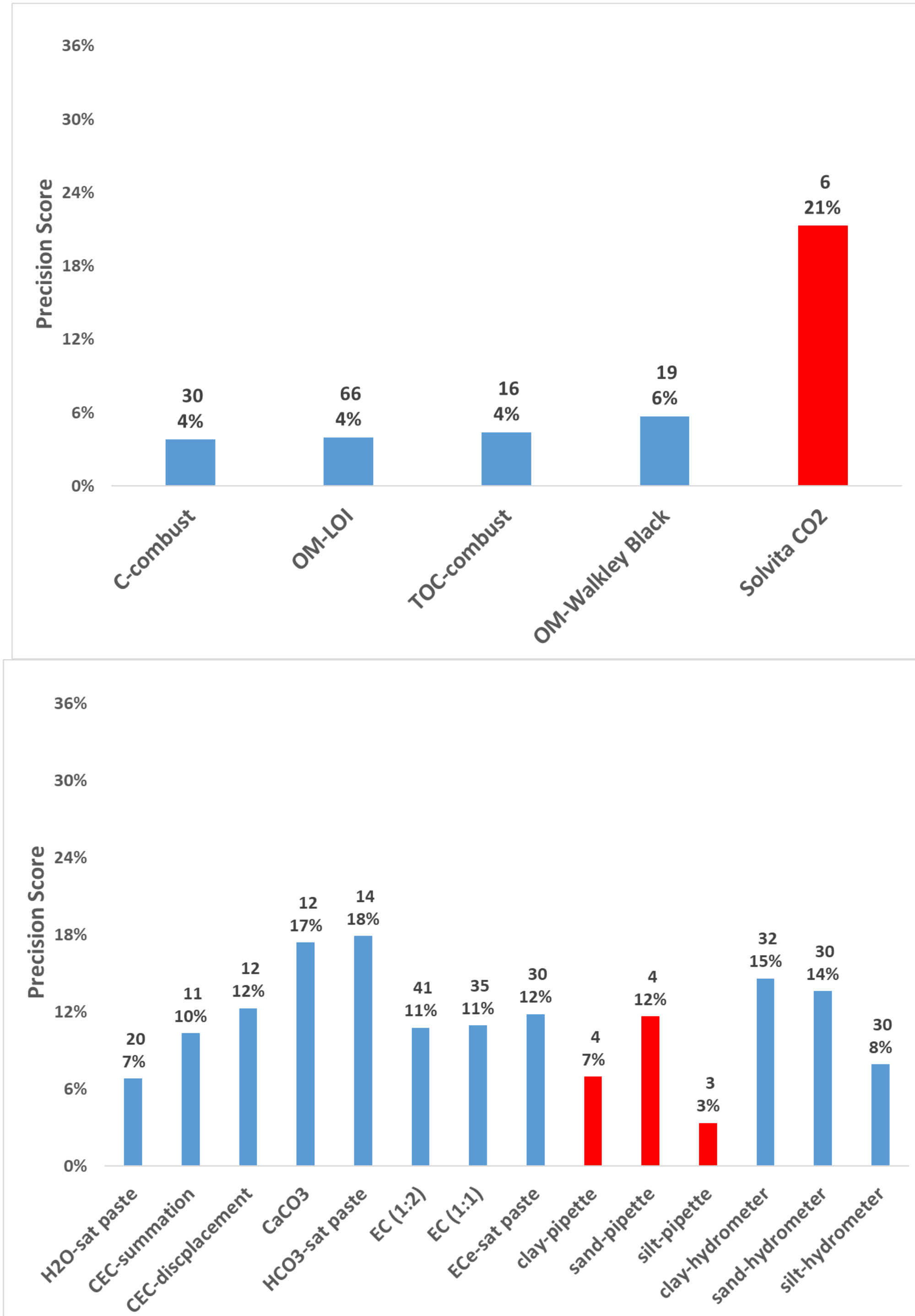

Fig. 4. Precision scores for various soil carbon related measures (top) and miscellaneous (bottom) analyses calculated from 43 samples tested by participating NAPT laboratories with the median absolute deviation (MAD) divided by the median for each and then averaged for each analyte. Value above the percentage listed at the top of each bar is the number of labs that submitted data for each analyte (those in red signify too few labs to generate statistics within the NAPT program).