SIMULATING RAINFALL TO MEASURE THE EFFECT OF THREE CULTIVATION METHODS ON PESTICIDE RUN-OFF

CAMBRIDGE ENVIRONMENTAL ASSESSMENTS

B Surfraz[1], G Woodward[1], N Brettell[1], L Fogg[1#], T Pepper[1], P Dalkmann[2] and S Mayer[2]
[1] CEA, RSK ADAS Ltd, Meden Vale, Mansfield NG20 9PD, UK; #Corresponding author: Lindsay.Fogg@cea-res.co.uk
[2] Bayer AG, Research & Development, Crop Science, 40789 Monheim, Germany

Introduction

It is important to reduce pesticide run-off and soil erosion from cultivated fields to protect the environment. Pesticides that make their way into water courses following heavy rainfall can be toxic to flora and fauna, and soils that are eroded provide fewer nutrients for the following year's crop.

Raindrop size and velocity are known parameters that affect run-off and soil erosion. When simulating rainfall it is therefore important to use equipment that produces a droplet spectrum close to that of natural rainfall. In addition, different tillage methods can affect the amount of run-off and hence potential for pesticides to enter surface watercourse.

In order to assess the influence of different cultivation practices used in establishing row crops on the rate of surface run-off (water and sediment) and loss of the pesticide active substances, irrigation equipment was developed and trialled for suitability.

Three tillage methods for row crops establishment

Conventional ploughing [1]

- Considered most intensive
- Multiple passes in field
- Buries crop residue in soil

Min-till[1]

- Single cultivation pass
- Disturbs soil no more than 5 - 10 cm deep
- Incorporates crop residues

Strip-till drilling[1]

- 1/3 field area disturbed or cultivated
- Grass allowed to grow between cropping cycles
- Grass then sprayed off immediately after drilling

Field work set up

An overhead irrigation rig, consisting of multiple wheel mounted gantries, was developed to simulate storm events over the test plots. During pre-testing, 12 nozzles which were adjusted to 15 PSI (1 bar) pressure were located on each gantry span, at a height of 2.7 m above ground level to provide optimum plot coverage. A tipping bucket and automatic water sampler were used to quantify runoff and collect samples. A data-logger was used to capture data.

Nozzle

Automatic water sampler

Tipping bucket

Rig set up on the plot (left) and rainfall simulation in progress (right)

Flour box method for determining droplet size distribution

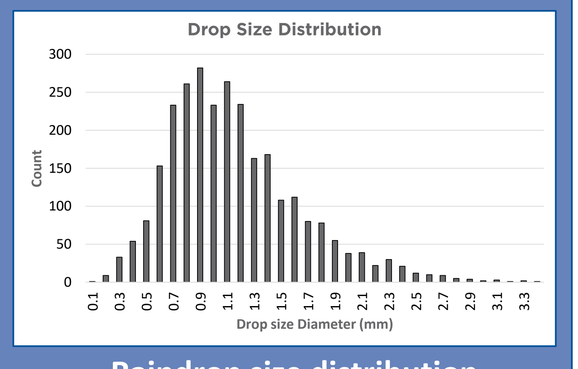
Baking trays of flour with covers were placed in 6 different positions on the 5 x 11 m plot. During simulated rainfall the covers were lifted from each tray for 1 sec before being replaced. After the rainfall event, the covers were removed and photographs were taken of the raindrop impressions in each tray and then digitally processed. The diameter of each impression was measured and documented. Finally, the equations[2] below were used to determine the raindrop velocity from the raindrop diameter.

Tray with raindrop marks

$$m = \frac{4 * 3.14 * r^3 * d}{3} * 10^{-6} \qquad b_s = \frac{1}{2} p_a C_d A$$

$$Vt = \sqrt{\frac{mg}{b_s}} tanh \sqrt{\frac{b_s g}{m}} t$$

m = mass (kg)
r = radius (mm)
d = density
p_a = air density (1.225 kg/m^3)
C_d = air drag constant (0.47)
A = area of raindrop (πr^2)
g = gravity (9.8m/s^2)
t = time (s)

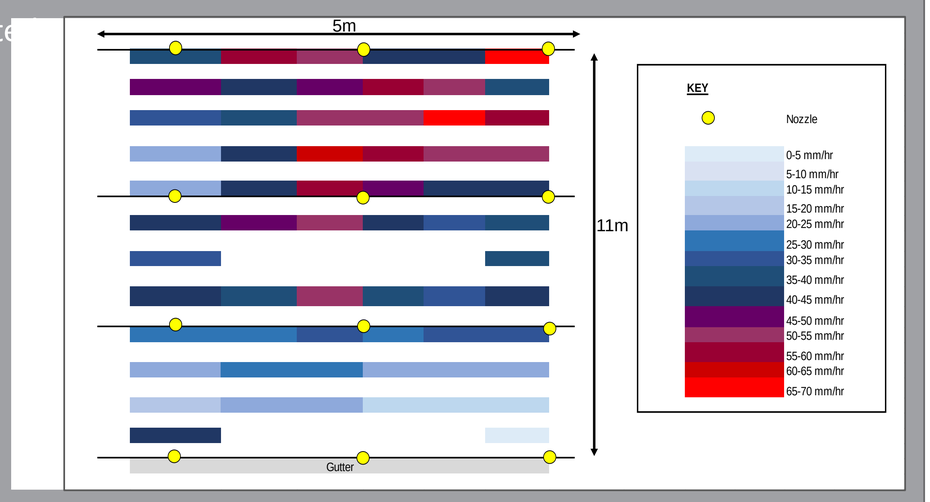


Raindrop size distribution

The average raindrop diameter was 1.19 mm, giving a velocity of 5.2 m/s. The smallest and largest velocities are 1.78 m/s and 8.7 m/s for the smallest and largest raindrops, respectively.

Rainfall Intensity distribution

- The rainfall gantries were located along the length of the plot at 0 m, 3.5 m, 7 m, and 11 m.
- Rainfall collection jars were placed on the plot in a 6 m x 11 m grid with 1 m between each jar.
- The water collected from each jar was measured and converted into rainfall intensity (mm/hr)



Plot rainfall distribution

Conclusions

- The average rainfall intensity from the rig (38.5 mm/hr) is above that of a worst case scenario (e.g. 25 mm/hr for a heavy thunderstorm) that would cause the most runoff.
- South-westerly winds of 4.5 to 5.4 m/s affected the pattern of the distribution, leading to an underestimation of the rainfall intensity on the bottom half of the plot. Therefore little/no wind or steps to minimise the effect of wind is necessary to carry out this study.
- Raindrop sizes are smaller compared to those of natural rainfall of similar intensity in one study[3] (diameter is typically >= 2mm). This can be due to less falling time reducing the opportunities for raindrops to merge. Further optimization of the rig may help increase average raindrop size.
- As the rainfall intensity from the rig was higher than a heavy thunderstorm this likely offsets the impact of smaller droplets.

References:

1. Web images: i) Conventional ploughing (https://www.clarkemachinery.ie/products/ab-and-ad-mounted-conventional-ploughs/), ii) Min-till (https://www.agriland.ie/farming-news/watch-putting-min-till-systems-to-the-test-in-co-carlow/) and iii) Strip-till (https://www.farmmanagement.pro/common-strip-till-mistakes-and-how-to-avoid-them/)
2. Mhaske et al.; 2019; A comprehensive design of rainfall simulator for the assessment of soil erosion in the laboratory, *Catena*, 172, pp408-420
3. Yakubu et al.; 2016; The influence of rain intensity on raindrop diameter and the kinetics of tropical rainfall: case study of Skudai, Malaysia, *Hydrological Sciences Journal,* 61, pp944-951