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Water use efficiency of sorghum and maize treated with PENTAKEEP-V

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Summary

In weighable lysimeters the effect of Pentakeep-V on the water balance of sorghum and maize is tested combined with an irrigation experiment. Pentakeep-V is a special foliar fertilizer containing the precursor of chlorophyll synthesis, namely 5-aminolevulin acid (5-ALA). As the effect of PV on water balance of the soil is not known, therefore an experiment was set up in 2007 to determine the evapotranspiration of three sorghum hybrids and continued in 2008 with a comparison test of maize and sorghum. The considerable effect of both treatments could be quantified by means of the precision weighing lysimeter devices. We found differences in the amount of evapotranspiration and increase in yield and sugar content due to the treatments. By means of different indexes we calculated, water use efficiencies were compared. As we found a new probable effect of Pentakeep-V, we think it accelerates ripening, further studies are needed to get more detailed information in this respect.

Keywords: water balance, weighable lysimeters, foliar fertilisation

Introduction

Experiments in weighable lysimeters have being carried out for 16 years in the Karcag Research Institute of University of Debrecen, Centre for Agricultural Sciences and Engineering mainly focussing on the determination of the elements of the soil water balance influenced by various soil cultivation methods. In 2008 a complex experiment including irrigation and foliar fertilisation was set.

PENTAKEEP-V (PV) is a nitrogen liquid fertiliser that is blended with 5-aminolevulinic acid (or ALA), which promotes plant photosynthesis. ALA is an important amino acid in the bodies of plants and animals, a substance that is a precursor to chlorophyll in plants. PENTAKEEP-V has been confirmed that conventional fertiliser and ALA have synergy effects for plant growth. By using PENTAKEEP-V, photosynthesis is flourished, and water and fertiliser uptake are increased. Several results are published about the positive effect of this fertiliser, but mainly vegetables, fruits (BINDU ROY-VIVEKANANDAN 1998, YOSHIDA et al. 2003) or trees were tested so far (DRAZIC-MIHAILOVIC 1998).

Complex effect of several processes can be expected when a foliar fertiliser is applied, hence the resultant is not always obvious from the point of view of the water uptake of the crop. Precise measurements are needed to determine the changes in the water balance due to liquid fertilisation. For that purpose weighable lysimeters are very good tools as our investigations proved so far (ZSEMBELI 2003, 2006).

Material and Methods

The experiment aiming the investigation of the water use of maize and sorghum was set on 8th May, 2008 at the lysimeter station of the Karcag Research Institute of University of Debrecen CASE in 6 weighable lysimeters of 2 m² surface area each. The treatments of the experiment are listed in *Table 1*.

Sweet sorghum (*Sucrosorgo*) and sweet corn (*Aranymazsola*) in 3-3 lysimeters were sawn as indicator crops on 8th May, 2008. The proper spacing among the plants was set after the germination. Parallel to the sowing, TTN-M type probes were inserted into the soil in order to measure the soil moisture content and temperature.

The first PV application was one week before blooming, as PV was expected to have positive effect on the development of the panicles. The sugar content was intended to be increased by applying further treatments during sugar accumulation of sorghum. Under field conditions the latter applications are highly limited, but under lysimeter circumstances the foliar spraying could be carried out. 0.1256 ml Pentakeep-V / lysimeter solved in 1.57 l water was sprayed, which is the equivalent of the standard dose of 400 ml PV/ha in 5 000 l/ha water. The first application was on 25th June 2008 and then three further treatments were applied biweekly. The PV treatment was managed by manual spraying in the early morning hours.

In an average year irrigation in droughty summer periods is necessary to fulfil the water demand of the crops. All the 4 irrigated lysimeter units got the same amount of input water (natural precipitation + irrigation water) during the

Table 1: **The treatments of the experiment**

Lysimeter unit	Indicator crop	Treatment
SL 1	Sweet sorghum	Control
SL 2	Sweet sorghum	Irrigated
SL 3	Sweet sorghum	Irrigated + PV application
SL 4	Maize	Control
SL 5	Maize	Irrigated
SL 6	Maize	Irrigated + PV application

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Table 2: **The amount of input water in the lysimeters (mm)**

Water source	SL 1	SL 2	SL 3	SL 4	SL 5	SL 6
Irrigation (mm/m²):	30	75	75	30	75	75
Rainfall (mm)	280.9	280.9	280.9	280.9	280.9	280.9
Total input (mm)	310.9	355.9	355.9	310.9	355.9	355.9

investigated period (May-August). Even the control version was irrigated by the middle of June as the germination and the beginning phase of the development of the crops must have been helped by irrigation. Irrigation was started on 30th May, 2008 and implemented in smaller doses when no natural precipitation fell. The total amount of natural rainfall was 280.9 mm during the investigated period (May-August). *Table 2* summarises the water inputs for the lysimeter units.

According to the principle of weighing lysimetry the components of the water balance of each lysimeter unit are measured while the evapotranspiration (ET) is calculated. The water equation valid for the lysimeters is as follows:

$$ET = P + I - D - \Delta W$$

where ET: evapotranspiration (mm), P: natural precipitation (mm), I: irrigation water (mm), D: drainage water (mm), ΔW: change of mass = water balance (mm).

Results

In *Figure 1* the evapotranspiration values during the investigated period (from the first PV-treatment till harvest) are shown. The difference between the evapotranspiration of the irrigated and non-irrigated crops is obvious, while lower evapotranspiration was detected in the case of the PV-treated sorghum compared to the purely irrigated one. No significant difference was found between the two irrigated lysimeters with maize.

Two different yield parameters were also measured. In the case of the sweet sorghum hybrid, the sugar content was measured by refractometry, while in the case of maize, as the variety was a sweet corn variety, thee corn+cob weight was the main yield parameter. The yield results of the experiment are shown in *Figure 2,3*.

In order to get information on the water use efficiency of the investigated crops different indexes were calculated from the yield data and the different components of the water balance. These indexes are summarised in *Table 3*.

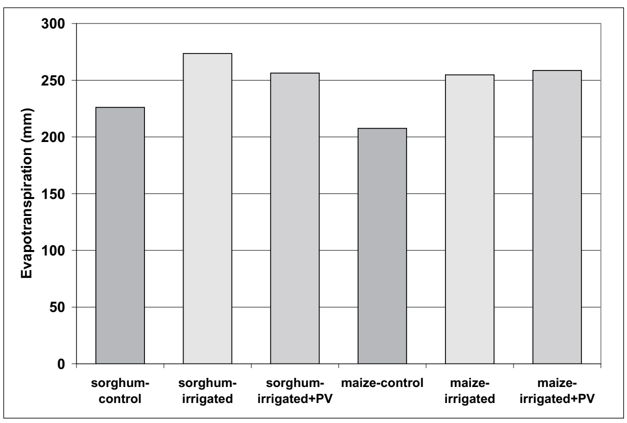

Figure 1: **Evapotranspiration from the lysimeters after the PV-treatment (18th June-12th August)**

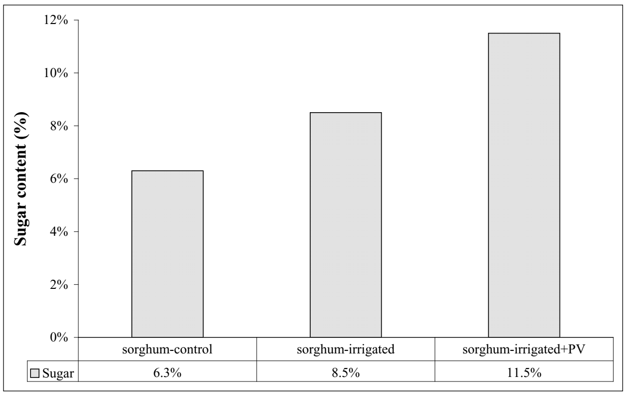

Figure 2: **Sugar content of sorghum in the lysimeter experiment**

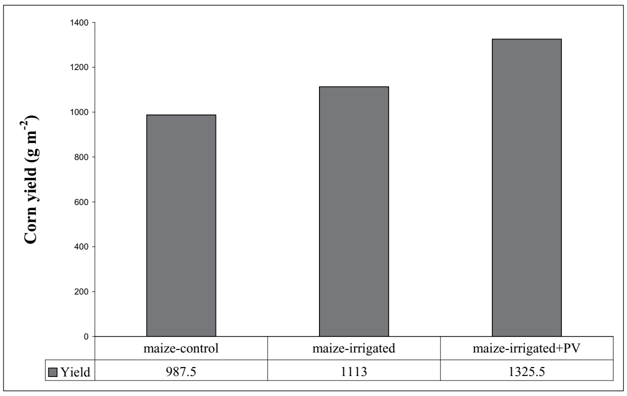

Figure 3: **The yield of maize in the lysimeter experiment**

Discussion

Although the absolute values of evapotranspiration were higher, the water use efficiency (*ET/water input*) of sorghum was found better when irrigation was applied (*Table 3*). These values also show the negativity of the water balance for each treatment. We could not figure out significant effect of Pentakeep-V on the water use efficiency, neither in the case of sorghum, nor of maize, probably due to the fact that the water inputs of the treatments were not so different due to the quite high amount of the natural rainfall. Nevertheless we have to add that a previous PV-treatment experiment with 3 sorghum hybrids under drier circumstances showed different results (ZSEMBELI et al. 2008).

On the base of the yield data (*Figure 2,3*), it can be concluded that both irrigation and PV-treatment resulted in higher sugar content of sorghum. The sugar content of the PV-treated crop was almost double of the non-treated one. Maize also repaid for irrigation (12.7% extra yield compared to the control) and even more for the PV-treatment: 34% higher yield than the control and 19% higher than the purely irrigated versions had.

The *evapotranspiration/sugar* content index shows us how much water was used by sorghum to generate sugar content of 1 per cent. According to the relevant values of this index (*Table 3*) much less water is needed to build up the same

Table 3: **Water use efficiency indexes calculated for the lysimeter experiment**

Index	Sorghum Control	Sorghum Irrigated + PV	Sorghum Irrigated	Maize Control	Maize Irrigated	Maize Irrigated + PV
ET/water input (%)	113	105	104	105	103	106
ET/ sugar content (mm/%)	55.5	43.9	32.1	-	-	-
ET/corn yield (mm kg^{-1})	-	-	-	329.7	329.6	283.4

amount sugar in the plant if PV is applied. Unfortunately we could not taken the total sugar content into account as no total dry biomass weight was measured. Nevertheless another, not measured experiences can be reported: earlier drying, hence earlier ripening of sorghum was found in the case of the PV-treated variant, which was very visible directly before the harvest on 12th August, 2008. The earlier drying of the crop was obviously detected in the green biomass weights: the weight of the biomass of the irrigated+PV-treated sorghum was only 70% of the irrigated plants.

The *evapotranspiration/corn yield* index (*Table 3*) determined for the maize gives an idea about the amount of water consumed by the maize plants to generate 1 kilogram of corn yield. Though irrigation resulted in extra yield, the water use efficiency in this respect was not better than of the control plants, while the PV-treated maize plants needed approximately 16% less water to build up 1 kg of corn compared to the other two treatments.

On the base of the results introduced above we can conclude that new information was gained concerning the effect of Pentakeep-V on the water balance and water use efficiency of sweet sorghum and sweet maize in irrigated and non-irrigated conditions. The quantified results show an increased sugar content in the case of sorghum and increased corn yield in the case of maize due to the application of Pentakeep-V. One of the lessons of the assessment of the results is that the moisture content of the plants should have been monitored regularly in order to have an idea about the supposed ripening effect of this foliar fertiliser. In the framework of the researches based on the lysimeter station at Karcag further investigations are planned to reveal more details about the effects of Pentakeep-V.

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