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Quality Control in Soil Testing using the Internal Standards: Temporal Variability in Organic Carbon and Extractable Nutrient Elements

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Internal soil standards are used in an analytical laboratory as one of the tools for providing feedback on the quality of soil-testing service provided. The objective of this study is to provide results on the temporal variability in soil-test values of the internal soil standards used for soil organic carbon and extractable phosphorus (P), potassium, sulfur, boron, and zinc determination in our analytical service laboratory. The range, mean, standard deviation, and coefficient of variation values for the internal standards for various fertility parameters varied according to the parameter and were generally of acceptable quality, except for the extractable P (Olsen P) in the lower range of extractable P. Our results show that the use of internal soil standards in an analytical service laboratory is a simple, inexpensive, and effective tool for providing feedback on the quality of soil-testing service.

Keywords Analytical research support, extractable soil nutrients, fertility evaluation, internal soil standards, quality control, soil testing, variability in soil-test value

Introduction

Since 1997, the natural resources management group at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) center in Patancheru, Andhra Pradesh, India, has been carrying out studies on the diagnosis and management of nutrient deficiencies in the semi-arid tropical regions of India. Soil testing has been used as a diagnostic tool for evaluating the soil fertility status of a large number of soil samples collected in watersheds (Sahrawat et al. 2008) from the farmers' fields in the various states of India (Sahrawat et al. 2010). Our results showed that in addition to the deficiencies of nitrogen (N) and phosphorus (P), the deficiencies of sulfur (S), boron (B), and zinc (Zn) were very widespread. In these studies, we have been using soil organic carbon (C) as an index of soil N availability (Sahrawat et al. 2010).

As one of the measures for quality control in soil testing for fertility evaluation, we have been using internal standard soil samples for various soil fertility parameters including organic C and extractable P, potassium (K), S, B and Zn. The internal standard soil samples in the ICRISAT analytical laboratory are prepared from bulk soil samples collected

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from fields, and the collected soil samples were standardized against external standard soil samples obtained in an earlier soil sample exchange program.

The objective of this communication is to report on the temporal variability in soil-test values of the internal standards in organic C and extractable nutrients that are widely deficient in farmers' fields. There is little information in the published literature on this aspect, although the information can be useful not only as a feedback on the quality of soil testing but also in taking remedial measures to plug the sources of errors. Moreover, we want to share our experience that temporal variability in the values of internal standards is a simple, inexpensive and effective mechanism to provide feedback on the quality of soil testing provided for fertility evaluation in an analytical service laboratory.

Materials and Methods

The internal soil standards were used to get a feedback on the quality of soil-testing results for common chemical fertility parameters. Before use, the internal standard soil samples were air-dried, crushed using a wooden hammer, and passed through a 2-mm sieve. For organic C analysis, the soil samples were ground to pass through a 0.25-mm sieve.

For soil analysis, organic C was determined using the Walkley–Black method (Nelson and Sommers 1996). Extractable K was determined using the ammonium acetate method (Helmke and Sparks 1996); extractable S was extracted using 0.15% calcium chloride ($CaCl_2$), and S in the extract was determined using inductively coupled plasma-atomic emission spectroscopy (ICP-AES) as described by Tabatabai (1996). Extractable P was measured using the sodium bicarbonate ($NaHCO_3$) test (Olsen and Sommers 1982). Extractable B was extracted by hot water, and B in the extract was measured using ICP-AES (Keren 1996). Extractable Zn was extracted by the diethylenetriaminepentaacetic acid (DTPA) reagent, and Zn in the extract was measured by atomic absorption spectrophotometry (AAS) as described by Lindsay and Norvell 1978).

During a period of 3 months (January–April 2009), the internal soil standard samples were analyzed 20 times for organic C and extractable P, K, S, B, and Zn using the described methods by including them along with the other routine soil samples analyzed in the ICRISAT laboratory.

Precision for various soil chemical fertility parameters from the results of the analysis of the internal standard soil samples ($n = 20$) was determined by computing range, mean, standard deviation (SD), and coefficient of variation (CV).

Results and Discussion

The observations on the results of analysis of the internal soil standard samples for various soil fertility parameters were made for 3 months, during which period the standard soil samples were analyzed 20 times. The internal standard soil samples were chosen in the lower range because majority of the samples that we analyze routinely in the ICRISAT laboratory are in that range, except for extractable K, which was in the greater range as the deficiency of K in the farmers' fields is not widespread as are those of other plant nutrient elements (Rego et al. 2007; Sahrawat et al. 2007, 2010). The results of analyses for organic C and extractable P, K, S, B, and Zn are given in Table 1.

The results showed that the precision in the analysis of various soil fertility parameters, as indicated by range, mean, SD, and CV, was the greatest for organic C, followed by extractable S, extractable K, DTPA-extractable Zn, and extractable P (Table 2). The results on Olsen extractable P in the very low range showed the greatest variability

Table 1

Results of the internal standard soil samples analyzed for organic C and extractable P, K, S, B, and Zn (the internal standard samples were analyzed 20 times along with other routine soil samples)

No. analysed	Organic C ($g\ kg^{-1}$)	Extractable nutrient elements ($mg\ kg^{-1}$ soil)				
		P	K	S	B	Zn
1	5.4	0.3	159	19.0	0.66	0.56
2	5.6	0.3	164	18.5	0.72	0.54
3	5.2	0.3	166	17.0	0.64	0.53
4	5.0	0.3	156	19.0	0.64	0.50
5	5.1	0.4	151	18.5	0.64	0.53
6	5.4	0.4	171	17.5	0.64	0.54
7	5.4	0.6	144	19.0	0.60	0.57
8	5.4	0.3	161	19.5	0.66	0.55
9	5.5	0.4	162	19.0	0.60	0.54
10	5.3	0.5	168	19.0	0.60	0.54
11	5.1	0.6	148	18.0	0.60	0.55
12	5.3	0.6	154	17.0	0.60	0.51
13	5.6	0.5	149	19.0	0.64	0.56
14	5.2	0.3	156	19.5	0.68	0.52
15	5.1	0.5	149	19.0	0.70	0.47
16	5.1	0.6	149	19.0	0.60	0.46
17	5.3	0.5	158	19.0	0.68	0.55
18	5.3	0.4	159	18.5	0.66	0.55
19	5.3	0.5	150	19.0	0.72	0.54
20	5.2	0.6	154	18.5	0.66	0.55

Table 2

Precision in the analysis of the internal standard soil samples for organic C and extractable P, K, S, B, and Zn (the internal standards were analyzed 20 times during the 3 months of observations)

	Organic C ($g\ kg^{-1}$)	Extractable nutrient elements ($mg\ kg^{-1}$ soil)				
		P	K	S	B	Zn
Range	5.0–5.6	0.3–0.6	144–171	17.0–19.5	0.60–0.72	0.46–0.57
Mean	5.3	0.45	156	18.6	0.65	0.53
SD	0.02	0.12	7.43	0.72	0.04	0.03
CV	3.18	26.76	4.76	3.88	6.12	5.38

Notes. SD, standard deviation; CV, coefficient of variation in percent (%).

(CV 26.76%), which is not entirely unexpected. We have earlier observed large variability in extractable Olsen P in soil samples that are very low in extractable P. The results of this study once more confirm our earlier observations. Further, these results also suggest that extra attention is needed while analyzing soil samples very low in extractable P.

There is little information in the published literature on the use and efficacy of internal soil standards as one of the tools for quality control in routine soil testing results, although we are aware that selected laboratories do use internal soil standards to obtain feedback on the quality of soil test results. Indeed, plant samples are more commonly used for checking the quality of plant material testing (Mills and Jones 1996; Sahrawat 2006).

Overall, the results of this study show that the internal soil standards can be used as one of the tools to assess the quality of routine soil testing for chemical fertility evaluation in an analytical laboratory used for providing analytical research support service. Except for extractable P analysis in very low range, the precision of for the other fertility parameters seemed in the acceptable range.

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