THE RESULTS OF THE MODERN DRIP IRRIGATION OF MAIZE IN SZARVAS

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Abstract: *The results of Hungarian maize production are significantly below the yields and total quantity als in the world. Maize yields can be increased significantly if we improve the plant's water supply. To increase the yield of maize in Hungary, we can respond faster with the development of irrigation. The irrigation reaction of maize is excellent, increase on the yield of the irrigation, depending on the year and the amount of precipitation, 10-90%. The proportion of agricultural irrigated areas in the world is steadily increasing, in 2013 has exceeded 325 million hectares, which contributes significantly to the increase in the average yield in the world. The yield of maize can be significantly increased by improving the water supply of the plant. In many areas, only little water is available for irrigation. Traditional irrigation has been switched to drip irrigation in the experiment. Drip irrigation is up-to-date, energy and water-saving irrigation. Energy consumption is only a quarter of its rainwater irrigation. The water consumption of drip irrigation is only half of the water consumption of traditional irrigation. There is not a large evaporation loss and leakage loss. Dropping irrigation is not cheap, but it is very beneficial for water consumption, energy consumption and results in a high yield. The water requirement of maize is not too high, 450-550 mm. Daily water consumption is 4.5-5.5 mm/ha (45-55 m3/ha). The effect of drip irrigation in our experiment was examined for the yield of corn. The experiment was set up at Szarvas in the experimental field of the University of Szent István, Faculty of Agricultural and Economics Studies, in Iskolaföld. The yields increased by 22.3-24.5% compared to the yields of control plots. In our experiment, the growth of the average yield was good for economically. It has been found that drip irrigation can be successfully used in maize producting. The large yields resulted in economical drip irrigation.*

Keywords: *corn, irrigation, drip irrigation, crop average,*

INTRODUCTION

The growing population of the world poses a major challenge to world agricultural production. According to our present knowledge, over the next 50 years the Earth's population will grow significantly and will exceed 9-10 billion. Growing populations require very substantial food production, so the higher quantity of maize produced is also needed.

In recent years, the corn field has been grown in the largest area and after wheat corn is the most widely cultivated crop. Its spread throughout the world is due to its good adaptability. According to FAO data, the total yield in 2013 has already exceeded 1.0 billion tonnes. 5.3% of the world's production area and 6.5% of the production is made up of EU Member States, Hungary's share is around 0.7%.

Maize water requirements are moderate, 450-550 mm. Daily water consumption is 4.5-5.5 mm / ha (45-55 m^3/ha). We must also distinguish between static water demand and absolute water consumption. The static water requirement of maize means how many percent of the pore volume of the soil is filled out by water and how many percent of the air is used;(maize static water requirement: 67-79%). The transpiration coefficient of maize means that the amount of water used (about 350 l/kg of maize) is used to produce a unit of dry matter (eg 1 kg). (BOCZ, 1992; PEPÓ AND SÁRVÁRI, 2011)

Water demand changes during the growing season. Most of the water is picked up by the corn during the period from the tasseling season to the seed fill up period. In this case the daily water requirement is between 4.5 and 5.5 mm and the total water requirement reaches 200 to 250 mm. (CSAJBÓK, 2004)

The rate and growth trend of maize water consumption, parallel to the growth rate of vegetation, is parallel to the increasing vegetative mass according to classical findings. At the beginning of development and post-grafting, the water consumption of plants is lower. Most of the water requires maize from the tasseling season to the seed fill up season (ANTAL ET AL, 2005).

To increase the yield of maize in Hungary, we can respond faster with the development of irrigation. The irrigation response of the maize is excellent, depending on the extraction caused by irrigation, depending on the year and the amount of precipitation, it can reach 10-90%. The proportion of agricultural irrigated areas in the world is increasing steadily in 2013 to over 325 million hectares, which contributes significantly to the growth of crops in the world (FUTÓ AND BENCZE, 2017).

The corn is rooted deep in the soil (200-250 cm) so it absorbs much of the moisture stored in the soil. The recycled water, except for extremely bad conditions, makes good use of it. The peak period of corn's water demand is due in July, August and seems to be a long period in relation to other plants of ours so the maize's drought sensitivity is high. (SZALÓKI, 1989)

The irrigation reaction of maize is good enough. Expected crop surplus due to irrigation is 2-6 t / ha depending on vintage and genotype. The extra yield per irrigation water of 1 mm can be 20 to 40 kg. Only hygroscopic hybrids with good irrigation reaction can be successfully irrigated, and hybrids have significant differences. (CSAJBÓK, 2004; RUZSÁNYI 1981)

MATERIAL AND METHODS

In 2016 and 2017, we tested the effect of tape drip irrigation on the change of corn yields and yielding elements of maize. In the study we used the Aqua Traxx tape drip system, sold by Metra company. During the experiment, non-irrigated (control) plots were used, then plots satisfying 75% and 100% tape drip irrigation parcels in the maize water requirement and finally, irrigation satisfying the 100% water requirement was supplemented with complex water-soluble fertilizer (NPK) in the fourth treatment. In 2017 a humic acid treatment was used instead of water-soluble fertilizer. In the experiment, we investigated a leading Pioneer hybrid, a leading Monsanto hybrid, and a hybrid sweet corn of Martonvásár.

The soil of the experiment is characterized by the fact that its physical characteristics is clay, as for its acidity it is acidic and slightly acidic, the cultivated layer does not contain $CaCO_3$, and the N-content of the soil is medium ranged based on humus content. The water management of the soil is characterized by poor water flow capability and high water retention capacity. The cultivated level is compressed, its porosity, and within that, the ratio of gravity pores is smaller.

The effect of irrigation in any case is significantly influenced by the water supply of the given year and the amount of fallen precipitation. The year 2016 was very favorable in the area of Szarvas. Considering both the amount and the time distribution of fallen precipitation, they were very favorable for maize. (see Table 1)

In 2017, during almost the whole growing season the precipitation was less than that compared to the longevity average, due to which fact the maize was to have started the most sensible development in its bloom with significant water scarcity. The lack of rainfall in July and August has further deteriorated the yield potential of maize, which results in the fact that the year 2017 created only good-medium climatic conditions for the plant.

Table 1.

Weather data for January - October 2016, Szarvas, 2016-2017.

Months	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Average**
Rainfall (mm) 2016	61,6	88,5	20,0	12,3	18,8	124,4	124,4	50,5	9,8	68,4	**578,7**
Rainfall (mm) 2017	28,3	30,2	13,4	49,7	40,9	69,3	31,8	33,3	56,1	56,2	**408,8**
30-year average rainfall (mm)	30,6	32,4	30,9	43,9	58,9	68,4	51,4	52,4	39,8	43,6	**452,3**
Difference 2016. (mm)	31,0	56,1	-10,9	-31,6	-40,1	56,0	73	-1,9	-30,0	24,8	**126,4**
Difference 2017. (mm)	-2,7	-2,2	-17,5	5,8	-18,0	0,9	-19,6	-19,1	16,3	12,6	**-43,5**

The development of plants and the development of the crop average are largely influenced by the photosynthetic activity of the plant. Photosynthesis depends most strongly on two important factors: 1. the surface and the durability of the plant, 2. the photosynthetic chlorophyll content of the leaf. That is the reason why in this experiment, we measured the relative chlorophyll content of the plant, which shows how much the photosynthetic activity of the leaf can be influenced by continuous nutrient supply (hydroponic treatment) with irrigation and irrigation water. The relative chlorophyll content was measured with a Konica Minolta SPAD 501 meas75% and 100% of the water requirement for maize was carried out in the knowledge of the average temperature of the experimental area and the evapotranspiration of the stock. The water demand of the 100% parcels was completely replaced by the evapotranspiration, the area had a natural water capacity of about 85-100%. In response to a 75% water demand, evapotranspiration only gave ¾ of the amount of water evaporated occasionally resulting in a constantly decreasing water supply. Plots have a natural water capacity of between 45-80%. The control plots did not receive any irrigation, the natural precipitate determined the natural water capacity of the area. Since precipitation was favorable in the year, the water capacity of the parcels was similar to the control parcels, ranging from 40 to 75%.

RESULTS AND DISCUSSION

The results show that water supply increased the relative chlorophyll content of maize only at 100% water demand. The 75% water supply this year did not differ significantly from the results of the control irrigation plots, due to the excellent precipitation distribution. (see Table 2).

First of all, the average yield of sweet corn was examined, which occured only in the 2016 study. During the measurement of the averge yields, we compared the yields of plots without irrigation (control), the irrigated plots to 75% water demand, the irrigated plots to 100% water demand and the irrigated plots with fertilization. The yields of sweet corn were expressed by a higher (~ 60-70%) moisture content than the average and a cob harvest weight.

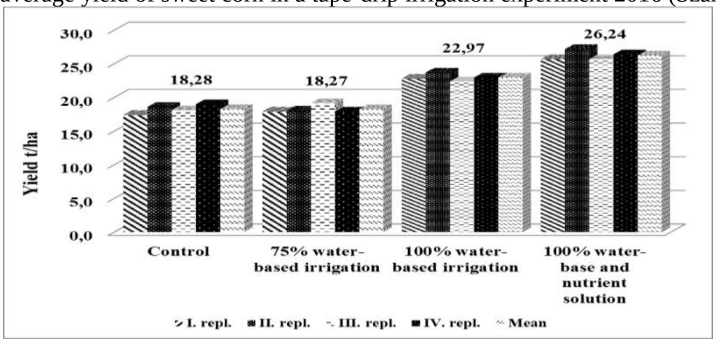
Table 2.

The relative chlorophyll content of maize is 2016-2017. (SPAD value)

	Control	**75% water-based irrigation**	**100% water-based irrigation**	**100% water-base and nutrient solution**
Sweet Corn	41,7	41,6	46,1	46,6
P9903	43,2	43,5	46,7	46,8
DKC4541	43,0	43,6	46,6	46,8
Average 2016	**42,63**	**42,90**	**46,46**	**46,73**
P9903	44,1	43,7	45,9	46,4
DKC4541	43,2	43,9	45,8	46,7
Average 2017	**42,80**	**43,17**	**45,67**	**46,33**

Figure 1.

The average yield of sweet corn in a tape-drip irrigation experiment 2016 (Szarvas)



From the results, it can be seen that the yields of sweet corn could be significantly increased in the very favorable year 2016 by the use of tape drip irrigation technology. Due to the favorable precipitation, there was no difference between the yield of parcels without irrigation (control) and those with irrigation of 75% water demand in the experiment. However, the crop-enhancing effect of irrigation, which satisfies the entire water demand of the plant, was very significant even in this year's favorable water supply. The yield of sweet corn reached 22.97 t/ha, which is very favorable. This yield in the experiment was only surpassed by the yields of the plots with nutrient supply, the yield reached 26.24 t/ha.

During the statistical analysis we could conclude that drip irrigation was able to increase the available yield averages for sweet corn cultivation even in a favorable water supply year in a statistically verifiable way. A similar finding was made when testing the effect of the nutrient solution, and the nutrient applied with the drip drip irrigation further increased the yields of sweet corn where the crop growth exceeded the significant limit. The reliability of the variance analysis is very strong and the calculated R^2 value is 0.973 *(see Table 3.)*.

Table 3.

The variance table of the yield average of sweet corn

	SQ	df	MS	F	Sig.
Intercept	6449,958	1	6449,958	15510,454	,000
Irrigation	58,844	2	29,422	70,752	**,000**
Nutrient Supply	21,386	1	21,386	51,427	**,000**
Error	4,990	12	,416		
Total	7540,698	16			

a. R Squared = ,973

In the next group of studies, we examined two feedstuff maize hybrids whose crops were monitored during the test.

The analysis of the yields of feedstock corn showed similar results in 2016 than sweet corn hybrid. There was no difference between the yields of no irrigation and the yields with irrigation that meet the 75% water demand. This was due to the satisfying amount and distribution of precipitation.

However, the total water demand of the plant could not be covered by the naturally falling rainfall even in this favorable year, which meant that the yield could be increased by satisfying the 100% of water demand of corn in 2016. The yields increased by 22.3-24.5% compared to the yields of control plots. (see Figures 2 and 4.)

Figure 2.

Evolution of the yield of P9903 hybrid in a tape drip irrigation experiment 2016 (Szarvas)

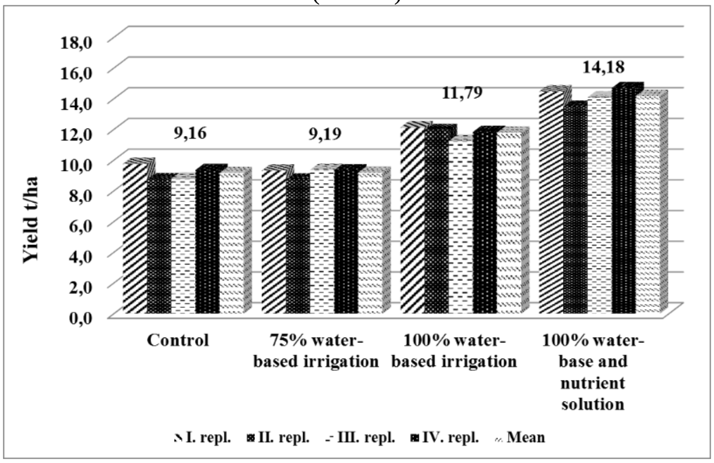


Figure 3.

Evolution of P9903 hybrid crop average in a tape drip irrigation experiment 2017 (Szarvas)

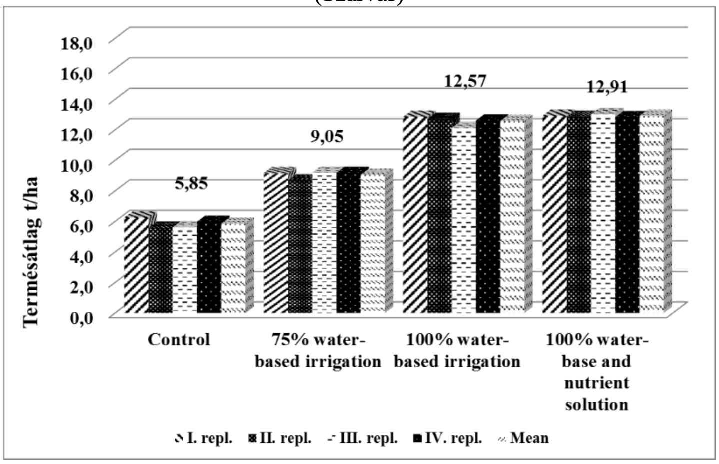


Figure 4.

Evolution of the DKC4541 hybrid yield ratio in a tape drip irrigation experiment 2016 (Szarvas)

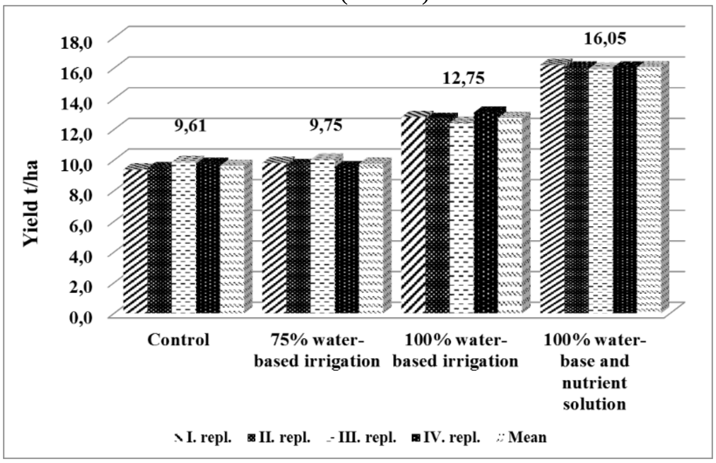
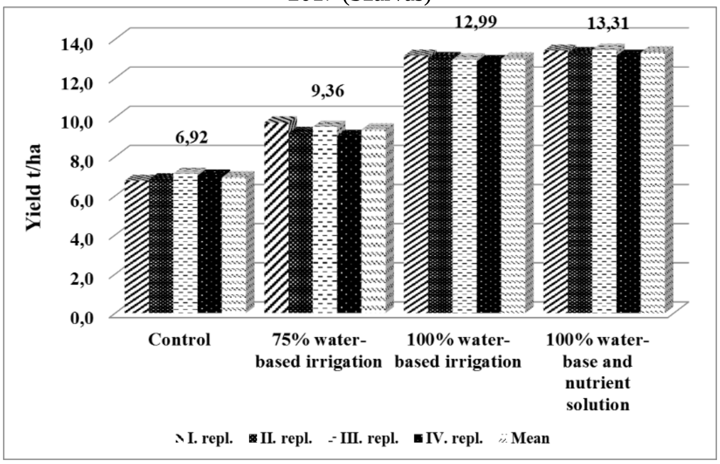


Figure 5.

Evolution of the DKC4541 hybrid yield average in a tape drip irrigation experiment 2017 (Szarvas)



In 2017 precipitation was much less favorable, and precipitation in the growing season did not reach the 30-year average values. Therefore, average yields were significantly lagging behind the results of the previous year. (see Figures 3. and 5.)

The largest drop in yields compared to the previous years was on control plot of no irrigation. This is mainly due to the low precipitation period of maize water supply (July, August). With irrigation of satisfying the 75% of the water demand of the plant, the yields have increased very strongly, for both tested hybrids it exceeded 9 t / ha (9.05 and 9.36 t / ha).

If the water requirement of the plant was 100% satisfied during the irrigation, yields of 12-13 tons of hybrids were formed. The favorable water supply resulting from irrigation in hybrids shows that the decreasing effect of ever-increasing dry periods in climate change is significant, yields decreased in the control plots with bad water supply by 6.72 t / ha (P9903) and 6.07 t / ha (DKC4541).

In 2016, the nutrient parcels could further increase this, which is primarily due to the favorable phytophysiological condition of the plant that the plant immediately comes to the dissolved form of nutrient in the root hair zone of the root. This also refers to the important fact that optimal nutrient supply is possible only in the presence of sufficient amounts of water in the form of being available for the plant. The average yield of the plots with nutrient supply ranged from 14.18 to 16.05 t / ha, which reached the limit of the economically favorable production and profitability by the results of the experiment.

In 2017, instead of the conventional nutrient solution, a humic acid treatment was tested by applying tape drip irrigation. As a result of the treatments, similarly to year 2016, we could measure a further increase in crop average. The yield increase in 2017 was 340 kg / ha (P9903 hybrid) and 320 kg / ha (DKC4541 hybrid).

Table 4.

The variance table for maize crop average 2016

	SQ	df	MS	F	Sig.
Intercept	2227,447	1	2227,447	4908,988	,000
Irrigation	43,080	2	21,540	47,471	**,000**
Nutrient Supply	32,405	1	32,405	71,415	**,000**
Error	12,705	28	,454		
Total	4467,583	32			

a. R Squared = ,933 (Adjusted R Squared = ,926)

In the statistical analysis of crop yields in 2016, it was found that, similar to sweet corn, the commodity hybrids also achieved a significant increase in yields both by irrigation and nutrient treatment. Since tape drip irrigation is easy to implement the nutrient solution without a separate investment, there is an outstanding importance of further significant increase in yields.

Table 5.

The variance table for corn yield averages 2017.

	SQ	df	MS	F	Sig.
Intercept	1481,352	1	1481,352	9406,608	,000
Irrigation	164,140	2	82,070	521,145	,000
Nutrient Supply	,436	1	,436	2,766	,107
Error	4,409	28	,157		
Total	3689,476	32			

a. R Squared = ,982

In the course of the statistical evaluation of the results of 2017, the variance analysis of yield averages was also the first task. According to the results, irrigation also showed significant growth rates this year, but the yield increase as a result of the introduction of humic acid treatment did not reach the statistically justifiable difference, and the yield increase was not significant.

In addition to the variance analysis, the correlation and regression analysis of the factors was also performed. In the Pearson correlation study, it was found that irrigation had a positive effect on crop yields in year 2016 *(see Table 6.)*.

Table 6.

Examination of correlation between maize yield and irrigation 2016.

		Irrigation	**Crop**
Irrigation	Pearson Correlation	1	**,795****
	Sig. (2-tailed)		,000
Crop	Pearson Correlation	**,795****	1
	Sig. (2-tailed)	,000	

**. Correlation is significant at the 0.01 level (2-tailed).

The result of the study is that there is a close positive correlation between yield and irrigation. The test gave a significantly reliable result at a very low level of 0.01.

The correlation test was carried out also in year 2017, which shows that there is even a stronger positive correlation in the dry year due to irrigation treatment. The value were 0,988, which was significant at the 0.01 level.

CONCLUSIONS

Overall, it was found that tape drip irrigation of maize is of very low water-use, energy-efficient and generally efficient irrigation technology, which can be a major domestic technical innovation for maize irrigation in future for intensive farming.

The yield of maize can be significantly increased by improving the water supply of the plant. In many areas, only little water is available for irrigation. The effect of drip irrigation in our experiment was investigated for corn yields in 2016 and 2017. In 2016, yields increased by 22.3-24.5% compared to the yields of control plots, while the yield gains in the drier year of 2017 reached 46.73-53.46%. In our experiment, the growth of the average yield was economically measurable.

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