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Impact of crop residues on soil water evaporation in weighing lysimeters

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Zusammenfassung

Verdunstung ist eine signifikante Form des Wasserverlustes von abgeernteten Äckern. Pflanzenreste können als Mulch die Bodenfeuchte schützen indem sie den Boden bedecken und dadurch die Verdunstung reduzieren. Wir untersuchten den Effekt vom Stroh des Winterweizens (*Triticum aestivum* L.) auf die Verdunstung und das Auflaufen von Unkräutern. Fünf präzisionswiegende Lysimeter wurden an der NAIK ÖVKI Lysimeter-Station (Szarvas, Ungarn) verwendet. Wir haben Wasserspeicherung in verschiedenen Menge ausgebrachten Weizenstrohs (0.41 kg*m^{-2}, 0.63 kg*m^{-2}, 0.84 kg*m^{-2}) gemessen. Unsere Ergebnisse zeigten, dass Ernterückstände die Verdunstung aus dem Boden um 62.12-81.92% reduzieren können, im Vergleich zur ET von unbedeckten Stoppelfeldern nach der Ernte. Die Ergebnisse liefern ergänzende Informationen zu den Resultaten der Kollegen des Forschungsinstituts Karcag, in denen die Wirkung verschiedener Bodenoberflächenformationen und -bedeckungen auf die Wasserbalance des Bodens untersucht wurden.

Schlagwörter: präzisionswiegende Lysimeter, Evapotranspiration, Ernterückstände, Mulch, Winterweizen

Summary

Evaporation is a major form of water loss from agricultural soils after harvest. Crop residues as mulches can protect soil moisture by covering soil surface and thus reducing evaporation. We studied the effect of winter wheat (*Triticum aestivum* L.) straw on the soil water evaporation and on the emergence of weed plants. Five precision weighing lysimeters were used at the NAIK ÖVKI Lysimeter Station Szarvas, Hungary. We have measured retention of water by the winter wheat residue after the application of 0.41 kg*m^{-2}, 0.63 kg*m^{-2} and 0.84 kg*m^{-2} wheat straw, respectively. Our results demonstrated that crop residues can reduce the evaporation from soil to 62.12-81.92% compared to the ET of bare field of stubble. These results provide complementary information to those gained by the colleagues at the Research Institute of Karcag where the effect of different soil surface formations and coverings on the water balance of the soil was determined.

Keywords: weighing lysimeters, evapotranspiration, crop residue, mulch, winter wheat

Introduction

Evaporation is a major form of water loss from agricultural soils after harvest. According to Knoblauch (2019) rape and winter wheat fields after the harvest are able to evaporate as much water, as much precipitation is characteristic in that period. Crop residues as mulches can protect soil moisture by covering soil surface and thus reducing evaporation (Klocke et al. 2009). Another positive effect of soil covering is the suppression of weed

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germination and emergence, which leads to a reduced water loss through the reduced transpiration of weedy plant populations. The daily evaporation of straw covered stubble can be reduced 0.4 mm/day compared to the non-covered and untreated field (Knoblauch 2019). But without precipitation, the effect of wheat straw or any mulch material on evaporation is small during long drought periods (Wuest 2019).

The water preserver effect of natural materials (wheat straw, sorghum or corn stem by-products, grass clippings, and leaf debris etc.) or artificial materials (paper, plastic film etc.) are used in a horticultural cultivation for a long time (Ranjan et al. 2017). McMillen (2013) tested the effect of mulch type (wheat straw, grass clippings and leaf debris) and thickness (5, 10, 15 cm) on the soil surface evaporation rate, where the evaporation was reduced even with the 5 cm mulch as 40%. However, there was no significant difference between the materials used as mulch. Among artificial materials, plastic mulch cover is widely used and according to Qin et al. (2018) the evaporation is only 4.04-7.07% compared to E value of a bare soil surface in a corn field.

The soil moisture saved after the harvest by surface covering will be more and more important in the crop production because the tillage process can be more cost-efficient, we can protect the soil structure and soil life for the preparation of optimal seed beds. Based on that, mulching suppress the evaporation losses and improves the water use efficiency and land productivity in wheat and rice growing systems (Batt és Kukal 2017). In our study, the effect of winter wheat (*Triticum aestivum* L.) straw on the evaporation was measured in large weighing lysimeters.

Material and methods

Our experiment was conducted to study the effect of winter wheat (*Triticum aestivum* L.) residues on the soil water evaporation and on the emergence of weed plants in two consecutive years. Five precision weighing lysimeters were used at the NAIK ÖVKI Lysimeter Station (46°51‘44.7“N 20°31‘35.5“E, 81 m elevation above sea level), Szarvas, Hungary (Jancsó et al. 2019). Lysimeters of 2.7 m^2 surface and 1.2 m depth were applied. The soil type of the experiment was clay loam. During the trial periods, the average temperatures were 23.1 °C and 23.7 °C, while the total precipitation were 66.5 mm and 54.4 mm between 17.07-17.08.2019 and 19.07-20.08.2020, respectively. In 2019, crop residues were applied as 100% (0.78 $kg*m^{-2}$) of the harvested wheat straw for all the lysimeters. In 2020, four different treatments were set on the stubble as Ø control, 0.41 $kg*m^{-2}$, 0.63 $kg*m^{-2}$ and 0.84 $kg*m^{-2}$. Additionally, we maintained a lysimeter with bare soil surface in both years.

Results

In the first year, cumulative soil water evaporation was measured as 46.0±2.25 mm at the end of the experimental period. The average daily evaporation was 1.44 mm. This was 55.8% of the evaporation measured for the bare soil surface. In 2020, highest cumulative evaporation and evapotranspiration (104.0 mm) were calculated in the control lysimeter (*Figure 1*). After the harvest on 6th of July, first weeds were observed without the covering in the fifth day of the trial period. In case of thinnest mulching, weed emergence was started after 30th of July and cumulative evapotranspiration was measured as 85.2 mm. With the application of 0.63 $kg*m^{-2}$ wheat residues, the evapotranspiration remained 73.1 mm and the weeds started to develop after 10th of August. In the second year, the smallest evaporation was measured as 64.6 mm for the 0.84 $kg*m^{-2}$ mulch treatment. In that lysimeter, there was not found any weeds. The daily average values of evapotranspiration were 3.15 mm, 2.58 mm, 2.22 mm and 1.96 as a result of control, 0.41 $kg*m^{-2}$, 0.63 $kg*m^{-2}$ and 0.84 $kg*m^{-2}$ treatments, respectively.

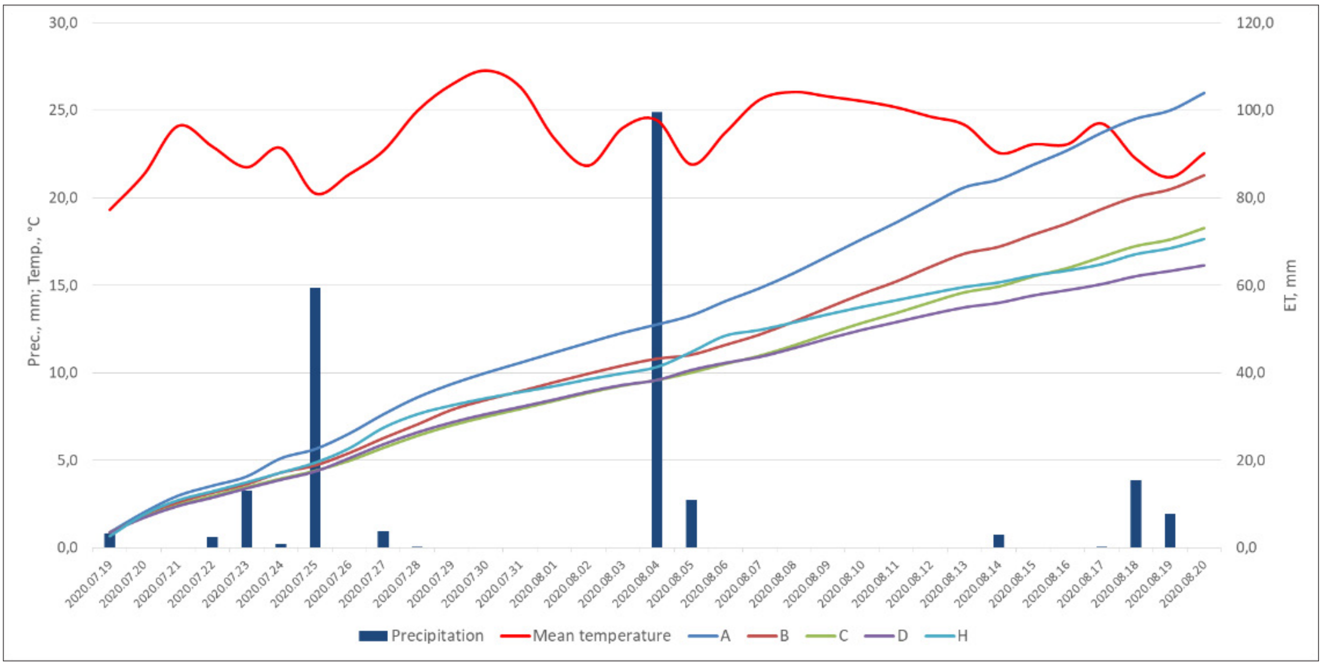

Figure 1. Cumulative soil water evaporation and evapotranspiration measured in lysimeters covered with Ø (A), 0.41 kg*m^{-2} (B), 0.63 kg*m^{-2} (C) and 0.84 kg*m^{-2} (D) of wheat straw after the harvest. Cumulative evaporation of bare soil surface (H), precipitation and daily mean temperature during the experimental period in 2020.

Discussion

We have found the same effects as Klocke et al. (2009), crop residues as mulches can significantly reduce evaporation. Moreover, weed suppression improve the positive effect of mulches on soil moisture conservation. In case of 0.84 kg*m^{-2} treatment, we have measured the evaporation as 62.12% of the uncovered stubble. Even the smallest mulch layer (0.41 kg*m^{-2}) had positive effects on water retention, what was further improved by 24.19% with the application of two-times higher amount of crop residues (0.84 kg*m^{-2}). According to Knoblauch (2019) the daily evaporation of straw covered stubble can be reduced by 0.4 mm/day compared to the uncovered field. In our experiment, daily average values of evapotranspiration were reduced by 0.57 mm, 0.93 mm and 1.19 mm, respectively.

Conclusion

Crop residues can be applied as natural mulches in order to protect the soil moisture via reduction of evaporation. Moreover, different amount of crop residues have different effect on the weed emergence on the field. In our experiment, with the application of 0.84 kg*m^{-2} wheat straw, weeds were completely supressed during the investigated period. With the application of the wheat residues as mulching, evaporation and evapotranspiration was decreased by 62.12-81.92% compared to the bare soil of stubble. These results provide complementary information to those gained by the colleagues at the Research Institute of Karcag where the effect of different soil surface formations and coverings on the water balance of the soil was determined by means of similar weighing lysimeters. Improving management of crop residues after harvest can help us to save more water in the soil and improve soil properties and thus biological activities.

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