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SALINITY EFFECTS ON SWEET CORN YIELD AND WATER USE EFFICIENCY UNDER DIFFERENT HYDROGEL DOSES

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Abstract

The research was carried out at 2015 to determine the effects of the irrigation water salinity and different hydrogel doses which controlled releasing fertilizer and soil conditioner on soil as PAM hydrogel source on sweet corn (Zea mays saccharata Sturt.) yield under greenhouse condition. The experiment was conducted 4 different irrigation water salinity level (S_1: 0 dS m^{-1}; S_2: 1.5 dS m^{-1}; S_3: 3.0 dS m^{-1}; S_4: 5.0 dS m^{-1}) and 4 different hydrogel doses (H_1: 0 gr pot^{-1}; H_2: 0.5 gr pot^{-1}; H_3: 1.0 gr pot^{-1}; H_4: 1.5 gr pot^{-1}). The experimental design was randomized factorial design with three replications. According to the results; significant and negative relationship was observed between the water salinity and dry and wet plant weight. The highest wet and dry weights was observed for irrigation water salinity and hydrogel doses at the S_1 as 170.94 gr $pot^{-1}$and 22.77 gr $pot^{-1}$and the H_2 as 179.75 gr pot^{-1} and 26.47 gr pot^{-1} respectively. Hydrogel effect decreased when the salinity level increase. Irrigation water use efficiency was obtained the highest value belong to S_1H_2 with the value of 0.26.

Key words: *corn, hydrogel, irrigation water salinity, yield.*

INTRODUCTION

The quality of water resources around the world is getting worse each year (Jimenez and Asano, 2008). For this reason, it is necessary to use lower quality waters in order to increase crop water productivity and economic value of the productions. Especially in arid and semi-arid regions, the use of new methods and technologies is becoming popular to make more effective use of water resources (such as green manure, animal fertilizer, hydrogel). For this purpose, in addition to organic resources, polymer substances have been developed as soil conditioners. However, due to the economic reasons at the cost of production, these materials did not see the need to be concerned. In the recent years, the efficiency of the polymers has been increased and higher effective polymers have been produced with lower costs and they have started to be used in agricultural areas. Hydrogels, which were developed to increase the water holding capacity of amended media, have been used to aid plant establishment and growth in dry soils (Al-Sheikh and Al-Darby, 1996). They have the potential to absorb water many times their weight, retain it and supply it to plant roots during water stress, thereby enhancing plant survival and growth (Agaba et al., 2010). Due to the wide variety of such products there is not enough technical information about the effects of irrigation water quality. This study aimed to determine the effects of different hydrogel doses on yield and development of corn (*Zea mays saccharata* Sturt.) under saline irrigation water.

MATERIALS AND METHODS

The experiment was carried out at 2015 in 2.5 kg plastic pots with a diameter of 25 cm and a height of 20 cm under the plastic greenhouse conditions in Aksu district of Antalya. The soil texture was Silty Clay Loam, field capacity (FC) 27 %, permanent wilting point 17%, bulk density 1.38 gr cm^{-3} and electrical conductivity (EC) 1.04 dS m^{-1}. According to soil fertility analysis results for basal fertilizer was applied to the pots. Polyacrylamide (PAM) polymer was used which was a water absorption capacity as high as 400-500 times the hydrogel weight. It is insoluble in water and organic solutions. Sweet corn (*Zea mays saccharata*) of Merit F_1 variety was used in this study and this genotype was moderately sensitive to the salt stress. Five seeds were planted in each pot and irrigated to FC according to weight base.

The experimental design was factorial randomized block design. The treatments of the experiment was 4 different irrigation water salinity with S_1 - 0 dS m^{-1}, S_2 - 1.5 dS m^{-1}, S_3 - 3 dS m^{-1}, S_4 - 5 dS m^{-1} and 4 different hydrogel doses with H_1 - 0 gr pot^{-1}, H_2 - 0.5 gr pot^{-1}, H_3 - 1.0 gr pot^{-1}, H_4 - 1.5 gr pot^{-1}. NaCl was used while preparing different salinity level of irrigation water. Pots were weighed regularly and irrigation treatments were made when soil moisture content decreased below the 30% field capacity. The plants were harvested 46 days after the saline water application. After harvesting plant wet weights were measured. The plants were dried until the plants reached a constant weight at 65°C and the values obtained were reported as dry weight. Results were analysed by Duncan test of variance analysis using SPSS 18.0 statistical program and evaluated according to the principles given by Yurtsever (1984).

RESULTS AND DISCUSSIONS

Effects of irrigation water salinity on wet and dry weight of corn

The average wet and dry weight of corn and Duncan classes was given at Table 1.

Table 1. Wet and dry weight of corn (gr pot^{-1})

Treatments	Wet weight	Dry weight
S_1	170.94^{a*}	22.77^{a}
S_2	140.67^{b}	21.88^{a}
S_3	118.92^{b}	18.61^{b}
S_4	93.06^{c}	16.18^{c}

*Duncan class

According to results the highest yield (as wet and dry weight) was obtained the lowest salinity level. Increasing the salinity of the irrigation water caused the yield to decrease. There was negative and important relationship between plant dry and wet weight and irrigation water salinity. Determination coefficients (R^2) were 0.98 and 0.96 for dry and wet weight, respectively (Figure 1). Similar results have been reported by Ashraf and O'leary (1997), Turan et al. (2009), Tekeli and Kale Celik (2017).

Relative yield values were calculated on the basis of S_1 treatment which was non saline water. It was presented in Table 2.

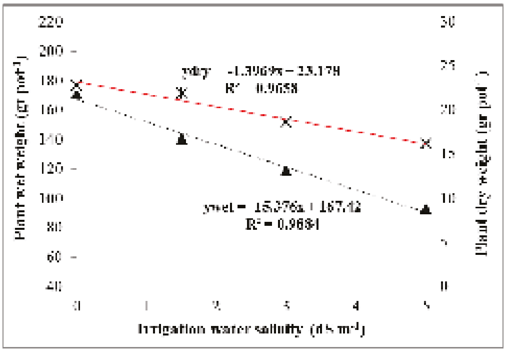

Figure 1. Irrigation water salinity and crop wet and dry weight relationship

Table 2. Relative percentage and variation of yield at different salt doses

Treatments	Wet weight		Dry weight	
	RP	RD	RP	RD
S_1	100.0	0.00	100.0	0.00
S_2	82.29	17.70	96.09	3.90
S_3	69.57	30.40	81.73	18.20
S_4	54.44	45.50	71.06	28.90

RP: Relative persentage, RD: Relative difference.

The wet weight reduction was around 50% at the highest salinity level (S_4). It was 30% for dry weight.

Effects of different hydrogel doses on wet and dry weight of corn

The average wet and dry weight of corn for different hydrogel doses and Duncan classes was given at Table 3.

Table 3. Wet and dry weight of corn (gr pot^{-1})

Treatments	Wet weight	Dry weight
H_1	170.94^{b}	22.77^{b}
H_2	179.75^{a}	26.47^{a}
H_3	175.46^{a}	25.39^{a}
H_4	171.53^{b}	24.34^{a}

*Duncan class

The wet and dry weight at H_2 treatment was higher than the other treatments. However H_2 and H_3 treatment was the same Duncan classes. There was a negative significant quadratic relationship between hydrogel level and plant wet and dry weight (Figure 2).

The coefficient of determination (R^2) was 0.82 and 0.85 for wet weight and dry weight, respectively.

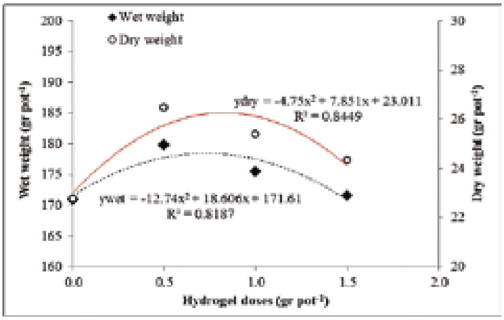

Figure 2. Relationship between wet and dry weight of corn and hydrogel doses

Relative dry and wet weight values were calculated on the basis of H_2 treatment which was obtained the highest yield. It was presented in Table 4.

Table 4. Relative percentage and variation of yield at different hydrogel doses

Treatments	Wet weight		Dry weight	
	RP	RD	RP	RD
H_1	95.10	4.90	86.02	13.98
H_2	100.00	0.00	100.00	0.00
H_3	97.61	2.39	96.92	4.08
H_4	95.43	4.57	91.95	8.05

RP: Relative persentage, RD: Relative difference.

Relative yield and relative differences were 4.90%, 2.39% and 4.57% and 13.98%, 4.08% and 8.05% for H_1, H_3 and H_4 for wet weight and dry weight, respectively.

Irrigation water salinity and hydrogel relationship

The salinity and hydrogel doses were evaluated together and the average wet and dry weight values are given in Table 5.

The highest average wet and dry weight was obtained at S_1H_2 treatment. When the salinity of the irrigation water increased, it was observed that to get a highest yield the hydrogel dose to be used increased up to the H_3 dose. If the salinity level continues to increase more than 3 dS m^{-1}, the hydrogel use dose decreased. As the concentration of salt in the medium increases, the swelling rate of the gel decreases.

Therefore, after a certain level of salinity, the hydrogel function decreases. It can be said that the amount of hydrogel used to reduce the loss of yield caused by the increase of irrigation water salinity should increase up to the determined threshold value. Several studies have suggested that hydrogels are less effective as salinity increases (Shannon 1978; Epstein 1985; Gumuzzio et al., 1985; Ashraf 1994; Aydın et al., 2000; Aydın, Malkoç 2003).

Table 5. Wet and dry weight according to different salt and hydrogel doses of corn

Wet weight (gr pot^{-1})					
Treatments	H_1	H_2	H_3	H_4	Average
S_1	171	180	175	172	174^a
S_2	141	149	170	143	151^b
S_3	119	121	125	139	126^b
S_4	93	96	103	100	97^c
Average	131^c	136^a	142^b	151^c	
Dry weight (gr pot^{-1})					
Treatments	H_1	H_2	H_3	H_4	Average
S_1	22.77	26.47	25.39	24.34	24.70^a
S_2	21.88	23.17	23.89	22.84	22.90a
S_3	18.61	21.12	21.49	21.77	20.70^b
S_4	16.18	16.66	17.89	17.15	16.90^c
Average	19.68	21.86	22.17	21.53	

Irrigation water use efficiency

The irrigation water use efficiency (IWUE) values calculated for each pot using the amount of dry weight obtained from the experiment and the amount of irrigation water applied (Table 6). The highest water use efficiency is obtained at S_1H_2 treatment (salinity: 0 dS m^{-1} and hydrogel dose: 0.5 gr pot^{-1}) with a value of 0.26.

Table 6. Irrigation water use efficiency (kg m^{-2}mm)

Treatments	H_1	H_2	H_3	H_4	Average
S_1	0.24	0.26	0.24	0.25	0.25^a
S_2	0.22	0.25	0.25	0.24	0.24^a
S_3	0.20	0.23	0.22	0.23	0.22^b
S_4	0.17	0.19	0.19	0.19	0.19^c
Average	0.21^b	0.23^a	0.23^a	0.23^a	

CONCLUSIONS

The highest average yield was obtained on non-saline irrigation water and 0.5 gr pot^{-1} hydrogel doses. As the salinity of the irrigation water increases, the swelling rate of the hydrogel was decreasing. According to this study results 1 gr pot^{-1} the hydrogel dose can be accepted as a threshold value. If irrigation water salinity up to 3 dS m^{-1} the hydrogel function is decreasing. In order to increase yield and IWUE, using 0.5 gr pot^{-1} hydrogel dose with good quality irrigation water can be recommended.

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