INFLUENCE OF MAIZE SEED DIRECTION ON WATER USE EFFICIENCY IN THE CONDITIONS OF AN ERODED SOIL FROM NORTH -WESTERN ROMANIA

Pantiș Ionuț*, Domuța Cornel, Borza Ioana

*University of Oradea, Faculty of Environmental Protection, Oradea, Romania

Abstract

The research conducted at the Agricultura Research and Development Station Oradea in the preluvosoil conditions. Field research is placed on a land with a slope of 10%. In both variants of maize cultivation differences between yields obtained on the base of the hill compared to top of the hill it was highly statistically significant. In 2013 at 1 m^3 water consumed at the top of the slope were obtained 0.72 kg maize grain sown in variant top to the valley and 38% more in variant sown. At maize sowing on the level curves direction at 1 m^3 of water was obtained more main yield compared with variant of maize sown from top of hill to valley, and the quantity of water used per 1 kg yield declined. In 2014, at the maize crop, the effects of erosion on the slope studied was characterized by a difference of 90%, highly statistically significant, between the base and the top of the slope of the hill in variant sown on the level curves direction. Sowing maize on the direction from top to the valley caused a statistically very significant loss of yield of 39% and the difference between yields on base and the top of the slope was also higher in this variant.

Keywords: maize, slope, water use efficiency, yield, level curves direction

INTRODUCTION

The maize sowing direction is very important element of the technologies applied on the land with slope (Borza, Stanciu 2010; Budoi, Penescu, 1996; Budoi et al., 1997; Răuță et al., 1995)

The first research regarding on agrotechnics of sloping land in Bihor were made by Colibas I. during 1972-1976 on two agroterraces at Cordau under a medium eroded soil. The research was continued by Ciobanu Gh. through the publication in 1977 of the paper "Research on the effect of agro-technical measures to increase the yield of wheat and maize on a forest brown soil weak podzolit, eroded in zone of Crisului Repede " anniversary 20 years of the Central Research Station for Soil Erosion Perieni. The paper highlights that this type of soil, plowing deep 18-20 cm do not increases the yield at wheat or maize grain and organic fertilizers alone or combined with chemical fertilizers ensures the highest yield increases. (Domuta, 1999, 2005, 2011; Domuta, Brejea, 2009).

Colibas I., Colibas M. and Mihuţ I. in the period 1982-1984, at the Hidiselul de Sus, on unterraced land, studied the effects of chemical fertilizers (combinations, doses) on the yields of wheat, maize, clover and soil fertility. (Domuta et. al., 2003 a,b).

In 1983 in the villages Pocola and Rabagani standard perimeter was realized. On the 1505 hectares of the perimeter were arranged terraces bench (505 ha), fords pears, falling rock and channels and outlets, regulation valleys Pocola and Săucan, bridges, land road network, combating excess moisture from the slopes drainage works, modeling and ripping strips ridges. The research on soil erosion were performed in standard perimeter of soil erosion by Colibas I., Maria Colibas M. and Mihuţ I. After 1987 the research was coordinated by Domuta C. The research regarding the crop rotation, organic and chemical fertilization were made. Here were made determinations on soil loss from crops of clover, wheat, maize, oats and fiber grown on terraces were made, too. (Domuta, 2012).

Between 1990 and 1994, Domuta C. has conducted research regarding soil erosion in leak control plots from Beius, Bihor. In the years 1995, 1996 research on soil erosion were held in Hidiselul de Sus on a side slope of 15%.

Since 1997 stationary research on soil erosion were made in Oradea on the hill with slope of 10%. In autumn 1999, the first tender national projects under the national program of research Relansin, Domuta C. won funding for the project "Research to establish a system of sustainable agriculture for arable eroded land, undeveloped and arranged anti-erosion in Bihor" , scoring 91 of 100 possible points. One of the three general objectives of the project was as follows: erosion behavior of crops adapted to the area and erosion influences on yields. Realizing the objectives involved setting leakage plots control, that realized in 2000 on a hillside with a slope of 10%.

Research on soil erosion and agrotechnics of land slope were the subject of the following projects won by public auction: CNCSIS project (2005-2007) "Research to improve agricultural technique on sloping land in north-western Romania towards a sustainable agriculture system "project director: Domuta C; CEEX (2006-2008) " Study of risk factors, quantifying their impact on agricultural systems, creation of new genotypes and technology for sustainable development", project manager: Ciobanu Gh. Scientific Director project: Domuta C. (Domuta coord., 2012)

MATERIAL AND METHOD

The variants studied and effectuated determinations

Researches were conducted in Oradea, a town located at $45^{0}03$ 'north latitude and $21^{0}56$' east longitude. Field research is placed on a land with a slope of 10% in the Agricultural Research and Development Station (ARDS) Oradea. One of the important method for soil erosion study is the use of the leakage control plots (Budoi, Penescu, 1996; Gus et al., 1998; Lăzureanu, 1993; Neamțu, Râclea, 1992; Onisie, 1992; Neamțu, 1996)

In the leakage control plots were studied following variants:

V_1: winter wheat

V_2: maize seeded from top to valley

V_3: maize seeded on the level curves direction

V_4: clover

V_5: black fallow

A plot of leakage has dimensions of 45 x 3.5 m and delimitation was done by metal panels and dikes based on sloping ground. (Fig.1.)

Fig.1. Control plots of leakege on eroded soils

Measurements of soil physics were conducted in laboratory of ARDS Oradea and included: soil structure - determined by Cseratzki method, bulk density (BD), hydraulic conductivity (K) and resistance to penetration (RP) determinate according to the methodology of the Research Institute for Soil Science and Agrochemistry Bucharest. The total porosity (PT) was determined by the formula: PT = 1 - BD / D; where D = specific density = 2.65 g /cm^3. (Brejea, 2009)

Determination of chemical properties were performed after the usual methodology.

Water consumption was determined by the method of water balance in the soil and water efficiency indicators were calculated by known formulas (Borza, 2007).

Harvesting of experiences and results calculation was performed by following the instructions provided by experimental techniques (Săulescu, 1967). Interpretation of the results was performed using variance analysis.

Soil from the research field

The preluvosoil had following profile: Ap = 0-24 cm, El = 24-34 cm; Bt_1 = 34-54 cm; Bt_2 = 54-78 cm; Bt/c = 78-95 cm, C = 95-145 cm. It is noted that migration of colloidal clay causes the apparition of horizon El with 31.6% colloidal clay and two horizons of colloidal clay accumulation with Bt_1 and Bt_2 with 39.8% and 39.3% colloidal clay.

Main physical and hydrophysical properties

Luvosoil from the research field is characterized by a very high hydrostability of soil aggregates more than 0.25 mm, 47,.% of layer by 0-20 cm. (tabel 1.).

The soil had a total medium porosity at depth by 0-20 cm, 20-40 cm, 40-60 cm and less in depth by 6-80 cm, 80-100 cm and 100-150 cm. Total porosity values decrease on the soil profile from the surface to depth.

Hydraulic conductivity is high on the depth 0-20 cm, medium on depth by 20-40 cm and 40 cm, low and very low on the following depths studied. (table 1.).

Table 1.

Physical and hydro physical properties of preluvosoil from research field of Oradea

Depth - cm -	Total aggregates %	Clay 0.002%	BD g/cm3	K mm/h	TP %	Field Capacity		Wilting Point coefficient		Easily available water content	
						%	m^3/ha	%	m^3/ha	%	m^3/ha
0-20	47.5	31.5	1.41	21.0	21	24.2	682	9.2	259	19.2	542
20-40	-	34.1	1.52	10.5	49	23.6	717	9.4	286	18.9	575
40-60	-	39.8	1.58	4.4	48	25.1	768	11.1	351	19.9	630
60-80	-	39.3	1.65	1.0	43	24.4	828	10.8	356	20.4	672
80-100	-	38.8	1.57	0.5	40	23.8	766	12.2	383	20.4	640
100-150	-	37.6	1.54	0.1	39	24.0	1833	14.2	1093	20.6	1586
0-50	-	-	1.49	-	-	24.0	1787	9.7	720	19.2	1431
0-75	-	-	1.53	-	-	24.2	2782	10.1	1158	19.5	2240
0-100	-	-	1.55	-	-	24.3	3769	10.5	1627	19.7	3055
0-150	-	-	1.55	-	-	24.1	5611	11.7	2720	20.0	4646

Bulk density - 1.41 g/cm3 - characterizes a poorly compacted soil at depth 0-20 cm; on other depths studied the apparent weight highlights a moderately and strongly compacted soil. On watering depth (0-50 cm, 0-75 cm) and on 0-150 cm the soil is strongly compacted.

Field capacity had a midLSDe value throughout the soil profile and wilting coefficient is also worth to midLSDe depth of 80 cm and higher below this depth.

Chemical properties

The soil in the research field has a slightly acid reaction throughout the depth studied, with increasing values from surface to depth .

Humus supply is poor, and the total nitrogen, low – medium on the entire depth researched. C/N ratio has a value higher on depth of 0-20 cm (8,01) and decreases with depth determination.(table 2.).

Fertilizing year by year with phosphorus doses specific to agrotechnical soils irrigated determined increasing of phosphate level of soil from field research that after 16 years of stationary research quantity of phosphorus in the soil increased from 22.0 ppm arable layer (ground midLSDe supplied) to 150.8 ppm (soil very well stocked).

Mobile potassium content of soil is low - medium, with values increasing from the arable layer (124.5 ppm on the 0-20 cm) to depth (145.4 ppm in the 100-150 cm) (Ciobanu Gh., Domuta C., 2003).

The soil content in exchangeable magnesium on soil profile has a similar pattern with potassium content, the soil being midLSDe supplied with this item's full profile.

Manganese characterize the soil from field research like a soil with medium content at depth 0-20 cm and 20-40 cm and low content at next depths.The soil is moderately submezobazic on the entire deep studied (Table 2).

Table 2.

Chemical properties of preluvosoil from research field of Oradea

Depth - cm -	pH (H_2O)	Humus %	N_{total} %	C/N	P_{AL}	K_{AL}	Mg^{+2}	Mn^{+2}	V %
					ppm				
0-20	6,8	1,75	0,127	8,01	50,8	124,5	254	34	79,8
20-40	6,11	1,71	0,157	6,11	36,6	119,9	309	27	70,1
40-60	6,35	1,44	0,156	4,89	20,7	144,7	396	22	85,9
60-80	6,35	-	-	-	16,1	139,7	199	22	85,9
80-100	6,63	-	-	-	9,3	145,4	496	23	86,0

RESULTS AND DISCUSSIONS

The influence of erosion and seed direction on the maize yield in 2013

The research highlights a stronger distinction between the yields obtained at the top of the slope against the slope to the valley in the conditions of maize crop sown from top to valley compared to maize seeded on the level curves direction. In both variants the cultivation of maize difference between yields obtained at the base of the hill based compared to top of the hill was highly statistically significant (Table 3).

Table 3.

Influence of the position on the hill on maize yield in the variant sown from top to valley and on the level curves direction in the conditions from Oradea, 2013

Variant	Position on hill	Yield kg/ha	Yield %	Difference kg/ha	Difference %	Statistically signification
From top to valley	Top	3320	100	-	-	Ct
	Base	4910	148	1590	48	xxx
$LSD_{5\%}$ 210 $LSD_{1\%}$ 390 $LSD_{0,1\%}$ 610						
On the level curves direction	Top	3680	100	-	-	Ct
	Base	4590	125	910	25	xxx
$LSD_{5\%}$ 170 $LSD_{1\%}$ 290 $LSD_{0,1\%}$ 574						

On average, at the maize sown from top to the valley was registered a loss highly statistically significant compared with yields of maize seeded on the level curves direction, its value is 1250 kg / ha. (Table 4).

Table 4.

Influence of seed direction on maize yield in the conditions from Oradea, 2013

Variant	Yield		Difference		Statistically signification
	kg/ha	%	kg/ha	%	
On the level curves direction	4750	100	-	-	Ct
From top to valley	3500	74	-1250	-26	000

$LSD_{5\%}$ 260
$LSD_{1\%}$ 386
$LSD_{0,1\%}$ 592

An aspect from the variant with maize seeded from top to valley is presented in the figure 2.

Fig.2. The erosion phenomenon in maize crop sowed from top of the hill to the valley

Total water consumption in 2013

Soil water reserve determined at maize sowing had lower values at the base of the hill compared to the top of the slopes, both in a variant sown from top to valley and variant with maize seeded on the level curves direction. Also at the top of the slope, the water supply had a lower value in variant from top to the valley versus variant with maize seeded on the level curves direction. The values of water consumption of maize sown at the base and at the top of the slope were similar in both variant regards the seed direction (Table 5).

Table 5.

Soil water balance (0-150 cm) in maize sown from top to valley and on level curves direction at the top and base of the hill, Oradea 2013

Position	Interval		Days number	Initial reserve	Rainfall	Total in soil	Final reserve	Total water consumption
	From	To						
Maize sown from top to valley								
Top	26.04.	29.09.	155	5127	2757	7884	3305	4593
Base	26.04.	29.09.	155	5360	2757	8117	3480	4637
Maize sown on the level curves direction								
Top	26.04.	29.09.	155	5140	2757	7897	3310	4580
Base	26.04.	29.09.	155	5290	2757	8047	3440	4607

Water use efficiency in 2013

For 1 m^3 of water used in the top of the hill was obtained 0,72 kg maize gain in variant sown from the top to the valley with 38% more in variant on the level curves direction. Between water uses efficiency determined at the base and top of the hill there is a greater difference in the variant sown from top to the valley compared with variant sown on the level curves direction, 48% vs. 24% (table 6).

Table 6.

Influence of position on the slope on water use efficiency (WUE) and on water used efficiency coefficient (CWUE) in maize crops sowing from top to valley and on the curves level direction , Oradea 2013

Position on versant	WUE		CWUE	
	Kg/m^3	%	m^3/kg	%
Maize sown from top to valley				
1.Top	0.72	100	1.39	100
2. Base	1.06	148	0.95	69
Maize sown on the level curves direction				
1. Top	0.81	100	1.25	100
2. Base	1.00	124	1.01	81

In maize sowing on the curves level direction for 1 m^3 water used was obtained more main yields compared to variant sown from top to valley and the quantity of water used on 1 kg main yield decreased (table 7).

Table 7.

Influence of seed direction on water use efficiency (WUE) and on water used efficiency coefficient (CWUE) in maize crop, Oradea 2013

Seed direction	WUE		CWUE	
	Kg/m^3	%	m^3/kg	%
From top to valley	0.77	100	1.32	100
On level curves direction	1.05	137	0.97	74

The influence of erosion and direction of sowing on maize yield in 2014

In 2014, at maize crop, the effects of erosion on the slope studied was characterized by a difference of 90%, highly statistically significant between the base and the top of the slope of the hill in variant sown on direction from top to the valley. (Table 8).

In the variant sown on the level curves direction and the difference between the top and the base of the slope was lower, 39% (Table 9).

Table 8.

Influence of the position on the hill on maize yield sown from top to valley and on the level curves direction in the conditions from Oradea, 2014

Sowing variant	Position on versant	Yield		Difference		Statistically signification
		Kg/ha	%	Kg/ha	%	
From top to valley	Top	2020	100	-	-	Ct
	Base	3820	190	1800	90	***
LSD 5% = 210 LSD 1% = 390 LSD 0,1% = 540						
On level curves direction	Top	2750	100	-	-	Ct
	Base	3810	139	1060	39	***
LSD 5% = 190 LSD 1% = 330 LSD 0,1% = 524						

Table 9.

Influence of seed direction on maize yield in the conditions from Oradea, 2014

Variant	Yield		Difference		Statistically signification
	kg/ha	%	kg/ha	%	
On the level curves direction	3280	100	-	-	Ct
From top to valley	2920	89	-360	-11	00

$LSD_{5\%}$ 260
$LSD_{1\%}$ 386
$LSD_{0,1\%}$ 592

Total water consumption in 2014

Water consumption values were determined at the base of the hill were higher than the top of the hill (Table 10).

Soil stronger erosion determined differentiation of water use efficiency (WUE and CWUE) at the top at the slope versus base of the slopes. (Table 11.)

Maize sowing on the level curves direction obtained a higher quantity of maize at 1 m^3 water consumed and at 1kg of maize obtained the quantity of water consumed was lower. (Table 12)

Table 10.

Soil water balance (0-150 cm) in maize sown from top to valley and on level curves direction at the top and base of the hill, Oradea 2014

Position	Interval		Days number	Initial reserve	Rainfall	Total in soil	Final reserve	Total water consumption
	From	To						
Maize sown from top to valley								
1. Top	01.04.	20.09.	173	4360	2771	7131	3271	3860
2. Base	01.04.	20.09.	173	4510	2771	7281	3370	3911
Maize sown on the level curves direction								
1. Top	01.04.	20.09.	173	4470	2771	7240	3260	3980
2. Base	01.04.	20.09.	173	4710	2771	7481	3340	4141

Table 11.

Influence of position on the slope on water use efficiency (WUE) and on water used efficiency coefficient (CWUE) in maize crops sowing from top to valley and on the curves level direction, Oradea 2014

Pozition	WUE		CWUE	
	Kg/m^3	%	m^3/kg	%
Maize sown from top to valley				
1. Top	0,52	100	1,91	100
2. Base	0,98	189	1,03	54
Maize sown on the level curves direction				
1. Top	0,69	100	1,45	100
2. Base	0,92	134	1,09	76

Table 12.

Influence of seed direction on water use efficiency (WUE) and on water used efficiency coefficient (CWUE) in maize crop, Oradea 2014

Seed direction	WUE		CWUE	
	Kg/m^3	%	m^3/kg	%
From top to valley	0.75	100	1.39	100
On the level curves direction	0.81	108	1.24	90

CONCLUSIONS

Maize is one of the crops that assure a bad protection against erosion. Sowing maize from top to valley intensified the erosion phenomenon. The research were carried out in the leakage control plots located on a land with a slope of 10% at Agricultural Research and Development Station Oradea concerning on studying the influence of sowing direction on the maize yield.

The researches were conducted in 2 different years in terms of climatic conditions.

In 2013, yield losses in the variant with maize sowing maize from top to valley was 26% and difference between yield registered at the base of the hill and top of the hill was higher in variant with maize sown from top to valley compared with maize sowing on level curves direction.

In 2014, sowing of maize from top to valley determined an yield loss very significant statistically of 39% and difference between yield obtained at the base and the top of the hill was higher in this variant.

Sowing maize on level curves direction provides better efficiency of water used, resulting a higher quantity of the yield from 1 m^3 of water used.

The research highlights the necessity for maize cultivation on the level curves direction, thereby avoiding major damage caused by erosion.

REFERENCES

1. Borza I., 2007, Valorificarea apei de către cultura porumbului din Câmpia Crişurilor. Ed. Universităţii Oradea, p.195-208
2. Borza I., Stanciu A., 2010, Fitotehnie, Ed. Universităţii Oradea
3. Brejea R., 2009, Practicum de pedologie. Ed. Universitatii din Oradea
4. Budoi Gh., Penescu A., 1996, Agrotehnică. Ed. Ceres, Bucureşti.
5. Budoi Gh. şi colab., 1997, Lucrările solului componentă de bază a sistemului de conservare a solului. Simpozionul „Alternative de lucrare a solului”, 9-10 oct., Cluj-Napoca.
6. Domuţa C., 1999, Ameliorarea fertilităţii solurilor erodate pe terenurile în pantă din vestul ţării. Cereale şi plante tehnice nr. 7.
7. Domuţa C., et al., 2003,The erosion influence on the main physics properties and on the yield in the conditions from Bihor. Proceedings of the international symposium „Natural resources and sustainable development”, Oradea – Debrecen 2003.
8. Domuţa C., et al, 2003, Agricultura durabilă pe terenurile erodate din Bihor. Editura Universităţii din Oradea.
9. Domuţa C., 2005, Agrotehnica trerenurilor în pantă din nord-vestul României. Ed. Universităţii din Oradea
10. Domuţa C, şi colab., 2010, 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.
11. Domuţa C., Brejea R., 2011, Eroziunea terenurilor în panta din Bihor. Ed. Universităţii din Oradea.
12. Domuţa C., 2012, Agrotehnica. Ed. Universităţii din Oradea
13. Domuţa C. (coord), 2012, 50 de ani de cercetări agricole în Oradea. Ed. Universităţii din Oradea
14. Dumitru E., 1998, Cercetări privind modificarea însuşirilor fizice şi a relaţiilor solului cu apa sub influenţa tehnologiilor agricole. Teză de doctorat. ASAS „Gheorghe Ionescu Şişeşti”.
15. Guş P. şi colab., 1998, Agrotehnica. Ed. Risoprint Cluj–Napoca .
16. Lăzureanu A., 1993, Agrotehnica. Ed. Helicon Banat S.A. Timişoara.
17. Neamţu T., Râclea C., 1992, Protecţia agroecosistemelor din zona colinară, consecinţă a introducerii complexului de măsuri antierozionale. Cereale şi plante tehnice nr.3.
18. Neamţu T., 1996, Ecologie, eroziune şi agrotehnică antierozională. Ed. Ceres Bucureşti.
19. Niţu I. şi colab., 2000, Lucrările agropedoameliorative. Ed. Ceres, Bucureşti.
20. Onisie T., 1992, Agrotehnica. USAMV Iaşi.
21. Răuţă C., Canarache A., Niţu I., 1995, Îndrumător privind lucrările agropedoameliorative. ICPA Bucureşti

**** - Metodologia elaborării studiilor pedologice. ICPA Bucureşti, 1987.