

Agronomic benefits of long term trials

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Abstract: Long term trials have been established in favour of exploring and observing plant and soil interrelations on site. We may determine long term trials as live instruments providing *ceteris paribus* conditions in temporal sequences. This review is dealing with the introduction to major long term trials in the World and in Hungary. Giving a brief summary on plant nutritional research roots beginning with some data from Homer, and the fabulous initial willow tree experiment of van Helmont, as well as the basic inventions of physiological processes by von Liebig, Lawes and Boussingault. The most profound long term trials like Padova's Orto Botanico, the Linné Garden of Uppsala and the Broadbalk of Rothamsted are presented in the lecture.

Agronomic, educational and scientific benefits of the major Hungarian long term trials are also discussed from Westsik 1929 via Maronvásár and the National Plant Nutrition Trials (OMTK) founded in 1963. There is a list of experimental sites giving information on the most important recent long term trial locations and the activities.

Keywords: long term trials, plant nutrition, crop physiology, adaptability

Roots

Field trials in general and long term trials in particular have been established in favour of exploring and observing plant and soil interrelations on site. We may determine long term trials as live instruments providing *ceteris paribus* conditions in temporal sequences (Kellogg 1957). The utility of such trials is in their exact layout and the length of period they are operated. Simply, the older is the better regarding the mathematical plausibility of such scientific instrument (Jolánkai 2017).

The first written information on manure is almost dated back to three millennia. Homer (BC 11th Century) presents a story in the Odyssey about the homecoming of Odysseus to Ithaka, when he is recognized by his old dog ... “ ... *lying on a heap of dung with which the thralls were wont to manure the land*”. Homer's description is of an appropriate agronomic phenomenon giving the evidence, that people of his age knew about the fertilising value of animal excreta, the collection and storage of that material, and the means of dispensing that to the field.

The fabulous initial willow tree experiment of van Helmont was recorded in 1635. It was the

first scientific plant analysis approach detecting physiology of plant growth. A young willow tree of determined weight was placed into a pot containing measured amount of soil. The pot's surface was sealed to provide any alien material to access the growth substance. Then water was applied regularly to the system over two years. Terminating the trial all measurements were done precisely. van Helmont stated that there was a significant growth and development of the willow tree, and since there was no major difference between the soil data – he assumed that the few ounces loss could be due to measurement mistakes - and upon the results he concluded, that the only material source of life is water alone. However the experiment had no plausible results, it can be assumed as the dawn of a new period.

The development of chemistry and almost two Centuries were needed afterwards to the basic inventions of physiological processes by von Liebig, Lawes and Boussingault. Justus von Liebig has described the level of development with the help of a barrel, where staves are uneven in size. According to his thesis plant growth is determined by the minimum level of a certain plant nutrient. His theses were clear

and widespread, however they were immediately doubled by Sir John Bennet Lawes who tried the theses in his replicated exact field experiment and could not verify them. Who was right and who failed? Both of them were right, however the discrepancies were induced by the system of approach. Liebig as a chemist has followed a static model, and Lawes as a practicing landlord made a dynamic assessment – say, the proof of the pudding is in eating that. A third person and a new invention was needed to formulate the physiological process. Jean Baptiste Boussingault was the man who described first the Nitrogen cycle and so gave an explanation to diverse situation. Also, it was the time when urgent need appeared in establishing exact field trials to provide in vivo conditions for research in plant physiology.

Historical long term trials

The first long term trials were not established by agriculturists, but botanists. The basic task of these trials was to provide „*ceteris paribus*” (equal measures) conditions for scientific observations. It had long been known, that to study the behaviour, growth and development of any living creature, identical conditions and replicated methods are needed (Cserháti 1901). It is difficult to identify which trial in the World can be labelled as the first, because there are at least a dozen of candidates for that. Even we may have problems to define what is a trial, and what do we mean on long term. From a point of view regarding plant growth physiology the oldest long term trial should be Padova’s Orto Botanico, founded in 1545. Various plant species have been tested here since that time under rainfed and irrigated conditions in a controlled system.

Another long term trial, with some similarities to the previous one is the Linné Garden of Uppsala founded in 1728. Carolus Linné was a botanist, and he was keen to exclude environmental effects that may have altered plant morphology, so he set up a design for parallel observations. Linné Garden is not in operation anymore, it is a sort of a live museum of science maintained nicely by the local community.

The oldest long term trial dealing with plant nutrition as well as monocropping problems is the Broadbalk of Rothamsted. Sir John Bennet Lawes an English nobleman, entrepreneur and agricultural scientist established that in 1843 with an aim among others to clarify plant nutrition principles. He was the man who employed Joseph Henry Gilbert with whom developed the superphosphate fertiliser. He founded an experimental farm at his home at *Rothamsted* Manor that eventually became the *Rothamsted* Experimental Station, one of the most powerful scientific research institutions in agriculture.

National long term trials

Hungary has always been a land dedicated to agricultural activities and so to agronomic research. For historical reasons most of the 19th Century trials did not survive. What are the longterm trials in Hungary like? Our national longterm trials have been founded in favour of to explore various scientific hypotheses and to observe agronomic techniques (Várallyay 2006). The oldest site maintained since 1929 is the Westsik long term trials at Nyíregyháza. It was set up by Vilmos Westsik to study agronomic methods suitable for sandy soils. The trial has been introducing various crop rotation systems. The main problem of that area is twofold; water scarcity and poor soil properties.

The Martonvásár trials were initiated by Professor Béla Győrffy in 1958. The main purpose of the trial was to study plant nutrition and crop rotation versions as well manure and chemical fertiliser interactions in relation with the variety specific reactions of field crops. The trials have been designed in a polyfactorial structure with replications.

The National Plant Nutrition Trials (OMTK), founded in 1963. The OMTK plant nutrition trials were established to gain reliable data on mineral fertilization of field crops in all regions of Hungary. The experimental network was initiated by Professor Géza Láng with the active participation of Béla Debreczeni, József Antal and Ernő Bocz.

Crop production and soil tillage trials. During the past half of a Century several crop production and soil tillage trials were established in favour of better understanding of crop physiological processes within given agri-environments. Valuable results have been obtained in the field of crop yield quantity and quality, in abiotic and biotic stress tolerance, soil pollution and remediation, and climate change phenomena.

training and extension services may benefit from the research results obtained from long term trials. Some of today's long term trials were originally designed for educational purposes. Such is the above mentioned Westsik trial at Nyíregyháza demonstrating sand-soil tillage methods for farmers. Other long term trials were designed to solve certain specific scientific problems, but most of them can also be used

Table 1. Main data of the Hungarian National long term trials, 2017 (Source: Kismányoky and Jolánkai 2017)

Location and number of long term trials	Established
Nyíregyháza 3	1929
Fülöpszállás 1	1982
Keszthely 12	1963
Debrecen (Látókép, Hajdúböszörmény) 4	1967
Iregszemcse, Bicsérd 2	1967
Karcag 3	1984
Szarvas 1	1989
Kompolt 2	1967
Gödöllő (Józsefmajor, Nagygombos) 3	1972
Nagyhörcsök 6	1967
Órbottyán 2	1959
Nyírlugos 1	1962
Martonvásár 15	1958

Long term trials are not only scientific curios or honoured relics of a museum, but high value live ecological models that can never be replaced or restarted whenever ceased or suspended, nevertheless terminated. These trials provide valuable and dynamic databases for solving scientific problems.

Long term trials are therefore „major tools” in basic research on crop science, agro-chemistry, soil science and agro-ecology. Their role is similar to any of the man-made tools, instruments or implements, such as phytotrons, lysimeters, hydroponics or reactors.

The benefit of long term trials in education

Regardless to their scientific value and utility, long term trials play a major role in education. Various branches of education, including undergraduate and PhD courses, vocational

for educational purposes. All long term trials in Hungary whether owned and operated by research institutions or universities, are involved in one or more accredited educational programmes. They can also be visited, studied and examined within the framework of regular scientific and extension programmes.

Economic contribution

Long term trials may have a role in the implementation of certain economic processes, as well as in prevention or handling of hazards and disasters. Without the databases of long term trials most of crop production technologies and plant protection applications would be less efficient. Even in the case of adaptation of international research results, materials, instruments and technologies, long term trials may help us in a more accurate, successful and plausible application regarding the local

conditions. Also, long term trials often contribute to the success of avoiding and managing the consequences of natural hazards, catastrophes, climatic extremes, anomalies, epidemics, gradations (eg. flood, water logging, drought, eutrophication, cyanid pollution, red sludge flood etc), just to mention some of these from recent years. Environmental protection and nature conservation should be based on long term trials. Over 80 % of the territory of Hungary is covered by terrestrial ecosystems, the vast majority of which are agro-ecosystems, a situation that is unique in Europe.

Key to international cooperation

Hungarian long term trials represent a virtual network and most of them have a role in national programmes. They also provide the basis for regional cooperation as well. Within the Carpathian basin many of the transfrontier collaborations are based on research activities of long term trials. Research results contribute to solve problems in the field of natural and social sciences. Some examples to highlight the latter: Keszthely (Hungary) - Nitra (Slovakia), Látókép-Nyíregyháza (Hungary) - Livada (Romania), or

Nagyhörcsök (Hungary) - Eszék (Croatia) joint research programmes, or the utilization of the OMTK (National Fertilization Long-term Trials) results and data in EU climate change research projects are essential for scientific cooperation (Jolánkai 2008).

The Alps-Adria scientific cooperation provides a scientific forum for presenting and discussing the research results obtained in longterm trials in the region. At these conferences during the past decade more than a thousand scientific papers have been presented, around 200 of which were based on long term trials (Jolánkai 2009). International cooperation in this field is extremely valuable and will continue to contribute to plant and soil research in the future.

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