Research specificity and standardization of agrophysical methods on the example of investigations in soil physics

A. BIEGANOWSKI, W. SKIERUCHA, R.T. WALCZAK

Institute of Agrophysics, Polish Academy of Sciences, Lublin, Poland

ABSTRACT: The study presents agrophysics as an interdisciplinary branch of science dealing with the application of physical methods to examine the properties of agricultural materials and products as well as processes in soil-plant-atmosphere and plant-machine-crop systems, sustainable plant and animal production, modern food processing technology, especially concentrating on the quality of substrates and food products. The discussed specificity of agrophysical metrology results mainly from the big diversity as well as spacial and temporal variability of the studied objects and processes. The complexity of the field covered by agrophysics requires the efforts to be made in standardization of agrophysical measurement methods.

Keywords: agrophysics; agrophysical method standardization

The multitude of the research objects, with reference to which the research methods of the physical sciences are applied, caused the separation of the disciplines, such as: biophysics, geophysics or agrophysics. The prefix in the name of each of these disciplines usually shows the subject of the study.

Respectively, *agro-* in the name of *agrophysics* informs that the objects of the investigations can be soils, plants, plant and animal materials as well as the machines, used for the processing of the above-mentioned objects. *Physics* – physical sciences are considered here as all the natural and technical sciences, which precisely define the investigated values, deal with their measurement/monitoring and undertake the analysis and interpretation of the results (Table 1, Fig. 1). The analysis and interpretation of the investigated dependencies between parameters values and the courses of the processes enables to elaborate simulation and prognostic models which with some approximation, conditioned by needs and possibilities, describe the studied phenomena. Monitoring and modeling are two main features of physical research work.

The definition qualify agrophysics as an interdisciplinary science that applies physical methods for research in agricultural materials and products properties as well as processes in the soil-plant-atmosphere, plant-machine-crop systems, sustainable plant and animal production, modern food processing technology, especially concentrating on the quality of substrates and food products (BIEGANOWSKI et al. 2003; GLIŃSKI et al. 2000; HAMAN, KONSTANKIEWICZ 2002).

The results of agrophysical investigations can be used in sustainable plant and animal production as well as for implementation and improvement of modern processing technologies with special consideration of raw materials and food products (ŘEZNÍČEK et al. 1978; BRO, HEIMDAL 1996; JAMROZ et al. 1999; KONSTANKIEWICZ et al. 2002; MOLENDA et al. 1998; TOMÁS-BARBERÁN, ESPIN 2001).

An important area of activity for agrophysics is elaboration and/or improvement of the measuring methods (ROTH, WITKOWSKA-WALCZAK 1992; ROTH et al. 1992; COMSTOCK 2000; WHALLEY et al. 2000; PACHEPSKY et al. 2001; KONSUNKAIA et al. 2004).The dynamical development of agrophysics during the last years reveals high demand of the consumers (agriculture with its surrounding in its broad sense and processing industry) for research methods and specific methods of

Table 1. Interpretation of the term *Agrophysics*

Agro-	*-Physics*
Object of investigation	Methods of investigation
Agricultural	Physical
– system: soil-plant-atmosphere	– definitions of quantities
– system: soil-plant-machine-crop	– experiment
– materials	– physical-mathematical hypothesis
	– verification
	– physical-mathematical theory

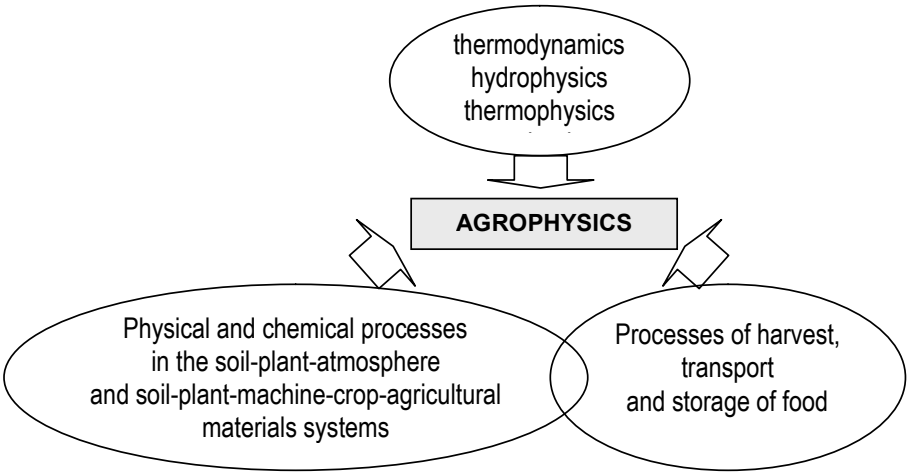

Fig. 1. Natural sciences providing scientific methodology to agrophysics

analysis and interpretation of the results concerning differentiated objects, including the objects with biological activity.

Specificity of agrophysical measurements

The specificity of agrophysical measurements refers to two fundamental aspects:

1. The multitude and high diversity of the studied objects, e.g.:
   - material objects: plants (mostly considered in the context of their behavior in the environment, as understood in broad sense); soil as the environment of plant growth and development; environments in greenhouse production; nutritive substances for plants; plant pesticides; plant materials; animal materials,
   - processes: taking place in the environment of plant growth and development; of plant production; of food production (from raw materials of plant and animal origin).
2. Spatial and temporal variability of the investigated objects:
   - agrophysical objects are characterized by natural spatial variability, e.g. spatial variability of parameters describing the soil status in the micro-scale (i.e. local status) and in the macro-scale (i.e. averaged for a chosen volume or area),
   - agrophysical objects also reveal temporal variability caused by the dynamics of the extorting processes (e.g. change of atmospheric conditions or biological activity, including micro-biological activity). Temporal variability caused by biological activity is one of the reasons that generate difficulties when trying to select methods, which follow one of the basic rules of metrology, i.e. not to disturb the properties of the investigated object.

The application of geostatistical methods and the analysis of the time-space series make it possible to determine the way of performing representative measurements, i.e. to localize in space the measuring points, the number of repetitions and the frequency of measurement.

It should be stressed, that the discussed earlier aspects of the specificity of agrophysical measurements can, in particular situations, occur in any combinations, causing additional difficulties with proper interpretation of obtained results (DIRKSEN 1999; BLAHOVEC, KUTÍLEK 2002).

Problem of standardization of soil physical methods

The International Organization for Standardization (ISO) is engaged in elaboration of international standards, which in practice refer to all areas of human activity.

Before the international standard is finally accepted, the procedure of standards elaboration provides several intermediate stages with lengthy discussion among experts from various scientific centers and engaged companies. Particular projects of a given standard, which are the effect of the work performed in a stage, are accordingly denoted at the standard's number (Fig. 2).

ISO has perceived the problems of measurements, realized in the soils (NORTCLIFF 2002). The confirmation of this fact is the output of the Technical Committee TC 190 *Soil quality*. This committee, which is divided into 6 sub-committees, has elaborated 70 standards* till now:

TC 190/SC 1 *Evaluation of criteria, terminology and codification* (6 standards)
TC 190/SC 2 *Sampling* (5 standards)
TC 190/SC 3 *Chemical methods and soil characteristics* (32 standards)
TC 190/SC 4 *Biological methods* (15 standards)
TC 190/SC 5 *Physical methods* (9 standards). The whole breakdown of SC 5 standards is presented in Table 2.
TC 190/SC 7 *Soil and site assessment* (3 standards).

*http://www.iso.ch/iso/en/stdsdevelopment/tc/tclist/TechnicalCommitteeDetailPage.TechnicalCommitteeDetail?COMMID=4381. State actual on 10/02/2004.

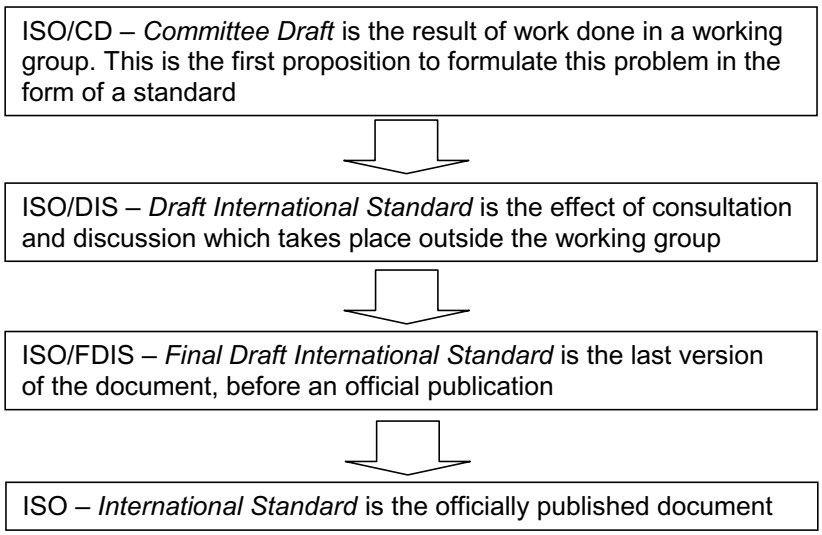

Fig. 2. Scheme for the international standard development

Table 2. Numbers and titles of standards elaborated by TC190/SC 5 *Physical methods*

ISO number: year of publication	Title of the standard
ISO 10573: 1995	Soil quality – Determination of water content in the unsaturated zone – Neutron depth probe method
ISO 11272: 1998	Soil quality – Determination of dry bulk density
ISO 11274: 1998	Soil quality – Determination of the water-retention characteristics – Laboratory methods
ISO 11276: 1995	Soil quality – Determination of pore water pressure – Tensiometer method
ISO 11277: 1998	Soil quality – Determination of particle size distribution in mineral soil material – Method by sieving and sedimentation
ISO 11277: 1998 Cor1: 2002	Correction of ISO 11277
ISO 11461: 2001	Soil quality – Determination of soil water content as a volume fraction using coring sleeves – Gravimetric method
ISO 11508: 1998	Soil quality – Determination of particle density
ISO 16586: 2003	Soil quality – Determination of soil water content as a volume fraction on the basis of known dry bulk density – Gravimetric method

Taking into consideration the quantity of officially published standards, concerning the chemical and biological methods, it should be stated that the number of standardized physical methods is relatively small.

It is obvious that the development of standards concerning physical methods in agriculture for implementation in the soil or other "living" media as well as environment is not easy. However such standards are specially needed (BIEGANOWSKI, WALCZAK 2002). It is worthwhile for the agrophysical community to notice these problems and strengthen collaboration in the process of development and improvement of European/International Standards. Also the work on standardization of agrophysical measurement methods may be a perfect opportunity for wide discussion on the methods that are widely applied but still are controversial in the range and scope of application.

SUMMARY

1. Agrophysics is an interdisciplinary branch of science dealing with the application of physical methods in examining the properties of agricultural materials and products as well as processes in soil-plant-atmosphere and plant-machine-crop systems, sustainable plant and animal production, modern food processing technology, especially concentrating on the quality of substrates and food products.
2. Specificity of agrophysical measurements is manifested by the diversity of research objects and processes as well as special and temporal variability of their properties.
3. The problems encountered during measurements (caused by the specificity of measurement) become strong arguments for the development of standards

(European and International) in agrophysical measurements.

4. Experts from research centres from various countries should actively collaborate in the standardization process.
5. The development and improvement of European and International Standards may become the chance for preparation of the inventory of research methods applied in agrophysics.

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Received for publication July 2, 2004
Accepted after corrections August 13, 2004

Specifičnost výzkumu a normalizace agrofyzikálních metod na příkladu výzkumu fyziky půdy

ABSTRAKT: Studie představuje agrofyziku jako mezidisciplinární vědecké odvětví zabývající se aplikací fyzikálních metod ve výzkumu vlastností zemědělských materiálů a produktů, procesů probíhajících v systémech půda–rostlina–atmosféra a rostlina–stroj–sklizeň, v udržitelné rostlinné a živočišné výrobě, v moderní technologii výroby potravin; soustřeďuje se zejména na kvalitu substrátů a potravinářských výrobků. Diskutovaná specifičnost agrofyzikální metrologie vyplývá hlavně z velké rozmanitosti a druhové variability zkoumaných objektů a procesů a jejich proměnlivosti v čase. Složitost výzkumného pole zkoumaného agrofyzikou vyžaduje značné úsilí v normalizaci agrofyzikálních měřicích metod.

Klíčová slova: agrofyzika; normalizace agrofyzikálních metod

Corresponding author:

Ing. ANDRZEJ BIEGANOWSKI, Instytut Agrofizyki PAN, ul. Doświadczalna 4, P.O. Box 201, 20-290 Lublin 27, Polska
tel.: + 48 744 50 61, fax: + 48 744 50 67, e-mail: biegan@demeter.ipan.lublin.pf