INFLUENCE OF IRRIGATION AND FERTILIZATION ON MAIZE YIELD IN DOBROGEA (SARICHIOI, TULCEA)

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ABSTRACT

The paper presents the average results of the research conducted in the agricultural years 2015/2016 and 2016/2017, analyzing the influence of irrigation methods and volumes on maize yield obtained for different fertilization levels in Sarichioi, Tulcea (Dobrogea area). Split plot method was used for the field design, in order to establish the optimum interaction of technological factors in terms of the yield obtained in the climatic and soil conditions of Dobrogea area. The following factors were studied: factor A - irrigation regime with: a_1 - Dripping 300m^3/ha (Ct), a_2 - Dripping 600m^3/ha, a_3 - Sprinkling 600m^3/ha, a_4 - Sprinkling 1200 m^3/ha; Factor B – fertilization with three graduations: b_1 - $N_{120}P_{60}$, b_2 - $N_{180}P_{60}$, b_3 - $N_{180}P_{90}$; Factor C – maize hybrid: c_1 - DKC4717, c_2 - P0023. Yield varied from 12.1 t/ha (DKC4717, fertilized $N_{120}P_{60}$, Dripping 300 m^3/ha) to 15.1 t/ha (P0023, fertilizer $N_{180}P_{90}$, Sprinkling 1200 m^3/ha), both irrigation regime and fertilization lead to statistically assured yield growths.

INTRODUCTION

Dobrogea is one of the driest regions in south-eastern Romania (Bandoc G., Pravalie R., 2015) with a frequency of 89% of dry years (Maftei C. and Barbulescu A, 2008) and an irregular distribution of rainfall in time and space (Stoica G. et al., 2012). In these climatic conditions the irrigation of agricultural crops is imperative, while the efficiency of water use is closely correlated to the irrigation regime.

The pronounced water deficit has a significant impact on maize yield (Naescu V., Alionte E., 2008; Domuta C., 2008; Pravalie et al., 2014), and the choice of watering moments and water volume are essential to ensure optimal irrigation (Hamlyn G.J., 2004, Muresan, 1970, quoted by Dragomir C.L. and Partal E., 2014).

To obtain profitability when growing maize in rainfall restrictive conditions it is necessary to establish a rational irrigation and fertilization regime in relation to plant's requirements (Morrison J.L. et al., 2008, Mounce, R. B., 2016).

In addition, the irrigation regime and application methods should consider area's specificity and fertilizer doses used, to avoid leakage of active substances, the results of research indicating the need to adapt the technology to area's specificity (Di Paolo, E., Rinaldi, M 2008, Muresanu S.G. et al., 2014, Domuta, C.G. 2016, Çarpıcı, E.B. et al., 2017, Wu D. et al., 2017).

The aim of this research was to analyze the influence of the interaction of irrigation volumes and methods and fertilization on maize yield grown in Dobrogea area.

MATERIALS AND METHODS

The research was carried out in 2016-2017 in a polyfactorial experience set up on a chernozem soil at SC Transmeteorit SRL farm in Sarichioi, Tulcea county (44.9123, 28.8523).

The experimental design randomized into four repetitions the following factors:

- **Factor A** – *irrigation regime with four graduations: a_1 - Dripping 300m^3/ha (Ct), a_2 - Dripping 600m^3/ha, a_3 - Sprinkling 600m^3/ha, a_4 - Sprinkling 1200 m^3/ha*;
- **Factor B** – *fertilization with three graduations: b_1 - $N_{120}P_{60}$, b_2 - $N_{180}P_{60}$, b_3 - $N_{180}P_{90}$*;
- **Factor C** – *maize hybrid: c_1 - DKC4717, c_2 - P0023*.

Maize was sown after winter wheat *(Triticum aestivum* L.*).* The basic soil tillage was plowing at 25 cm, and the preparation of the germinating bed was made at 5-6 cm depth.

The two hybrids were sown at a density of 80.000 germinating seed/ha on 13.04.2016 and 25.04.2017 respectively, and the harvest was carried out in the second decade of September.

Pre-emergence control of weeds was carried out using the commercial product Adengo 465 SC based on *isoxaflutole* 225 g/l + *thiencarbazone-methyl* 90 g/l + *ciprosulfamide* 150 g/l at a dose of 350 ml/ha, and for post-emergence weed control the herbicide usedwas based on *foramsulfuron* 22.5 g/l + *isoxadifentenyl* 22.5 g/l (commercial product Equip in a dose of 1.7 l/ha).

Tanymecus dilaticollis control was carried out using a product based on *thiacloprid 480 g/l* (Calypso 480 SC in a dose of 90 ml/ha).

Fertilizers were applied in phases, first at germinative bed preparation using NPK 20:20:0 at a dose of 60 kg/ha of active substance (a.s.) for the fertilization levels $N_{120}P_{60}$, $N_{180}P_{60}$ and at a dose of 90 kg/ha a.s. for the fertilization level $N_{180}P_{90}$, secondly at during vegetative development using ammonium nitrate (N33.5%) at a dose of 60 kg/ha a.s. for the fertilization levels $N_{120}P_{60}$, $N_{180}P_{60}$ and at a dose of 90 kg/ha a.s. for the fertilization level $N_{180}P_{90}$.

To determine the influence the researched factors on maize yield, the variance analysis and the Fisher test were used. The relationship between the researched factors and yield was determined using correlation and regression analysis.

Water efficiency (WUE) was calculated by dividing yield value by the irrigation volume (Stanhill, 1987; Huang, 2002).

Climatic conditions

Climatic conditions recorded during the maize vegetative period showed significant variations mainly in relation to the multiannual average (Table 1), but also between the two agricultural years.

The average temperature during plants development recorded average values of 1.2^{o}C in 2016 and 1.5^{o}C in 2017 above the multi-year average temperature (Table 1), reflecting the drought tendency of the area.

Also, the sum of rainfall during plants development was 10.8 mm lower in 2016 and 47.8 mm higher in 2017 (Table 1), compared to the multiannual value specific to the area.

Table 1.

Climatic conditions, Sarichioi, Tulcea County, 2016-2017

Month	Temperature (°C)			Rainfall (mm)		
	2016	2017	Normal	2016	2017	Normal
May	15.9	16.4	16.4	77.1	15.7	37.8
June	22.3	22	20.7	48.3	78.5	40.0
July	24.2	23.2	22.8	0	93.5	33.7
August	24	24	22.2	15.3	13	29.2
September	19.4	21.4	17.6	24.2	22.8	35.0
Avg/Sum.	**21.2**	**21.4**	**19.9**	**164.9**	**223.5**	***175.7***

Rainfall distribution in the vegetation period shows differences compared to normal values, especially in June and July, when the water consumption of plants is very high, potentially increasing the risk of yield decline.

RESEARCH RESULTS

Influence of the irrigation regime on maize yield

Analysis of the average results obtained during the two years of research reflects the influence of irrigation regime on maize yield for all three fertilization levels.

The highest grain yields (Table 2) were obtained for Sprinkling 1200 m^3/ha, the values varying between 13.8 t/ha ($N_{120}P^{60}$) and 14.8 t/ha ($N_{180}P_{90}$). This irrigation regime brought statistically significant increases of yield compared to control (Dripping 300 m^3/ha) for each of the two hybrids. For this irrigation regime, the highest grain yield was obtained by P0023 (15.1 t/ha) at the fertilization level $N_{180}P_{90}$.

Dripping 600 m^3/ha also produced statistically significant positive differences of the grain yield compared to control, for all fertilization levels, its effectiveness being particularly highlighted for high nitrogen and phosphorus fertilization levels ($N_{180}P_{60}$, $N_{180}P_{90}$) where yield increases were very significant, while for $N_{120}P_{60}$, this irrigation regime resulted in a distinctly significant increase (Table 2).

Sprinkling 600 m^3/ha determined the smallest increases in terms of grain yield compared to control (Dripping 300m^3/ha), but statistically assured for all fertilization levels. The highest yield for this irrigation regime on all fertilization levels was recorded by P0023.

Table 2.

Effect of irrigation volume and method on maize yield

Fertilizer	Irrigation	*Grains yield (t/ha)*			
		DKC 4717	P0023	Avg.	Diff.
$N_{120}P_{60}$	Dripping 300	12.1	12.7	**12.4**	Ct
	Dripping 600	13.3	13.4	**13.4**	1.0*
	Sprinkling 600	12.8	13.2	**13.0**	0.6*
	Sprinkling 1200	13.5	14.1	**13.8**	1.4***
LSD 5%					*0.6 t/ha*

LSD 1%					*0.8 t/ha*
LSD 0.1%					*1.2 t/ha*
N_{180} P_{60}	Dripping 300	12.9	13.5	**13.2**	Ct
	Dripping 600	14	14.3	**14.2**	1.0**
	Sprinkling 600	13.5	14	**13.7**	0.6*
	Sprinkling 1200	14.4	14.8	**14.6**	1.4***
LSD 5%					*0.6 t/ha*
LSD 1%					*0.9 t/ha*
LSD 0.1%					*1.3 t/ha*
N_{180} P_{90}	Dripping 300	13.1	13.8	**13.4**	Ct
	Dripping 600	14.4	14.7	**14.5**	1.1***
	Sprinkling 600	13.9	14.3	**14.1**	0.7**
	Sprinkling 1200	14.6	15.1	**14.8**	1.4***
LSD 5%					*0.4 t/ha*
LSD 1%					*0.5 t/ha*
LSD 0.1%					*0.8 t/ha*

*ns – not significant, * significant, ** distinctly significant, *** very significant, Avg = average of the two hybrids*

Analyzing the influence of the irrigation method on the average yield of the two hybrids (Table 3) it can be noticed that drip irrigation with 600 m^3 generated yield increases between 0.4 and 0.5 t/ha compared to sprinkling irrigation with 600 m^3.

Yield growth were statistically assured for the fertilization levels $N_{180}P_{60}$ and $N_{180}P_{90}$.

Table 3.

Influence of the irrigation method on maize yield, difference between dripping and sprinkling

Fertilizer	Irrigation method at 600 m^3 /ha	*Grains yield (t/ha) differences*			
		DKC 4717	P0023	Avg.	Signf.
$N_{120}P_{60}$	Dripping - Sprinkling	0.5	0.2	0.4	ns
LSD 5%					*0.3 t/ha*
LSD 1%					*0.6 t/ha*
LSD 0.1%					*1.2 t/ha*
N_{180} P_{60}	Dripping - Sprinkling	0.5	0.3	0.5	*
LSD 5%					*0.4 t/ha*
LSD 1%					*0.6 t/ha*
LSD 0.1%					*1.3 t/ha*
N_{180} P_{90}	Dripping - Sprinkling	0.5	0.4	0.4	*
LSD 5%					*0.4 t/ha*
LSD 1%					*0.7 t/ha*
LSD 0.1%					*1.3 t/ha*

*ns – not significant, * significant, ** distinctly significant, *** very significant, Avg. = average of the two hybrids*

When large quantities of fertilizer were used, a higher water use efficiency (WUE) was recorded (Figure 1) for drip irrigation compared to sprinkling irrigation on each of the three fertilization levels.

WUE was highly correlated (*r = 0.996)* with the irrigation volume (Figure 2).

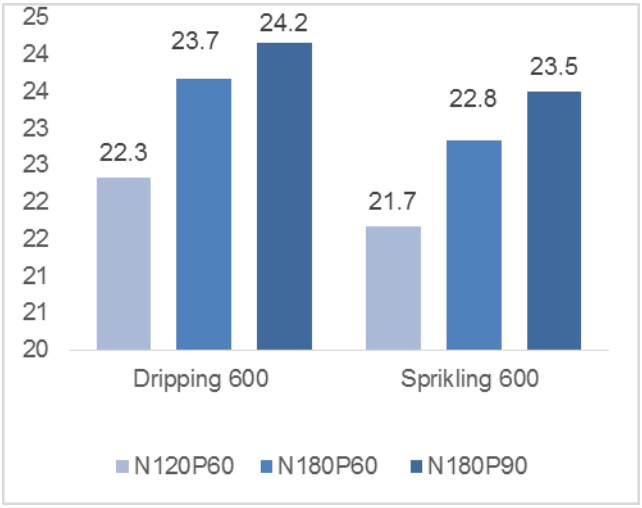


Figure 1. Water use efficiency (kg grains /m^3)

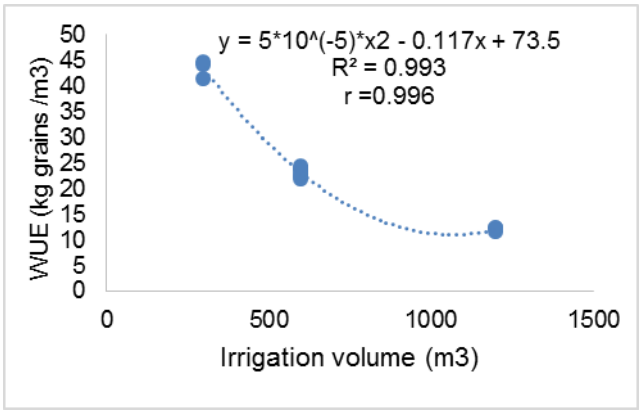
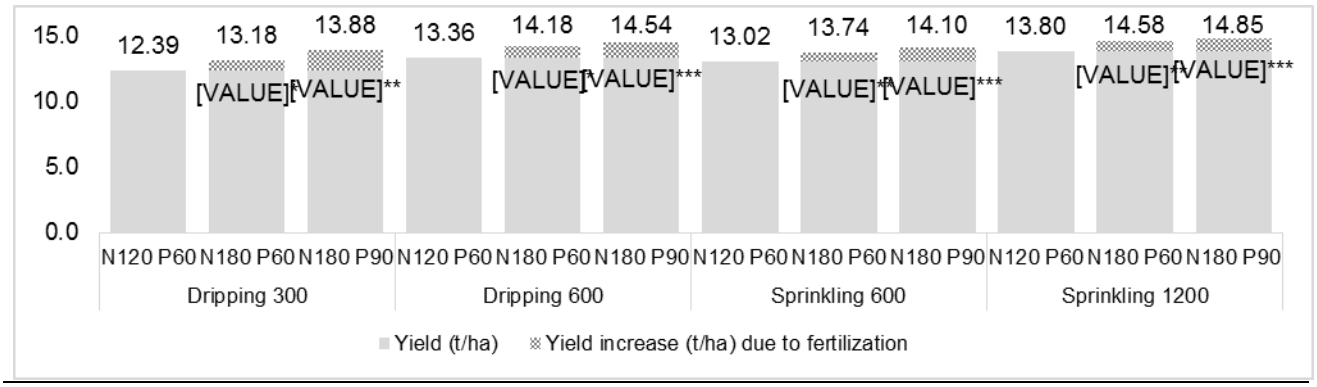


Figure 2. Water use efficiency (kg grains /m^3)

Yield analysis under the influence of fertilization

Applying an additional dose of 60 kg/ha N at a constant P_{60} basis produces statistically assured increases in yield (Figure 3), for irrigation regimes dripping 300 m^3, dripping 600 m^3, and sprinkling 600 m^3 while at a higher irrigation volume applied by sprinkling (1200 m^3) the differences were not statistically significant.

Under the fertilization level $N_{180}P_{90}$, yield increases were statistically significant compared to control ($N_{120}P_{60}$) for all irrigation regimes.



LSD 5%	*0.65 t/ha*	*0.60 t/ha*	*0.49 t/ha*	*0.50 t/ha*
LSD 1%	*0.90 t/ha*	*0.83 t/ha*	*0.68 t/ha*	*0.69 t/ha*
LSD 0.1%	*1.24 t/ha*	*1.14 t/ha*	*0.94 t/ha*	*0.94 t/ha*

*ns – not significant, * significant, ** distinctly significant, *** very significant*

Figure 3. Influence of fertilizer on average grains yield

CONCLUSIONS

Yield analysis under the influence of irrigation methods and volumes highlights that:

- when high doses of fertilizer active substance were used, the irrigation regimes with volumes of 600 and 1200 m^3/ha determined statistically assured yield increases compared to the control variant (dripping 300 m^3/ha);
- drip irrigation with a volume of 600 m^3/ha determined a larger yield compared to sprinkling at the same volume, with statistically significant differences for $N_{180}P_{60}$ and $N_{180}P_{90}$.
- drip irrigation provided a higher use efficiency.

Fertilization led to the increase of the average yield of the two hybrids with values ranging from 0.72 t/ha to 1.48 t/ha comparted to control ($N_{120}P_{60}$). The yield was closely correlated with the dose of fertilizer active substance applied (*r = 0.9372*).

Based on the results obtained in 2016-2017 for maize crop grown in Sarichioi, Tulcea County (Dobrogea area), an irrigation regime with a minimum volume of 600 m^3/ha and the application of mineral fertilizers with nitrogen and phosphorus in a ratio of 2:1, at the level of 150 kg/ha N a.s. and 75 kg/ha of P a.s. is recommended.

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