Drop Velocity of Simulated Rains

Matheus F. B. Colares[1], Pedro L.T. Lima[2], Luiz A. Lima[1] and Chi-Hua Huang[3],

(1) Agricultural Engineering, Universidade Federal de Lavras, Lavras, Brazil.

(2) Soil Science, Universidade Federal de Lavras, Lavras, Brazil.

(3) USDA-ARS National Soil Erosion Research Lab, West Lafayette, IN, USA.

INTRODUCTION

- Different spray nozzles are frequently used to simulate natural rains for soil erosion and chemical runoff studies.
- Physical properties that enable to estimate kinetic energy, such as drop size, shape and fall velocity of rain drops, are not well quantified.
- These information are important in order to estimate erosivity, which is the rain potential to cause disaggregation and transport of soil particles.
- Oscillating VeeJet nozzles are used mostly in soi erosion research while constant spray FullJet nozzles are commonly used for phosphorus runoff studies.
- To measure the velocity of drops generated by those nozzles, a dynamic pluviometer developed in Brazil (UFLA Rotary Rain Gage) by Prof. Luiz Antonio Lima, was used to obtain the velocity spectrum. In addition, an commercial LASER disdrometer, was used to measure drop size and velocity, for comparison.

UFLA Rotary Rain Gage (Dynamic Pluviometer)

A 52-cm span rotating arm containing 14 collection cups with 45^0 opening is made to have adjustable speeds. As the tangential speed varies, depending on the rotational speed and the radial distance, each cup will collect water drops falling at certain velocity range. A simple relationship can be derived to define the range of drop velocity for each collection cup. For example, at 130 rpm, the outermost cup only collects drops with a fall velocity of 9.86 m/s or greater. Circular cup at the center is a static pluviometer. The two arms are replicates. Water collected at each cup can be used to build a frequency histogram (Figure 2).

The unity shown here built at the USDA-ARS National Soil Erosion Research Laboratory, West Lafayette, IN.

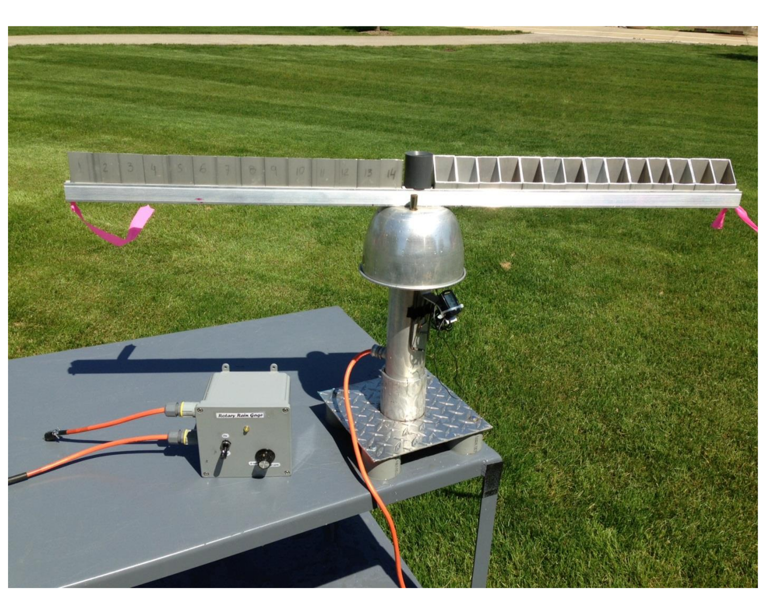

Figure 1: UFLA Rotary Rain Gage

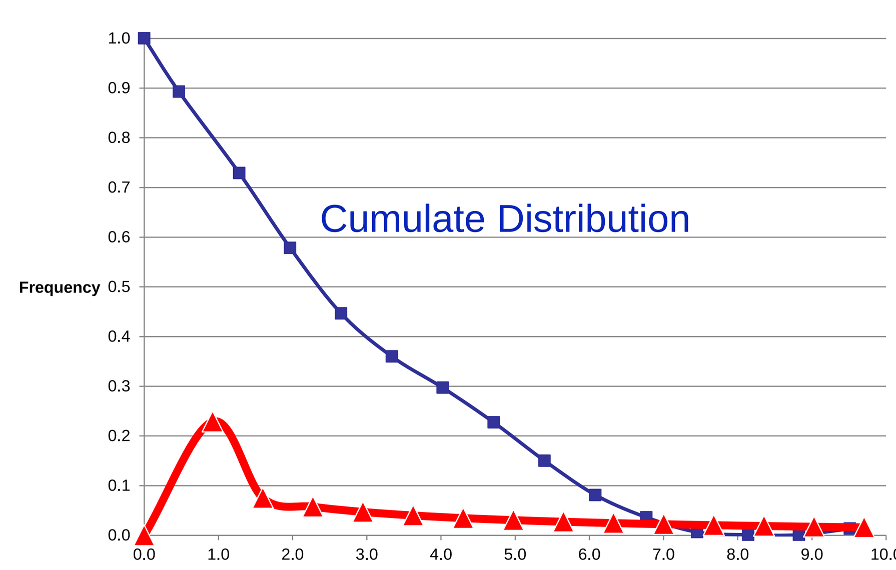

Figure 2: Frequency Histogram

PARSIVEL II LASER DISDROMETER

Rain drops passing through a LASER beam 3 cm wide by 18 cm long are measured for their sizes and velocities. Figure 4 shows the drop size - velocity spectrum.

Figure 3: Parsivel II LASER disdrometer

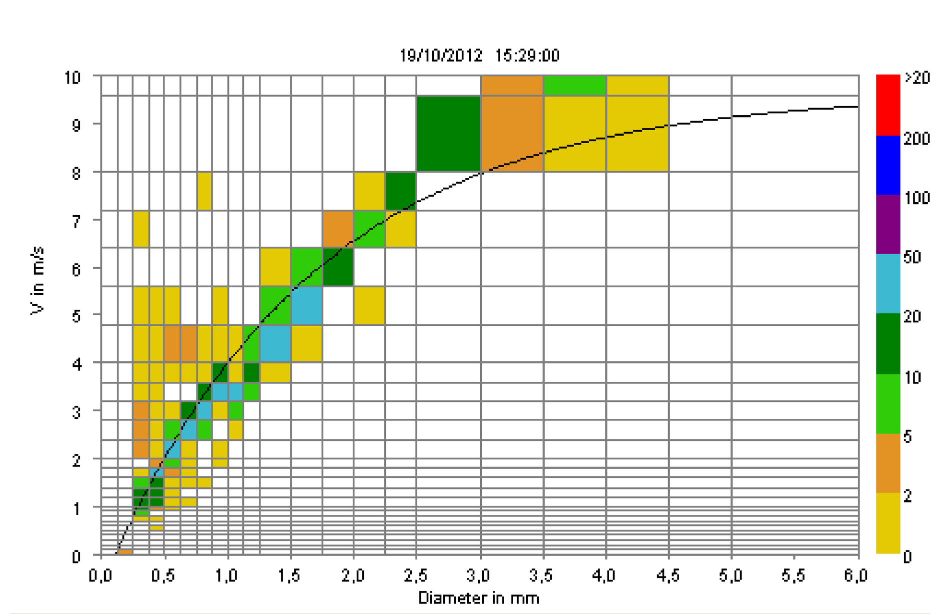

Figure 4: Example of Parsivel II display

METHODOLOGY

- Measurements for simulated rain from VeeJet nozzles were conducted with four nozzles located at the corners of a 1.16 x 0.92 m grid. The nozzle was 3 m above the testing surface. The insrument was located at the center of the four nozzles. The nozzle pressure was set at 6 psi.
- For measurements under the FullJet nozzle, only one nozzle was used and the nozzle height was 3-m and preesure was 3.5 psi. Instrument was placed at the center.
- The measuring time for the rotary rain gage was 10 minutes and and Parsivel 2 minutes.

RESULTS

Table 1. Mean velocity of drops and intensity of rain generated by VeeJet 80-100 nozzle.

Nominal Intensity (mm/h)	Rep	Parsivel II		UFLA Rotary Rain Gage	
		Velocity (m/s)	Intensity (mm/h)	Velocity (m/s)	Intensity (mm/h)
10	3	3.61Aa	16.30Aa	3.43Aa	12.95Ba
50	3	3.88Ab	56.43Ab	3.35Ba	45.59Bb
100	3	3.95Ab	109.62Ac	3.48Ba	97.78Bc

Statistical analyses (Scott Knott 5% level) showed that rain intensity detected by the two methods, i.e., Laser Distrometer and ULFA Rotary Rain Gage, was statiscally different. Differences were also detected for the mean velocity from the two methods at two high intensities, i.e., 50 and 100 mm/h.

Since both rain intensity and drop velocity are needed to estimate kinetic energy, more tests are needed to clarify the discrepancy between both equipment.

Table 2. Mean velocity of rain drops generated by a single Fulljet ½ SS HH WSQ nozzle.

Nominal Intensity (mm/h)	Rep	Parsivel II		UFLA Rotary Rain Gage	
		Velocity (m/s)	Intensity (mm/h)	Velocity (m/s)	Intensity (mm/h)
75	3	2.83A	47.99A	3.07A	69.57B

When the FullJet nozzle was tested (three replicates), velocity measured was not different statistically. Rain intensity varied from one method to the other, mainly because of spatial variance due to the fact that only one nozzle was used. In fact, a set of fourteen pluviometers distributed under the single nozzle revealed that intensity values ranging from 52 to 81 mm/h which are greater than the values detected by Parsivel, but more closer to those obtained by the rotary rain gage.

Considering the lower velocity of rain drops generated by the FullJet nozzle as compared to the VeeJet nozzle, it is expected that the kinetic energy might be different.

CONCLUSION

- As a new method, the Rotary Rain Gage appears to be a simple and low cost technology. Its potential for rain evaluation should be further investigated.
- Velocity of drops generated by the FullJet nozzle is lower than the VeeJet nozzles.
- Additional tests should be carried out to compare the LASER disdrometer to the Rotary Rain Gage, if possible under natural rains.

SPONSORS:

CAPES

FAPEMIG
Fundação de Amparo à Pesquisa do Estado de Minas Gerais

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico