EXAMINATION OF SOIL COMPACTION IN A LONG-TERM EXPERIMENT

A. Ujj, Cs. Gyuricza, M. Birkás, A. Stingli
Institute of Crop Production, Szent István University, Hungary

Abstract
Amongst soil threats, one of the most harmful processes is soil compaction, which is one of the most widespread forms of soil degradation. Compaction is a process whereby air is crowded out from the three –phase- system of the soil, and its volume decreases due to physical stress. An experiment was set up in 1994 in Gödöllő (Hungary) on the experimental site of Szent István University, Institute of Crop Production, to study the alleviation of harmful compaction, and the prevention of its formation.. The soil type of the experimental site was a Chromic Luvisol, with 3 replications and 9 treatments. Under conservation tillage (no traffic on the field; soil disturbance only to planting depth) and the crop sequence (mulch, oil seed radish, wheat, maize) the compaction on the surface or underneath the surface declined, but the originally loose soil consolidated over time. This research is supported by NKFP-OM-3B/0057/2002 and OTKA 32.851.

Additional Keywords: soil conservation, soil condition, mulch.

Introduction
The main purpose of the long-term experiment is to examine soil degradation types, their causes and consequences in Hungarian arable land. In this project, nine models were designed to represent the most common and frequent soil degradation types under Hungarian circumstances. The experiment was set up in 1994 in Gödöllő, with 3 replications and 9 treatments. The nine different soil degradation types were human-induced, with compacted layers in different depths. In some treatments, two compacted layers were found. Compacted layers were found as follows: 1: at the depth of 0.16-0.20 m and under 0.40 m; 2: at the depth of 0-0.04 m and under 0.40 m; 3: under 0.40 m; 4: at the depth of 0.28-0.32 m and under 0.40 m; 5: at the depth of 0.16-0.20 m; 6: at the depth of 0.28-0.32 m ; 7: at the depth of 0.08-0.10 m; 8: at the depth of 0-0.04 m, 9: control, free from compaction.

With the knowledge of the applied crop sequence (*maize-oil seed radish* as green manure and soil loosening plant-*winter wheat-mulch* in 1-1 m^2) and crop composition, the study focused on the changes of the soil condition, with special regard to the soil penetration resistance. On the one hand the examination focused on the effects of the plants on the soil, but on the other hand it studied the effects of the soil (with different soil condition problems) on the plants, on their growth and on their green mass.
In this experiment the crop sequence gave the best result (regarding the green mass and plant growth), where the plant, which is sensitive to the soil condition, was the last one in the crop sequence (in this case, we sow it in the 4^{th} year of the experiment).

Materials and Methods
Field Site
The experiment was set up in 1994 in Gödöllő (Hungary) on the experimental site of Szent István University, Institute of Crop Production. The treatments were carried out according to the most frequently detected soil condition problems in Hungary. Such problems can be produced by:

- ploughing at the same depth during some consecutive years, and the lack of soil loosening
- mistakes during seed-bed preparation particularly in rainy period around sowing and the lack of soil loosening
- lack of soil loosening
- typical plough-pan compaction, and the lack of loosening
- typical disk-pan compaction
- typical plough-pan compaction
- mistakes during seed-bed preparation
- mistakes during seed-bed preparation

The layout of the plots was randomized. The area of one treatment was 4 m^2 with a crop rotation of four plants: maize (1994-1995: MIRNA SC, 1996: HELGA SC 1997-1998: FURIO SC)-green manure plant (oil seed radish)-winter wheat (FATIMA 2)-mulch. The type of the soil in the experimental field is Chromic Luvisol with sandy loam. The average annual precipitation was 564 mm and the amount during the growth period was 313 mm. According to the data, the year of 1994 was drier and warmer than the average, while the year of 1995 was warmer and rainier. The year of 1996 was equivalent to the average, while the year of 1997 was dry and the year of 1998 was much wetter.

Analysis
In the experimental field, the phenology of the plant (sprout, early growth, height and green biomass) was observed and measured. We adopted variant analysis for the statistical evaluation of data. (Baráthné *et al.* 1996).

Results and Discussion

Relationship between soil condition and green biomass:
The germination, the plant height at harvest time and the dry matter weight of plants were measured and observed during the whole time of the experiment. From the perspective of the germination, the most unfavourable treatments were where the surface is compacted (treatments 2, 8.). In the case of early plant growth, the most unfavourable treatments were where there was a compacted layer near the surface (treatments 7, 1). The conclusion is that the most advantageous soil condition is free from any compaction in the upper 0.40 m for the sprout and early growth (treatments 9, 3, 6.). The favourable effect was the most visible one in the first two years.

Biomass was influenced mainly by the effect of the year. The volume of the biomass of maize, winter wheat and oil seed radish gave a similar result, therefore it is more reasonable to work and make an evaluation with the average of the 3 plant-dry matter weights concerning the effect of each year. Figures 1-5 show the results. The white column illustrates the most favourable soil conditions, while the black column shows the lowest dry matter weight. The difference between the highest and lowest ones is significant in each year of the experiment. During the years of the experiment, the soil of the most favourable treatments consolidated, and their dry matter weight decreases. Treatments N^o 9 and N^o 3 were the most advantageous at the time of their set up. These treatments were free from compacted layers in the upper 0.40 m while the most unfavourable treatments were 2, 7 and 8, with compacted layers near the surface.

The treatments with compacted layers near the surface may have improved and may have loosened due to the suitable crop sequence. These treatments, after certain years, have given better results with regard to the biomass. The range between the nine treatments did not change too much in 1995 and in 1996 but in the third year it started to be more expressive which can be explained with the suitable crop sequence, the lack of treading and conservation tillage. The compaction on the surface or underneath the surface loosened (treatment 7, 1, 2.) and these treatments started to give higher amount of biomass.

The conclusion of the experiment is that a suitable crop sequence which has economic and soil protection roles is indispensable. Applications of such a soil conservational primary tillage or tillage system are suggested, which are suitable for the economic requests at the same time. The primary tillage has to be soil protecting, with different tillage depths (avoiding plough-pans or disk-pans). It has to provide regular loosening and a suitable soil structure preservation.

References:

Baráth Cs.-né-Ittzés A.-Ugrósdi Gy. (1996). Biometria. Mezőgazda Kiadó, Budapest.
Birkás M. (1987). A talajművelés minőségét befolyásoló agronómiai tényezők értékelése. Kandidátusi értekezés, Gödöllő.
Birkás M. (2000). A talajtömörödés helyzete Magyarországon. Következményei és enyhítésének lehetőségei. MTA Doktori Értekezés, Budapest.
Chervet, A.-Maurer, C.-Sturny,W.G.-Müller,M. (2001). Effets sur la structure du sol. Revue suisse d’agriculture. 33:1, 15-19.
Farkas Cs.-Gyuricza Cs.-László P. (1999). Egyes talajfizikai tulajdonságok vizsgálata talajművelési tartamkísérletekben gödöllői barna erdőtalajon. Növénytermelés, 48.3: 323-336.
Fenyves T. (1996). A fenntartható gazdálkodás néhány agronómiai feltétele, különös tekintettel a művelés hatásra, a gyomosságra és a trágyázásra. Doktori (PhD) értekezés, Gödöllő.
Gyuricza Cs.-Baráth Cs.-né-Birkás M. (1998). Polinomiális regresszió alkalmazása a talajellenállás statisztikai értékelésére. Növénytermelés, 47. 3: 176-188.
Gyuricza Cs. (2000). Az értékőrző és hagyományos talajművelés egyes fizikai és biológiai hatásainak értékelése. Doktori (PhD) értekezés, Gödöllő, p.148
Könnecke, G. (1969). Vetésforgók. Mezőgazdasági Kiadó, Budapest.
Lal, R.-Pierce, J. (1991). Soil management for sustainability. Soil and Water Conservat. Soc. Ankeny, Iowa, 3-5:175-179.
Szabolcs I.-Várallyay Gy. (1978). A talajok termékenységét gátló tényezők Magyarországon. Agrokémia és Talajtan, 27. 1-2: 181-202.

Tóth Z.-Kismányoky T. (2001). A kukorica (Zea mays L.) és a búza (Triticum aestivum L.) szemtermésének vizsgálata különböző vetésforgókban és kukorica-monokultúrában. Növénytermelés, 50.1:123-134.
Varvel, G.E. (1994). Monoculture and rotation system effects on precipitation use efficiency. Agron.J. 86:204-28.

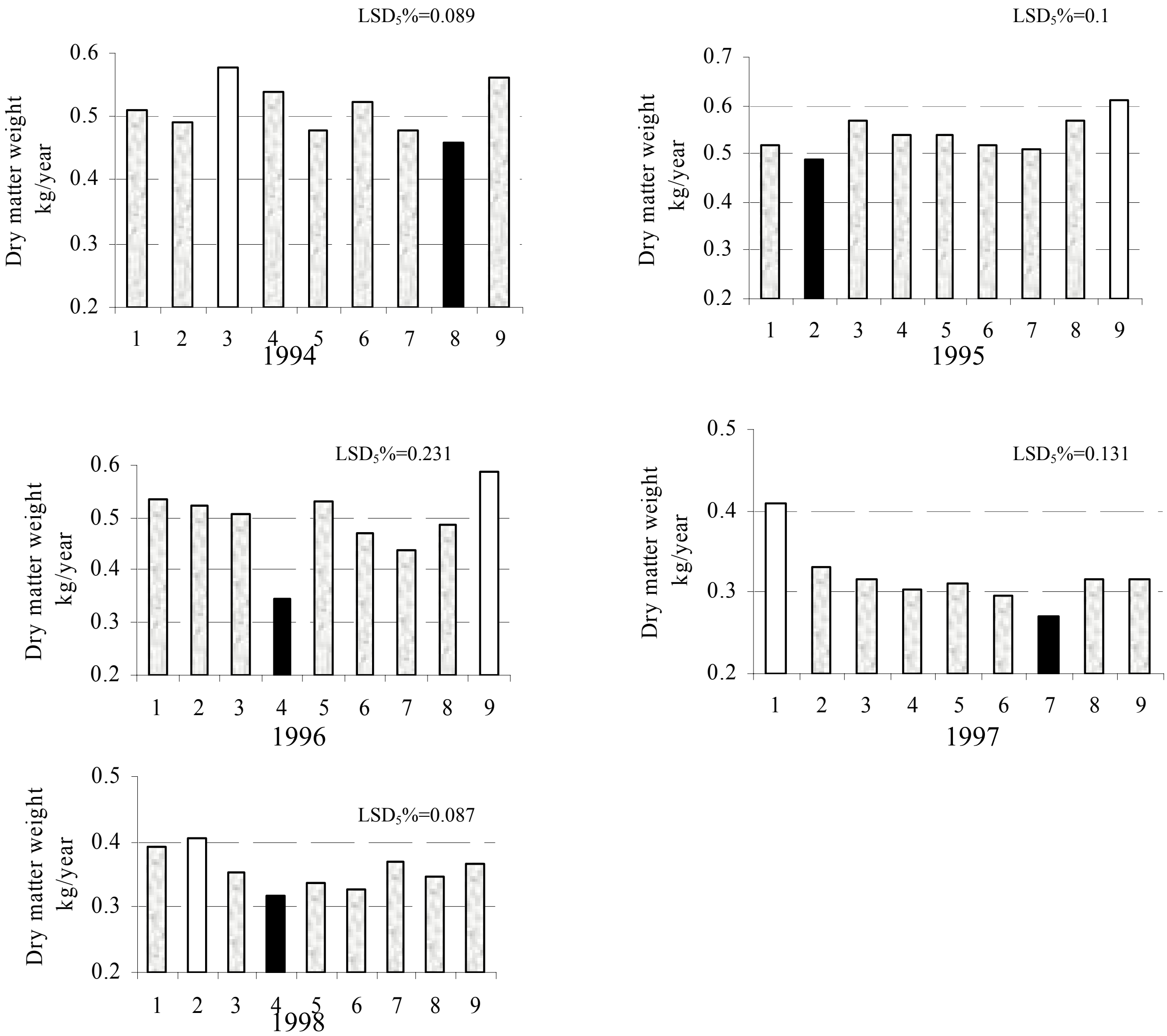

Figure 1. The change of the soil condition range in the case of conservation tillage (Gödöllő 1994-1998)