Evaluation of Crop Effects on Runoff and Washout of Soil from the Surface of Agricultural Land

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Abstract: Measurements of the runoff intensity (i.e. its volume and amounts of washed out soil particles) were performed on experimental plots with the slope gradient of 5° within the period of 2004–2008. Experimental plots were covered with different types of crops: crops with wide rows (maize, potatoes), no row crops (cereals) and permanent grasslands (both extensively and intensively managed). The main objective of this study was to quantify the effect of individual crops on the reduction of runoff and erosion transport (i.e. washout) of soil from the surface of agricultural land. Data measured on individual experimental plots were compared with control, which was represented by a plot of bare soil. As compared with control, markedly reduced values of both runoff and washout (86 and 99%, respectively) were measured on plots covered with cereals within the study period. In maize stands, the corresponding values were 21 and 11%, respectively. The obtained results may support and contribute to the proposal of organisational soil protection measures and their implementation on agricultural land. In erosion-endangered localities an appropriate selection of individual crops represents an important tool, which can significantly support other protective measures, especially those of technical character.

Keywords: water erosion; runoff; precipitations; vegetative cover

Protection of soil by means of the vegetation cover is the basic principle of fight against water erosion. This can be attained by means of soil protection measures of an organisational and agro technical character (Gordon *et al.* 2008). The organisational measures involve above all selection of crops suitable for growing on slopes (i.e. a soil protection distribution of crops) and protective grassland (i.e. a delimitation of endangered land) (Janeček *et al.* 2007). The elimination of using crops increasing the risk of the occurrence of erosion phenomena (above all of wide row crops) is possible to reduce the erosion wash out and runoff on slopes (Uhlířová & Podhrázská 2007) The soil covered by grassland supports the water infiltration into the subsoil and protection of soil against degradation (Hejduk & Kasprzak 2004, 2005; Kvítek *et al.* 2004).

Measurements of runoff and washout values from experimental plots were performed in the Experimental Station of Mendel University of Agriculture and Forestry in Brno near the village Vatín within the period from 2004 to 2008. The obtained results support the implementation of soil conservation measures on agricultural land.

MATERIAL AND METHODS

The Experimental Station Vatín is situated in the Bohemo-Moravian highlands (49°15'5''N, 15°58'15''E) in the altitude of 540 m a.s.l. Its cli-

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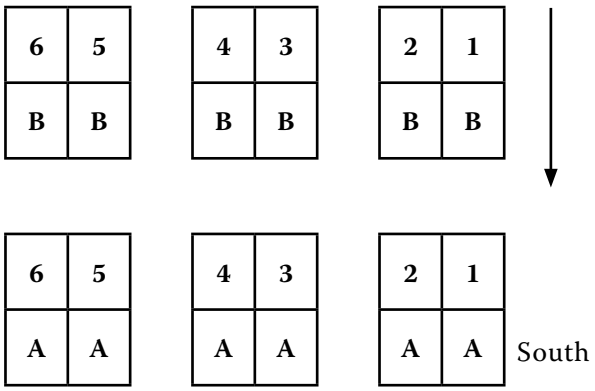
Figure 1. Experimental plots in locality Vatín (2005)

mate is mild and the soil was classified as an acid cambisol (KMa) developed on biotitic orthogneiss. The long-term sum of precipitation (1970–1990) and the average annual temperature are 619 mm and 7.03°C, respectively.

The experiment was established on 12 plots which were arranged into 6 pairs (exposed to the north – B and to the south – A) with the slope of 5° (see Figure 1). Two pairs were covered with grassland, one was used as control (bare soil) and the remaining pairs were under winter wheat, maize and potatoes. Runoffs (including eroded sediments) resulting from atmospheric precipitation were accumulated through small collecting channels in buckets and/or barrels placed into an underground corridor. The plots were adapted for measuring the amount of surface runoff and washout of soil. Runoffs were measured all the year round. Recorded data about amounts of water were converted to cubic meters per hectare (m^3/ha). Data about amounts of washed-out soil related to the measuring unit of tons per hectare (t/ha) in a similar manner.

Management of experimental plots



Experimental plots were covered with following agricultural crops during growing season:

1 – Permanent grassland – standard management (3 cuts, 100 kg N + PK)
2 – Permanent grassland – extensive management (2 cuts, without fertilizing)
3 – Bare soil (control)
4 – Winter wheat (sown without tillage after potatoes)
5 – Silage maize treated with herbicide after sowing
6 – Potatoes (typical crop in studied area)

Permanent grasslands were established in 2001. Variants 3 to 6 were changed according to the crop rotation plan.

A schematic presentation of experimental plots (2004)

1 A, B – Permanent grassland – standard management (3 cuts, 100 kg N + PK)
2 A, B – Permanent grassland – extensive management (2 cuts, without fertilizing)
3 A, B – Winter wheat
4 A, B – Bare soil (control)
5 A, B – Silage maize treated with herbicide after sowing
6 A, B – Potatoes

A schematic presentation of experimental plots (2005)

1 A, B – Permanent grassland – standard management (3 cuts, 100 kg N + PK)
2 A, B – Permanent grassland – extensive management (2 cuts, without fertilizing)
3 A, B – Potatoes
4 A, B – Silage maize treated with herbicide after sowing
5 A, B – Bare soil (control)
6 A, B – Winter wheat (sown without tillage after potatoes)

A schematic presentation of experimental plots (2006)

1 A, B – Permanent grassland – standard management (3 cuts, 100 kg N + PK)
2 A, B – Permanent grassland – extensive management (2 cuts, without fertilizing)
3 A, B – Spring barley (sown instead the destructed winter wheat)
4 A, B – Potatoes
5 A, B – Silage maize treated with a herbicide after sowing
6 A, B – Bare soil (control)

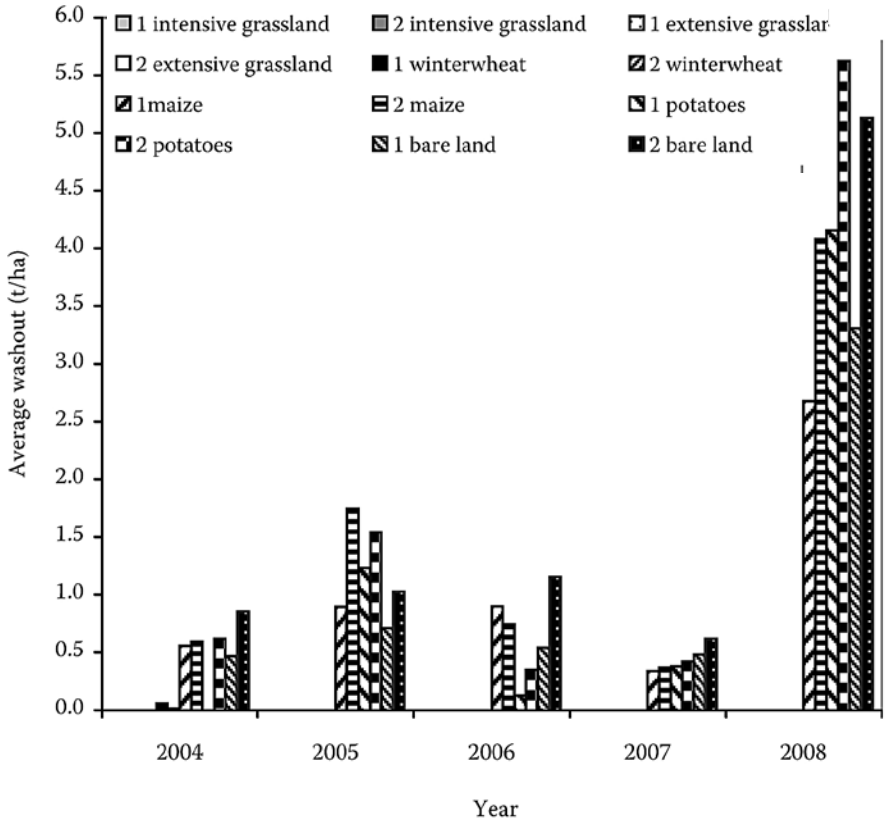


Figure 2. Average washout values for individual crops and variants A (1) and B (2) in year (period 2004–2008)

A schematic presentation of experimental plots (2007)

1 A, B – Permanent grassland – standard management (3 cuts, 100 kg N + PK)
2 A, B – Permanent grassland – extensive management (2 cuts, without fertilizing)
3 A, B – Silage maize treated with herbicide after sowing
4 A, B – Winter wheat
5 A, B – Bare soil (control)
6 A, B – Potatoes

A schematic presentation of experimental plots (2008)

1 A, B – Permanent grassland – standard management (3 cuts, 100 kg N+PK)
2 A, B – Permanent grassland – extensive management (2 cuts, without fertilizing)
3 A, B – Bare soil (control)
4 A, B – Silage maize treated with a herbicide after sowing
5 A, B – Potatoes
6 A, B – Winter wheat

The objective of these experiments was to quantify the effect of cultivated crops on reduction of surface runoff and erosion washout of soil on agricultural land. On erosion-endangered localities a proper selection of crops can significantly improve effects of other protective measures, especially those of technical character. Technical interventions enable to control and delimitate the length and boundaries of individual fields or areas of agricultural land; however, unless some other soil-protecting measures are not taken, plots situated above and below these areas remain to be unprotected and face the risk of washout and erosion.

RESULTS AND DISCUSSION

Data recorded after each rainfall causing surface runoffs and soil erosion from experimental plots were tabulated and statistically analyzed. Conversion of atmospheric precipitation to sums of individual rainfalls were not a part of this analysis; compared were only relations between values

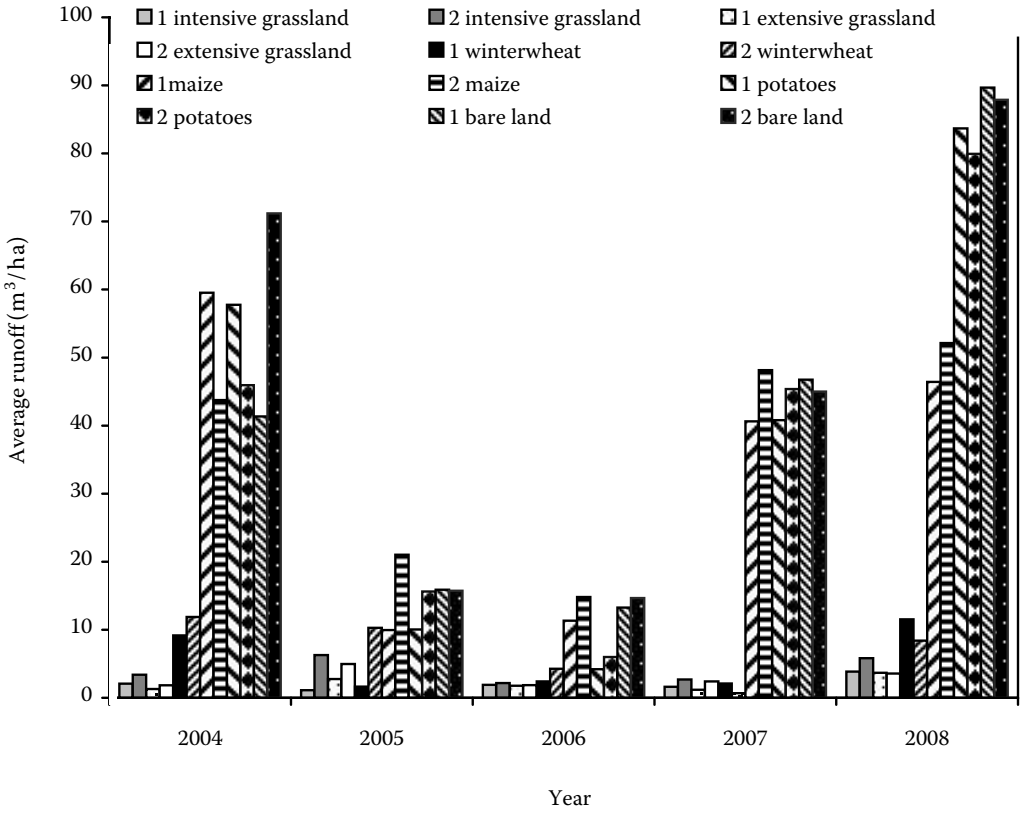


Figure 3. Average runoff values for individual crops and variants A (1) and B (2) in year (period 2004–2008)

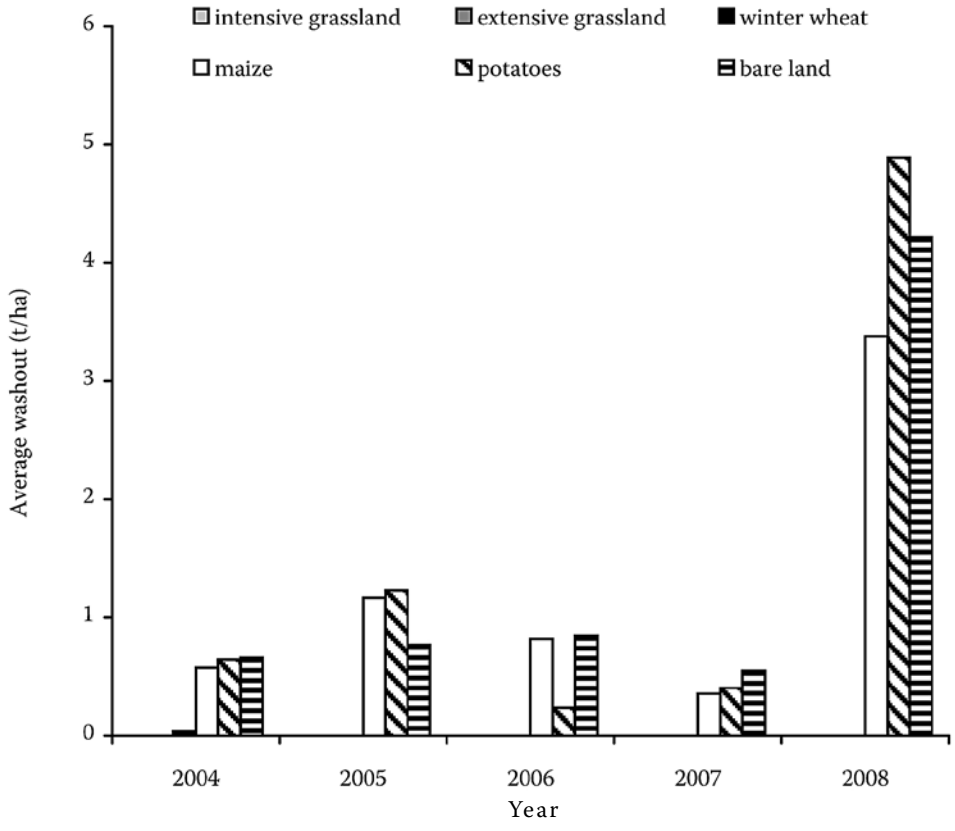


Figure 4. Average washout values for individual crops in year (period 2004 to 2008)

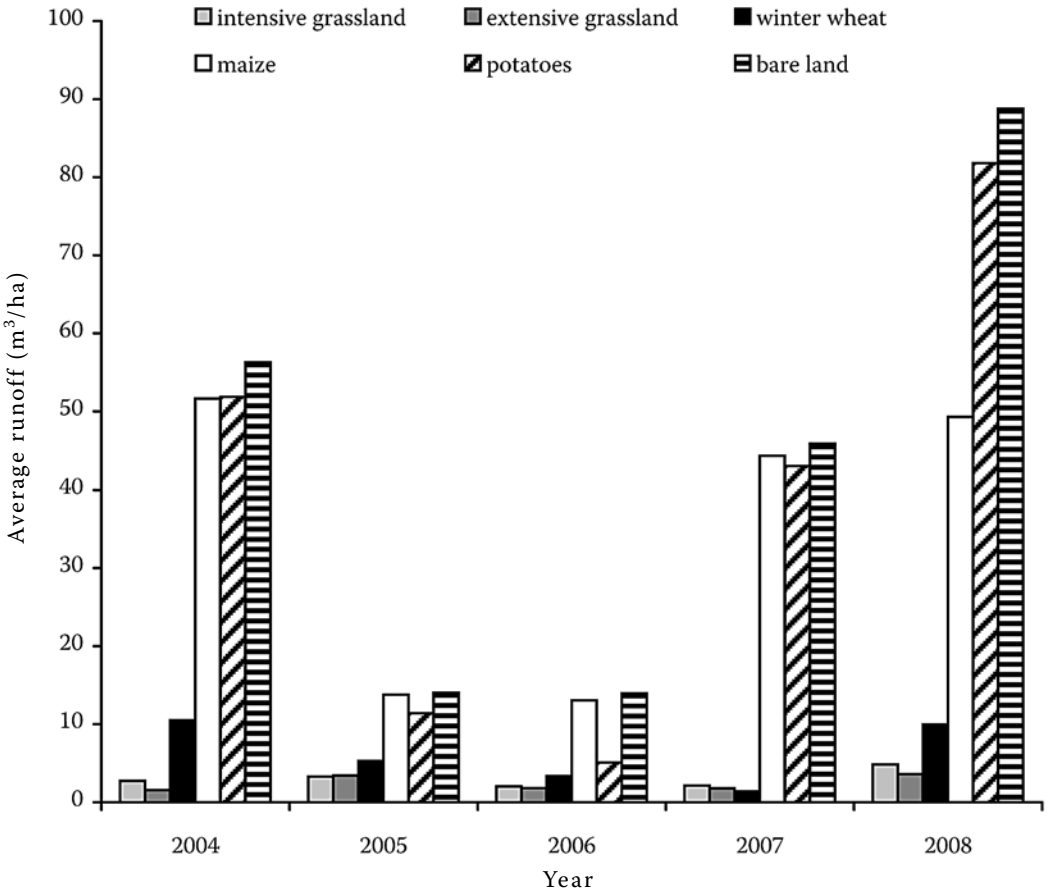


Figure 5. Average runoff values for individual crops in year (period 2004–2008)

recorded in individual crops after each rainfall. Table 1 shows the typical surface runoffs after the rain occurred in June 4th 2008. In the Table 2 there are presented surface runoffs in growing season at individual soil covers in the period 2004–2008.

As it is shown in Table 3, the results obtained within the study period pointed out protective function cereals and permanent grasslands against creation of surface runoff and soil erosion. Figures 2–6 illustrate the differences between individual covers of the soil during the presented period.

In intensive grassland stands, the average values of surface runoff were higher by 1% than those recorded in extensive grassland stands. Both stands were established in 2001 and their localisation on

Table 1. A typical surface runoffs after downpour rain occurred in June 4th 2008, amount 16.1 mm, duration 20 min, maximal intensity 2.2 mm/min; soil crust was developed one day before this rain occurrence, soil surface was wet

Soil cover	Surface runoff (m^3/ha)	Soil erosion (kg/ha)
Grassland intensive	2.5	0
Grassland extensive	2.0	0
Winter wheat	6.0	0
Potatoes	120.0	8254
Silage maize	100.0	5208
Bare soil*	130.0	4543

*A slightly lesser soil erosion on bare soil than on maize stand was done probably by weeds

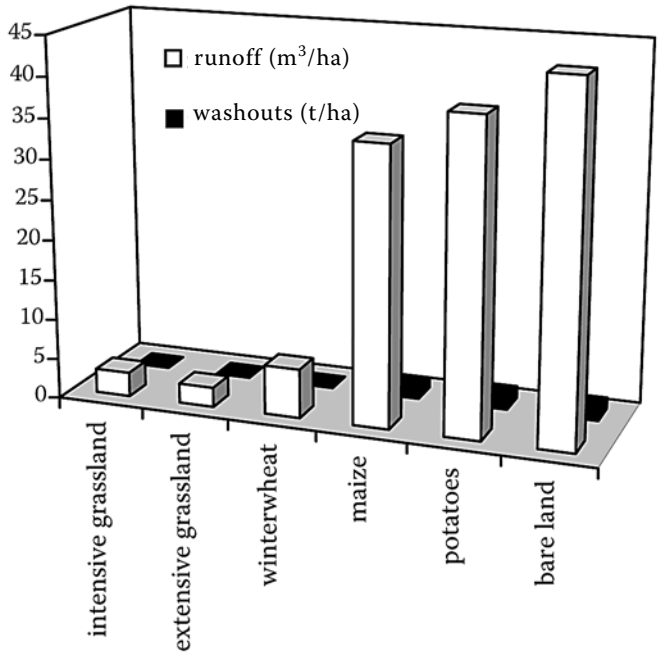


Figure 6. Average amount of runoff and washout values for individual crops in period 2004-2008

experimental plots remained unchanged during the whole experiment.

As comparing grasslands with bare land, the values of surface runoff were lower in average by 86% and those of washout even 99% than those recorded on the bare land. Maize crops reduced runoff and washout values by 21% and 11%, respectively. Badalíková and Hrubý (2005) reported that in row crops the washout values were lower by 50% than those recorded on bare soil.

Results obtained in the potato crop were rather variable. The average runoff was lower by 12% than that from the bare land plots but the average washout values were higher by approximately 5%. This was significantly influenced above all by rainfalls in 2005 and 2008; they occurred at the beginning of June when the young plants were just emerging. The runoff in this crop was lower than that from the bare land; this resulted in a higher percolation but the values of total washout of soil particles were higher.

Table 2. Comparison of surface runoffs in growing season at individual soil covers in the period 2004–2008 (m^3/ha)

Growing season (V–IX)	Soil cover					
	grassland standard	grassland extensive	wheat	bare soil	maize	potatoes
2004	53.2	34.4	89.6	416.0	363.2	449.1
2005	43.1	40.3	606	136.7	128.1	105.5
2006	48.4	35.2	28.1	213.4	206.6	120.7
2007	32.8	27.3	31.4	385.4	350.3	374.3
2008	56.8	44.8	99.9	808.3	483.6	728.8
2004–2008	234.3[a]	182.0[a]	309.6[a]	1959.7[b]	1531.8[b]	1747.6[b]
Proportion from precipitations (%)	1.3	1.0	1.7	10.6	8.3	9.5

[a,b]Different letters indicate statistically significant differences between volumes of runoff ($P < 0.05$)

Table 3. Average surface runoffs and soil erosion at individual soil covers compared with the control (bare soil) in the period 2004–2008

Soil cover	Surface runoff (%)	Soil erosion (%)
Grassland intensive	6.9	0
Grassland extensive	5.6	0
Winter wheat	13.9	0.5
Potatoes	88.3	105.1
Silage maize	78.6	89.5
Bare soil	100.0	100.0

CONCLUSIONS

Results obtained on experimental plots with different vegetation cover within the period of 2004–2008 indicate explicitly a significant decrease in washout values on sloped plots covered with no row crops and/or permanent grassland. The intensity of washout values recorded on individual experimental plots was not evaluated by Wischmeier and Smith's Empirical Soil Loss Model (Wischmeier & Smith 1978). Evaluated were only relative washout values (i.e. percentages) recorded on individual plots because they can be related to individual crops. The obtained results might support the proposal of erosion control measures and their implementation in agricultural practice.

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