Comparison of different types of medium scale field rainfall simulators

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Motivation

Rainfall simulators are used in numerous experiments to study runoff and soil erosion characteristics. Rainfall simulators usually vary in construction details, rainfall generation, plot sizes and other technical parameters. Medium to large scale rainfall simulators (plot length 3 - 8 m) are often used for field experiments with high demand to labour power, financial costs and water consumption. Therefore, mutual comparison of three similar field rainfall simulators of similar scale was performed, to prove if their results are comparable. This would allow exchange and combination of results (runoff, erosion) into common databases.

Rainfall simulators

The device of CTU Prague is usually applied to a plot size of 9,5 x 2 m employing 4 nozzles SS Full Jet 40WSQ mounted on folding arm, working pressure is 0.8 bar, height of nozzles is 2.65 m. A digital control unit is used to produce rainfall with desired intensity by opening each nozzle for a certain time.

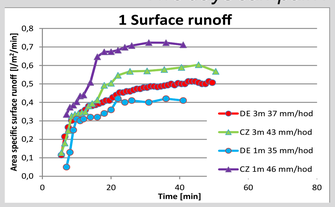
More about rainfall simulator of CTU in Prague in EGU2015-10736, EGU2015-11025, EGU2015-11319

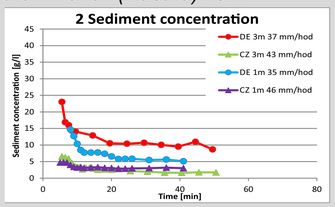
Field simulation

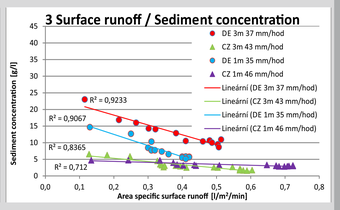
Two experimental campaigns were organized to compare three field rainfall simulators of similar scale (plot size), different technical parameters of RS devices and different plot preparation (compacted x non-compacted cultivated fallow). The results were compared, to identify parameters that are crucial for soil loss and surface runoff formation and test if the results from individual devices can be reliably compared. The rainfall simulators compared CTU Prague (Czech Republic) BAW (Austria) and TU Bergakademie Freiberg (Germany).

Nossen 2013 (Germany)

Two days campain Petzenkirchen (Austria) 2014







Trend of surface runoff CZE x DE differ due to rainfall intensities and heterogeneity of surface. (Graph 1). Trend is similar in the mutual comparison.There is significant relation of runoff/sediment concentration of both devices separately (1m,3m). This trend is plot size independent. However between devices difference is evident. (Graph 3). Concentration of sediment in DE experiment is much higher than in CZE (Graph 2). This relation can be explained by kinetic energy of RS devices (CZE=8,9; DE=20,5 J/m2/mm). "Steady state" condition has been reached in 20 min (or earlier) in all experiments (Graph 5). As expected DE 3m reached higher sediment concentrations than DE 1m. The same comparison has not been evaluated at CZE 1m and CZE 3m.

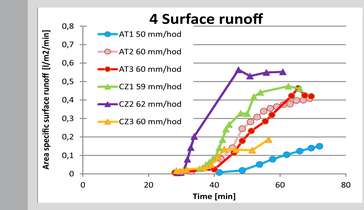
Results

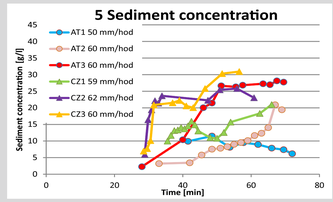
	Duration	Intensity	Total soil loss	Total runoff	Max. sed conc.
	min	mm/hod	g	l	g/l
CZ1	67	59	1519	102	21
CZ2	68	62	6313	266	37
CZ3	61	60	829	31	40
AT1	83	41	209	29	12
AT2	77	50	1058	95	21
AT3	74	50	2320	85	43
CZ1m	48	46	95	35	5
CZ3m	53	43	176	79	7
DE1m	47	35	105	15	15
DE3m	50	37	656	59	23

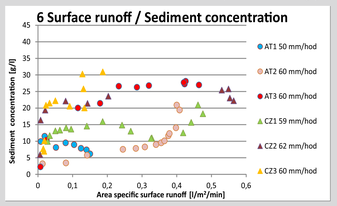
Sumarry results

	Kinetic energy	drop size	Plot length	plot width	drop height
	J·m⁻²·mm⁻¹	mm	m	m	m
CZ	8,91	1,5-2	8 (1)	2 (1)	2,6
AT	17	1,95	5	2	2,6
DE	20,45	2-3	3	1	2

Kinetic energy of RS´s







No steady state conditions have been reached in experiments due to soil characteristics. (Graph 4) Despite of similar initial conditions and surface preparation the sediment concentration is highly variable. (Graph 5). Consistent surface preparation and surface homogeneity is crucial for the experiments. Because steady state conditions have not been reached there are differences in sediment concentration and also dependence of runoff/sediment concentration is not significant. (Graph 5, Graph 6)

Conclusion

The **rainfall simulator of Freiberg University** consist of three linked simulator modules at a height of 2 m. Each module is equipped with one VeeJet 80/100 nozzle (Spraying System) which provides intermittent rain by oscilation. Rainfall intensity during experiments is about 37 mm/h and is regulated by the nozzles rotation speed and by the time the nozzle remains at the reversal points where all water is collected. The 3 x 1 m experimental plot is bound by a metal frame.

- Preparation of the surface is crucial step for mutual comparison and the comparison of different devices and therefor has to be done with exceptional care
- Compaction of "fresh fallow" surface significantly shortens surface runoff initiation, which saves time and water amount necessary for the experiment as well as helps to stabilize initial conditions of the experimental plots
- Correct setting of rainfall intensity has great impact on surface runoff and therefore it shall be measured and checked carefully
- Kinetic energy of raindrops is essential for soil lossintensity. Each simulator has to be well defined by this parameter.
- It is crucial to set up the methodology of using RS devices and evaluation of their output data if results of more devices are to be compared
- Comparison of the results or use more devices in one task

The basic unit of the **BAW simulator** consists of 3 nozzles mounted at 2,6 m with a distance of 1 m each. At the moment 4 units are available with possible plots size up to 11 m by 2 m. Spraying Systems fulljet nozzles HH30WSQ and HH40WSQ are used. Each nozzle is driven by 3-way solenoid valve which gets powered by an electronical interface. The interface is connected to a computer program which enables to change the rainfall intensity at any step of the simulation, thus making it freely programmable.

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