Splash erosion experiments with silt loam and loamy sand soil under simulated rainfall produced by two types of rainfall simulators

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Study Overview

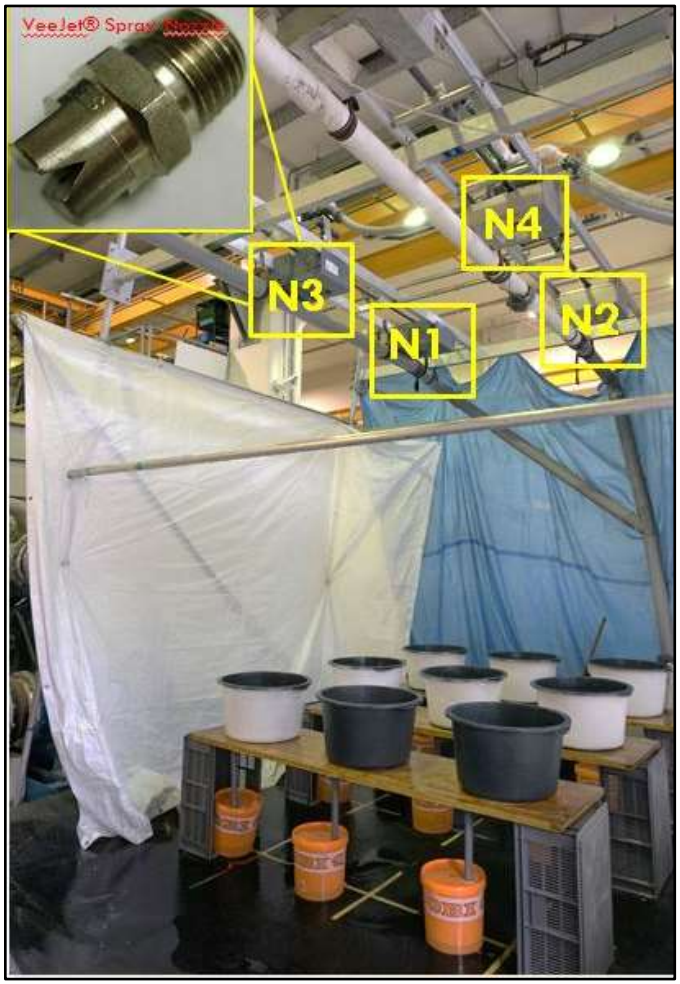
STUDY QUESTIONS

- what are the differences in rainfall characteristics produced by two rainfall simulators?
- do the two different rainfall simulators produce different splash erosion rates?
- if yes, which rainfall parameters affect those differences?
- can the experiments in soil (splash) erosion studies be reproducible by using different rainfall simulators?

STUDY AIM

- quantify the differences in rainfall parameters between the two different rainfall simulators;
- quantify the differences in splash erosion rates for three soils affected by the rainfall produced by different rainfall simulators.

Materials and methods



Rainfall simulator "BOKU" with splash erosion collectors; N1-N4 denote four VeeJet nozzles

Rainfall Simulator specifications (BOKU):

- Norton Ladder type;
- four oscillating VeeJet 80100 nozzles (N1-N4) arranged in two rows;
- operating pressure of 0.45 bar at nozzles;
- elevation of the nozzles 2.3 m from the soil surface;
- water supplied from the tank with deionized water;
- intensity range: 20-54 mm h^{-1}.

Positions of splash cups and collectors marked with numbers
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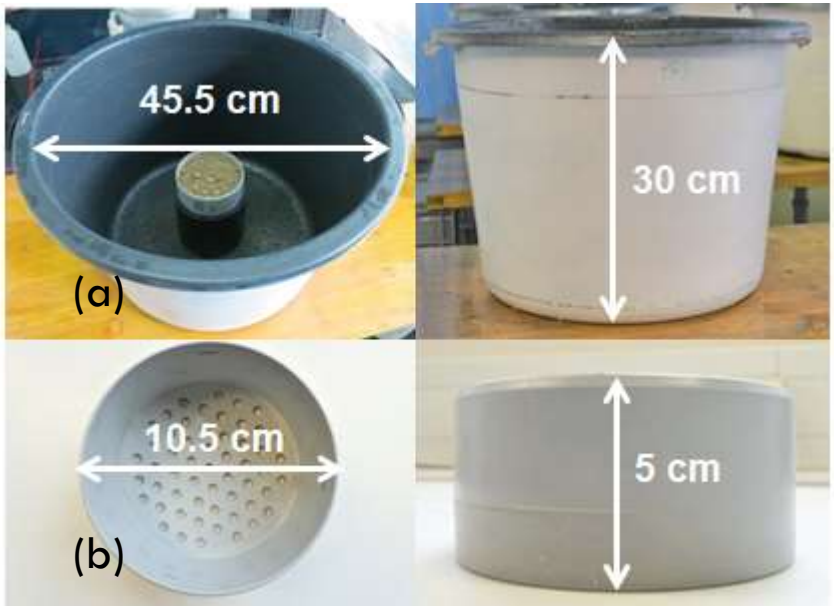
Materials and methods

Rainfall simulator "BAW" with one FullJet nozzles with positions of splash cups marked with numbers.

Rainfall Simulator specifications (BAW):

- one FullJet nozzle (½ HH-30WSQ)
- operating pressure 0.25 bar at nozzles;
- elevation of the nozzles 2.3 m from the soil surface;
- water supplied from the tank with deionized water;
- intensity range: 35-81 mm h^{-1}.

Materials and methods



Splash collector (a) and splash cup (b)

Splash erosion measurements:

- modified Morgan splash cups (Morgan, 1981);
- sampling area: 0.0084 m^2;
- three replicates of splash erosion measurements were obtained for each position under rainfall simulator.

Investigated soils:

- soil was collected in seed bed condition, air-dried and sieved (<10 mm);
- **Zwerbach (ZW)** and **Mistelbach (MI)**- silt loam texture
- **Býkovice-** loamy sand texture

Splash cup filled with Zwerbach, Mistelbach and Býkovice soil (© Tomas Laburda)

Materials and methods

Rainfall measurements with OTT Parsivel disdrometer

OTT Parsivel
(OTT Hydromet, 2018)

Rainfall parameters measurements:

- rainfall intensity was measured by collectors for each position of splash cups under rainfall simulators;
- raindrop size and velocity was measured with OTT Parsivel to calculate the rainfall kinetic energy (KE).

Results

Tables showing the rainfall parameters measured for (a) BOKU and (b) BAW rainfall simulator

Position	Intensity [mm h^{-1}]	Kinetic energy [J $m^{-2}h^{-1}$]	Kinetic energy / Intensity [J m^{-2} mm^{-1}]
1	28.32	504.44	17.81
2	37.83	618.97	16.36
3	35.34	681.01	19.27
4	42.48	701.06	16.50
5	49.59	716.50	14.45
6	54.24	923.15	17.02
7	28.25	566.32	20.04
8	32.28	546.28	16.92
9	35.90	712.24	19.84

(a)

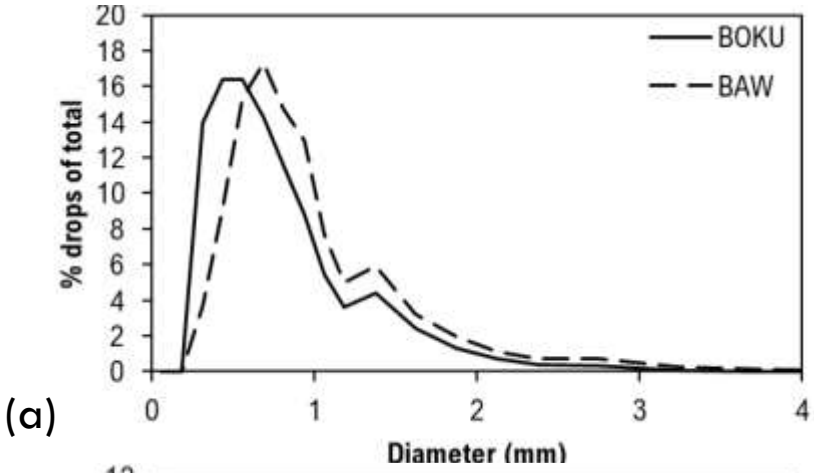
Position	Intensity [mm h^{-1}]	Kinetic energy [J $m^{-2}h^{-1}$]	Kinetic energy / Intensity [J m^{-2} mm^{-1}]
1	70.17	773.57	11.02
2	81.24	961.81	11.84
3	56.65	667.03	11.77
4	35.31	375.76	10.64
5	43.46	421.19	9.69
6	56.32	560.75	9.96

(b)

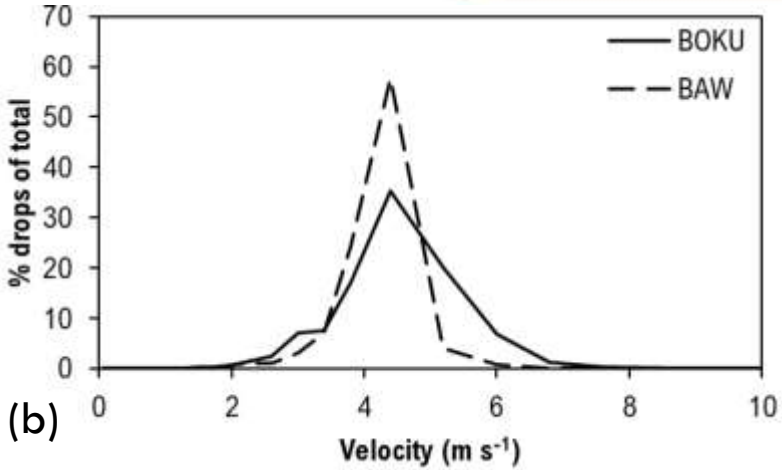
Rainfall parameters:

- for the similar rainfall intensities the KE under BOKU rainfall simulator was almost 2 times higher than under the BAW rainfall simulator.

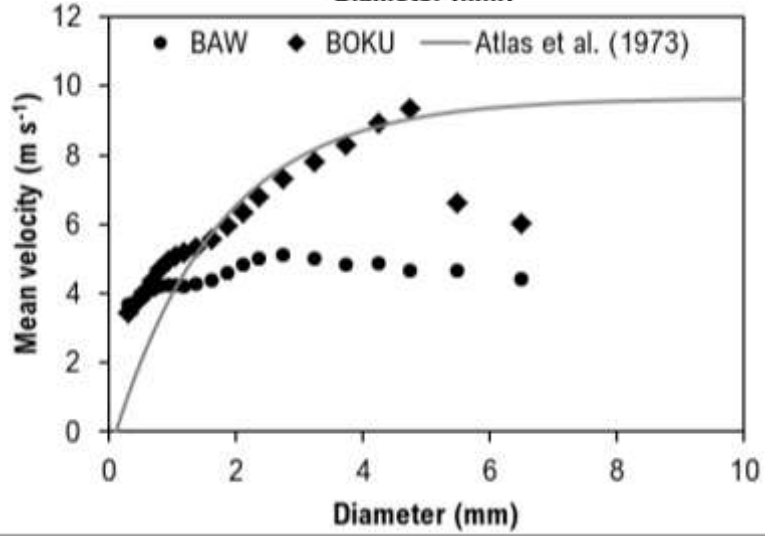
Results



(a)



(b)



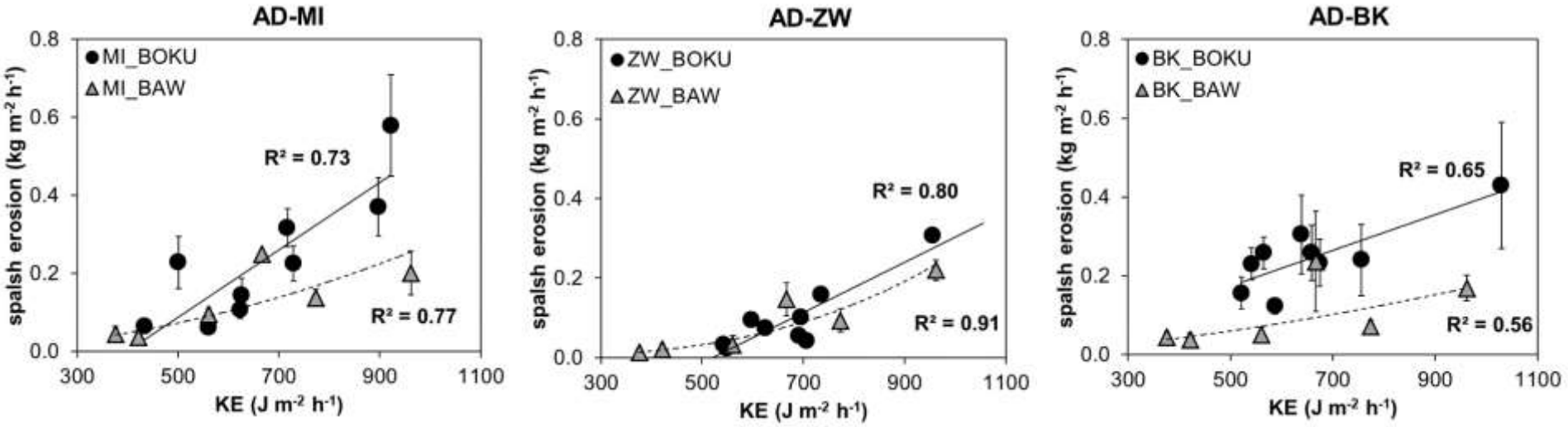
(c)

Raindrop size and velocity distribution:

- BAW rainfall simulator measured larger drops;
- higher drop velocity was produced by BOKU rainfall simulator;
- terminal velocity of raindrops was reached for most positions under BOKU rainfall simulator.

Figures showing; (a) drop size distribution, (b) velocity distribution and (c) mean drop velocity of each drop size class for BAW and BOKU rainfall simulator.

Results



Average splash erosion (n=3) for MI (silt loam), ZW (silt loam) and BK (loamy sand) versus rainfall KE for BOKU and BAW rainfall simulator

Splash erosion for three soils:

- in average 45% and 55% higher splash erosion rates were measured for the MI and BK soil, respectively, under the BOKU rainfall simulator than under the BAW rainfall simulator;
- the highest splash erosion rates were measured for BK soil under BOKU rainfall simulator and for MI soil under BAW rainfall simulator;
- positions with largest drop diameter produced higher splash under BAW rainfall simulator;
- surface ponding was present on the positions with KE>700 J m^{-2} h^{-1} under the both rainfall simulators.

Conclusions

- Two rainfall simulators produced same intensity rates but considerably different KE;
- Correspondingly, splash erosion rates were higher for the rainfall simulator with higher rainfall KE;
- Higher rainfall KE was the result of higher raindrop velocities rather than larger raindrop sizes, which increased the rainfall erosivity and the splash erosion;
- Reproducing the experiments in soil erosion studies requires careful calibration of the rainfall properties (raindrop size and velocity) produced by different simulators;
- This result highlighted the influence of rainfall simulator specific parameters in splash erosion experiments, where special care should be paid when comparing the results obtained from different rainfall simulators.