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On-the-go georeferenced measurements of soil mechanical strength and differentiation of soil structure

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Soil strength is defined as the resistance which as to be overcome to obtain a given soil deformation. Amongst the numerous methods developed to measure soil strength, two are classically used. On one hand, a laboratory method based on triaxial tests of undisturbed soil samples allows the estimation of cohesion and internal friction angle by the Mohr-Coulomb equation. On the other hand, measuring soil penetration resistance by pushing a cone into a soil is a widely used technique. Both techniques deliver discontinuous field information and are not suited to produce digital soil mapping. The objectives of this paper are to present a sensor able to continuously measure soil strength variations.

The sensor was constituted of a thin blade pulled in the soil at a constant depth and speed and a beam which transferred the soil-blade forces to a transducer fixed on a vehicle. The transducer measures the draft force Fx, the vertical force Fz and the moment My thanks to an octagonal ring dynamometer. A measurement chain was developed to acquire simultaneously the signals provides by the soil strength sensor and those of a DGPS. Signal processing was notably based on geostatistics and allows soil mapping [1].

Four fields representative of the soils used in silty areas for arable production in Belgium were selected. The measurements were repeated several times during 1999-2003 (Table 1). Targeted test plots were chosen in each field to perform reference measurements, namely granulometry, cohesion, friction angle, pF, water content, dry bulk density, and cone index. The within-field studies revealed high variability caused by texture, history, traffic, etc., and showed a correlation between the sensor signals and physical parameters, such as cone index and soil moisture, as long as no over-consolidation of the soil occurred [2].

To assess the similarity of soil strength between the fields, the data Fx, Fz and My were classified by using *canonical variates* (CV). The two first CV represented 95.9 % of the variability, which means that two main variables contain the essential part of the information. Fig. 1 gives this information in a plane (Fz, Fx). Three clusters could be distinguished. The first one (trials 1 and 5), characterized by a low draft and a high Fz, corresponded to trials performed in March on soils ploughed during the winter, naked or covered with small vegetation, and characterized by small values of cone index. The second one (trials 2, 3, 4, 7) with high values of Fx and Fz grouped measurements done just after wheat harvest in August. The third cluster (trials 6) corresponded to measurements performed during wheat growth.

It may be concluded that the signals from the sensor treated by suited statistical analysis have the potential to differentiate soil structures at a field scale.

REFERENCES

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<u>Table 1.</u> Trials scheme

* After Belgian soil classification; w: gravimetric water content mean value (standard deviation); IP25: mean value of the cone index in the first 25 cm (standard deviation).

Fig. 1. Classification of soil mechanical strength values.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Field location	Ernage	Gembloux	Hannut	Hannut	Hannut	Hannut
Soil type*	Aba,Abp	Abp, Ahp	Aba	Aba	Aba	Aba
Size (ha)	4.3	10.7	13.3	13.3	13.3	13.3
Measurement date	25/03/02	31/08/00	06/10/99	29/08/00	29/03/02	04/04/0
Control plots number	17	10	10	15	18	18
w (g/g)	24.9 (0.8)	23.5 (3.5)	23.3 (1.1)	22.5 (0.5)	20.7 (1.1)	23.4 (0.7)
IP25 (MPa)	0.59 (0.09)	1.55 (0.30)	1.23 (0.25)	1.10 (0.16)	0.81 (0.12)	1.41 (0.20)
Soil state or crop during measurement	Naked soil after winter plough	After wheat harvest	After wheat harvest	After wheat harvest	Naked soil after winter plough	Wheat growin