GLOSOLAN Proficiency Testing Global PT 2025

Individual Report

This report aims to provide each laboratory with feedback on its performance in the inter-laboratory comparison exercise of the Global Soil Laboratory Network (GLOSOLAN).

A statistical analysis of individual laboratory results is provided, which can be used by the laboratory to assess its performance in the corresponding inter-laboratory comparison exercise. This includes the analysis and graphical presentation of the z-score, and the laboratory's precision, for each analysis performed.

The objective of this proficiency test is to compare the performance of the soil laboratories in the network regarding the analysis of selected soil parameters, to continuously improve the quality, comparability, and traceability of analytical results across laboratories.

Please note that this report does not certify the proficiency of any laboratory in soil analysis. Therefore, it cannot be used to claim that a laboratory is certified or deemed competent by GLOSOLAN.

Date of issue: July 2026

General information

Laboratory ID:	76
RESOLAN:	SEALNET
Country:	Bhutan
Laboratory name:	Soil and Plant Analytical Laboratory (SPAL), National Soil Services Centre (NSSC), Department of Agriculture, Ministry of Agriculture and Livestock
Laboratory address:	Soil and Plant Analytical Laboratory, National Soil Services Centre, Dept of Agriculture, P.O.Box 907
Contact person for the laboratory:	Namgay Karma Dorji

Statistical analysis of individual laboratory results

1. Methodology

1.1. Reference material ID

Your laboratory received a package containing nine self-sealing bags of soil labelled with a unique sample code: GLO-17 to GLO-25.

The nine sample bags were divided into two groups:

- Chemical set: Six self-sealing soil bags, each labelled with a unique code: GLO-17, GLO-18, GLO-19, GLO-20, GLO-21, and GLO-22.
- Physical set: Three self-sealing soil bags, labelled GLO-23, GLO-24, and GLO-25.

Important note: Although six samples were provided for chemical testing, they represented only four distinct soil types. Three samples (GLO-17, GLO-19, and GLO-22) were replicates.

For the purpose of performance analysis, the sample identifiers were simplified. The chemical set samples were re-labelled as A, B, C1, C2, C3, and D, while the physical set samples were labelled E, F, and G.

Within the chemical set, samples primarily differed in their soil carbon (C), and the re-labelling was based on descending soil carbon content, as determined through the dry combustion method. Accordingly, sample A had the highest soil carbon content, while sample D had the lowest.

Within the physical set, samples were re-labelled based on descending percentage of sand content, as determined through the Pipette method. Accordingly, sample E had the highest percentage of sand, while sample G had the lowest.

1.2. Analytical Methods

Your laboratory was requested to analyse C, N, P, pH, potassium (K), copper (Cu), manganese (Mn), iron (Fe), zinc (Zn), chromium (Cr), aluminium (Al), arsenic (As), and selenium (Se), following GLOSOLAN's Standard Operating Procedures. You were also requested to determine Particle Size distribution using the pipette method following the Kellog Soil Survey (KSSL) procedure. The specific analytical methods requested for this inter-laboratory comparison exercise were:

- Soil pH determined using soil to water ratio of 1:2.5 H_2O, (pH_H_2O)
- Soil organic carbon by Walkley and Black - (C_WB) (%)
- Soil total carbon by dry combustion - (C_Dum) ($g \cdot kg^{-1}$)
- Available phosphorus by Olsen - (P_Ols) ($mg \cdot kg^{-1}$)

- Available phosphorus by Bray I - (P_B1) ($mg \cdot kg^{-1}$)
- Available phosphorus by Bray II - (P_B2) ($mg \cdot kg^{-1}$)
- Soil nitrogen by Kjeldahl - (N_Kj) ($g \cdot kg^{-1}$)
- Soil total nitrogen by Dumas dry combustion - (N_Dum) ($g \cdot kg^{-1}$)
- Heavy metals by acid digestion - Cr (Cr_Aqua Regia) ($mg \cdot kg^{-1}$); Al (Al_Aqua Regia) ($mg \cdot kg^{-1}$); As (As_Aqua Regia) ($mg \cdot kg^{-1}$); Se (Se_Aqua Regia) ($mg \cdot kg^{-1}$)
- Exchangeable potassium using 1N ammonium acetate pH 7.0 - (K_Amm Act) (K cmol(+) kg^{-1})
- Extractable micronutrients using the DTPA method - Cu (Cu_DTPA) ($mg \cdot kg^{-1}$); Fe (Fe_DTPA) ($mg \cdot kg^{-1}$); Mn (Mn_DTPA) ($mg \cdot kg^{-1}$); Zn (Zn_DTPA) ($mg \cdot kg^{-1}$)
- Particle size distribution analysis by pipette method - Clay (Clay_Pip) (%); Sand (Sand_Pip) (%); Silt (Silt_Pip) (%)

Additionally, the laboratories were asked to report on the weight (g) of the samples received.

2. Evaluation of results (Laboratory performance)

Statistical tables are provided below, giving a summary of the analysed soil parameters in the inter-laboratory comparison exercise, including the number of participating laboratories and corresponding statistics for the analysed soil parameters. The accuracy (bias) is evaluated by calculating the Z-score, while precision (repeatability) is evaluated by calculating the coefficient of variation from the mean value of the different replicates.

The tables below provide overall summaries of the results received from all participating laboratories, where 'n' is the number of participants who provided results for the specific soil and parameter in question; 'Median' is the median value for all n results; 'MAD' is the median absolute deviation, a robust description of the dispersion of the analytical results. Median and MAD are expressed in the same unit as the analysed parameter.

Additionally, 'Reporting Laboratory' indicates the information concerning your laboratory. 'Sample ID' is the identification name provided on the label of the analysed sample; 'Reported value' is the value your laboratory has reported to GLOSOLAN; and z-score is a standardised metric used to assess the accuracy of your analysis. The z-score quantifies how far a result deviates from the median, in terms of MAD. A negative z-score indicates the result is below the median, while a positive value indicates it is above the median.

The z-score is calculated from the experimental result, the median, and the MAD of the measured results for all participants, i.e.:

$$z\text{-score} = [\text{reported result from your lab} - \text{median}] / (c \cdot \text{MAD})$$

Where:
c = 1.4826, which is the scaling factor used to make the MAD statistically equivalent to the standard deviation of a normal distribution.

A zero z-score indicates that the result aligns with the median. A z-score between -2 and +2 suggests the deviation from the median is within 2 MAD, which is generally considered 'satisfactory'. When the absolute z-score falls between a magnitude of 2 and 3, the result is considered 'questionable'. A z-score below -3 or above +3 is deemed 'unsatisfactory' and should prompt further assessment and corrective action once the root cause is identified.

Table 1: Bag weight (g)

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
A	144	46.47	0.25 /	GLO-18	46.3	-0.46
B	143	47.6	0.79 /	GLO-20	47.4	-0.17
C1	144	45.63	0.3 /	GLO-17	45.9	0.61
C2	143	46.15	0.2 /	GLO-19	46.0	-0.51
C3	143	46.72	0.38 /	GLO-22	46.6	-0.21
D	143	43.4	0.6 /	GLO-21	44.0	0.67
E	92	16.49	0.14 /	GLO-25	16.4	-0.43
F	93	14.01	0.09 /	GLO-23	14.0	-0.07
G	93	12.3	0.1 /	GLO-24	12.2	-0.67

Table 2: Soil pH determined using soil to water ratio of 1:2.5 H_2O

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
A	162	5.98	0.16 /	GLO-18	6.2	0.93
B	161	7.95	0.2 /	GLO-20	8.3	1.18
C1	164	7.11	0.15 /	GLO-17	7.3	0.85
C2	162	7.1	0.16 /	GLO-19	7.37	1.14
C3	160	7.12	0.13 /	GLO-22	7.34	1.14
D	161	6.08	0.18 /	GLO-21	6.18	0.37

Table 3: Soil organic carbon by Walkley and Black (%)

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
A	132	13.26	1.93 /	GLO-18	11.8	-0.51
B	133	1.76	0.16 /	GLO-20	1.4	-1.52
C1	136	2.93	0.3 /	GLO-17	2.5	-0.97
C2	134	2.93	0.31 /	GLO-19	2.6	-0.72
C3	134	2.9	0.31 /	GLO-22	2.7	-0.44
D	136	2.15	0.22 /	GLO-21	1.9	-0.77

Table 4: Exchangeable Potassium using 1N ammonium acetate pH 7.0 (Cmol·kg^{-1})

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
A	121	0.33	0.05 /	GLO-18	0.31	-0.27
B	120	1.46	0.19 /	GLO-20	1.55	0.32
C1	120	0.42	0.05 /	GLO-17	0.39	-0.4
C2	120	0.41	0.06 /	GLO-19	0.38	-0.34
C3	122	0.41	0.05 /	GLO-22	0.42	0.13
D	118	0.41	0.05 /	GLO-21	0.38	-0.4

Table 5: Soil nitrogen by Kjeldahl (g·kg^{-1})

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
A	101	6.74	1.0 /	GLO-18	6.6	-0.09
B	102	1.8	0.4 /	GLO-20	1.5	-0.51
C1	102	2.18	0.42 /	GLO-17	2.0	-0.29
C2	102	2.21	0.42 /	GLO-19	2.1	-0.18
C3	102	2.14	0.41 /	GLO-22	1.9	-0.39
D	102	1.58	0.34 /	GLO-21	1.5	-0.16

Table 6: Available phosphorus by Bray I (mg·kg^{-1})

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
A	56	28.21	9.96 /	GLO-18	27.82	-0.03
B	48	1.82	1.19 /	GLO-20	0.63	-0.67
C1	52	68.06	15.77 /	GLO-17	68.39	0.01
C2	52	67.74	13.24 /	GLO-19	73.61	0.3
C3	52	68.63	16.22 /	GLO-22	67.41	-0.05
D	54	9.35	1.4 /	GLO-21	9.35	0.0

Table 7: Particle Size Distribution by pipette method, Sand (%)

	Global			Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**	**Sample ID**	**Reported value**	**z-score**
E	59	56.49	8.45 /	GLO-25	35.0	-1.72
F	60	52.26	10.12 /	GLO-23	26.4	-1.72
G	59	17.5	5.81 /	GLO-24	5.9	-1.35

Table 8: Particle Size Distribution by pipette method, Silt (%)

	Global				Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**		**Sample ID**	**Reported value**	**z-score**
E	59	26.1	7.65	/	GLO-25	34.8	0.77
F	60	31.35	8.06	/	GLO-23	50.8	1.63
G	59	25.1	8.98	/	GLO-24	20.0	-0.38

Table 9: Particle Size Distribution by pipette method, Clay (%)

	Global				Reporting Laboratory		
Sample code	**n**	**Median value**	**MAD**		**Sample ID**	**Reported value**	**z-score**
E	58	13.89	4.66	/	GLO-25	30.2	2.36
F	58	11.85	5.78	/	GLO-23	22.8	1.28
G	59	51.52	12.18	/	GLO-24	74.1	1.25

Additionally, the following figures show your analytical performance for each soil parameter and sample you have analysed in the GLOSOLAN inter-laboratory comparison exercise. A colour code is used to indicate your performance category:

- Green for |z-score| ≤ 2 - 'Satisfactory'
- Orange for 2 ≤ |z-score| ≤ 3 - 'Warning'
- Red for |z-score| ≥ 3 - 'Unsatisfactory, requiring corrective action'

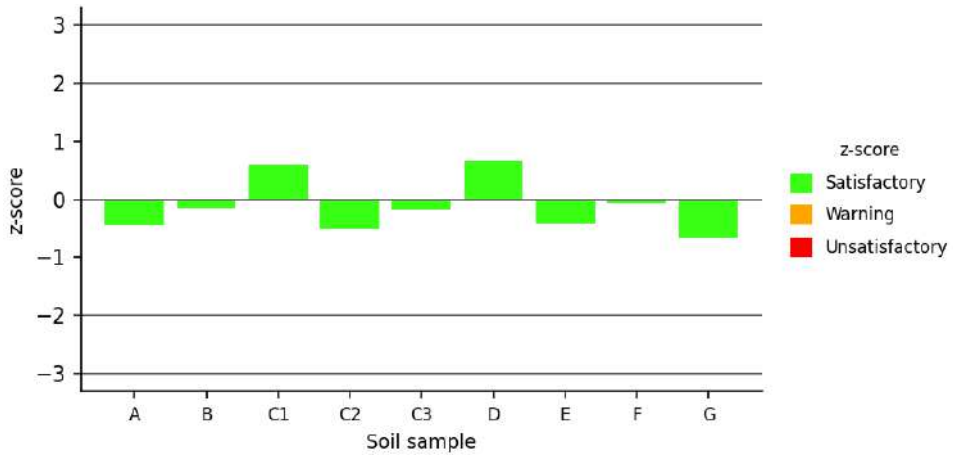

Figure 1: Bag weight (g)

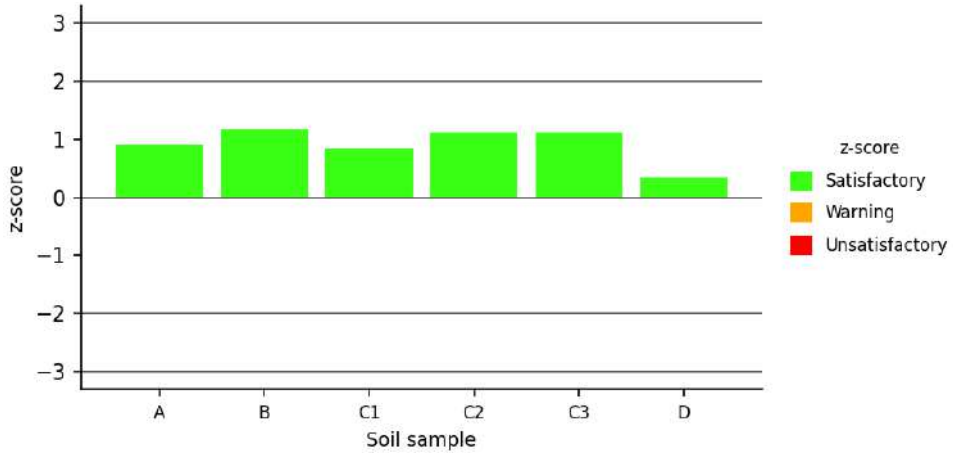

Figure 2: Soil pH determined using soil to water ratio of 1:2.5 H_2O

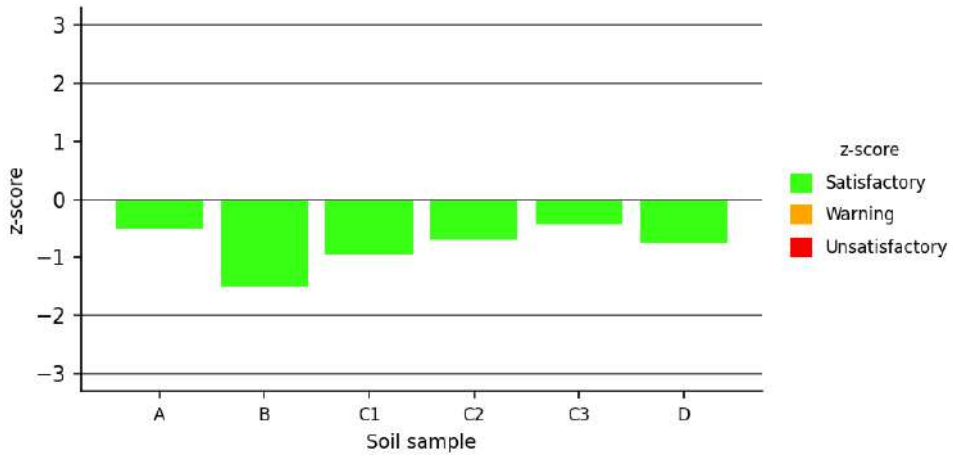

Figure 3: Soil organic carbon by Walkley and Black (%)

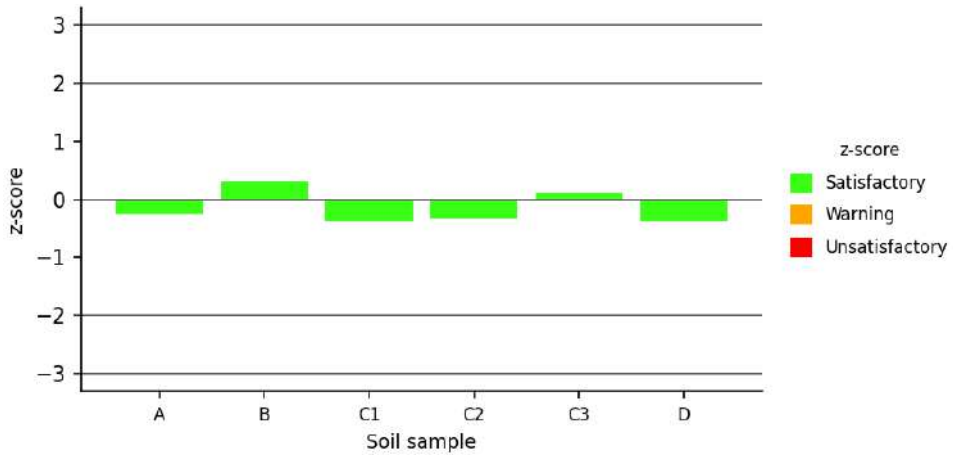

Figure 4: Exchangeable Potassium using 1N ammonium acetate pH 7.0 ($Cmol \cdot kg^{-1}$)

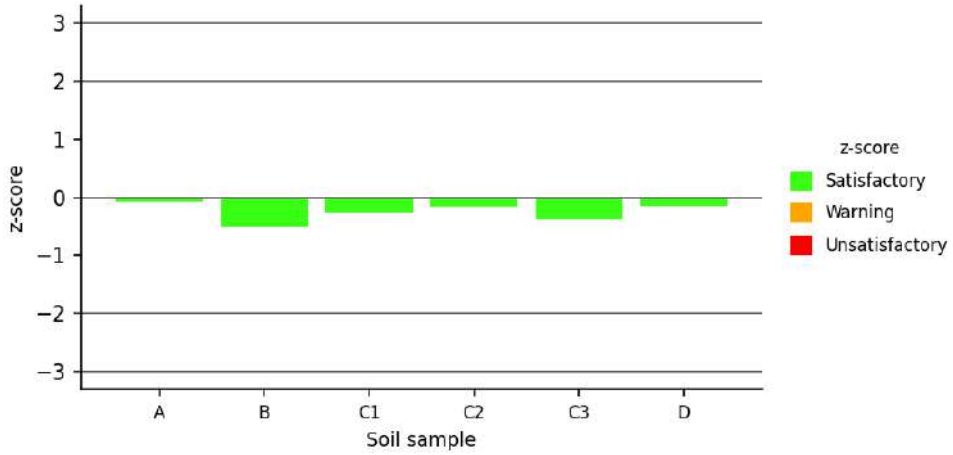

Figure 5: Soil nitrogen by Kjeldahl (g·kg^{-1})

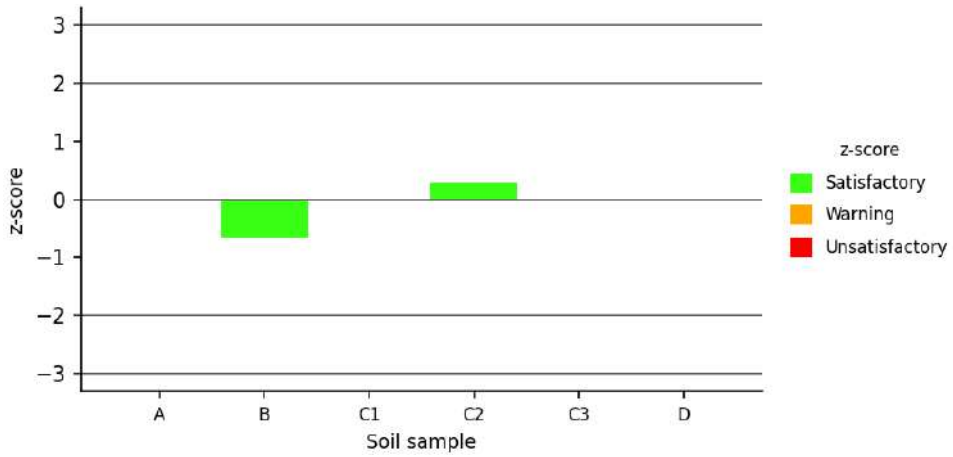

Figure 6: Available phosphorus by Bray I (mg·kg^{-1})

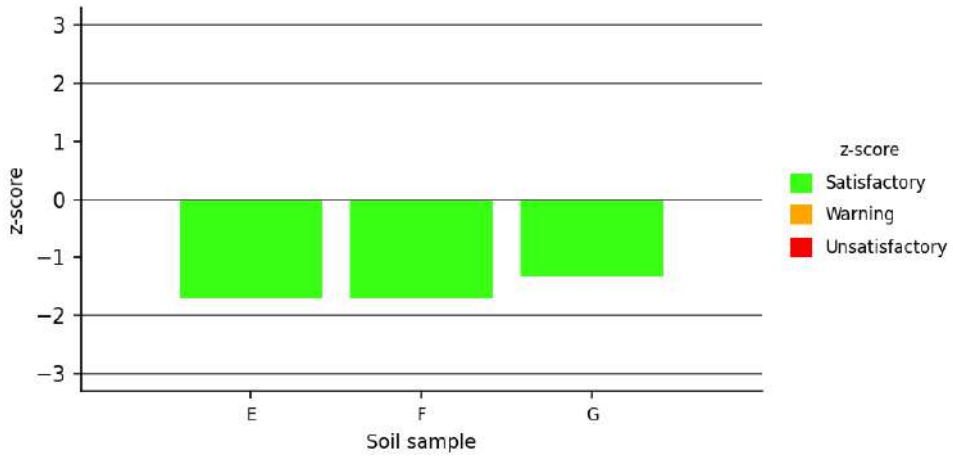

Figure 7: Particle Size Distribution by pipette method, Sand (%)

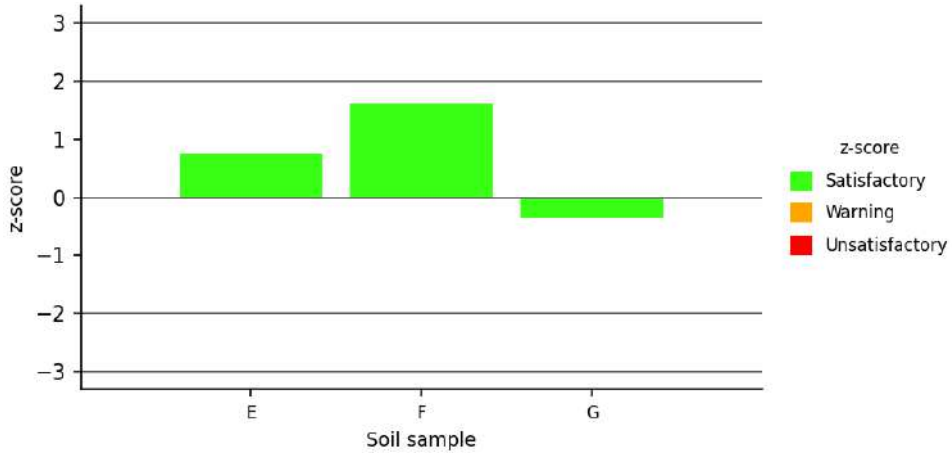

Figure 8: Particle Size Distribution by pipette method, Silt (%)

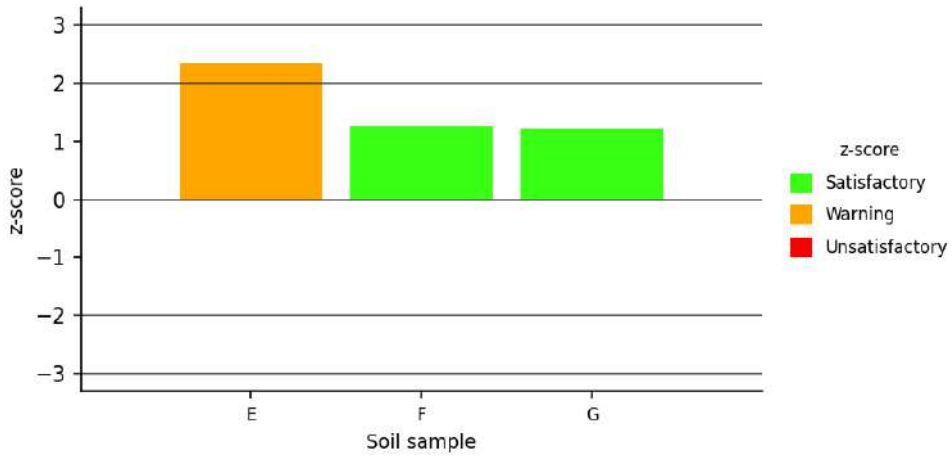

Figure 9: Particle Size Distribution by pipette method, Clay (%)

Your laboratory's precision (repeatability) is presented in the figures below. Precision was evaluated by calculating the standard deviation of replicate measurements around the mean value obtained using the same analytical method and procedure. To facilitate comparison between different parameters and results, the standard deviation was expressed as the coefficient of variation (%CV). Samples C1, C2, and C3 were used in the statistical evaluation of precision.

Your laboratory's analytical performance for each soil parameter in the GLOSOLAN inter-laboratory comparison exercise is classified as follows:

- Green for %CV ≤ 10% — 'Satisfactory'
- Orange for 10%≤|%CV|≤ 20% — 'Warning'
- Red for %CV ≥ 20% —'Unsatisfactory, requiring corrective action'

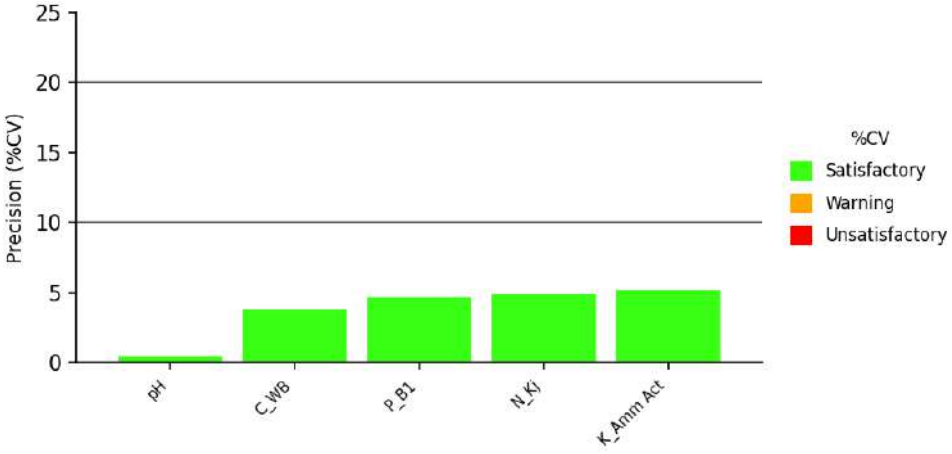

Figure 10: Precision assessment

Proficiency Test Provider

This inter-laboratory comparison exercise was organised by GLOSOLAN, which also provided this report on the results.

Acknowledgements:

GLOSOLAN thanks your laboratory for participating in the GLOSOLAN Global PT 2025, which aimed to provide information to help you continuously improve the performance of your laboratory in soil analysis.

Thanks to the financial support of PHOSAGRO®.