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APPLICABILITY OF THE INDICATOR METHOD FOR THE DETERMINATION OF DYNAMICS OF THE SOIL PROFILE DENSITY AGAINST THE BAKGROUND OF GRAVIMETRIC PROCEDURES

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A b s t r a c t. Commonly used gravimetric method of determining soil density was compared under laboratory conditions with the indicator method developed at the Department of Soil Cultivation and Fertilization Techniques, IUNG Jelcz-Laskowice. The tests were carried out on artificial soil profiles with four degrees of compaction. Differences in the soil density determined with respective methods were in most cases contained within the limits of the measurement error. Discrepancies of the results obtained with the methods compared were decreasing along an increasing degree of soil density and thickness of the layer measured. The results obtained encourage to acknowledge the indicator method tested as an applicable measuring device for the density dynamics of soil profile.

K e y w o r d s: soil density, indicator method, gravimetric procedures.

INTRODUCTION

Density is one of the most often determined physical properties of soil. Commonly used gravimetric method allows to determine precisely that property only in the analysed sample. However, because of high spatial variability of the soil medium, the collected sample is often far from being representative of the medium examined. To obtain a reliable result, samples should be collected in several replications. The fact that the gravimetric method is labour-consuming is one of its major shortcoming. Another drawback is no possibility of recording changes at the place where the soil material was removed from the field for density determination. Stationary methods are free from such shortcomings [1,2], among them the indicator method developed at the Department of Soil Cultivation and Fertilization Techniques IUNG, Jelcz-Laskowice [3,4]. The experiments aimed at comparing results of soil density measurements obtained with the latter method and those obtained with commonly used cylinder or volumetric method.

METHODS

The tests were carried on under laboratory conditions on artificial soil profiles formed identically in the containers 70 cm in height and diameter. Artificial profiles of about 1.2 Mg m^{-3} density were formed in the containers out of the soil with 10 % silt and clay and 10 % dry matter moisture. The soil was compacted up to four degrees: weak, medium, strong and very strong by kneading it in the container until its surface was lowered towards the edge of the container by 2, 4, 6 and 8 cm, respectively. The results of soil density measurements obtained with the indicator, cylinder and volumetric methods were compared.

The indicator method consists in recording vertical soil deformations in the measurement horizons at any time. In our experiments the indicators were installed at 10, 20, 30 and 40 cm depth. First of all, position of the indicator tops and soil surface in relation to the bench mark placed at the edge of the container was measured. After superficial compaction of the soil in the container measurement of the position of indicators and soil surface in relation to the bench mark was repeated. On the basis of changes in the thickness of soil profile layers and initial soil density, its actual density was calculated from the known proportion.

For comparison density was also determined with the commonly used cylinder method (undisturbed soil samples of 100 cm^3 capacity), as well as with the volumetric method by weighing the soil removed from the container and dividing its weight by its volume. The results of soil density determinations in 10 cm profile layers obtained with the methods tested were subjected to statistical analysis. Compared was repeatability of measurements in 0-20 and 20-40 cm layers and the results collated with theoretical density calculated on the basis of whole soil dry matter contained in the layer analysed.

RESULTS AND DISCUSSION

Statistical analysis of the results obtained with the methods compared has shown that in case of weak kneading those obtained with the cylinder method were significantly higher than the others in all the 10 cm layers - on an average 0.11 Mg m^{-3} with the indicator method and by 0.14 Mg m^{-3} with the volumetric one (Table 1). Higher soil density with the cylinder method was found to be due dipping of the cylinder into the soil. While dipping the cylinder, its edge exerts pressure on the soil exceeding its shear resistance. Relatively high resistance of soil aggregates, the force applied to the cylinder caused diminution of large pore

Table 1. Comparison of soil density (Mg m^{-3}) determined with different methods in 10 cm layers

Layer (cm)	Method			LSD
	indicator	volumetric	cylinder	
		Weak keading		
0-10	1.32	1.27	1.49	0.06
10-20	1.24	1.23	1.31	0.04
20-30	1.20	1.17	1.30	0.07
30-40	1.18	1.18	1.29	0.09
		Medium kneading		
0-10	1.41	1.44	1.53	0.09
10-20	1.30	1.30	1.38	0.07
20-30	1.23	1.22	1.29	n.s.
30-40	1.22	1.17	1.20	n.s
		Strong kneading		
0-10	1.52	1.60	1.60	n.s.
10-20	1.40	1.45	1.41	n.s.
20-30	1.28	1.36	1.35	n.s.
30-40	1.26	1.31	1.33	n.s.
		Very strong kneading		
0-10	1.56	1.68	1.65	n.s.
10-20	1.47	1.47	1.42	n.s.
20-30	1.34	1.32	1.35	n.s.
30-40	1.23	1.21	1.29	n.s.

LSD - least significant difference; n.s., not significant difference.

voids in the sample drawn, thus increasing soil density. Similar effect, though to a lesser degree, was that of soil friction against the cylinder walls, bringing about an additional increase in density. Significant differentiation occurred also with medium density, but only in the 0-10 and 10-20 cm layers. In other cases (harder kneading of the soil) the differences were insignificant and well within the limits of measurement error. With strong and very strong kneading of 1.6 Mg m^{-3} order and higher there occurred merely a tendency to somewhat lower density levels than those determined with the indicator method.

When analysing density levels of the soil measured with the compared methods in the 0-20 and 20-40 cm layers, differentiation of results was found lower than in the case of the profile divided into 10 cm small layers (Table 2). Still less scatter of results was obtained for the 0-40 cm layer. Accuracy in determining density levels in large volumes depended on the precision of delimiting horizon

Table 2. Comparison of soil density ($Mg\ m^{-3}$) determined with different methods in layers of 20 and 40 cm thickness

Layer (cm)	Method			LSD
	indicator	volumetric	cylinder	
		Weak kneading		
0-20	1.28	1.25	1.40	
20-40	1.19	1.18	1.26	
0-40	1.24	1.21	1.35	1.24
		Medium kneading		
0-20	1.36	1.37	1.46	
20-40	1.23	1.20	1.29	
0-40	1.29	1.28	1.37	1.31
		Strong kneading		
0-20	1.46	1.53	1.51	
20-40	1.27	1.29	1.34	
0-40	1.37	1.41	1.42	1.39
		Very strong kneading		
0-20	1.52	1.58	1.54	
20-40	1.29	1.27	1.32	
0-40	1.40	1.42	1.43	1.42

measurement. Measurement error with the indicator and volumetric methods oscillated around 2-3 mm. When referred to a layer of greater thickness, the error in density determination was getting lower.

At all the density degrees from weak to very strong the soil density determined with the cylinder method was higher than any measured with the other method, the difference diminishing along an increasing density degree. It was the highest for weak kneading - 0.14 $Mg\ m^{-3}$, while for very strong one hardly 0.03 $Mg\ m^{-3}$.

Theoretical soil density calculated for the whole layer was very close to the results obtained with indicator and volumetric methods. That concerned all the density degrees. For strong and very strong kneading the results obtained with the cylinder method were comparable, while for weak and medium kneading they were evidently higher than theoretical values.

Discrepancies of the results obtained with the methods compared were decreasing with increasing degree of soil density and thickness of the layer measured.

CONCLUSIONS

1. The methods for determining soil density, compared under laboratory conditions, gave approximate results only when measuring strongly and very strongly kneaded soil material.

2. Determination of soil density with the cylinder method yields results burdened with methodical error, which gives raised results when measuring scarified soil.

3. The results obtained so far encourage to acknowledge that the indicator method is less labour-consuming and gives results closer to the actual density condition; therefore, it can be applied for measuring the dynamics of the soil profile density.

REFERENCES

1. **Turski R., Domżał H., Słowińska-Jurkiewicz A., Hodara J.:** Metody badania i wskaźniki oceny agrofizycznego efektu działania narzędzi uprawowych na glebę. Probl. Agrofizyki, 26, 1977.
2. **Slesarew W.N., Betehtin J.F:** Ustroistwo dla registracji wiertikalnych deformacji poczw. Poczwowiedienije, 6, 134-137, 1976.
3. **Włodek S.:** Depth indicators method for determination of bulk density dynamics. Soil Till. Res., 19, 197-201, 1991.
4. **Włodek S.:** Oznaczanie dynamiki gęstości gleby metodą wskaźników. IX Szkoła "Fizyka z elementami agrofizyki". Wyd. IA PAN, Lublin, 85-86, 1997.