Design and calibration of the small portable rainfall simulator of Trier University

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Introduction and Main Objective

The small portable nozzle-type rainfall simulator of Trier University has been used in Germany, Spain, Morocco and Burkina Faso since 1995. It was methodically improved in 2008/09 aiming on homogeneous spatial rainfall distribution, better drop spectrum and reproducibility of both. Because of better spraying characteristics, the previously used hollow cone nozzle (Hardi Syntal 1553-89 10) has been exchanged by a full cone nozzle (Lechler 460.608). The rainfall regulation changed from regulating water flow and pressure with a conventional valve to an exact regulation by a flow meter and needle valve.

Calibration Methods

1) Laser Disdrometer (Thies) ➔ Drop sizes/-fall velocities
2) Calibration Plate ➔ Rainfall intensity
3) Rain Gauges ➔ Spatial rainfall distribution

Plot diameter: 0.6 m

0.28 m²

Main Parts of the Rainfall Simulator

Nozzle-type Rainfall Simulator based on design by Calvo Cases et al. (1988) and Lasanta et al. (1994)
Intensity 40 mm h⁻¹

Motor Pump
Motor (97 cm²)
Pump max. 20 bar
Water Tank (max. 100 l)

Aluminium Linkage with Rubber Tarpaulin

2 m
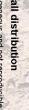
Rainfall Regulation (former version)

Nozzle
Hardi Synta 1553-89 10

Conventional Valve
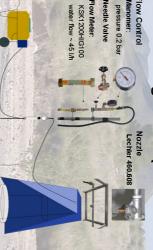
1) Spatial rainfall distribution
➔ Clearly heterogeneous and not reproducible rainfall
2) Drop size distribution and fall velocity
➔ Low similarities with natural rainfall (velocity of small drops is too high, velocity of large drops is too low)

test run1   test run2
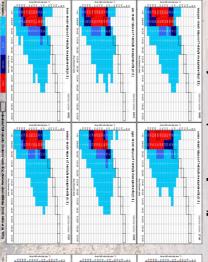
Rainfall Regulation (current version)

Nozzle
Lechler 460.608

Flow Control
Manometer: pressure 0.2 bar
Needle Valve
Flow Meter
KSK1200HIGI00
water flow ~ 45 l/h

1) Average spatial rainfall distribution a) and spatial rainfall variability b)

a) Concentric Pattern
➔ Lowest intensities in the centre, highest intensities at the rim
➔ Christiansen Uniformity 91 % (after Christiansen 1942)

b) Very good reproducibility

Deviation Class	Area covered
0 % - 5.0 %	85 %
5.1 % -10.0 %	15 %
maximum variability of 6.4 %	

2a) Average drop size distribution and fall velocity on five positions [see 1)]

2b) Drop size distribution and fall velocity: Average deviation from mean (%)

2c) Drop size distribution variability and Marshall Palmer Distribution

2 a) ➔ Complete naturally occurring drop spectrum is covered
➔ The velocities of smaller drops often are similar to that of natural ones.
➔ Due to low fall heights, larger drops are too slow compared to natural rainfall droplets; maximum velocities: 3.4 to 5 m s⁻¹

2 b) ➔ Highest deviations where the least drops are measured
➔ Very low deviations where most drops are measured
➔ Good reproducibility
➔ Variability on total plot is caused by concentric rainfall distribution pattern

2 c) ➔ Drop distribution corresponds approximately to Marshall & Palmer Distribution (Marshall & Palmer 1942)
➔ Good reproducibility: Max. variability of drop amount is 28% in drop diameter class 0-0.49 on total plot

Conclusions

➔ Modifications clearly improved reproducibility as well as drop characteristic of artificial rainfall
➔ Due to general physical limitations a still better simulation of natural rainfall is not possible with this device
➔ The new setup proved worthwhile in laboratory tests and in field campaign

Literature

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Lasanta, T., Pérez-Rontomé, M.C., García-Ruiz, J.M., 1994. Efectos hidromorfológicos de diferentes alternativas de retirada de tierras en ambientes semiáridos de la depresión del Ebro. In: García Ruiz, J.M., Lasanta, T. (eds.). Efectos geomorfológicos de semiáridos de la depresión del Ebro.
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