Water drop erosivity: Effects on soil splash

Erosivité de la goutte d'eau: Effets sur l'arrachement des particules de sol

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ABSTRACT

Detachment and transport of soil particles by water drop impact can be analysed in terms of the kinetic energy (½ MV^2), or momentum (MV) of the water drop. Therefore density, diameter, fall height, velocity of the water drop and area of impact need to be considered. The drop impact pressure, which is the mathematical combination of these characteristics, has been interacted with soil splash characteristics such as the amount, the mass distance distribution and the mean distance.

A splash board divided into 13 concentric compartments to collect the splashed particles and different capillaries produced drops with diameters between 3.7mm and 5.8mm formed the basis of the laboratory work.

The results shown that the involvement of the drop diameter steepened the curves representing the relationship between soil splash and drop pressure, which means that the drop diameter has an effect on soil splash. But, according to the correlation analysis, the involvement of the diameter did not improve the coefficient of determination of the relation between drop pressure and soil detachment except for the exponential function. In addition, the relationships between drop pressure and soil splash characteristics are mostly presented by a power functions.

RÉSUMÉ

L'éclaboussure (splash) et le transport de particules solides, dus à l'impact d'une goutte d'eau, sont étudiés en termes d'énergie cinétique et de quantité de mouvement de la goutte caractérisée par sa densité, son diamètre, sa hauteur de chute, sa vitesse et sa surface d'impact. C'est ainsi qu'on détermine alors la pression d'impact de la goutte qu'on utilise comme paramètre pour évaluer les caractéristiques du splash, comme la quantité transportée, la distribution de masse avec la distance et le trajet moyen des particules solides.

Le dispositif expérimental est constitué essentiellement d'une planche horizontale divisée en 13 secteurs concentriques servant à collecter les particules solides éjectées par des gouttes, de diamètres compris entre 3.7mm et 5.8mm, produites à l'aide de tubes capillaires.

On montre que l'introduction du diamètre de la goutte a pour effet d'accentuer l'évolution des courbes représentant la variation de l'éclaboussure du sol avec la pression d'impact de la goutte ; ceci montre que le diamètre de la goutte influe sur l'éclaboussure du sol. Une étude statistique révèle cependant que l'introduction de l'effet du diamètre n'améliore pas notablement la détermination de la fonction d'évolution de la masse transportée avec la pression d'impact, hormis pour l'allure exponentielle. Dans le cas général, ce sont plutôt les fonctions en puissance qui représentent le mieux l'évolution des caractéristiques de l'éclaboussure.

1. Introduction

The splash process begins when water droplets strike the soil surface. Raindrop force serves to break down aggregates on the soil surface and detaches soil particles from the mass. Detached particles are splashed and fall back to the surface in a more dispersed state (Bradford et al [2]).

The splash process can be characterised as two subprocesses; the detachment or the dislodgement of the particles from the surface mass and the transport of these particles in random directions. These subprocesses are the result of the water-soil collision. The water drop effects can be related to the drop's diameter, mass, velocity, shape, fall height, drop force and impact pressure.

The soil effects can be related to two main characteristics: the soil mass properties and soil surface properties. From these associated variables, we attempted to summarise all the principal interactions of the soil properties and water drop characteristics in the following water splash process diagram (Figure 1).

The effect of raindrop impact on soil is commonly attributed to the kinetic energy of the drop, or to its momentum, or to some combination of these. But the concept of eroding pressure (corresponding to the impact of the water drops with different diameters) can be better visualised by considering the mechanism of soil detachment.

The concept of eroding pressure is based on the mathematical combination of water drop characteristics such as mass, velocity and diameter of the drop and the area of impact. The purpose of this combination is to see how much the mass, velocity and drop diameter (with different powers, e.g. d, d^2; d^3) affect soil detachment and transport and provide more information about the effects of the addition of the drop diameter to the erosive parameters, in addition to mass and velocity (e.g. MV and MV^2).

Explanation of the eroding pressure

By definition, the pressure P_e equals the force divided by the area (surface) covered by this force.

$P_e = F/A$

In this investigation, P_e is considered as the eroding pressure and F is the force of the water drop.

A is the area of impact at the effective plane of impact and is equal to:

$A = \pi d^2/4$ (Tan, [18])

where d is the diameter of the drop water.

As mentioned in the findings of Riezebos and Epema [16]:

$F = MV^2/d$

where M,V are the mass and the velocity of the drop water respectively.

So:

$$P_e = 4\,MV^2/\pi d^2 \qquad (1)$$

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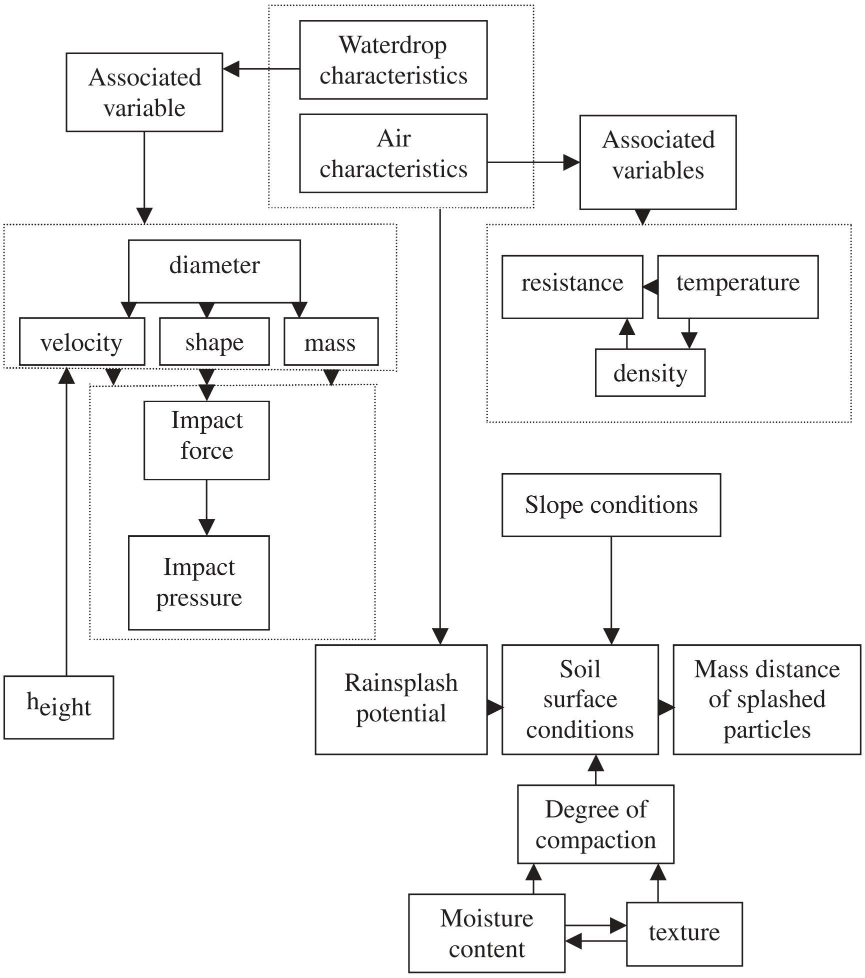

Fig. 1. Water Splash Process Diagram
Diagramme du processus d'arrachement

2. Experimental equipment and procedures

Variation of drop diameter was accomplished in the laboratory by placing a burette fitted with a capillary at constant elevation. Different capillaries (glass tubes) produced drops with diameters between 3.7 and 5.8mm. The tip of the capillary was smooth and flat to avoid any kind of deformation of the drop. Samples of drops were taken at different levels of water in the burette and the average value was taken to avoid the influence of the water height on the drop diameter. An electronic balance was used to measure the drop mass immediately after sampling.

The falling drop, in the presence of air, should respect the Archimede law and the apparent mass of a spherical drop is as follows:

$$M_{app} = (\rho w - \rho a)\frac{\pi}{6}d^3 \tag{2a}$$

The equivalent diameter of the drop, defined as the diameter of a spherical drop with the same mass, was determined using equation (2a):

$$d_{eq} = \left[\frac{6\,M}{\pi\,(\rho_w - \rho_a)}\right]^1 \tag{2b}$$

where d_{eq} is the equivalent diameter (mm), ρ_w and ρ_a are the density of water and air respectively, M is the mass of the drop collected immediately after sampling in a small collector.

The experimental set up for measurement of splash detachment and transport was following this procedure. The equivalent drop sizes were 3.7 mm, 4.3 mm, 4.9 mm and 5.8 mm, produced by capillary tubes. The height of fall for these drop sizes was 8 meters because, at this height, the drop velocity attains 95% of the natural raindrop velocity (Laws [10]). For all the runs, a volume of 50ml water of an approximate constant temperature (20°C) was used.

The agricultural sandy soil was examined for stones and roots which were removed in order to have a homogeneous structure. Before each experimental run, the cups were filled with soil until the surface soil was in level with the cup rims. These filled cups were then dried for 24 hours at 105°c in order to eliminate all the water content, and then put into the dessicator to cool them gradually in such a way that the air humidity did not affect the consistence of the soil particles.

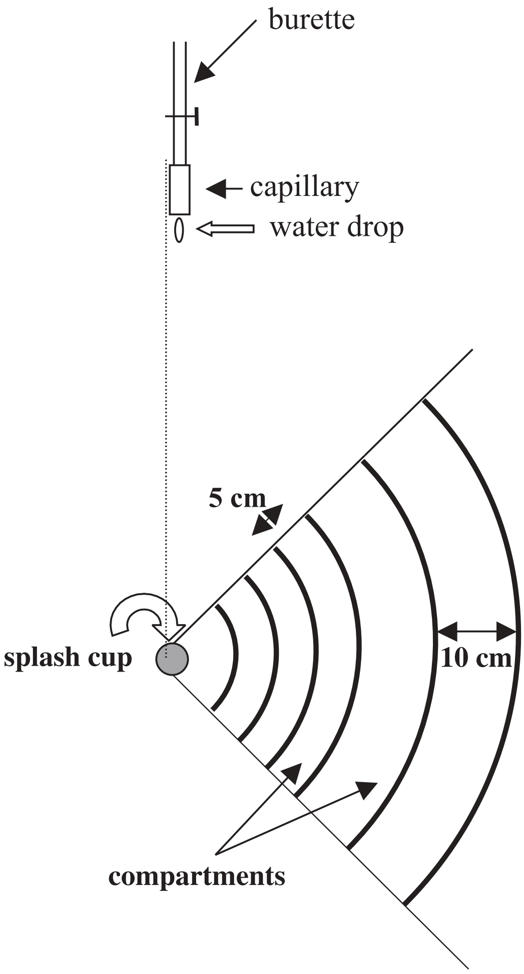

Plate 1. Splash board sketch
Schéma de la planche d'expérimentation

The splash board is a device made to assess the weight of the detached soil particles and the distance travelled by these particles (Plate 1). The splash board is similar to that described by Riezebos and Epema [16]. The splash board forms a quarter of a circle with a maximum radius of one meter divided into 13 concentric compartments by vertical aluminium strips. These aluminium strips were rolled to the appropriate radius on a machine. The rims have the same height as the splash cup. The six inner-compartments are 5cm wide whereas the seven outer-compartments are 10cm wide.

A splash cup filled with agricultural sandy soil (8cm in diameter and 5cm in height) was placed in the centre of the splash board. The top of the splash cup was in level with the rims of the splash board.

After each test, the splashed particles were flushed from the splash board compartments with a wash bottle and the particles filtered and dried. The weight of material splashed, into the different compartments, was measured per compartment and the mean splash weighted distance $\bar{x}$ was assessed using the following usual expression:

$$\bar{x} = \sum_{i=1}^{i=13} m_i x_i \Big/ \sum_{i=1}^{i=13} m_i \tag{3}$$

x_i was measured from the middle of the cup to the middle of the compartment and m_i is the weight of the particles in the compartment i. The mass collected in each compartment, for each run, is the mean value of the mass ejected from the samples (3 cups of soil samples), and the mean value of the experiment is the mean of five runs with each drop size.

3. Discussion of the results

3.1. Water drop and soil splash characteristics

The drop diameters used in this investigation varied from 3.7mm to 5.8mm. These drops, characterising the heavy rains, are responsible for high rates of soil erosion. The kinetic energies, corresponding to these diameters, were computed and varied from $0.89604\ \mathrm{g.m^2.s^{-2}}$ to $3.94454\ \mathrm{g.m^2.s^{-2}}$ and the drop pressure from $4.504.10^4$ Pa to $5.148.10^4$ Pa respectively. The variation in drop pressure was quite small in comparison to the variation of the drop diameter, that could be the consequence of the small variation of the drop terminal velocity.

The splash erosion, which was the consequence of the erosivity parameters, could be analysed in terms of three properties; the total mass splashed from the point of impact, the distribution of these particles over the distance from the target and, finally, the mean distance travelled by the particles. A description of the splash process is needed to clarify the splash phenomenon.

Upon hitting the bare sandy soil surface, the droplets appeared to split into several droplets of different sizes. Sets of droplets were splashed out carrying soil particles, the quantity of these particles depending on the droplet's characteristics such as diameter, volume, transport capacity, and the arrangement of the particles. Some fine droplets were found without soil particles. These phenomena were observed on the white 'splash board' apparatus. The rest of the drop wetted the soil. This last subprocess contributed to the compaction of the soil surface by pushing the fine particles into the soil pores, or voids, or by reducing the voids' volume. During the run, a very thin water film was formed between the craters crests but never a clear water depth. This could be related to the volume of 50 ml used to generate the water drops, to the high porosity of the sandy soil, to the initial dry state of the soil or to all of them. The transport of fine particles into the soil pores has been referred to by the term 'puddle erosion' (Zachar, [20]). From observations on the splash board, most of the splashed particles were ejected in groups inside water droplets and very few particles were single. These single particles could have been ejected by the impact of drops on neighbouring particles or detached from the droplets. Ghadiri and Payne [7] found that droplets smaller than 10µm may have evaporated before landing, and this could be one reason for the observed single particles. In addition to this, the big droplets have landed in compartments adjacent to the point of impact. Ghadiri and Payne [7] investigated the formation and characteristics of splash following raindrop impact on soil; they found that small droplets were released at small angles (angle between the horizontal surface and droplet's trajectory) and high speeds, but that they rapidly slowed, presumably because of air resistance. Large droplets, on the other hand, were formed only towards the end of the splash process when release velocities were low and splash angles much larger. In the presence of a surface layer of water, the process is different.

As regards the soil surface damage by the drops, from the experiments, the craters and the surface damage varied with the drop diameter. The crater or cavity characteristics, seen on the damaged soil, reflected the description of Al-Durrah and Bradford [1] when they found that the bottom surface of the cavity, caused by raindrop impact, was convex rather than flat. The cavity diameter was slightly larger than the diameter of the drop and enlarged as the velocity of the drop increased. Bisal (1950) in Kinnell [8] suggested that the roughness of the surface, developed by the drop impact, may have a significant influence on the rate of splash loss. During the run, the splash-cup area was sufficiently small for the detached soil particles to leave the cup and not be replaced. The soil surface, being flash with the cup rim, allowed the particle to move horizontally as well as obliquely. A further observation was that the crater bottom was compacted and the particles, forming the raised rims, were easily removed by the following impact. In addition to this, the roughness increased with increasing drop diameter.

3.2. Drop characteristics-total weight of splashed particles relationships

The number and sizes of droplets ejected by the drop impact depend on the drop pressure and on grain size uniformity. In this study, the sand used had a range of grain sizes.

The influence of drop erosivity was tested by relating detachment and transport of agricultural sandy soil particles with erosivity parameters. In addition to drop pressure, $4MV^2/\pi d^3$, in which the surface of the impact area was included, the drop diameter, momentum and kinetic energy were used. Impact area was calculated from drop weight by using the equivalent diameter of the drop expressed in equation (2b). The total weight versus drop pressure relationship is plotted in Figure 2a. The relationship shows a sharp increase in total soil detached with increasing drop pressure in a power function form.

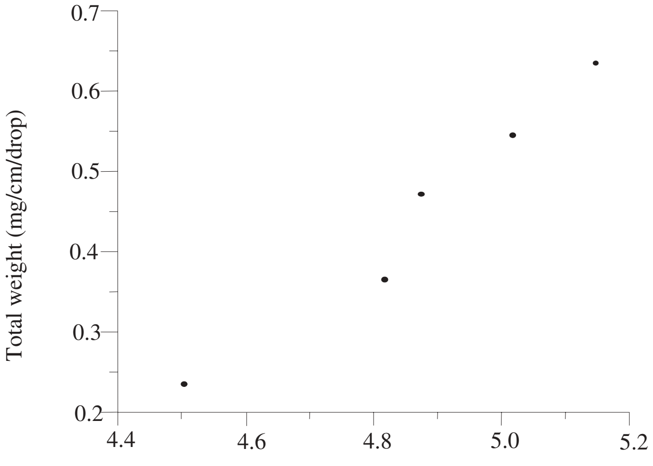

Fig. 2a. Relationship between total weight of detached soil and drop pressure
Evolution de la masse totale éjectée avec la pression d'impact

Riezebos and Epema [16] investigated soil splash with variable fall heights. They plotted soil detachment versus the erosivity parameter, MV^2/d, and found a sharp increase in soil splash with increasing erosivity (Figure 2b). The same relationship, representing the experimental data of this study, was plotted on the same graph. The scale was changed for comparison purposes.

We note that both graphs evolve in the same fashion. In addition to this, we point out that the experimental data of this study are clearly fitting a parabolic curve.

From these curves, we may see that the combination of drop characteristics, such as diameter, velocity and mass, affects soil detachment in the form of a power function.

As regards the effect of the other erosive parameters, many authors based their investigations of soil splash by raindrops on the kinetic energy of rainfall or of a single water drop. Poeson and Savat [13] found that, since a positive relationship exists between kinetic energy and amount of material splashed, this parameter can be used to assess the total amount of material detached by raindrop impact on a given surface. Meyer (1971) in Morgan [11] modelled splash detachment by rainfall and proposed that the rate of splash detachment (DET), without a plant cover, varies with the kinetic energy (KE) of the rainfall. The relationship can be expressed by the power function $DET = k\,(KE)^b$, where k is an experimentally-derived measure of the detachability of the soil and b ranges in value, from 0.8 for sandy soil to 1.4 for clayey soils, with a value of 1.0 being reasonably representative and mathematically convenient. The same relation was proposed by Poeson [14] with k and b as functions of material properties (b=1 for sandy sediment). In this case, k can be replaced by R^{-1}, R being a parameter describing the resistance of material to raindrop detachment. Other workers laid stress on kinetic energy, and considered it to be the basic issue, regarding the discovery of a correlation between kinetic energy and the erosive effect of raindrops as most important (Zachar, [20]).

For some workers, rainfall intensity remains the best predictor of

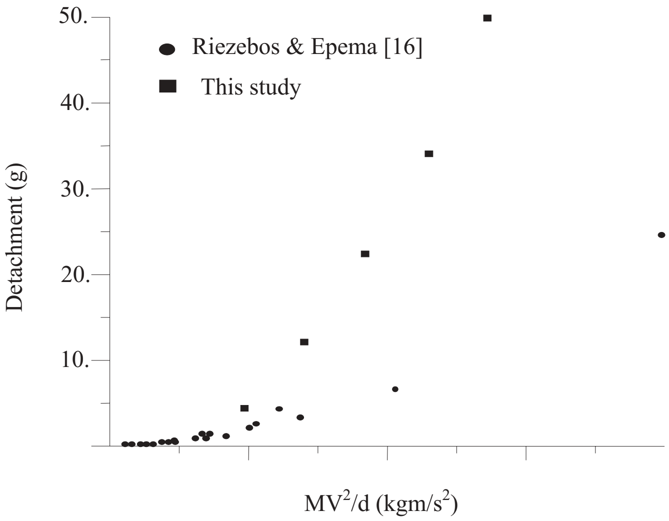

Fig. 2b. Relationship between detachment and erosivity parameter (replotted graph after Riezebos and Epema [16]).
Evolution de l'arrachement avec le paramètre d'érosivité. (Reproduction du graphe de Riezebos et Epema [16])

splash erosion. Kneal [9] reported that at low intensities there is little to chose between intensity, momentum or kinetic energy as 'predictors' of splash movement. This is not surprising as drop-size distribution exerts only a minor influence on energy and momentum, compared to total rainfall mass at low rainfall intensities. However, at high rainfall intensities, Wright [19] reported that particles, exposed to high rainfall intensities, travel further and in greater quantities than those exposed to moderate intensity. This difference occurs for two reasons. First, there are more raindrop impacts per second for the more intense rainfall. Secondly, the size distribution of the raindrops alters such that the more intense the rainfall the greater the proportion of large drops. Both of these effects serve to increase the amount of soil splashed and the distance over which it is carried.

Given the results of these findings, the soil detachment was plotted against kinetic energy of the drop in Figure 3. According to this figure, the total soil detachment increased with increasing kinetic energy in a power function form, but the increasing steepness in Figure 2 was more significant than in Figure 3. This difference could be related to the drop diameter involvement in the drop pressure equation. To clarify this point, correlation analysis was performed for four types of relations (linear, logarithmic, exponential and power function) and the determination coefficients are given in Table 1.

Generally, the relations were best described by a power function. Second best was the linear function; but, for the drop pressure, the coefficient of determination of the exponential function was the highest. The correlation analysis results, presented in Table 1, have shown that the introduction of the drop diameter, in calculating the erosivity parameter (drop pressure), did not produce a significant improvement of the relationship between erosivity and soil detachment. The same conclusion was found by Riezebos and Epema [16] investigating the relation between drop shape and erosivity.

From the distinctions between Figures 2a, 2b and 3, it can be concluded that the involvement of the drop diameter was steepening the curves which means that the drop diameter has an effect on soil splash. But, according to the correlation analysis, the drop diameter did not improve the coefficient of determination of the relation between drop pressure and soil detachment, except for the exponential function.

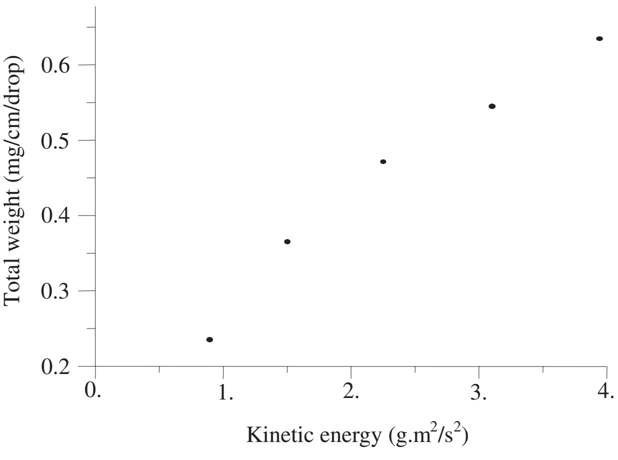

Fig. 3. Relationship between total weight and kinetic energy
Evolution de la masse totale avec l'énergie cinétique

Table 1. Coefficient of determination R^2 in (%) between erosivity parameters and splash detachment.
Coefficient de détermination R^2 en (%) entre les paramètres d'érosivité et la masse arrachée.

Erosivity parameters	Linear	Logarithmic	Exponential	Power
MV ($g.m.s^{-1}$)	99.2	91.9	94.2	99.8
KE ($g.m^2.s^{-2}$)	99.3	91.9	93.8	99.8
* P_e (Pa)	87.8	86.5	97.5	97.4

Pressure = $P_e.10^4$

MV, KE and P_e are momentum, kinetic energy and impact pressure of the drop.

The effects of the drop diameter on soil splash have been shown indirectly by some workers. Experiments, conducted by Bubenzer and Jones [3], showed that, for a constant kinetic energy, volume of splashed sediment is not influenced significantly by diameter or fall height of raindrops, except at low rainfall. Therefore, kinetic energy is chosen to express rainfall erosivity in the splash transport equation.

Al-Durrah and Bradford [1] showed high coefficients of determination ($R^2 = 0.88$ to 0.97) between splash weight and the ratio of raindrop kinetic energy and soil shear strength for nine soils.

Ellison [5] in his laboratory, combining drop diameter, terminal velocity and rainfall intensity, found the following relation between splash, drop diameter and velocity :

$$S = V^{4.33}\ d^{1.07}\ I^{0.43} \tag{4}$$

where S is splashed soil in 30 minutes (g), V the drop velocity ($ft.s^{-1}$), d the drop diameter (inch) and I the rainfall intensity ($inch.hr^{-1}$).

According to this equation, the exponent of the drop diameter is close to one whereas the exponent of the drop velocity is high, which means that the effect of the drop diameter is negligible in comparison to the effect of drop velocity.

In some cases, the exponent of the velocity is less significant in comparison to that of Ellison's equation. In Ghadiri and Payne [6], the results led to the conclusion that the erosive capacity of a raindrop is related to the product of its diameter and the square of its velocity, but that velocity still more significant in erosion than is diameter.

From all these findings, we pointed out that drop characteristics such as diameter, mass, velocity, drop shape, fall height, soil mass and surface characteristics, reacted in the same manner but with different degrees. Modelling all these parameters is needed to understand the splash process.

3.3 Splash distance distribution

The radial distribution of splash onto a horizontal surface divided in a wide range of splashed droplet sizes ejected from the point of impact. A wide range of splashed droplets sizes were found spread on the surface irrespective of the distance; this could be explained by the droplet concentrations. Droplets similar in size, with different particle concentrations, travel different distances. The total number of splashed droplets and the actual distance increased with initial drop size and velocity, but remained independent of target characteristics (saturated sand, various slopes, water films on fine sand and stationary and rotating sand paper, Ghadiri and Payne [7]).

The distribution of the splashed particles weight in the compartments was plotted in Figure 4. The splash process could be seen from another perspective. The distribution of the particles with distance, with different drop diameters, is plotted in Figure 5.

According to this graph, the distribution of the detached particles varied with the drop diameter in the same fashion. It was interesting to note that, regarding transport, the relation between the mass of soil particles and the distance moved was found to be exponential. The relation $M = a\,e^{-bx}$ was similar to that proposed by Savat and Poeson [17] and reported by Riezebos and Epema [16] and Wright [19]. The exponent b ranged between 0.0744 for the smallest drop (3.7mm diameter) and 0.0414 for the biggest drop (5.8mm diameter), while the constant a increased from 0.158 to 0.664. Coefficients of determination were high (Table 2). Riezebos and Epema [16], using different heights, found that the exponent b ranges between 0.10 for small heights (less than 1m) and 0.04 for a 13m fall height.

From these experimental curves, the same comment on the previous graph is repeated here; the weight of soil detached decreased sharply with distance and the drop erosivity has no effect on the soil splash for the greater distances.

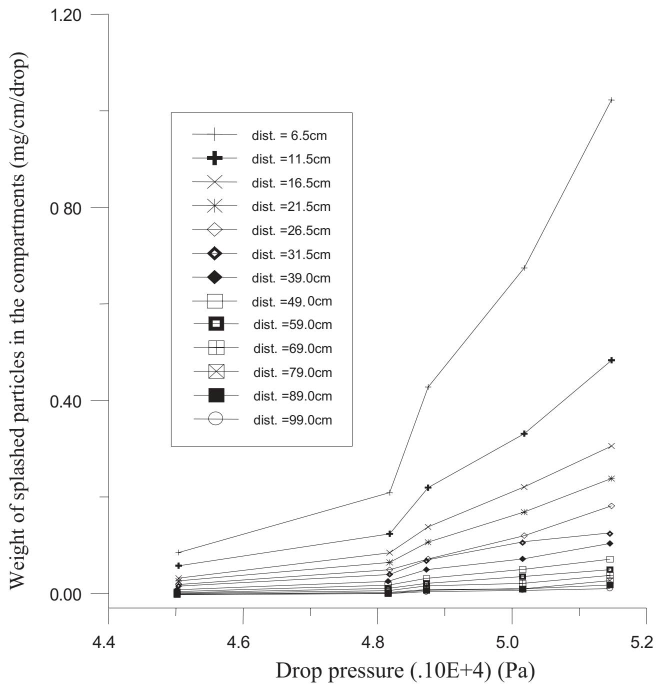

Fig. 4. Relationship between splash weight and drop pressure
Evolution de la masse arrachée avec la pression d'impact

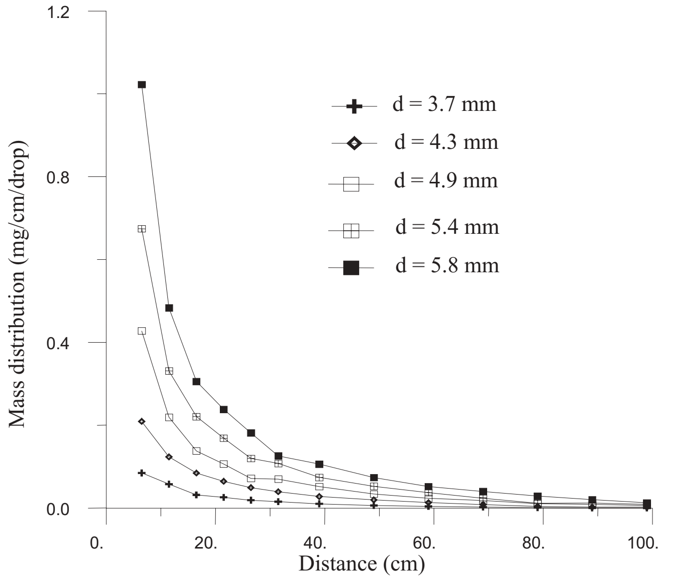

Fig. 5. Relationship between mass distribution of particles and distance for different drop diameters
Evolution de la distribution de la masse avec la distance pour différents diamètres de la goutte

Some authors have preferred to relate the splash distance to drop velocity and splash angle. In a horizontal plane, the splash distance x can be calculated using the following equation (De Ploey and Savat [4]):

$$x = v_0^2 \sin(2\theta)/g \tag{5}$$

where v_0 is velocity of projection, θ is splash angle and g is the gravity acceleration.

The calculation of ejected angles, from this equation, has shown that, on a horizontal surface, the boundary wall of the catching tray, which rises 30cm above the soil surface, is sufficient to catch all particles splashed at distances up to 45cm, and those splashed at greater distances with angles of ejection up to 31°. About 90% of the splashed soil particles fall within this range.

3.4 Mean splash distance

The coefficients of determination of the erosive parameters with mean splash distance are presented in Table 3 for four different variable transformations.

Considering these four forms of function, in general, the best are

Table 2. Equations and coefficients of determination of the mass distribution with different drop diameters.
Equations et coefficients de détermination de la distribution de la masse pour différents diamètres de la goutte.

Diameter (mm)	Equation	R^2
3.7	$M = 0.158\ e^{-0.0744x}$	94.0
4.3	$M = 0.214\ e^{-0.0490x}$	98.9
4.9	$M = 0.301\ e^{-0.0415x}$	96.5
5.4	$M = 0.481\ e^{-0.0427x}$	97.1
5.8	$M = 0.664\ e^{-0.0414x}$	95.7

M, x are the mass of the particles splashed into the compartment and the distance from the middle of the splash-cup to the middle of the compartment respectively.

provided by a power function followed by a logarithmic one. From the graph in Figure 6, the mean splash distance varied nearly in a parabolic form with increasing drop pressure. This variation from increasing to decreasing of the mean distance was clearly observed in the experimental data. It appears that the variation of the drop pressure did not progressively change the mean splash distance, even though it changed the total weight of splashed particles ($\sum_{i=1}^{i=13} m_i$) and the transport ($\sum_{i=1}^{i=13} m_i x_i$), but did not uniformly change the rate of these two factors which determined the mean splash distance. This contrast is also reflected in the low coefficients of determination cited in Table 3, and may be explained mathematically from the equation 3 and clarified graphically from figures 4 and 7. To obtain an increase in $\bar{x}$, $\sum_{i=1}^{i=13} m_i x_i$ should increase faster than $\sum_{i=1}^{i=13} m_i$, which it does not in our case, and vice versa to obtain a decrease in $\bar{x}$. In these experiments, from graphs 4 and 7, $\sum_{i=1}^{i=13} m_i$ and $\sum_{i=1}^{i=13} m_i x_i$ increased approximately at the same rate, and in the same manner, which meant that the rate of these factors was approximately constant. These are no comparable results from the literature review about the drop characteristics and mean splash distance.

Savat and Poeson [17], in (Part I), reported good results computed by the equation 3 in addition to the weighing method, using (100cm.20cm.6cm) trays filled with a 5cm thick sediment layer until the sediment surface was flush with the tray rim. Different grain sizes were used. Same authors [13] in (Part II) showed that mean weight projected splash distance in a horizontal plane was also a function of the median grain size of loose sediment, that is:

$$\bar{x} = 0.00192\,(D_{30})^{-0.218} \quad R = -0.964 \tag{6}$$

From this observation, it can be inferred that the particle size distribution will also influence splash distance. In this study, the sand used was a mix of particle sizes, so the grain sizes, at the surface, could change from run to run and affect the mean splash distance. Poeson and Torri [15] inferred that some surface properties, such as soil shear strength, particle size and thickness of a surface water film, also have a significant influence on mean splash distance.

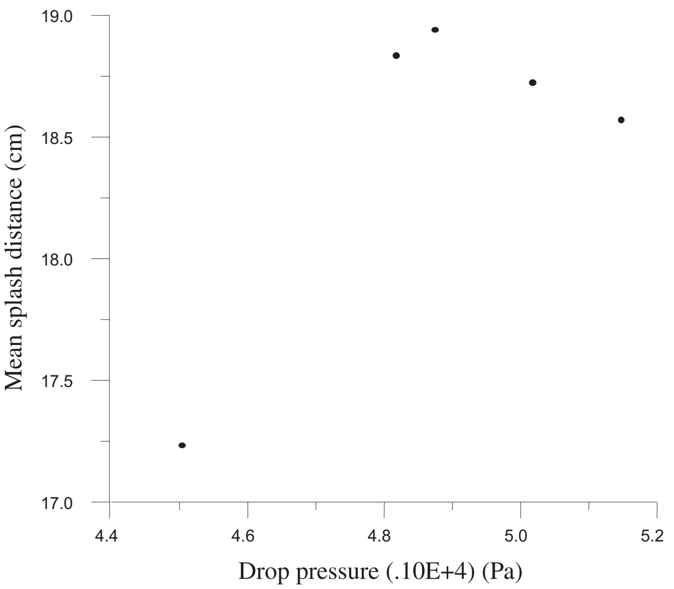

Fig. 6. Relationship between mean splash distance and drop pressure
Evolution de la distance moyenne d'éjection avec la pression d'impact de la goutte.

4. Conclusions

This study reached the following conclusions:

- The water drop energy is dissipated in two subprocesses: transport of particles from the soil surface and the contribution to the compaction of the soil surface by pushing fine particles into the soil pores.
- Two kinds of splash were observed: droplets with particles and single dry particles.
- Both big droplets and small droplets have landed in collection compartments adjacent to the point of impact.
- The cavity diameter was slightly larger than the diameter of the drop and enlarged as the velocity of the drop increased. In addition, the surface roughness increased with increasing drop diameter.
- Total soil splash increased sharply with increasing drop pressure in a power function form, e.g. in general, the drop characteristics, such as diameter, velocity and mass, affect soil detachment in the form of a power function.

Table 3. Coefficients of determination (%) between erosivity parameters and mean splash distance.
Coefficients de détermination (%) entre les paramètres d'érosivité et la distance moyenne d'éjection.

Erosivity parameters	Linear	Logarithmic	Exponential	Power
D (mm)	39.5	45.6	40.1	46.2
KE ($g.m^2.s^{-2}$)	27.7	46.6	28.3	47.3
*P_e (Pa)	54.5	56.6	55.2	57.4

**Pressure = $P_e.10^4$*

D, KE and P_e are diameter, kinetic energy and impact pressure of the drop respectively.

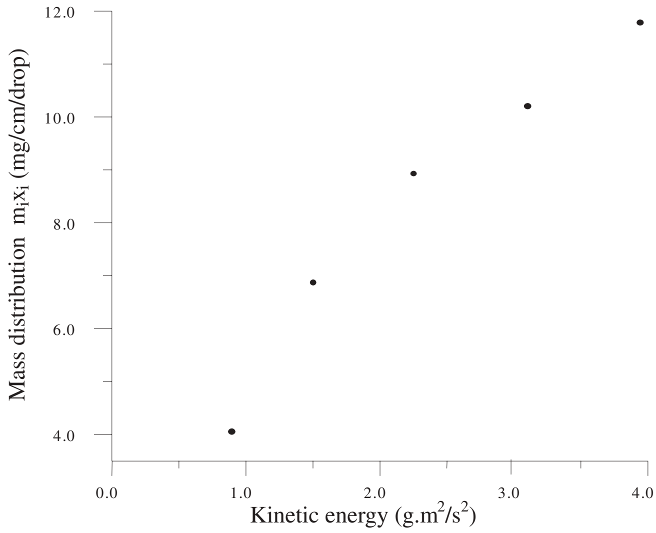

Fig. 7. Relationship between mass distribution and kinetic energy
Evolution de la distribution de la masse avec l'énergie cinétique.

- The involvement of the drop diameter steepened the curves representing the relationship between soil splash and drop pressure, which means that the drop diameter has an effect on soil splash. But, according to the correlation analysis, the diameter did not improve the coefficient of determination of the relation between drop pressure and soil detachment, except for the exponential function.
- In the compartments close to the splash cup (first and second), the increase in particle weight, with drop pressure, is a power function, whereas, in the other compartments, the increase in splash detachment was linear with the drop pressure and the slope of the lines decreased slowly from the third to the most distant compartment.
- The relationship between the mass and soil particles and the distance moved was found to be exponential. The exponent ‘b’ ranged between 0.0744, for the smallest drop (3.7mm), and 0.0414 for the biggest drop (5.8mm), while the constant ‘a’ increased from 0.158 to 0.664 with a high coefficients of determination.
- The best fit relationship between mean splash distance and drop pressure is provided by a power function. In addition, the variation of drop pressure did not progressively change the mean splash distance, even though it changed the total weight of splashed particles. This contrast is also reflected in the low coefficients of determination for this relationship.

Notations

F	Drop force
V	Terminal drop velocity
d	Drop diameter
P_e	Drop pressure
M_{app}	Apparent mass of the drop
M	Mass of the drop collected immediately after sampling
$d_{eq.}$	Equivalent diameter
ρ_w	Water density
ρ_a	Air density
x_i	Distance from the middle of the cup to the middle of the compartment
m_i	Weight of the particles in the compartment i
$\bar{x}$	Mean weighted splash distance
MV	Momentum
KE	Kinetic energy

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