# RESEARCHES REGARDING THE INFLUENCE OF THE POSITION ON THE HILL UNDER MAIN PHYSICAL PROPERTIES OF THE SOIL IN DIFFERENT CROP SYSTEM

Cornel DOMUTA[1], MARIA SANDOR[2], Cristian DOMUTA[2],
Radu BREJEA[2], Adrian VUSCAN[2], Cristian ONET[2], Aurelia ONET[2]

**Abstract** *The paper based on the researches carried out during 2008-2011 in Oradea in the plots for flow check placed on the hill with 10% slope. The area is characterized by average of the multianual rainfall of 620 mm.[1,2,3] The following variant were studied: clean fallow, pasture, maize seeded from hill to valley, maize seeded on the level curves direction, wheat. The physical analysis were made in the profiles situated in the top and at the base of the hill. The biggest difference between structure degree determined at the base of the hill and top of the hill was registered in the variant with clean fallow (40,2%); in the other variants the differences were of 33,3% in the variant with maize seeded from hill to valey, of 12% in the variant with maize seeded on the level curves, of 8,2% in the wheat and of 7,6% in the pasture. In the horizons of the profile from the base of the hill the values of the bulk density were smaller than the values registered in the top of the hill, the total porosity values were bigger, the hydraulic conductivity values were bigger too and the penetration rezistance values were smaller. As consequence, the yields determined at the base of the hill were bigger than the yields determined in the top of the hill; in the maize seeded from hill to valley the differenes were bigger than the differenes registered in the variant with the maize seeded on the level curves. The results researches sustain the need of the soil management against erosion based on the protective plants and the crop on the level curves direction.*

**Keywords:** macrostructure hydrostability, bulk density, total porosity, penetration rezistance, hydraulic conductivity, erosion.

## Introduction

Erosion affects important surfaces in Romania; the erosion affects the soil from Western Romania too; in the Bihor county (North Western part) a surface of 200.000 hectares (38%) have a slope bigger than 5% and there is a potential erosion. [1,2,3] A specific soil management is needed on the erosioned soil [4,5,6,7,8,9, 10,12,13] and the researches regarding this point of view started in 1973 at Cordău by Colibaş I et all. Colibaş I, Maria Colibaş and Mihuţ I., were made researches regarding the soil management of the erosioned soil in Hidişelu de Sus (1980-1983) and Pocola (starting with 1983). After 1986, the coordinator

[1]Prof., PhD, Academy of Romanian Scientists – Associate Member, University of Oradea, Environmental Protection Faculty, Romania, domuta_cornel@yahoo.com
[2]PhD, University of Oradea, Environmental Protection Faculty, Romania

of the researches regarding soil erosion from Pocola was Domuţa C.; the researches regarding the crop rotation, chemical and organic (manure and green manure) fertilizers were made. After 1990, the researches were continued at Beiuș and the researches in the plots for soil losses were added. In 1999, the researches regarding the soil management and the soil losses determination in the special plots were carried in Oradea; this paper presents the results obtained in these plots.

## 2. Materials and methods

The researches were carried out during 2008-2011 in Agricultura Research and Development Station Oradea on a hill with 8% slope. The plots for the soil erosion measurement were placed in the following variants: V1=clean fallow, V2=maize from top to valley, V3=maize on the level curve direction, V4=wheat, V5=pasture. The plots' dimensions were 45x3.5 m and metal panels were placed at the base of the plots as well as soil dams between the plots on the hill.
The physical and chemical properties of the soil after 10 years of research were determined in a laboratory from the Agricultural Research and Development Station Oradea. The macroaggregates' hydrostability was determined by wet sifting using the Cseratzki method. The bulk density (BD) was determined in 5 repetitions using cylinders with a diameter of 100 $cm^3$; the same cylinders were used in order to determine the penetration resistance and the hydraulic conductivity of the soil. The total porosity was calculated using the following formula: TP=(1-DA/D)x100, in which D=density=2.65 $g/cm^3$. The rainfall data was registered in the Meteorological Station Oradea at $45^o03'$ latitude and $21^o56'$ longitude, the annual rainfall registered were of 585,7 mm, of 501,4 mmin 2009, of 869,0 mm in 2010 and of 569,7 mm in 2011. The data regarding the soil physical properties and yield were worked using the analysis variant method. [14]
The correlations between bilk density and hydraulic conductivity, bulk density and penetration rezistance, penetration rezistance-hydraulic conductivity were determined using spredsheets software. The generated equation that had the best R-squared value was taken into consideration; the regression types available were linear, logarithmic, exponential, power and polynomial ones.

## 3. Results and discussions

### Macroagregates hydrostability

In the top of the hill the smallest value of the macroagregates was registered in the variant with clean fallow (37.6%) and the biggest value was registered in the variant with pasture (56.0%). The biggest difference between macrostructure hydrostability in the top of the hill in comparison with the base of the hill was

registered in the variant with clean fallow (43.3%) and the smallest (5.9%) was registered in the variant with pasture; the differences are very significant in the variants with clean fallow, maize from top to valley, maize on the level curves and wheat and distingue significantin the pasture (table 1)

**Table 1.** The influence of the crop system on the macroagregates hydrostability in the top and base of the hill, Oradea 2011

| Positon on the hill | Macroagregates | | Difference | Statistically significant |
|---|---|---|---|---|
| | % | % | % | |
| Clean fallow | | | | |
| Top of the hill | 37.6 | 100 | - | Control |
| Base of the hill | 53.9 | 143.3 | 43.3 | *** |
| LSD $_{5\%}$ 2.1 | LSD $_{1\%}$ 4.6 | | LSD $_{0.1\%}$ 8.2 | |
| Maize from top to valley | | | | |
| Top of the hill | 42.0 | 100 | - | Control |
| Base of the hill | 54.0 | 128.6 | 28.6 | *** |
| LSD $_{5\%}$ 1.8 | LSD $_{1\%}$ 3.9 | | LSD $_{0.1\%}$ 6.4 | |
| Maize on the level curves | | | | |
| Top of the hill | 46.7 | 100 | - | Control |
| Base of the hill | 55.7 | 119.3 | 19.3 | *** |
| LSD $_{5\%}$ 1.5 | LSD $_{1\%}$ 2.9 | | LSD $_{0.1\%}$ 4.7 | |
| Wheat | | | | |
| Top of the hill | 50.2 | 100 | - | Control |
| Base of the hill | 56.3 | 112.2 | 12.2 | *** |
| LSD $_{5\%}$ 1.4 | LSD $_{1\%}$ 2.7 | | LSD $_{0.1\%}$ 4.3 | |
| Pasture | | | | |
| Top of the hill | 56.0 | 100 | - | Control |
| Base of the hill | 59.3 | 105.9 | 5.9 | ** |
| LSD $_{5\%}$ 1.3 | LSD $_{1\%}$ 2.5 | | LSD $_{0.1\%}$ 4.0 | |

**Bulk density**

Both in the top of the hill (1.61 g/cm$^3$) and in the base of the hii (1.50 g/cm$^3$), the biggest values of the bulk density were registered in the variant with clean fallow. The smallest values of the bulk density, 1.33 g/cm$^3$ in the top of the hil land 1.26 g/cm$^3$ at the base of the hill, were registered in the pasture. The biggest difference between bulk density value in the top of the hill in comparison with the base of the hill was registered in the variant with clean fallow (-6.8%) and the smallest value (-5.3%) was registered in the pasture. The bulk density values in the base of the hill are smaller than the values registered in the top of the hii, and the differences between the determination position are very significant statistically. (table 2)

## Total porosity

Total porosity values in the top of the hill are smaller than the vslues determine dat the base of the hill, the differences are very significant statistically in the all variants. Both in the top of the hill and at the base of the hill, the smallest values were registered in the variant with clean fallow and the biggest values were deetermined in the variant with pasture. The difference between the total porosity value registered in the top of the hill and base of the hill is very significant statistically in clean fallow, distingue significant statistically in maize from top to valley and maize on the level curves direction and significant statistically in the variants with wheat and pasture. The relative differences value between the total porosity value at the base of the hil land in the top of the hill decreased from the variant without plants (12%) to pasture (5.2%) : 8.3% in the variant with maize from top to valley, 7.6% in the variant with maize on the level curves direction, 4.0% in the variant with wheat. (table 3)

**Table 2.** The influence of the crop system on the bulk density (BD) of the soil in the top and base of the hill, Oradea 2011

| Positon on the hill | BD | | Difference | Statistically significant |
|---|---|---|---|---|
| | g/cm$^3$ | % | % | |
| Clean fallow | | | | |
| Top of the hill | 1.61 | 100 | - | Control |
| Base of the hill | 1.50 | 93.2 | -6.8 | ooo |
| | LSD $_{5\%}$ 0.03 | LSD $_{1\%}$ 0.06 | LSD $_{0.1\%}$ 0.09 | |
| Maize from top to valley | | | | |
| Top of the hill | 1.56 | 100 | - | Control |
| Base of the hill | 1.47 | 94.2 | -5.8 | ooo |
| | LSD $_{5\%}$ 0.02 | LSD $_{1\%}$ 0.05 | LSD $_{0.1\%}$ 0.08 | |
| Maize on the level curves | | | | |
| Top of the hill | 1.45 | 100 | - | Control |
| Base of the hill | 1.37 | 94.4 | -5.6 | ooo |
| | LSD $_{5\%}$ 0.02 | LSD $_{1\%}$ 0.04 | LSD $_{0.1\%}$ 0.06 | |
| Wheat | | | | |
| Top of the hill | 1.39 | 100 | - | Control |
| Base of the hill | 1.31 | 94.2 | -5.8 | ooo |
| | LSD $_{5\%}$ 0.03 | LSD $_{1\%}$ 0.05 | LSD $_{0.1\%}$ 0.07 | |
| Pasture | | | | |
| Top of the hill | 1.33 | 100 | - | Control |
| Base of the hill | 1.26 | 94.7 | -5.3 | ooo |
| | LSD $_{5\%}$ 0.02 | LSD $_{1\%}$ 0.04 | LSD $_{0.1\%}$ 0.06 | |

## Penetration resistance

The biggest values of the penetration resistance was registered in the variant without vegetation, both in the top of the hill (56.0 kgf/cm$^2$) and at the base of the hill (44.0 kgf/cm$^2$). Here, the biggest relative difference between the base and top of the hill was registered, 21.4%; in the other variant, the differnces were of -21.0% in the variant with maize seeded from top to valley, of -20.8% in the variant with maize seeded on the level curves direction, -20.7% in the variant with wheat and of -17.7% in the variant with pasture; the differences are very significant statistically.

**Table 3.** The influence of the crop system on the total porosity (TP) of the soil in the top and base of the hill, Oradea 2011

| Positon on the hill | BD | | Difference | Statistically significant |
|---|---|---|---|---|
| | g/cm$^3$ | % | % | |
| Clean fallow | | | | |
| Top of the hill | 39.2 | 100 | - | Control |
| Base of the hill | 43.4 | 112.0 | 12.0 | *** |
| | $LSD_{5\%}$ 1.2 | $LSD_{1\%}$ 2.3 | $LSD_{0.1\%}$ 4.0 | |
| Maize from top to valley | | | | |
| Top of the hill | 41.1 | 100 | - | Control |
| Base of the hill | 44.5 | 108.3 | 8.3 | ** |
| | $LSD_{5\%}$ 1.1 | $LSD_{1\%}$ 2.3 | $LSD_{0.1\%}$ 3.9 | |
| Maize on the level curves | | | | |
| Top of the hill | 45.3 | 100 | - | Control |
| Base of the hill | 48.3 | 107.6 | 7.6 | ** |
| | $LSD_{5\%}$ 1.0 | $LSD_{1\%}$ 2.2 | $LSD_{0.1\%}$ 3.85 | |
| Wheat | | | | |
| Top of the hill | 47.5 | 100 | - | Control |
| Base of the hill | 49.4 | 104.0 | 4.0 | * |
| | $LSD_{5\%}$ 1.1 | $LSD_{1\%}$ 2.3 | $LSD_{0.1\%}$ 3.7 | |
| Pasture | | | | |
| Top of the hill | 49.8 | 100 | - | Control |
| Base of the hill | 52.4 | 105.2 | 5.2 | * |
| | $LSD_{5\%}$ 1.2 | $LSD_{1\%}$ 2.6 | $LSD_{0.1\%}$ 4.1 | |

In comparison with penetration resistance determined from clean fallow in the top of the hill, 56.0%, in the other variant the values registered are smaller, with 9% in the variant with maize seeded from hill to valley, with 30% in the variant with maize seeded on the level curves direction, with 40% in the variant with wheat and with 53% in the variant whith pasture; at the base of the hill the differences were of 85% in the variant with maize seeded from hill to valley, of 29.9% in the variant with maize seeded on the level curves direction, of 39.1% in the variant with wheat and of 51.6% in the variant with pasture. (table 4).

**Hydraulic conductivity**

There was the smallest value of the hydraulic conductivity in the top of the hill in the variant with clean fallow, 1.25 mm/h; in the other variants, the values of the hydraulic conductivity increased with 50.4% in the variant with maize seeded from hill to valley, with 153.2% in the variant with maize seeded on the level curves direction, with 218.4% in the variant with wheat and with 376.8% in the variant with pasture. At the base of the hill, the values of the hydraulic conductivity are very close (3.05 mm/h and 3.06 mm/h) in the variants with clean fallow and maize from top to valley, respectivelly; in the other variants, the values are bigger, the differences in comparison with the clean fallow were of 40.9% in the variant with maize seeded on the level curves direction, with 64.3% in the variant with wheat and with 132.1% in the variant with pasture.

**Table 4.** The influence of the crop system on the penetration resistance (PR) of the soil in the top and base of the hill, Oradea 2011

| Positon on the hill | PR | | Difference | Statistically significant |
|---|---|---|---|---|
| | kgf/cm$^2$ | % | % | |
| Clean fallow | | | | |
| Top of the hill | 56.0 | 100 | - | Control |
| Base of the hill | 44.0 | 78.6 | -21.4 | ooo |
| | LSD $_{5\%}$ 1.9 | LSD $_{1\%}$ 3.7 | LSD $_{0.1\%}$ 5.6 | |
| Maize from top to valley | | | | |
| Top of the hill | 51.0 | 100 | - | Control |
| Base of the hill | 40.3 | 79.0 | -21.0 | ooo |
| | LSD $_{5\%}$ 2.1 | LSD $_{1\%}$ 3.4 | LSD $_{0.1\%}$ 6.1 | |
| Maize on the level curves | | | | |
| Top of the hill | 39.4 | 100 | - | Control |
| Base of the hill | 31.2 | 79.2 | -20.8 | ooo |
| | LSD $_{5\%}$ 1.8 | LSD $_{1\%}$ 3.1 | LSD $_{0.1\%}$ 5.7 | |
| Wheat | | | | |
| Top of the hill | 33.8 | 100 | - | Control |
| Base of the hill | 26.8 | 79.3 | -20.7 | ooo |
| | LSD $_{5\%}$ 2.2 | LSD $_{1\%}$ 4.4 | LSD $_{0.1\%}$ 6.6 | |
| Pasture | | | | |
| Top of the hill | 26.6 | 100 | - | Control |
| Base of the hill | 21.9 | 82.3 | -17.7 | ooo |
| | LSD $_{5\%}$ 1.7 | LSD $_{1\%}$ 2.9 | LSD $_{0.1\%}$ 4.3 | |

**Table 5.** The influence of the crop system on the hydraulic conductivity (HC) of the soil in the top and base of the hill, Oradea 2011

| Positon on the hill | HC | | Difference | Statistically significant |
|---|---|---|---|---|
| | mm/h | % | % | |
| Clean fallow | | | | |
| Top of the hill | 1.25 | 100 | - | Control |
| Base of the hill | 3.05 | 244.0 | 144.0 | *** |
| | LSD $_{5\%}$ 0.37 | LSD $_{1\%}$ 0.72 | LSD $_{0.1\%}$ 1.07 | |
| Maize from top to valley | | | | |
| Top of the hill | 1.88 | 100 | - | Control |
| Base of the hill | 3.06 | 162.8 | 62.8 | *** |
| | LSD $_{5\%}$ 0.45 | LSD $_{1\%}$ 0.91 | LSD $_{0.1\%}$ 1.13 | |
| Maize on the level curves | | | | |
| Top of the hill | 3.29 | 100 | - | Control |
| Base of the hill | 4.30 | 130.6 | 30.6 | ** |
| | LSD $_{5\%}$ 0.37 | LSD $_{1\%}$ 0.76 | LSD $_{0.1\%}$ 1.12 | |
| Wheat | | | | |
| Top of the hill | 3.98 | 100 | - | Control |
| Base of the hill | 5.01 | 125.9 | 25.9 | ** |
| | LSD $_{5\%}$ 0.41 | LSD $_{1\%}$ 0.79 | LSD $_{0.1\%}$ 1.14 | |
| Pasture | | | | |
| Top of the hill | 5.96 | 100 | - | Control |
| Base of the hill | 7.08 | 118.8 | 18.8 | ** |
| | LSD $_{5\%}$ 0.40 | LSD $_{1\%}$ 0.82 | LSD $_{0.1\%}$ 1.21 | |

The differences between the values of the hydraulic conductivity at the base of the hill and top of the hill are very significant in the variants with clean fallow and distingue significant in the other variants. (table 5).

**Influence of the position on the hill on the maize yield**

The yield maize obtained at the base of the hill are bigger than the yield obtained in the top of the hill. The differences are very significant every year both in maize seeded from hill to valley and in maize seeded on the level curves direction. All the differences are very significant statistically (table 6,7).

**Table 6.** The influence of the position on the hill on yield in maize seeded from top to valley, Oradea 2008-2011

| Year | Positon on the hill | Yield | | Difference | | Statistically significant |
|---|---|---|---|---|---|---|
| | | Kg/ha | % | Kg/ha | % | |
| 2008 | Top of the hill | 3300 | 100 | - | - | Control |
| | Base of the hill | 4970 | 150.6 | 1670 | 50.6 | *** |
| | $LSD_{5\%}$ 120 | $LSD_{1\%}$ 390 | $LSD_{0.1\%}$ 640 | | | |
| 2009 | Top of the hill | 2940 | 100 | - | - | Control |
| | Base of the hill | 4320 | 146.9 | 1380 | 46.9 | *** |
| | $LSD_{5\%}$ 170 | $LSD_{1\%}$ 490 | $LSD_{0.1\%}$ 810 | | | |
| 2010 | Top of the hill | 5200 | 100 | - | - | Control |
| | Base of the hill | 8120 | 157.7 | 2920 | 57.7 | *** |
| | $LSD_{5\%}$ 210 | $LSD_{1\%}$ 540 | $LSD_{0.1\%}$ 910 | | | |
| 2011 | Top of the hill | 2750 | 100 | - | - | Control |
| | Base of the hill | 4070 | 148 | 1320 | 48 | *** |
| | $LSD_{5\%}$ 225 | $LSD_{1\%}$ 490 | $LSD_{0.1\%}$ 860 | | | |

**Table 7.** The influence of the position on the hill on yield in maize seeded on the level curves direction, Oradea 2008-2011

| Year | Positon on the hill | Yield | | Difference | | Statistically significant |
|---|---|---|---|---|---|---|
| | | Kg/ha | % | Kg/ha | % | |
| 2008 | Top of the hill | 3910 | 100 | - | - | Control |
| | Base of the hill | 4810 | 123.0 | 900 | 23.0 | *** |
| | $LSD_{5\%}$ 130 | $LSD_{1\%}$ 290 | $LSD_{0.1\%}$ 530 | | | |
| 2009 | Top of the hill | 3405 | 100 | - | - | Control |
| | Base of the hill | 4150 | 121.9 | 745 | 21.9 | *** |
| | $LSD_{5\%}$ 155 | $LSD_{1\%}$ 320 | $LSD_{0.1\%}$ 590 | | | |
| 2010 | Top of the hill | 5930 | 100 | - | - | Control |
| | Base of the hill | 7720 | 130.2 | 1790 | 30.2 | *** |
| | $LSD_{5\%}$ 210 | $LSD_{1\%}$ 395 | $LSD_{0.1\%}$ 720 | | | |
| 2011 | Top of the hill | 3520 | 100 | - | - | Control |
| | Base of the hill | 4310 | 122.4 | 790 | 22.4 | *** |
| | $LSD_{5\%}$ 140 | $LSD_{1\%}$ 240 | $LSD_{0.1\%}$ 510 | | | |

**Corrrelations between the soil physical properties**

There were an inverse links between bulk density and hydraulic conductivity (y = -20,228 Ln (x) + 10,912, $R^2$ = 0,9607) and between penetration resistance and hydraulic conductivity (y = -5,7943Ln(x) + 24,588, $R^2$ = 0,9686). A direct link was registered between bulk density and penetration resistance (y = 103,93x2 - 204,27x + 116,21, $R^2$ = 0,9946). All the correlations are very significant statistically assured.

## Conclusions

(1)The researches carried out during 2008-2011 in Oradea in the plots for flow check in the following variants: clean fallow, pasture, maize seeded from hill to valley, maize seeded on the level curves direction, wheat.

(2)The biggest difference between structure degree determined at the base of the hill and top of the hill was registered in the variant with clean fallow (40,2%); in the other variants the differences were of 33,3% in the variant with maize seeded from hill to valey, of 12% in the variant with maize seeded on the level curves, of 8,2% in the wheat and of 7,6% in the pasture.

(3) In the horizons of the profile from the base of the hill the values of the bulk density were smaller than the values registered in the top of the hill, the total porosity values were bigger, the hydraulic conductivity values were bigger too and the penetration rezistance values were smaller. As consequence, the yields determined at the base of the hill were bigger than the yields determined in the top of the hill; in the maize seeded from hill to valley the differenes were bigger than the differenes registered in the variant with the maize seeded on the level curves.

(4)The results researches permetted to quantify the direct correlations between bulk density and penetration resistance and the inverse correlations between bulk density and hydraulic conductivity and between penetration resistance and hydraulic conductivity.

## References

[1] Benton J. Jons, Management of Crops, Soil and their Fertility, Ed. Hardcover, 2002

[2] Brejea R., Soil and Yield Losses on Erosional Soils in Different Crops From North Western Romania Analele Universităţii din Oradea, Fascicula:Protecţia Mediului Vol. XV, 2010 pp.570-573, 2010

[3] Brejea R. Ştiinţa solului- îndrumător de lucrări practice, 2011

[4] Brejea R., Domuţa C., Practicum de pedologie, 2011

[5] Brejea R., Tehnologii de protecţie sau refacere a solurilor, Ed. Universităţii din Oradea pp.57-120, 2009

[6] Budoi Gh., Penescu A., Agrotehnica. Ed. Ceres Bucuresti, 1996

[7] Domuţa C., Agrotehnica terenurilor în pantă din nord-vestul României, Ed. Universităţii din Oradea, pp. 35-64, 2005

[8] Domuţa C., Tehnică experimentală, Editura Universităţii din Oradea, pp 199, 2006

[9] Domuţa C. & Şandor M. & Bara V. & Borza I. & Domuţa Cr. & Bara C., & Bara L., Sabău N. C. & Brejea R. & Samuel A. D. & Vuşcan A., & Gîtea M., The Influence of the Crop System Under the Main Physical Properties of the Erosioned Soil in the North Western Romania Conditions Analele Universităţii Oradea Fascicula Protecţia Mediului, Vol XV Anul 15, pp.81-86, 2010

[10] Domuţa C., Brejea R., Monitoringul mediului, Ed. Universităţii din Oradea, 2010.

Douţa C., coord., Practicum de monitoring al mediului, Ed. Universităţii din Oradea 546 p, 2011

[11] Domuţa C., Brejea R., Eroziunea terenurilor în pantă din nord-vestul României Editura Universităţii din Oradea, 225p, 2010.

[12] Gus, P., T. Rusu, Ileana Bogdan, Factorii care impun tehnici de ameliorare, conservare si valorificare a terenurilor arabile situate pe pante. In „Ameliorarea, conservarea si valorificarea solurilor degradate prin interventii antropice", Editura „Ion Ionescu de la Brad" Iasi, pp. 13-19, 2007

[13] Neamţu T., Ecologie, eroziune şi agrotehnică antierozională. Ed. Ceres Bucureşti, pp 127-155, 1996

[14] Niţu I. & Drăcea M., & Răuţă C., & M. Mihalache, Lucrările agropedoameliorative, Editura Agris Bucureşti, , pp. 329 – 332, 2000