# THE IMPACT OF SOIL WORKS ON THE MAIN SOIL PHYSICAL FEATURES IN WINTER WHEAT AND GRAIN MAIZE

**G. CÂRCIU**[1] **, A. LĂZUREANU**[1]**, S. ALDA**[1]**,**
**Lenuţa Gheorghina POPOVICIU**[1]

[1] Agricole Sciences and Veterinary Medicine
University of Banat, Timişoara
*e-mail : lazureanuaurel@yahoo.com*

*In winter wheat, we analysed soil deep aeration with two graduations: not scarified and scarified with the following variants: ploughing 18-22 cm + discing, discing, soil work with a combined machine and direct sowing. In maize we monitored two graduations: non scarified and scarified with the variants ploughing 25-30 cm+discing, discing in summer + treatment with herbicides+discing in spring, soil work, with a combined machine, direct sowing. Apparent density has lower values in spring in the scarification–ploughing+discing (1.12-1.20 g/cm$^3$) system and higher in summer or autumn depending on the crop (wheat: 1.35-1.43 g/cm$^3$, maize: 1.42-1.52 g/cm$^3$). In wheat, on non scarified soil the water reserve in the soil oscillates between 1576 m$^3$/ha and 1856 m$^3$/ha, in the twining phase (april) and between 1354 m$^3$/ha and 1506 m$^3$/ha, upon harvesting. In grain maize cultivated on non scarified soil, soil moisture reserve in the 5-6 leaves stage was around 2000 m$^3$/ha. In the deep aeration variant, there is a surplus of water of 200 m$^3$/ha compared to the non scarified variant.*

***Key words****: wheat, maize, density, porosity, soil water reserve*

Soil working system has an impact on apparent density, porosity, setting degree etc [1]. In the physical characterisation of a soil texture and apparent density are basic features, the bare necessity that should be known through direct measurements [3]. Soil setting, other than the natural one, and particularly soil setting due to irrational soil works are the main cause of the damage to the pore network and to the structural setting of the soil with negative consequences over long periods of time [2].

## MATERIAL AND METHOD

The experiments were organised at the Didactic Station in Timişoara, on a cambic, poorly gleyied chernozem with a humus content of 3.41%, normally supplied with nitrogen (0.18%), poorly supplied in mobile phosphorus (17.80 ppm) and with a high supply of assimilable potassium (187.6 ppm). Experiments focused on two crops: winter wheat and maize sowed in the fall of 2005 (october) and in the spring of 2006 (april), respectively, organised after the subdivided plot method of the 2 x 4 with four replications [4]. In winter wheat, the experimental factors were as follows: *Factor A* – Deep aerating: $a_1$ – not scarified; $a_2$ – scarified, *Factor B* – Soil works: $b_1$ – ploughing

18-22 cm deep + discing; $b_2$ – discing; $b_3$ – working the soil with a combiner (LMC); $b_4$ – stubble direct sowing. In grain maize, the experimental factors were the following: *Factor A* – Deep aerating: $a_1$ – not scarified; $a_2$ – scarified, *Factor B* – Soil works: $b_1$ – ploughing (25 -30 cm) + discing; $b_2$ – discing in summer + treated with herbicides + discing in spring; $b_3$ – working the soil with a combiner (LMC); $b_4$ – stubble direct sowing.

## RESULTS AND DISCUSSIONS

**WHEAT.** Changing **apparent density** due to the soil working system is done in different ways, depending on the soil physical features and at a sampling depth (*tab. 1).*

Table 1

**Impact of soil working systems on apparent density (Da g/cm$^3$) in winter wheat, 2006**

| Pheno-phase | Depth (cm) | NOT SCARIFIED | | | | SCARIFIED | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ploughing + discing | Discing 2x | LMC | Direct sowing | Ploughing + discing | Discing 2x | LMC | Direct sowing |
| Twinning – April 2006 | 0-10 | 1.19 | 1.23 | 1.20 | 1.28 | 1.12 | 1.17 | 1.12 | 1.25 |
| | 10-20 | 1.22 | 1.28 | 1.28 | 1.30 | 1.21 | 1.27 | 1.20 | 1.28 |
| | 20-40 | 1.31 | 1.32 | 1.33 | 1.35 | 1.28 | 1.30 | 1.27 | 1.34 |
| | 40-60 | 1.40 | 1.42 | 1.40 | 1.43 | 1.35 | 1.38 | 1.35 | 1.33 |
| Harvesting – July 2006 | 0-10 | 1.24 | 1.26 | 1.27 | 1.29 | 1.22 | 1.24 | 1.25 | 1.27 |
| | 10-20 | 1.32 | 1.30 | 1.33 | 1.31 | 1.29 | 1.28 | 1.30 | 1.29 |
| | 20-40 | 1.38 | 1.32 | 1.35 | 1.38 | 1.35 | 1.30 | 1.34 | 1.36 |
| | 40-60 | 1.41 | 1.39 | 1.43 | 1.44 | 1.38 | 1.37 | 1.41 | 1.43 |

*In the non scarified version,* the values of apparent density during the twinning phase (April) over 0-10 cm depth are between 1.19 and 1.28 g/cm$^3$. In the direct sowing variant, over the first 10 cm the value of apparent density was 1.28 g/cm$^3$. *In the scarified variant*, the values of apparent density had an obvious decreasing trend in apparent density values both in the superficial layer and deep in the soil, the values of apparent density being influenced by soil scarification. Upon harvesting, apparent density had superior values compared to the values of apparent density determined upon twinning. *In the non scarified variant*, apparent density varied between 1.24 and 1.29 g/cm$^3$ in the first 10 cm, and then it decreased to more than 1.40 g/cm$^3$ at a depth of 40-60 cm. *In the scarified variant*, apparent density had lower values both over the first 10 cm and at depths of 40-60 cm, due to the soil mobilising works over 60 cm (*tab 1*).

**Total porosity values** oscillated, in general, between 40 and 60%, while in more set soils they were lower (42-45%). Total porosity values determined during the twinning phase (April 2006) in winter wheat are presented in *tab 2.* The highest values of total porosity in the non scarified variant and during the twinning period were over a working depth of 0-10 cm (i.e., 55-58%) in the variants ploughing + discing, discing 2x and LMC, and in the direct sowing system it reached 58%. If the soil is scarified, there is a slight increase of total porosity values and in all sampling depths. Upon harvesting, total porosity had lower values than those during the twinning phase. Over the first 10 cm, total porosity oscillated between 52 and 57%, and in the soil horizon 40-60 cm it had lower values, i.e. 46-49%.

Table 2

**The impact of soil working system on total porosity (PT, %) in winter wheat, 2006**

| Pheno-phase | Depth (cm) | NOT SCARIFIED | | | | SCARIFIED | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ploughing + discing | Discing 2x | LMC | Direct sowing | Ploughing + discing | Discing 2x | LMC | Direct sowing |
| Twinning – April 2006 | 0-10 | 56 | 57 | 55 | 58 | 59 | 58 | 60 | 61 |
| | 10-20 | 55 | 52 | 52 | 50 | 57 | 55 | 59 | 53 |
| | 20-40 | 48 | 46 | 47 | 46 | 53 | 52 | 53 | 48 |
| | 40-60 | 47 | 46 | 47 | 46 | 50 | 49 | 48 | 46 |
| Harvesting – July 2006 | 0-10 | 54 | 53 | 55 | 52 | 56 | 55 | 57 | 54 |
| | 10-20 | 52 | 51 | 51 | 50 | 54 | 54 | 53 | 51 |
| | 20-40 | 48 | 48 | 47 | 48 | 50 | 50 | 49 | 50 |
| | 40-60 | 47 | 47 | 46 | 46 | 48 | 49 | 48 | 48 |

The physical state reached by the soil under the impact of mechanical intervention due to soil working systems can best be assessed by the **setting degree**, an indicator that includes both apparent density and total porosity, all correlated with soil texture. The highest values of soil aeration are within 0-10 cm, upon twinning. In the variants in which soil works were done with a combiner or there was direct sowing, aeration degree is very high – it reaches 14%. The aeration degree diminishes upon harvesting within the first 10 cm, after which the soil becomes more set.

In winter wheat, **soil moisture** is influenced by both soil working type and the time of sampling. On non scarified soil, soil water supply oscillated between 1.576 $m^3$/ha (direct sowing) and 1.856 $m^3$/ha (ploughing + discing) during the twinning phase (April), and between 1.354 $m^3$ (discing) and 1.506 $m^3$/ha (ploughing + discing) upon harvesting. Soil water reserve had superior values when there was deep aeration. No matter the experimental variants, in scarified soil there were supplementary amounts of water from precipitations, i.e. about 150 $m^3$/ha. Water reserves measured within 0-60 cm in April 2006 are presented in *tab 3, 4*.

Table 3

**Moisture (U%) and water supply Ra ($m^3$/ha) depending on the soil working method on non scarified soil in winter wheat (April, July) in 2006**

| Pheno-phase | Depth (cm) | Ploughing + discing | | Discing 2x | | LMC | | Direct sowing | |
|---|---|---|---|---|---|---|---|---|---|
| | | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha |
| Twinning – April 2006 | 0-10 | 22.89 | 1856 | 19.78 | 1594 | 20.54 | 1633 | 18.90 | 1576 |
| | 10-20 | 24.37 | | 20.36 | | 22.67 | | 21.22 | |
| | 20-40 | 24.39 | | 20.24 | | 20.12 | | 20.46 | |
| | 40-60 | 22.86 | | 19.94 | | 19.78 | | 21.50 | |
| Harvesting – July 2006 | 0-10 | 17.16 | 1506 | 16.05 | 1354 | 16.90 | 1484 | 15.75 | 1368 |
| | 10-20 | 18.74 | | 16.75 | | 19.04 | | 15.96 | |
| | 20-40 | 18.28 | | 16.93 | | 19.01 | | 17.38 | |
| | 40-60 | 20.70 | | 18.65 | | 18.32 | | 17.97 | |

Table 4

**Moisture (U%) and water supply Ra ($m^3$/ha) depending on the soil working method on scarified soil in winter wheat (April, July) in 2006**

| Pheno-phase | Depth (cm) | Ploughing + discing | | Discing 2x | | LMC | | Direct sowing | |
|---|---|---|---|---|---|---|---|---|---|
| | | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha |
| Twinning – April 2006 | 0-10 | 24.32 | 1984 | 20.36 | 1678 | 22.48 | 1746 | 19.78 | 1652 |
| | 10-20 | 26.25 | | 21.12 | | 24.32 | | 23.15 | |
| | 20-40 | 26.78 | | 21.85 | | 23.93 | | 22.39 | |
| | 40-60 | 24.16 | | 20.90 | | 21.04 | | 22.42 | |
| Harvesting – July 2006 | 0-10 | 20.39 | 1650 | 18.34 | 1555 | 20.69 | 1640 | 17.24 | 1535 |
| | 10-20 | 20.43 | | 20.11 | | 20.22 | | 19.25 | |
| | 20-40 | 21.02 | | 20.85 | | 20.86 | | 19.81 | |
| | 40-60 | 22.11 | | 20.45 | | 20.43 | | 20.06 | |

**MAIZE.** The values of **apparent density** within 0-10 cm in june (5-6 leaves) confirm the moderate soil aeration, i.e. 1.22-1.36 g/$cm^3$ on non scarified soil and 1.20-1.34 g/$cm^3$ on scarified soil. During grain development, the values of apparent density are 1.39-1.43 g/$cm^3$ no matter the soil work. Upon harvesting, the values of apparent density increase in all variants within 0-20 cm, the highest value being 1.48 g/$cm^3$ in the two discing variant. Below 20 cm, the values of apparent density did not show differences (*tab. 5*).

Table 5

**Impact of soil working systems on apparent density (Da g/$cm^3$) in maize, 2006**

| Pheno-phase | Depth (cm) | NOT SCARIFIED | | | | SCARIFIED | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ploughing discing | Discing 2x | LMC | Direct sowing | Ploughing discing | Discing 2x | LMC | Direct sowing |
| 5-6 leaves – June 2006 | 0-10 | 1.22 | 1.33 | 1.28 | 1.36 | 1.20 | 1.30 | 1.26 | 1.34 |
| | 10-20 | 1.33 | 1.36 | 1.36 | 1.37 | 1.30 | 1.34 | 1.34 | 1.35 |
| | 20-40 | 1.46 | 1.47 | 1.41 | 1.41 | 1.44 | 1.44 | 1.39 | 1.39 |
| | 40-60 | 1.50 | 1.50 | 1.45 | 1.42 | 1.48 | 1.48 | 1.43 | 1.40 |
| Grain develop-ment – aug. 2006 | 0-10 | 1.34 | 1.35 | 1.36 | 1.39 | 1.31 | 1.33 | 1.35 | 1.36 |
| | 10-20 | 1.37 | 1.38 | 1.40 | 1.41 | 1.34 | 1.36 | 1.38 | 1.38 |
| | 20-40 | 1.47 | 1.49 | 1.44 | 1.44 | 1.45 | 1.47 | 1.42 | 1.41 |
| | 40-60 | 1.50 | 1.50 | 1.46 | 1.42 | 1.48 | 1.48 | 1.45 | 1.40 |
| Harvesting – October 2006 | 0-10 | 1.36 | 1.39 | 1.37 | 1.40 | 1.34 | 1.37 | 1.35 | 1.37 |
| | 10-20 | 1.38 | 1.40 | 1.39 | 1.41 | 1.36 | 1.38 | 1.37 | 1.39 |
| | 20-40 | 1.49 | 1.50 | 1.42 | 1.46 | 1.48 | 1.47 | 1.39 | 1.43 |
| | 40-60 | 1.52 | 1.51 | 1.45 | 1.44 | 1.51 | 1.49 | 1.42 | 1.41 |

The values of **total porosity** in grain maize depending on the soil working system correlate with soil setting such as determined by apparent density and show a high water holding capacity, high permeability, and good aeration (*tab. 6*).

Table 6

**The impact of soil working system on total porosity (PT, %) in maize, 2006**

| Pheno-phase | Depth (cm) | NOT SCARIFIED | | | | SCARIFIED | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ploughing + discing | Discing 2x | LMC | Direct sowing | Ploughing + discing | Discing 2x | LMC | Direct sowing |
| 5-6 leaves – June 2006 | 0-10 | 54 | 53 | 52 | 53 | 57 | 55 | 54 | 55 |
| | 10-20 | 51 | 51 | 48 | 51 | 54 | 53 | 50 | 53 |
| | 20-40 | 48 | 49 | 49 | 50 | 49 | 51 | 51 | 52 |
| | 40-60 | 46 | 47 | 45 | 56 | 48 | 49 | 48 | 59 |
| Grain development – August 2006 | 0-10 | 50 | 51 | 51 | 53 | 53 | 54 | 53 | 57 |
| | 10-20 | 49 | 48 | 49 | 50 | 51 | 50 | 51 | 52 |
| | 20-40 | 45 | 46 | 47 | 49 | 48 | 49 | 49 | 50 |
| | 40-60 | 44 | 45 | 44 | 47 | 45 | 47 | 47 | 48 |
| Harvesting – October 2006 | 0-10 | 48 | 47 | 52 | 49 | 50 | 49 | 53 | 49 |
| | 10-20 | 47 | 46 | 49 | 48 | 49 | 48 | 51 | 48 |
| | 20-40 | 45 | 46 | 47 | 48 | 46 | 48 | 49 | 50 |
| | 40-60 | 46 | 44 | 45 | 47 | 48 | 47 | 48 | 49 |

Both soil moisture and soil water supply are influenced by both soil work and vegetation phase. On non scarified soil, soil moisture in the 5-6 leaves phase is about 2.000 $m^3$/ha. In August, it diminishes with about 400 $m^3$/ha, increasing again upon harvesting and reaching 1,800 $m^3$/ha. In the deep aeration variant, there is higher accumulation of water than on non scarified soil, i.e. 200 $m^3$/ha (*tab 7* and *8)*.

Table 7

**Moisture (U%) and water supply Ra ($m^3$/ha) depending on the soil working method on non scarified soil in maize (April, July) in 2006**

| Pheno-phase | Depth (cm) | Ploughing +discing | | Discing 2x | | LMC | | Direct sowing | |
|---|---|---|---|---|---|---|---|---|---|
| | | U (%) | Ra $m^{3/}$ha | U (%) | Ra $m^{3/}$ha | U (%) | Ra $m^{3/}$ha | U (%) | Ra $m^{3/}$ha |
| 5-6 leaves – June 2006 | 0-10 | 24.72 | 2034 | 23.25 | 1974 | 23.56 | 1985 | 25.12 | 2058 |
| | 10-20 | 24.65 | | 23.35 | | 24.20 | | 25.73 | |
| | 20-40 | 24.60 | | 23.68 | | 24.55 | | 24.16 | |
| | 40-60 | 24.32 | | 22.41 | | 23.62 | | 23.72 | |
| Grain develop-ment – August 2006 | 0-10 | 18.32 | 1664 | 17.57 | 1590 | 18.41 | 1684 | 16.74 | 1562 |
| | 10-20 | 19.53 | | 18.47 | | 20.39 | | 17.25 | |
| | 20-40 | 19.44 | | 18.19 | | 20.01 | | 19.25 | |
| | 40-60 | 20.84 | | 19.94 | | 20.28 | | 20.06 | |
| Harvesting – October 2006 | 0-10 | 22.15 | 1985 | 20.97 | 1783 | 21.36 | 1797 | 19.15 | 1760 |
| | 10-20 | 23.54 | | 19.35 | | 21.01 | | 20.34 | |
| | 20-40 | 23.35 | | 20.05 | | 20.27 | | 12.15 | |
| | 40-60 | 22.85 | | 21.64 | | 22.26 | | 21.40 | |

Table 8

**Moisture (U%) and water supply Ra ($m^3$/ha) depending on the soil working method on scarified soil in maize (April, July) in 2006**

| Phenophase | Depth (cm) | Ploughing + discing | | Discing 2x | | LMC | | Direct sowing | |
|---|---|---|---|---|---|---|---|---|---|
| | | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha | U (%) | Ra $m^3$/ha |
| 5-6 leaves – June 2006 | 0-10 | 27.51 | 2262 | 24.45 | 2144 | 26.38 | 2172 | 27.48 | 2174 |
| | 10-20 | 28.41 | | 25.56 | | 26.50 | | 27.53 | |
| | 20-40 | 27.72 | | 26.48 | | 25.82 | | 25.36 | |
| | 40-60 | 27.25 | | 26.34 | | 27.79 | | 25.41 | |
| Grain development – August 2006 | 0-10 | 22.04 | 1871 | 20.06 | 1780 | 20.27 | 1814 | 18.75 | 1720 |
| | 10-20 | 22.07 | | 20.89 | | 21.24 | | 19.32 | |
| | 20-40 | 22.2 | | 21.75 | | 22.32 | | 22.30 | |
| | 40-60 | 22.79 | | 21.44 | | 22.54 | | 22.16 | |
| Harvesting – October 2006 | 0-10 | 24.40 | 2051 | 23.49 | 1968 | 23.37 | 1976 | 21.63 | 1908 |
| | 10-20 | 23.63 | | 21.97 | | 24.81 | | 22.05 | |
| | 20-40 | 23.94 | | 23.77 | | 24.05 | | 23.18 | |
| | 40-60 | 24.30 | | 22.54 | | 23.25 | | 24.02 | |

## CONCLUSIONS

1. **In winter wheat**, on non scarified soil, the values of apparent density during the twinning phase (april) within 0-10 cm are between 1.19 and 1.28 (g/$cm^3$), and upon harvesting they reach 1.24-1.29 (g/$cm^3$). On scarified soil, the values of apparent density show an obvious trend of diminution of the values of apparent density both in the superficial layer of the soil and deep down in the soil.

2. The highest values of total porosity on non scarified soil during the twinning phase were within 0-10 cm, i.e. 55-58%.

3. Soil water supply oscillated between 1.576 $m^3$/ha and 1.856 $m^3$/ha during the twinning phase (april) and between 1.354 $m^3$ and 1.506 $m^3$/ha upon harvesting.

4. **In maize,** the values of apparent density within 0-10 cm in June (5-6 leaves) confirm the moderate soil aeration, i.e. 1.22-1.36 g/$cm^3$ on non scarified soil and 1.20-1.34 g/$cm^3$ on scarified soil.

5. The values of soil total porosity depending on the soil working type correlate with soil setting.

6. On non scarified soil, soil moisture supply during 5-6 leave phase is about 2.000 $m^3$/ha. In the deep aeration variant, there is a surplus of water of 200 $m^3$/ha compared to the non scarified variant.

### BIBLIOGRAPHY

1. Cârciu, G., 2006 – *Managementul lucrarilor solului*, Editura Eurobit, Timişoara.
2. Gus, P., Lăzureanu, A., Săndoiu, D., Jităreanu, G., Iancu S., 1998 – *Agrotehnica*, Editura Risoprint Cluj-Napoca.
3. Lăzureanu, A., Manea, D., Cârciu, G., Alda S., 2006 – *Agrotehnică aplicativă*, Editura Eurobit, Timişoara.
4. Săulescu, N.A., Săulescu, N.N., 1968 – *Câmpul de experienţă*, Editura Agro-Silvică, Bucureşti.