CORRELATION BETWEEN WATER SUPPLY, SOIL WATER MANAGEMENT AND CROP-ROTATION IN MAIZE VEGETATION

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Abstract

Water management of a chernozem soil was investigated during the vegetation of maize plants in three different crop-rotation systems (mono-, bi- and triculture) in a 29-years long-term field experiment in a wet (2010) and a dry (2011) crop-year. In our experiment the change of soil moisture content in the 200 cm soil layer was more dynamic than in the previous crop-year in both not-irrigated and irrigated treatments of all three crop-rotation systems. The crop-year of 2010 was favourable for maize: water-deficit did not limit the development of high vegetative and generative biomass according to the results of our study regarding the water supply.

Key words: correlation, irrigation, precipitation, water-deficit, crop-rotation, maize.

INTRODUCTION

Water management is an important part of agricultural crop production, within the confines of which – in order to reach high yields in a sustainable and safe way – optimal water level of a certain period is ensured by the application of various technical, biological and agrotechnical measurements. Due to the fact that weather conditions have become rather extreme and the unbalanced distribution of precipitation during the vegetation period it can be stated that the yield results and safety of crop production in the main maize-production regions of Hungary are depending mainly on the water management and its extent (Antal, Jolánkai, 2005; Dégen, 1967).

Soil is a good reservoir for heat, water, plant nutrients and potentially harmful substances. It is able to compensate the extreme effects in the nature – to a certain level. Its water storage capacity has a determining role in the undisturbed functioning and adequate water supply of agro-ecosystems. Water demand of plants (e.g. autumn-crops) in the spring-time can be ensured safely from the water-stock stored in the soil that was filled up during the autumn-winter period (Farkas et al., 2004; Várallyay, 2006). Ruzsányi (1996a), just a Farkas and Gyuricza (2006) have stated that soil properties affect the water supply of plant through the changes of its water-content and water management. In fact this affect extends to the resistance of plants to the climatic stresses. In case the critical period turn frequently in dry and warm months (e.g. July or August), plant susceptibility to drought increases and thus yields show significant deviations. Maize is a good example for this case (Ruzsányi, 1996b). However, in case water supply of the vegetation period is ensured and favourable (for example by irrigation), outstanding yields can be produced. In contrast to a wet crop year, the intensity of photosynthesis and transpiration decrease due to stress caused by water-deficit in a drought crop-year and yields can even decrease by half (Domuta, 2010; Stan, Năeescu, 1997; Hegyi et al., 2007, 2008; Jambrovic et al., 2008; Hnilicka et al., 2008; Ceská et al., 2008; Hoffmann et al., 2007, Várallyay, 1989).

MATERIAL AND METHOD

Experiments have been carried out in the polifactorial long-term field experiment – set up in 1983 – at the Research Station of Látókép of the University of Debrecen CAAES, Faculty of Agricultural and Food Sciences and Environmental Management in the crop-years of 2010 ad 2011. The soil type of the experiment is a calcareous chernozem with good water infiltration and storage capacity. The area of each experimental plot was 41.1 m^2.

Our investigations were carried out by a nutrient supply level of N_{120}+PK, two irrigation treatments ($Ö_1$ treatment = not irrigated, $Ö_3$ treatment = irrigated), just as by a plant density of 60000 ha^{-1}, in three different crop-rotation systems (mono-, bi- and triculture). The studied hybrid was Reseda (PR37M81). There was no additional water supply in any of the irrigation treatments in the crop-year of 2010 due to the favourable distribution of the natural precipitation. Irrigation was in 29.06.2011., water quantity 50 mm.

For the study of the water management soil samples from the upper 200 cm soil layer by each 20 cm were taken three times in each crop-year. The first sampling time was before sawing, the second in the vegetation phase of maize with the highest water-demand (silting-fertilization), while the third sampling time was after harvest.

The wet weight of each soil sample has been measured. After this the samples were dried at 105 ^oC until no change in their weight has been detected. The dry weight samples were weighed again and soil water content was calculated from the difference between the wet and the dry weight of each sample that has been expressed as m/m%. Results have been expressed as V/V% as well, from that the density parameters of the given soil layer have been used.

Studying the two investigated crop-years (Table 1) it can be stated – also from the deviations from the 30-years average values – that 2010 was a wet, while 2011 was rather a dry crop-year. In each month of the crop-year of 2010 significantly – sometimes two-times – higher precipitation amounts than the 30-years average were measured. These resulted undisturbed and unlimited development for the maize plants. Temperature values were also favourable in each vegetation phase. Only in the month of September was a lower average temperature value measured, which was 1.7 °C lower than the 30-years average. Regarding the water supply of 2011 it can be stated that the precipitation was unbalanced distributed between the vegetation months. In May a value close (only 6.5 mm lower) to the 30-years average value was measured. In June this value was 109.3 mm higher than the average. The beginning development shooting development phase, just as the end of the vegetation were rather dry, that contributed to the dynamical decrease of the grain moisture content and to the ripening. Temperature played also an important role in this: the vegetation period of 2011 was 1.4 °C warmer than the 30-years average.

Table 1

Precipitation and temperature values in the vegetation of maize and 30-years average values in each month (Debrecen, 2010-2011)

	April	May	June	July	August	September	**Total**
Prec. (2010) [mm]	83.9	111.4	100.9	97.2	98.3	98.4	**590.1**
Prec. (2011) [mm]	15.6	52.3	22.0	175.0	42.7	6.2	**313.8**
30-years average	*42.4*	*58.8*	*79.5*	*65.7*	*60.7*	*38.0*	***345.1***
Temp. (2010) [°C]	11.6	16.4	19.7	22.3	19.0	14.1	**17.2**
Temp. (2011) [°C]	12.2	16.4	20.5	20.4	21.4	18.0	**18.2**
30-years average	*10.7*	*15.8*	*18.7*	*20.3*	*19.6*	*15.8*	***16.8***

RESULTS AND DISCUSSION

Due to the favourable water supply for the maize in the crop-year of 2010 the experimental soil water capacity was already saturated before sawing (Figure 1). Parallel to the development of the maize vegetative biomass, just as related to the high water-demand of the generative development phase, the water content of the 0-120 cm soil layer decreased in July. Still, its value was higher (18-26 V/V%) than the critical wilting point (14-16 V/V%). Due to the amount of rain the soil water management was favourable in the harvesting season too. Water-content value curves show similar tendency to the field acpacity values in the root soil layer of maize (0-120 cm). There was no significant difference detected between the soil water management of irrigated and not irrigated plots. According to our results there was no difference between the development of soil water management of the three crop-rotation systems, the graph curves show the same development.

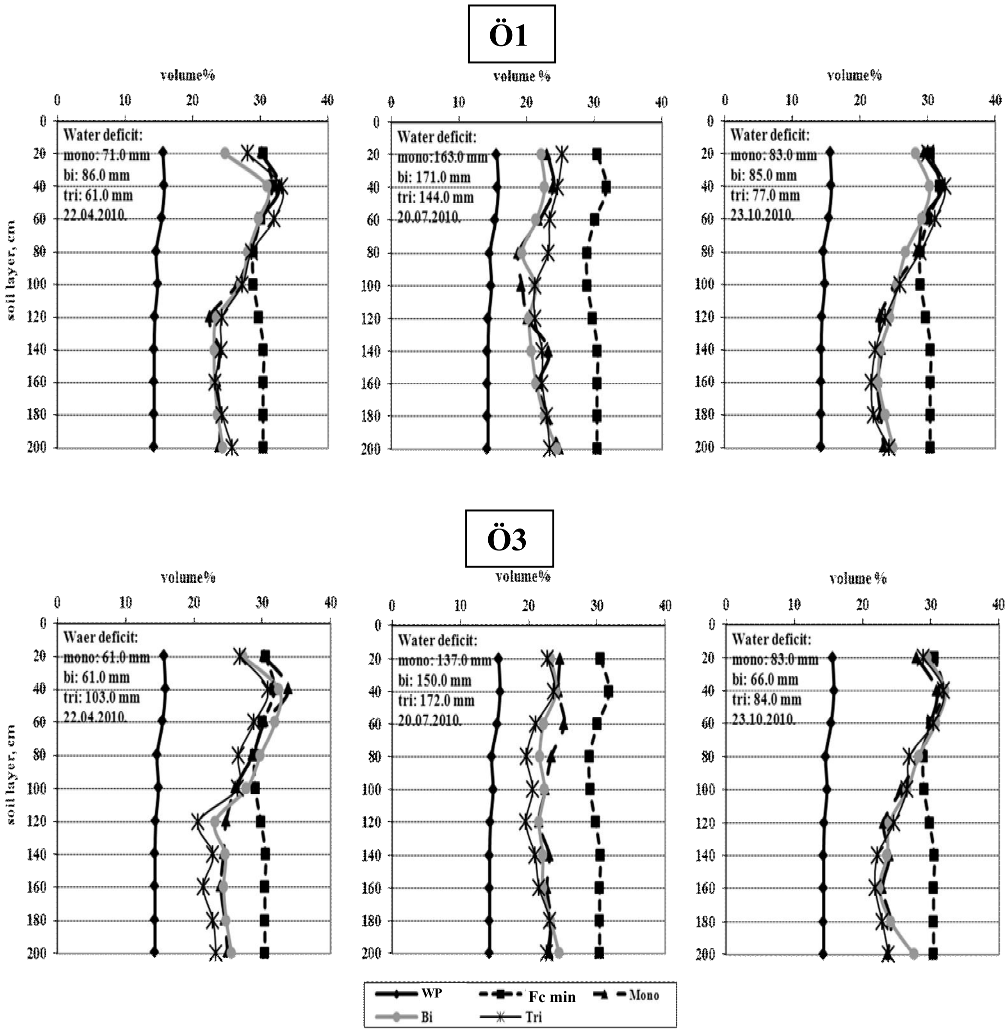

Fig. 1. Development of soil moisture in mono-, bi- and triculture maize in not irrigated and irrigated treatments during the vegetation (2010)

According to our results it can be stated that in the vegetation period of 2011 a water-defict of 90-120 mm was calculated already before sawing in each crop-rotation system (Figure 2).

Water deficit values increased significantly parallel to the plant development until the middle of July. Due to the silting and fertilization of maize plants the greatest water-deficit values were calculated in this period (values between 170-180 mm in each crop-rotation system). These high values have become more moderate until the end of the vegetation period – except for the biculture system.

The high amount of fallen precipitation in July had a positive effect on the soil water-stock. The water-content that is essential for the fertilization and gain filling of maize plants was available in the soil. The fact that the water-deficit values did not increase further in July and August proves this as well.

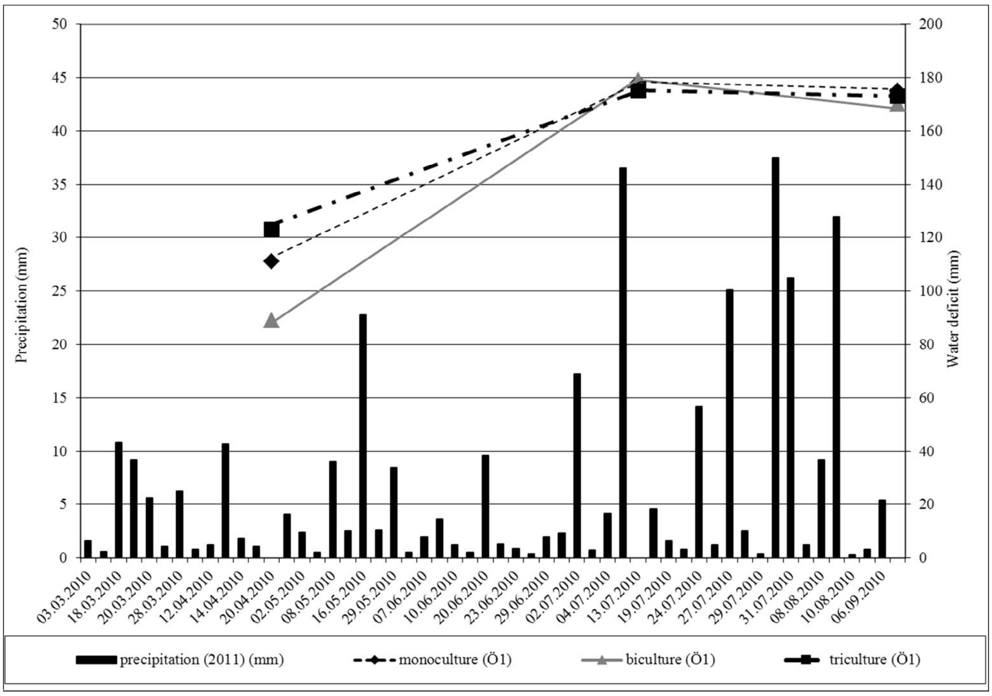

Fig. 2. Amount of preicipitation and water-deficit of the crop-year of 2011, in the not-irrigated treatments of the mono-, bi- and triculture crop-rotation systems

Correlations between the amount of fallen precipitation during the vegetation period and the soil water management have been studied too (Figure 3). The lowest water-deficit values were calculated in the biculture crop-rotation system in the irrigated treatments too.

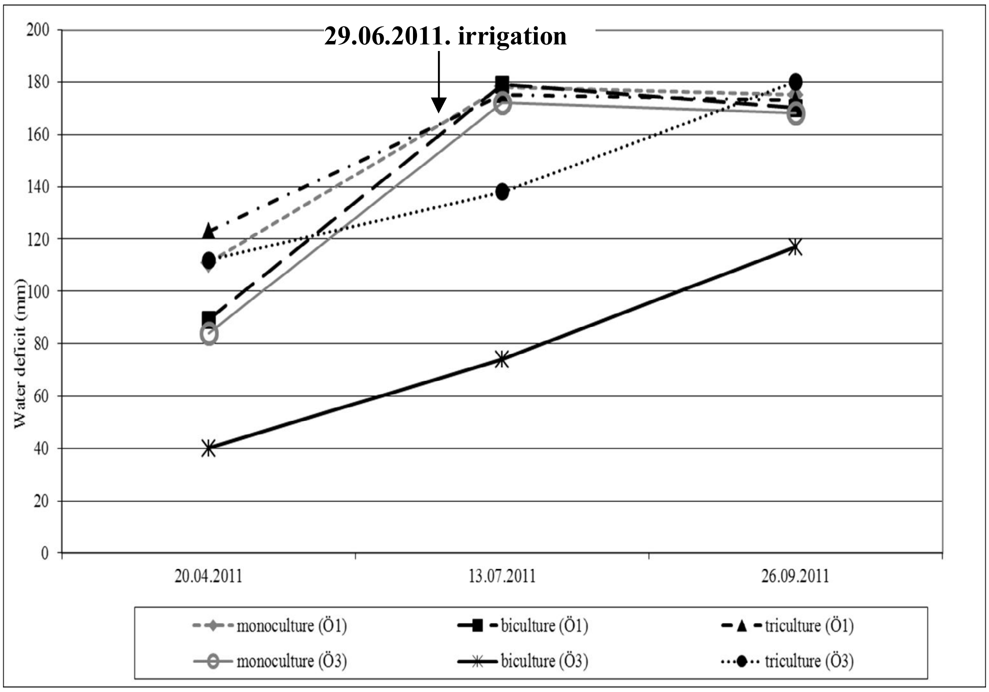

Fig. 3. Effect of irrigation and crop-rotation systems on the soil moisture content in the crop-year of 2011

The most severe water-deficit was detected in the monoculture cropping system: despite the irrigation, soil water management during the vegetation period shows similar tendency to the not-irrigated treatments even in the irrigated ones. The irrigation at the end of June resulted higher vegetative and generative biomass that utilized more water for their development. Thus in the harvesting period water-deficit values were between 160 and 180 mm in each crop-rotation and irrigation systems. The only exception was the biculture crop-rotation system – due to the favourable water management – in which 40 mm more soil water amount was available during the vegetation than in the other treatments.

CONCLUSIONS

Soil water management was studied in a 29-years polifactorial long-term field experiment in a wet (2010) and a dry crop-year with unbalanced water distribution (2011). In the crop-year of 2010 590 mm rainfall was measured that was balanced and favourable for maize plants. The filling effect of the wet crop-year (2010) on the soil water stock could be detected even in the beginning of the next vegetation. In the month before sawing 26.8 mm less precipitation fell than the 30-years average value and the extent of water-defict was between 90 and 120 mm in the different crop-rotation systems. In July 2011 109.3 mm precipitation fell that the 30-years average value. This resulted a favourable water supply of maize plants in the vegetation phases with the highest water-demand. From the involved three different crop-rotation systems it was the biculture system in which the water management was the most balanced – according to the calculated water-deficit values.

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