Mitigation of surface runoff from agricultural fields by micro-dam technology and conservation tillage results from maize field trials

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New results!

Introduction and Objective

On sloped agricultural fields, water and sediment can be transported downhill as runoff and erosion. These processes cause loss of valuable soil, nutrients and plant protection products (PPP) into adjacent surface water bodies. In European and US risk assessment for the registration of PPP, runoff is numerically calculated with the simulation model PRZM[1] which uses the USDA runoff curve number (CN) concept[2] for the water movement. Farmers apply mitigation measures to reduce runoff, e.g. the micro-dam technique or conservation tillage. Both allow for an improved water infiltration. Conservation tillage additionally helps binding CO_2 in the soil[3].

Results from runoff field trials are used to estimate the effect of the dedicated management practices of micro-dams and conservation tillage in maize on model input parameters. The mitigation effects in terms of runoff water are quantified by deriving a CN reduction. The derived parameter values can in turn be used in the simulation model to quantitatively consider the effect of mitigation on the surface water exposure.

Table 1: Details of the studies under investigation.

	Trial 2018	Trial 2019
Device (micro-dams)	Newly developed device from LSM (Belgium)	
Soil type	Sandy loam	
Irrigation	no	
PPP application	yes	no
Plot length [m]	24	18
Plot area [m²]	72	54
Slope [%]	9	

Figure 1: Resulting pattern of micro-dams on the field.

Materials & Methods

Field trials. The two trials (Tab. 1) were conducted on the Bayer ForwardFarm in Huldenberg (Belgium), applying regular tillage and conservation tillage, both with and without the installation of micro-dams (Fig. 1). The devices for creating the micro-dams (Fig. 2) and for conservation tillage (Fig. 3) are commercially available.

Calculations and simulations. Runoff curve numbers were calculated based on measured precipitation *P* [mm] and runoff *Q* [mm] in the field trials:

$$Q = \frac{(P - 0.2 \times S)^2}{P + 0.8 \times S}$$

The corresponding daily watershed parameter *S* [L] was inversely estimated, and consequently, the (dimensionless) curve number *CN*, being the quantification in risk assessment:

$$S = 25.4 \left(\frac{1000}{CN} - 10\right)$$

Figure 2: Device for the installation of micro-dams (LSM, Belgium).

Results & Discussion

Application of regular and conservation tillage with and without micro-dams, lead to a consistent decrease of runoff and erosion, and consequently to lower CN. (Table 2). The results support the approach to quantitatively consider risk mitigation measures in the context of regulatory surface water exposure calculations, as proposed e.g. by the MAgPIE workshop[4] and are in line with previous findings on the same site[5]. Based on this data, a robust case can be made to quantitatively consider innovative runoff mitigation for risk assessment purposes, e.g. by lowering the CN in the exposure scenarios or adapting parameters in the erosion calculations.

Both the installation of micro-dams and the application of conservative tillage reduce runoff. Micro-dams can be applied fast and easily on a regularly tilled field and become immediately effective. Conservative tillage adds a surplus, but comes with a longer time frame for reaching effectiveness (3 consecutive seasons).

Figure 3: Device to conduct the conservation tillage.

Table 2: Effects of micro-dams and conservation tillage in maize cultivation on runoff, derived curve numbers (CN; means), and erosion (percental means) in the two trials of 2018 and 2019

	Tillage			Conservation Tillage			Reduction conser. tillage vs. tillage	Reduction micro-dam + conser. tillage vs. tillage
	untreated	micro-dam	Reduction [%]	untreated	micro-dam	Reduction [%]	[%]	[%]
2018								
Runoff [L/ha]	72986	41528	43	12153	6597	46	83	91
CN [-]	78	75	4	73	72	2	6	8
Erosion [kg/ha]	2371	1046	56	62	34	43	97	99
2019								
Runoff [L/ha]	96852	33148	66	30000	15370	49	69	84
CN [-]	82	79	3	79	78	2	4	5
Erosion [kg/ha]	6655	1203	82	599	204	66	91	97

Conclusions and Outlook

The evaluation of the field studies suggests that micro-dams and/or conservation tillage justify a reduction of the average runoff curve number for surface water exposure modelling in maize of up to 6 points.

Ongoing work aims at the derivation of the mathematical description of the erosion process and the consequences for risk assessment.

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