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Monitoring of Soil Loss by Erosion in Different Variants with Intercrops

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Abstract: In a pilot experiment established in a sugar beet growing region the erosive washing away of soil was studied in the years 2006 to 2008. The area is located at an altitude of 246 m with the long-term mean precipitation of 500 mm and the mean annual temperature of 8.4 ^{0} C. The soils are classified as Chernozem, moderately heavy, loamy, with a good supply of nutrients, humus content of 2.30 % and an alkaline soil reaction. Slope gradient is 12 %, exposition is NE. To study the role of intercrops in erosion control, three variants were established after the harvest of the main crop, two variants with different intercrops and one (control) with no intercrop. These were Variant 1 with *Secale cereale L. var. multicaule* METZG. *ex* ALEF., a non-freezing intercrop, Variant 2 with cluster mallow (*Malva verticillata L.*), a freezing intercrop, and a control variant with no intercrop. In Variant 1 *Secale cereale L. var. multicaule* was desiccated with the herbicide Roundup in early spring. All the variants involved maize as the main crop. In variants 1 and 2, maize was sown in intercrop residues after seedbed preparation by Vario and a compactor. In Variant 3 maize was sown after conventional seedbed preparation. For assessment of soil conditions soil samples were taken to determine soil physical and chemical properties and water content in the soil. Soil loss by erosion was determined using specially-designed pockets. Erosive washing away of soil was monitored during the entire growing season of maize. The variants in which intercrops were used were found very effective in soil erosion control. In Variant 3 (control) without surface crop residues, the washing away of soil was recorded with each heavy torrential rain. During the all years the total amount of soil loss by erosion in this treatment was 2.25 t.ha^{-1}.
Key words: water erosion, intercrops, washing away of soil, maize

INTRODUCTION and LITERATURE REVIEW

To reduce the risks of erosion, erosion control practices are necessary. Erosion control is a complex of practices whose goal is to minimize or prevent erosion impact on the soil, soil moisture and surface water and the crops. Soil erosion control practices are mainly used in agriculture but they are also used to protect water resources, built-up areas, roads and other constructions as well as hygienic zones of water resources, protected natural formations, etc. Erosion control effects vary with erodibility of the soil. Soil erodibility is characterized by seasonal variations which become evident in changes to soil structure, aggregate stability and soil permeability (e.g. Imeson, Vis 1984; Bajracharyar, Lal 1992; Brown *et al.* 1995). Soil erodibility depends on a number of soil properties of physical, chemical and mineralogical character which can easily be measured (Kinnel 1993). A major factor is the level of soil aggregate stability under the impact of falling raindrops, therefore erosion-prone soil should not remain long without any vegetation cover (Kvítek, Tippl, 2003). One of the ways to protect soil surface and combat undesirable soil loss due to erosion is sowing non-winter-hardy or winter-hardy intercrops after the harvest of the main crop in autumn. Intercrops are suitable for erosion control system because they protect the soil by leaves and in winter by winter-killed crop residues. This has a considerable effect on soil water regime which is important from the viewpoint of soil erosion control. The key to successful intercrop growing is sowing the crop as soon as possible after the harvest of the main crop in the well-prepared seedbed (Vach *et al.*, 2005). Under optimum conditions it is possible to establish stands of intercrops in unprepared seedbed (Marko et al., 1996). With some technologies of crop cultivation intercrops might be used as mulch which until the sowing of the consequent crop plays a crucial role in soil protection (Šimon, 2004). Unless intercrops are sown in time there is a risk of poor plant emergence and a small increase in organic matter that protects the soil from erosion. As Haberle (2006) pointed out the increased risk of intercrop growing is not only under drier conditions of maize and sugar beet growing regions but also in a potato growing region.

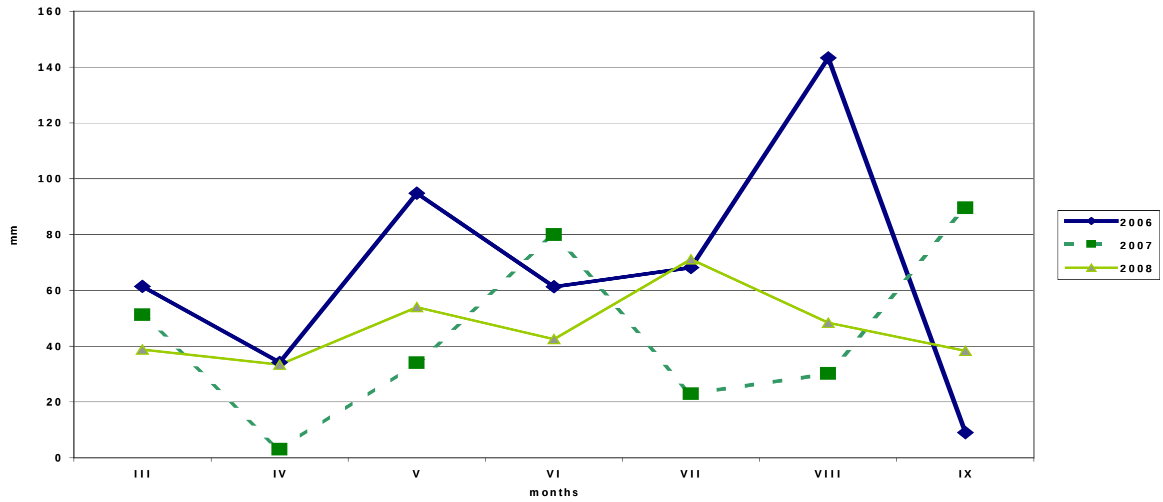

Figure 1. Precipitation volume during vegetation period 2006, 2007, 2008

MATERIAL and METHOD

To determine soil protection effects of intercrops in the erosion control system, erosive washing away of soil was monitored in the years 2006 to 2008 in a pilot experiment in a sugar beet growing region in Bonagro Inc., Blazovice. Three different variants were established and assessed to determine the most suitable intercrop for soil surface protection against soil erosion. After the harvest of the main crop treatments were established at the end of August using various non-conventional intercrops – non-winter-hardy (mallow) and winter-hardy (*Secale cereale L. var. multicaule*), which were developed by the Fodder Crop Research Institute Ltd. Troubsko.

Establishment of variants:

Variant 1 involves *Secale cereale L. var. multicaule* METZG. *ex* ALEF. (non-freezing)

Variant 2 involves *Malva verticillata L.* (freezing)

Variant 3 – control, no intercrop

In Variant 1 *Secale cereale L. var. multicaule* was early in spring desiccated by the herbicide Roundup. In all treatments maize was sown in April. It was sown in intercrop residues after seedbed preparation by Vario and a compactor in variants 1 and 2; and in variant 3 it was sown after conventional seedbed preparation.

To determine the soil properties of the experimental locality, the initial physical state of the soil was determined by using push tubes after Kopecký (1928), soil structure was determined by the method of dry aggregation (Facek, 1960) and soil moisture gravimetrically (Jandák *et al.,* 2003).

From the start of vegetation the washing away of soil was monitored. The washed-away soil was analyzed for the content of major nutrients, humus and soil reactions (Methodology of ÚKZÚZ). The results were compared with soil analyses carried out at the beginning of the growing season. To monitor the washing away of soil specially designed pockets were installed in the lower part of the slope and they were enclosed by side plates. The length of the slope monitored was ca 100 m and the width 1 m.

After sowing maize in intercrop residues (winter-killed or desiccated), the functionality of soil erosion control by intercrops was studied throughout the entire growing season of maize.

Soil and climatic conditions

The experimental locality is situated in a sugar beet growing region at an altitude of 246 m with a long-term average sum of precipitation of 500 mm and an average annual temperature of 8.4 ^{0} C. The soils are classified as Chernozem, moderately heavy, loamy, with a good supply of nutrients, an alkaline soil reaction and the average humus content of 2.30 %. Slope gradient is 12 %, slope exposition is NE.

The amount of precipitation over the period of study is shown in Fig. 1.

RESULTS and DISCUSSION

An essential prerequisite of soil erosion control is soil management practices which reduce breaking down of the crumb structure of the soil as much as possible, promote water infiltration and thus reduce surface runoff and its washing-away effect. It is important to considerably reduce tillage to the lowest possible frequency because frequent tillage operations change the crumb structure of the soil into unfavourable silt. The rate of change gets even faster if the soil is poor in organic matter. Ngo Kim Khoi

(2002) confirmed that there is no water erosion of the soil if the soil surface is protected by vegetation. The incorporation of organic matter into the soil has a very positive erosion control effect. It affects the stability of soil aggregates which become more resistant to erosion and mechanical destruction under striking raindrops (Hernanz et al., 2002). Wilson et al. (2004) also pointed out that organic residues left on the soil surface and adequate soil tillage operations may protect the soil against heavy rains.

Chemical analyses carried out early in spring at the beginning of the years 2006-2008 (Tables 1, 2, 3) showed similar levels of all components under study. There were no significant differences between treatments.

Table 1. Nutrient content-early vegetation 2006

variants	depth (m)	$pH/_{KCl}$	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	N_t (%)	humus (%)
1	0 - 0.15	7,4	75	286	180	0,157	3,50
	0.15 - 0.30	7,3	56	175	176	0,168	2,52
	average	7,4	66	231	178	0,163	3,01
2	0 - 0.15	7,5	80	228	163	0,161	1,53
	0.15 - 0.30	7,6	53	158	165	0,122	2,62
	average	7,6	67	193	164	0,142	2,08
3	0 - 0.15	7,4	82	220	160	0,160	1,68
	0.15 - 0.30	7,6	56	156	157	0,123	2,48
	average	7,5	69	188	159	0,142	2,08

Table 2. Nutrient content-early vegetation 2007

variants	depth (m)	pH_{KCl}	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	N_t (%)	humus (%)
1	0 - 0.15	7,2	23	231	285	0,119	2,68
	0.15 - 0.30	7,4	11	170	298	0,091	1,98
	average	7,3	17	201	292	0,105	2,33
2	0 - 0.15	7,4	18	217	323	0,095	2,33
	0.15 - 0.30	7,5	10	151	401	0,084	1,69
	average	7,5	14	184	362	0,090	2,01
3	0 - 0.15	7,5	41	271	338	0,100	2,46
	0.15 - 0.30	7,5	37	159	331	0,073	1,27
	average	7,5	39	215	335	0,087	1,87

Table 3. Nutrient content-early vegetation 2008

variants	depth (m)	pH_{KCl}	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	N_t (%)	humus (%)
1	0 - 0.15	7,4	44	222	289	0,112	2,55
	0.15 - 0.30	7,2	33	170	321	0,110	1,85
	average	7,3	39	196	305	0,111	2,20
2	0 - 0.15	7,3	56	242	355	0,103	2,43
	0.15 - 0.30	7,5	32	155	487	0,078	1,78
	average	7,4	44	199	421	0,091	2,11
3	0 - 0.15	7,3	33	255	356	0,098	1,98
	0.15 - 0.30	7,5	15	143	390	0,087	1,32
	average	7,4	24	199	373	0,093	1,65

Table 4. Soil loss 2006-2008 (t ha^{-1})

variants	2006	2007	2008	average	total
1	0,12	0	0	0,06	0,12
2	1,14	0	0	0,57	1,14
3	1,90	0,35	0	1,13	2,25

Table 5. Nutrient content-soil loss by erosion 2006

variants	date of sampling	elements					
		pH/KCl	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	N_t (%)	humus (%)
1	16.6.	0	0	0	0	0	0
	12.7.	0	0	0	0	0	0
	24.8.	7,3	62	218	232	0,140	1,54
	average	7,3	62	218	232	0,140	1,54
2	16.6.	7,3	104	377	190	0,255	2,80
	12.7.	0,0	0	0	0	0	0
	24.8.	7,3	71	185	179	0,133	2,45
	average	7,3	88	281	185	0,194	2,63
3	16.6.	7,2	81	298	210	0,230	1,34
	12.7.	7,1	63	226	171	0,151	2,66
	24.8.	7,2	66	231	201	0,178	2,61
	average	7,2	70	252	194	0,186	2,20

Higher humus content was recorded in all years in Variant 1 which involved *Secale cereale L. var. multicaule* as an intercrop.

After sowing maize (the beginning of May) soil erosion was studied in all the variants. The observations continued until maize grew tall and there was no threat of torrential rains and no danger of soil erosion, i.e. approximately the end of August. Table 4 gives the values of the soil loss by erosion in the years 2006-2008.

In the year 2006 the washing away of soil was reported in all the variants. In Variant 1 (*Secale cereale L. var. multicaule*) the washing away of soil was recorded only once in late August, soil loss being 0.12 t.ha^{-1}, in Variant 2 (*Malva verticillata L*) the washing away of soil was recorded twice, i.e. in June and in August, the total amount of soil loss being

1.14 t.ha^{-1} . The highest and most frequent soil loss by erosion was reported in Variant 3 (control) in June, July and August, soil loss being 1.90 t.ha^{-1}. In the year 2007 there was lower rainfall on the locality than in the year 2006 (Fig. 1), the soil loss by erosion was recorded only in Variant 3 (control) at the end of June and the total amount of soil loss was 0.35 t.ha^{-1}. In the year 2008 wasn´t recorded the soil loss by erosion. In this year was measured lowest quantity of rainfall. The largest soil loss by erosion due to erosion in the period of the two years was reported in Variant 3 (control) which had no soil surface cover. The total soil loss over the all years was reported to be 2.25 t.ha^{-1}. In this case, the soil loss by erosion occurred even after maize emergence when the stand canopy was closed. The reason was the rills in inter-row areas on the bare soil surface. With the soil loss by erosion there is also a reduction in nutrients which are washed away along with the soil. Tables 5 and 6 show nutrient contents, pH and humus content from the washed away soils.

Table 6. Nutrient content-soil loss by erosion 2007

variants	elements					
	$pH/_{KCl}$	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	N_t (%)	humus (%)
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	7,6	131	153	130	0,126	2,07

Table 7. Soil loss – analysis of variance

Source of variation	SS	Differ.	MS	F	P value	F crit
Between sampling	6035543,616	3	2011847,9	3412442,06	2,86252E-13	6,591392321
All sampling	2,35825	4	0,5896			
Total	6035545,974	7				

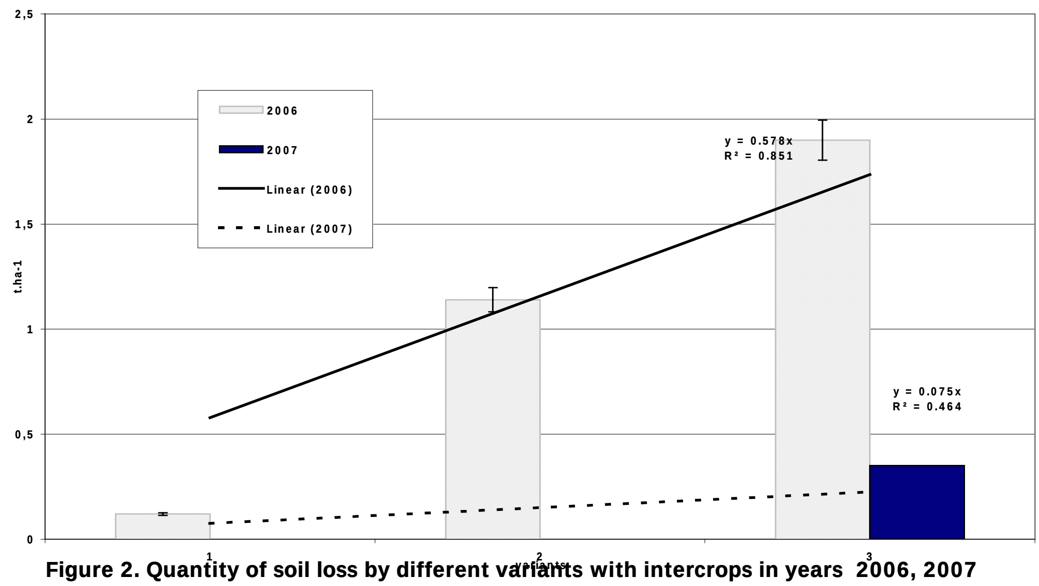

Figure 2. Quantity of soil loss by different variants with intercrops in years 2006, 2007

In the year 2006 there was a higher loss of nutrients due to more frequent erosion and also a loss of humus which has a stabilizing effect from the viewpoint of soil structure. As the values suggest, there is a significant loss of soil nutrients caused by the soil loss. Table 7 gives statistical results of analysis of variance between variants using intercrops over the years with a mean deviation and P value.

Analysis of variance (Fig.2) showed significant differences in the soil loss by erosion between variants 1x2 and 1x3, which confirms that the best control is provided in the variant involving *Secale cereale L. var. multicaule* desiccated in spring. The intercrop residues provide the best soil surface cover from maize sowing to the formation of a closed canopy stand.

Some research results confirm that soil erosion facilitates soil degradation processes which might be affected by different soil tillage practices. No-till planting of maize in organic residues of crops can effectively reduce water erosion of soil (Norton, Ventura, Dontsova, 2003). Intercrops might be beneficial not only from the viewpoint of soil erosion control but they also create favourable conditions for mineralization of organic matter in autumn months when there is sufficient soil moisture and high temperatures. Intercrops are also able to bind most of the nitrogen to organic matter, so there is no leaching to the groundwater. And moreover, the successive crops (potatoes, sugar beet) utilize it at the time of their increased needs. Intercrops are also associated with disease control, as it was found out in some research projects. For example, Kokais, Prokeš (1997) discovered that intercrops can reduce the occurrence of virus diseases of potatoes. In every aspect it has been confirmed that intercrops are beneficial in the intervals between main crops.

CONCLUSIONS

The goal of the experiment was to assess the water erosion control role of intercrops. The soil loss by erosion was monitored from the time maize was sown to the end of the growing season. In the soil loss by erosion from each variant the determinations were done of the amount of nutrients including humus. During the three-years studies of the role of intercrops in the soil surface erosion control it was found that the largest amount of soil loss due to erosion was in the control with no vegetation cover. The total soil loss here over the all years was 2.25 $t.ha^{-1}$. The soil loss by erosion here was even after maize emergence when the growth fully was closed. In the variant using *Secale cereale L. var. multicaule* as an intercrop the soil loss by erosion was reported only in the year 2006 in late August, the total soil loss being 0.12 $t.ha^{-1}$. There was also a significant loss of soil nutrients and humus, as shown by the chemical analysis of the washed away soils. This reveals the harmfulness of water erosion and the necessity of soil surface protection against erosive effects. Analysis of variance showed significant differences in the soil loss by erosion between variants 1 x 2 and 1 x 3. This confirms that the best erosion control is in the variant with *Secale cereale L. var. multicaule* desiccated in spring. The residues of organic matter of this intercrop best cover the soil surface from maize sowing to the time of the closed canopy of the stand.

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