Research Note:

THE EFFECT OF SCOOPING ON ANALYTICAL PRECISION IN SOIL ANALYSIS

O J VAN DER WALT & GAIL A VAN DER MEY, Grain Crops Research Institute

Introduction

Soil chemists all over the world have made considerable efforts to utilize modern analytical techniques and expand soil test information to regional, national and international levels. However, in spite of great technological advances in modern analytical techniques and laboratory equipment, analytical results generated by different soil test laboratories, using the same chemical extractants, vary considerably and make it extremely difficult to compare data from different laboratories. Some of these variations undoubtedly arise from the fact that samples are scooped in some laboratories while in others the samples are weighed. Because of the fact that there is considerable variation in the bulk density of soils, variation of analytical data in scooped samples can be expected. Another possible source of error arising in the scooping process lies in the human factor.

The arguments in favour of expressing analytical results on soil plant relationships on volumetric basis as being biologically more relevant than expressing it on mass basis, are abundant in literature. As early as 1972, Mehlich pleaded for calculating results on a volume basis. In an extensive review Mehlich (1972, 1973) presented a case on the rationale of calculating soil test results on a volume basis along with the relationships between weighed and measured soil samples. There is evidence that scooping was used in the USA even a long time before Mehlich made his plea for volumetric expression of soil analytical data. Some laboratories use an average bulk density of 1,25g cm^{-3} or 1,32g cm^{-3} (Mehlich 1973). This procedure is however open to criticism and is not favoured generally.

Prominent soil scientists in the RSA express themselves strongly in favour of volumetric expression of data. Van der Merwe (1980) came to the conclusion that no reason could be found why routine analysis for fertilizer recommendations should not be done on a volume extraction basis. Farina (1981) states that when we fertilize a unit area of land, we deal with a specific soil volume, the mass of which may vary considerably depending on texture. Many soil analysis laboratories in Southern Africa have adopted volume as basis of reporting data and have calibrated their research data accordingly. Uniformity of expression to promote better understanding of soil analysis results is very necessary in South Africa since there are some 40 laboratories in Southern Africa (handling about 170,000 samples annually) that render analysis services for agricultural purposes (Buys 1984).

The investment in highly qualified personnel, apparatus and laboratory facilities often contributes to a reluctance to change. On the other hand it can be argued that since an accurate and comprehensive analytical service is a necessity in the agricultural industry and because it is such a costly service, it requires the most efficient and at the same time, swiftest possible handling of samples without reduction in the accuracy and credibility of the analytical results. The advantages of scooping in this regard is obvious.

The object of this study is not to investigate the merits of volumetric expression of data of soil analysis versus mass, but merely to see if there is a significant loss of analytical precision when scooping is used.

Materials and methods

Soil samples were collected from seven geographically widespread localities in the maize producing areas of the RSA. The samples were air-dried and ground to pass through a 1mm sieve. Of these sample, 2,5g was weighed in duplicate. In addition soil was scooped from the same samples with a measured 2,5 mℓ container on a handle. The handle of the container was tapped twice to settle the soil, and excess soil was scraped off levelly across the container with a flat spatula blade so that it was filled completely without compressing the soil. This was also done in duplicate and the weighed and scooped samples were treated separately. Phosphorus was determined according to a method described by Van der Merwe, Johnston and Ras, (1984), using 25 mℓ extracting solution per 2,5 mℓ or 2,5 g soil.

Results and discussions

The P Content, mass and extractant/soil ratio of the duplicate samples are given separately in Table 1.

The variance in the mass of the soil samples scooped as well as weighed in duplicate, the average bulk density, and the average difference between the P content determined on a mass basis (P mass) and a volume basis (P volume) as well as P (mass) expressed as percentage of P (volume) is shown in Table 2.

$\overline{Y} = 11,71$; $\overline{X} = 1,29$

Corr. Coeff. = 0,79
Y Intercept = 32,40
Fault Var = 21,64
F value = 8,53

From the data in Tables 1 and 2 the following should be noted:

1. The mass of the duplicate samples (scooped) varies insignificantly. The average variance of the seven duplicates is 0,045 g which is 1,8% of 2,5 g of soil (See Table 2).

TABLE 1. Comparison of the phosphorus content of 2,5 g and 2,5mℓ of the same sample of seven different soils.

Lab no	District	Mass of 2,5 mℓ soil (g)	Extractable P.(mass basis) mg kg^{-1}	Extractable P. (volume basis) mg dm^{-3}	Extractable P. (mass) calculated from volume	Ratio V/M** extractant/ soil	Bulk density of sample
A02484	Delmas	3,39	29,0	42,0	30,9	7,31/1	1,36
		3,45	29,0	41,2	31,3	7,25/1	1,38
A02472	Bothaville	3,75	28,3	41,8	27,9	6,67/1	1,50
		3,80	28,5	41,6	27,3	6,58/1	1,52
A02490	Devon	2,79	7,5	6,0	5,4	8,96/1	1,12
		2,80	8,2	5,2	4,7	8,93/1	1,12
A02502	Greytown	2,54	72,3	71,1	70,0	9,84/1	1,02
		2,50	69,0	73,7	73,7	10/1	1,00
A02466	Coligny	3,58	50,4	74,1	51,7	6,98/1	1,43
		3,56	53,0	74,5	52,4	7,02/1	1,42
A02496	Ermelo	3,21	43,3	54,4	42,5	7,79/1	1,28
		3,23	42,9	55,3	42,8	7,74/1	1,29
A02478	Marquard	3,05	53,4	68,3	56,0	8,20/1	1,22
		3,17	56,0	71,1	56,1	8,04/1	1,27

** Ratio of 25 mℓ of P extractant solution to mass of 2,5 mℓ soil.

TABLE 2. Variance in mass of samples, bulk density, difference between P (mass) and P (volume), and P (mass) as a percentage of P (volume) of seven different soils.

Lab no	District	Variance (mass) of duplicate samples	P (volume) — P (mass) mg kg^{-1}	Bulk density of samples	$\frac{\text{mg kg}^{-1}}{\text{mg dm}^{-3}} \times 100$
A02484	Delmas	0,06	12,6	1,37	69,7
A02472	Bothaville	0,05	13,3	1,51	68,36
A02490	Devon	0,01	2,2	1,12	126,42
A02502	Greytown	0,04	1,75	1,01	97,57
A02466	Coligny	0,02	22,6	1,4	69,58
A02496	Ermelo	0,02	11,8	1,2	78,50
A02478	Marquard	0,12	15,0	1,2	78,48
Co-ordinates			Y	X	

2. The reproduceability of the P content of the duplicate samples suggests an acceptable degree of accuracy in the analysis of the samples. (See Table 1).

3. The congruity of the extractable P (mass) figures with the P (mass) figures calculated from volume, suggests that the variance in the extractant/soil ratio, as a result of the variance of the bulk density of soils is not a point of excessive concern (See Table 1). Mehlich (1972) as well as Van der Merwe (1980) and Sherrell (1970) commented on this issue. Although it is a problem that cannot be ignored especially in soils with high P values, it is possible to make adjustments in the soil/extractant ratio if the bulk density of the soil is known and with determination of the mass of the (scooped) sample the necessary adjustment can easily be made.

4. The difference between extractable P (volume) and extractable P (mass) varies between 22,6 and 1,8 and is, as can be expected, positively correlated with the bulk density of the soil samples (volume/mass) ratio and corresponds with what Mehlich (1972) has found.

Expressing data on a volume basis (mg ℓ^{-1}, mg dm^{-3}, cmol (+) ℓ^{-1}) without taking the mass or the bulk density of a specific sample into consideration, can give rise to considerable differences in the figures obtained as shown in this study which is in accordance with the findings of Mehlich (1980). Data determined on a mass basis will be equivalent to the volume and depth relationships only when mass/volume (mass/vol) is approximately = 1 as clearly shown in this study. Compare samples A

02472 (Bothaville) and A 02466 (Coligny) with A 02502 (Greytown).

Although the number of repetitions of scoops per sample in this study is not enough to draw scientifically significant conclusions, it concurs with statistical studies reported in literature and elsewhere. In this study the variance was found to be 1,8% compared to 1% (Farina 1981). As far as the considerable variance in the figures obtained when the data is expressed in volume versus mass is concerned, it can be stated that unless research data is calibrated according to volumetric expression for different types of soil varying in bulk density, one cannot avoid weighing the sample. Thus, to report data merely in volumetric terms without taking the bulk density into account can lead to considerable confusion and vice versa!

In the South African context the position is thus, that analytical data is used for advisory work by people with different backgrounds — agronomists, soil scientists, technicians, extension officers, salesmen etc. Not everyone using the analytical data has the knowledge and, or insight to realize that an analysis figue, as in the case of sample A 02484 (Delmas) in this study (see Table 1) expressed as 29,00 mg kg^{-1} or as 41,96 (42 approx) mg dm^{-3} (or 42 mg ℓ^{-1}) means one and the same thing. It is therefore strongly recommended that the means necessary to convert scoop data into mass data (in this case the mass and or the bulk density) is supplied with analysis reports of scooped samples. It can be argued that such a practice will defeat a major advantage of scooping.

However, with the modern apparatus and technology available, an acceptable compromise is possible. There are fairly cheap recorders, attachable to a mass meter, available on the market with which the mass of each scoopful of sample can be recorded with a mere pressing of a switch. With a proper time and motion study the time loss can be cut down to a minimum.

It seems therefore that scooping as a cost and time saving practice in the process of soil analysis can be seen as acceptable. It is however necessary that the people who use the data thus acquired, must have an insight into what is involved, and should be supplied with the mass and/or bulk density of the sample along with the analytical data which can then be converted for interpretation by people whose experimental data is not calibrated on volume basis.

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