CHARACTERISING EFFECTS OF SURFACE RESIDUES ON EVAPORATION FOR A SIMPLE WATER BALANCE MODEL

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INTRODUCTION

In Brazil the area with direct seeding mulch based cropping (DMC) systems increased from 1 million ha in 1990 to 12 million in 2000 (Figure 1). Initially, DMC adoption spread most rapidly in the southern states of Brazil. Over the last 5 years the highest adoption rate has, however, been observed in the tropical Cerrados region, where now over 4 million ha are cultivated using DMC systems (Saturnino, 2000). The effectiveness of DMC systems to protect soil depends in that region on the introduction of a second crop enabling to cover the soil throughout the year. The ability to grow a succeeding cover crop in the region in terms of water availability can be assessed using crop growth models. However, models that aim to evaluate cropping systems under DMC require a quantitative description of the effects of surface crop residues on the soil water balance.

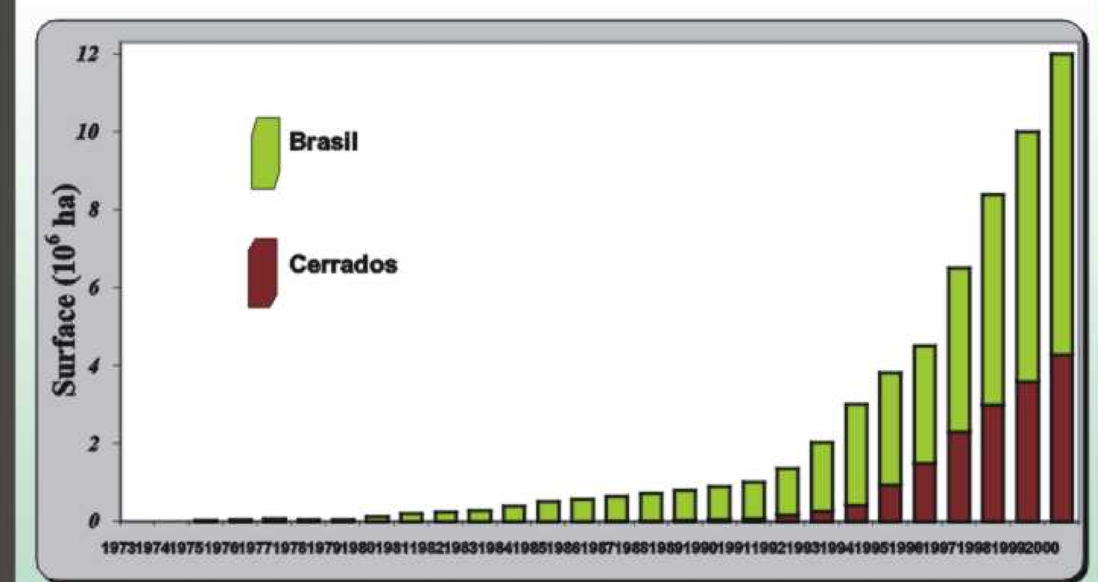

Figure 1. Evolution of the area under DMC in Brasil and Cerrado.

OBJECTIVE

The objective of this study is to quantitatively describe the effects of soybean, maize and millet surface residues on evaporation in forms that can be used in existing simple simulation models of soil water.

MATERIAL E METHODS

We conducted 3 experiments (each time with 4 replicates) using residues from soybean, maize and millet:

Experiment 1

Aim: to assess the capacity of the residues to store intercepted rainfall. Different amounts of each residue type were submerged in water for 15 hrs, and after that allowed to drain excess water by gravity for 2 hours, before weighing wet. The residues were then oven dried (70°C, 72hrs) and weighed dry to determine their water content.

Experiment 2

Aim: to assess radiation PAR and IR interception by a mulch of crop residues. For each residue type different amounts were randomly distributed on a 0.75 m^2 glass plate. The flux measurements were made over 30 sec intervals above and below the mulch of crop residues located on the plate using a Picqkhélios® radiometer (Figure 2).

Experiment 3

Aim: to assess evaporation from surface crop residues under field conditions. Different amounts of water saturated residues of each type were randomly distributed on 0.25 m^2 square meshes placed on bare soil (Figure 3), which had been wetted to field capacity. Water loss from the residues was recorded during 8 hours (from 8 am to 4 pm) of drying in the field by weighing the meshes with residues at hourly time intervals.

Figure 2. Picqkhélios radiometer.

Figure 3. Evaporation experiment.

RESULTS AND DISCUSSION

Experiment. 1

Water storage capacity of residues

The maximum amount of water retained by the residues was for each type proportional to the mass of residues (Figura 4). The specific water storage capacity factor was comparable for maize and millet (respectively 3.24 and 3.26 g H^2O g^{-1} residue dry weight), but lower for soybean residues (2.62 g g^{-1}). The results indicate that the amount of rainfall that can be intercepted by surface residues is fairly small, even for high quantities of residues left on the soil surface.

Experiment. 2

Radiation interception by surface residues

Radiation interception by a layer of residues varies exponentially with residue mass and the extinction coefficient depends on residue type (Figura 5). The results suggest that a mulch of maize crop residues causes higher radiation interception than a mulch of millet or soybean crop residues.

Experiment. 3

Evaporation from surface residues

Figure 6 shows as an example evaporation losses from different amounts of millet crop residues plotted against ETp. They illustrate that evaporation from residues occurs largely at rates that are higher or equal to ETp, suggesting that it is mainly an energy driven process. Our results also indicate that evaporation slows down and is lower then ETp once the residue moisture content drops below about 30%. This is probably due to resistance effects on water flows in the residue mulch.

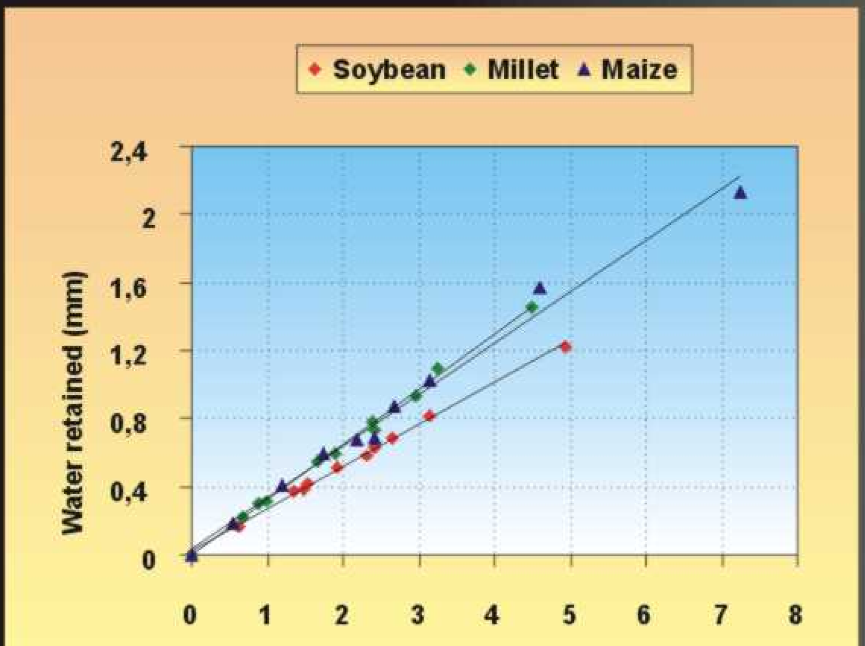

Figure 4. The maximum amount of water retained by the residues was for each type proportional to the mass of soybean, millet and maize residues.

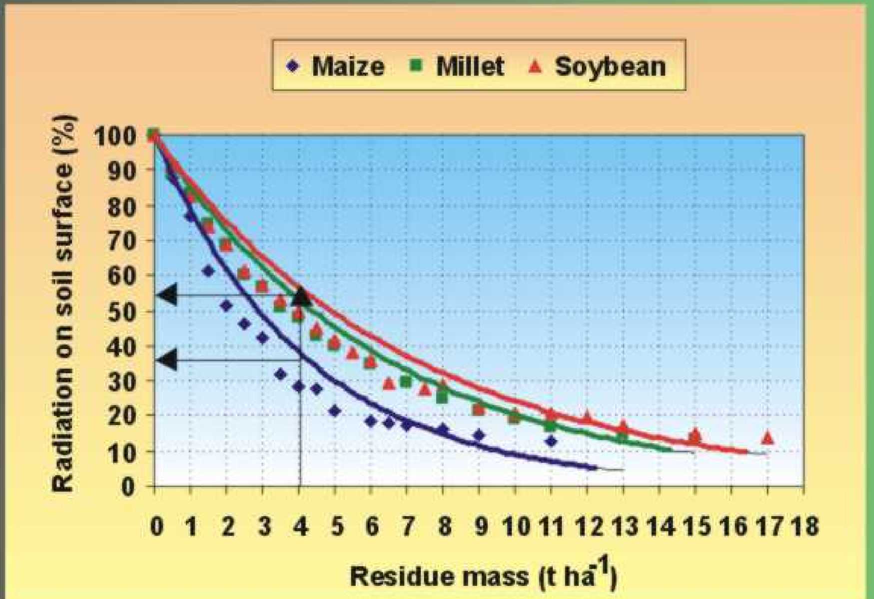

Figure 5. Radiation interception by surface residues as function of residue mass

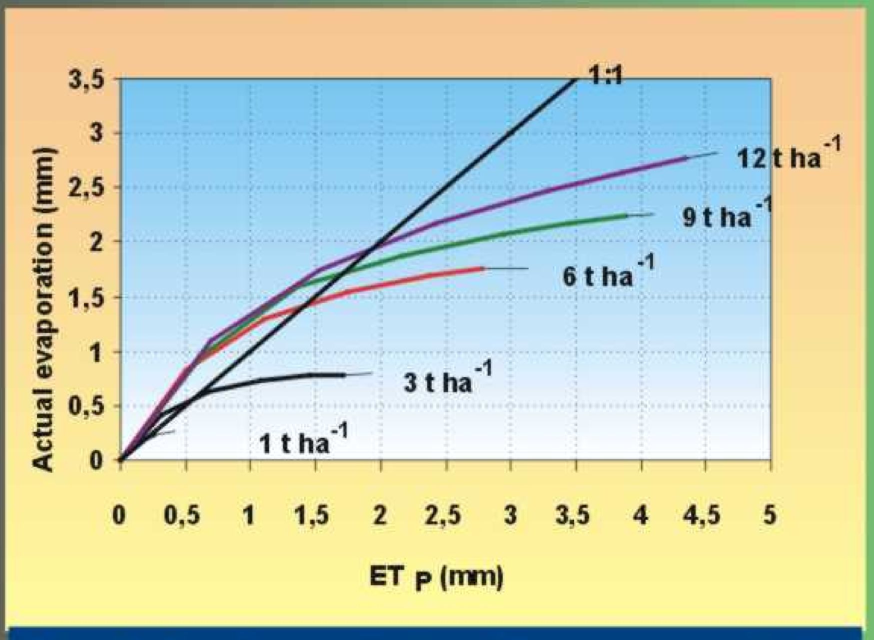

Figure 6. Actual evaporation from different amounts of millet residue as function of reference Penman evaporation.

CONCLUSIONS

- The residues have a relatively small capacity to store intercepted rainfall, but given the rapid evaporation they may cause quite significant evaporation losses during wet years.
- The major effect of crop residue mulching on soil evaporation is, however, through interception of radiation, reducing the energy available for evaporation of soil water.
- Residues from maize are accordingly more efficient than those from soybean or millet.
- These crop residue effects on water dynamics can be described in simple mathematical formalisms that easily can be included in existing soil water balance models.

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