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Article

Impact of Anti-transpiration, Deficit Irrigation and Soil Organic Conditioners Application on Yield and Water Productivity of Corn Crop

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Anti-transpiration and soil organic conditioners play an important role in increasing crop and water productivity. The aim of this study is to evaluate the effect of anti-transpiration (K_2SiO_3), deficit irrigation (DI) and soil organic conditioners (SOC) on crop and water productivity of corn. Three main plots were used to receive DI treatments: I_1, 100%, I_2, 80% and I_3, 60% of crop evapotranspiration (ETc). Three sub-main plots to receive K_2SiO_3 rates: zero, 5, and 10 mM ha^{-1}. Four sub sub-main plots to receive SOC applications: zero, 5 t ha^{-1} of vermi-compost (VC), 10 t ha^{-1} of biochar (Bio), and (2.5 t ha^{-1} VC + 5 t ha^{-1} Bio). The results indicate that the highest values of relative water content, grain yield, biomass yield and economic income of the corn crop were 81.30%, 9.948 t ha^{-1}, 73.728 t ha^{-1}, and 95148 L.E. ha^{-1}, recorded at I_1 with VC (5 t ha^{-1}) and K_2SiO_3 rate 10 mM ha^{-1}. The highest value of water productivity was 1.457 kg m^{-3} recorded at I_3 with VC (5 t ha^{-1}) and K_2SiO_3 at a rate of 10 mM ha^{-1}. The effect of SOC application on the plant growth, yield and economic income could be arranged in descending order as follows: VC > (½VC + ½ Bio) > Bio > control. Under scarcity of irrigation water, the use of K_2SiO_3 (10 mM ha^{-1}) and VC application (5 t ha^{-1}) under DI treatment (I_2) could save about 20% of applied irrigation water with a low decrease in corn yield (< 10%).

Keywords: Anti-transpiration, deficit irrigation, soil organic conditioners, growth and yield of corn, water productivity, economic income.

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1. Introduction

Deficit irrigation practice use to sustain the crop productivity under scarcity of irrigation water by improving the water extraction of subsoil layers **(Karimi and Gomrokchi, 2011)**. Irrigation and soil organic conditioners application have a highly significant impact on increasing maize yield **(Aiad, 2019)**. Water is one of the most important factors for plant growth. When drought stress occurred, some bio-chemical properties and antioxidant are changed in the plants **(Shojaei *et al.*, 2021)**. The irrigation treatment 105% of full irrigation is superior due to decreasing water consumption, and with 10 mM of K_2SiO_3 can be considered to obtain the anticipated performance in the sweet corn **(Karvar *et al.*, 2023).** Severe water stress resulted an increase in proline, antioxidant enzyme activity, hydrogen peroxide, and other aldehydes, ultimately led to a 42% reduction in the yield **(Nematpour and Eshghizadeh, 2024)**.

The foliar application of anti-transpiration (K_2SiO_3) at different doses has increased productivity, 100 grains weight and the shoots weight of maize plants **(Sousa *et al.*, 2010)**. K_2SiO_3 is compound applied of the plant leaves to reduce transpiration and protect the plants from quickly drying out. In addition, it works to form a thin, non-water loving layer on leaves surface of the plant and minimize the plant surface exposed to infection **(Khan *et al.*, 2020)**. The foliar application of K_2SiO_3 relatively alleviated water stress induced damage. It could be recommended to mitigate the effect of deficit irrigation on maize crop **(Ibrahim *et al.*, 2020).** K_2SiO_3 application can increase water use efficiency (WUE) and produce high grains yield requiring less irrigation **(Gomaa *et al.*, 2021)**. Si mitigate the harmful effects caused by severe deficit irrigation in maize plants, because it kept the relative water content, reduce the cell leakage index, and improve the efficiency of photosystem, and enhance content and use efficiency of macronutrients **(Teixeira *et al.*, 2022)**.

Vermi-compost (VC) application until 10-ton ha^{-1} a rate, increased plant growth and some plant nutrients concentration and uptake **(Erdal *et al.*, 2018)**. The VC is one of the important soil organic conditioners which is the product of the composting process of the different organic wastes, *i.e.*, crop residues and/or manures using different earthworms **(Kiran, 2019)**. Vermi-compost is organic conditioner used in agricultural processes to prevent the damage caused by mineral fertilization **(Abd-Elrahman *et al.*, 2022)**. The maximum grains yield (7.504 t ha^{-1}) was obtained from application 4 t ha^{-1} of VC with 100 kg ha^{-1} of mineral nitrogen fertilizer **(Ensermu *et al.*, 2023)**. Increasing VC application rates caused increases in the total biomass of maize crop, due to increase the content of the available nutrients in the VC **(Neupauer *et al.*, 2023).**

Biochar (Bio) application to the soil under limited irrigation water might be led to increases in the maize yield and WUE by minimizing the negative effect of drought stress **(Alfadil *et al.*, 2021)**. Bio is a highly porous carbon rich material, which obtained after the pyrolysis of organic biomass. It applied of the agricultural soils to increase the soil, crop and water productivity **(Christian *et al.*, 2021).** Soil treated with Bio and compost had increasing the grains and biomass yields by 46.29% and 13.4%, respectively, as compared to control **(Zahra *et al.*, 2021).** The increasing rate of Bio application at rate 5 t ha^{-1}, led to increase the grains yield of maize by 28.0% **(Partovi *et al.*, 2021).** Bio application to the fine textured soils increased cropproductivity of sweet corn **(Singh *et al.*, 2022)**. The highest yield of maize crop (14.93 t ha^{-1}) was obtained by using combination of 15 t ha^{-1} of Bio with 276 kg mineral N ha^{-1} **(Li *et al.*, 2022).** Bio application had a significant effect on maize crop yield by changes in maize physiological characteristics and soil properties **(Cong *et al.*, 2023).** Each value of the grains and biomass yield were highest under Bio addition at rate 5 t ha^{-1} **(Park *et al.*, 2023).**

Maize is one of the widely cultivated crops and has a more ability to adaptation in different climates and soil environments. It accounts for 36% of the global food grains production, after rice and wheat crops **(FAO, 2019)**. Higher of the maize biomass yield were obtained under full irrigation **(Wani *et al.*, 2021)**. The world corn production is 1,214.47 million metric tons, and 7.6 million metric tons in Egypt **(USDA, 2023).** The composition of the corn grains endosperm containing carbohydrates (66.2%), lipids (3.6%), proteins (11.1%), vitamins and minerals (3.6%) and fibers (2.7%) **(Kaushal *et al.*, 2023).** Maize yield ranged from 7.15 to 13.15 t ha^{-1}, and the increasing trend in the maize crop yield with increased the irrigation water levels **(Palle, 2023)**.

Bio application is very important practice that can conserve the irrigation water, and increase the yield and water productivity of crops (**Alghamdi *et al.*, 2021).** Maize plants irrigated at deficit irrigation 50% of full irrigation water increased the WUE with minimal yield decreased **(Wani *et al.*, 2021)**. Bio addition decreased evaporation of the soil and delayed the required time for the soil moisture content drop to field capacity, and increased the water upward transport from the deeper soil layers **(Feng *et al.*, 2023).** Deficit irrigation at 0.66 of ETc had a low impact on the plant height, yield components and crop yield of maize, the water consumption of maize crop reduced by more 20%, and the irrigation water utilization efficiency increased from 25 to 40% **(Yuan *et al.*, 2024)**. Deficit irrigation water, soil conditioners and growing drought tolerant crops are using as irrigation water saving techniques in the agriculture sustainable (**Farag *et al.*, 2024)**.

The lowest values of the yield and net income were obtained at severe water stress in maize crop **(Sampathkumar *et al.*, 2014)**. The highest values of the total income, and net profit from water unit resulted by application of the compost at rate 11.9 t ha^{-1} under deficit irrigation I_2 (80% of full irrigation) **(Aiad, 2019)**. The current study aims to evaluate the effect of anti-transpiration (K_2SiO_3) spraying and soil organic conditioners applications on yield and water productivity of corn grown in heavy clay soils under deficit irrigation treatments.

2. Materials and Methods

2.1. Installation of the experiments

Field experiments (two summer seasons, 2020 and 2021) were conducted at Menshat Rabie Village, Itsa District, Fayoum, Egypt, (about 11 km south of Fayoum city). The coordinates of the experimental soil location are 29° 14` 04.3" N and 30° 51` 19.9" E. The aim of this study was evaluate the effect of anti-transpiration (K_2SiO_3), deficit irrigation (DI) and soil organic conditioners (SOC) on crop and water productivity of corn. To achieve this aim, three main plots were used to receive the deficit irrigation treatments, *i.e.*, 100, 80 and 60% of crop evapotranspiration (ETc), and named I_1, I_2 and I_3, respectively. Each main plot was divided into three sub-plots to receive the foliar anti-transpiration application concentrations

K_2SiO_3 (30% SiO_2 + 18% K_2O), i.e., control (zero addition), 5 mM ha^{-1} (1 L ha^{-1}), 10 mM ha^{-1} (2 L ha^{-1}),. Each sub-main plot was divided into four sub sub-plots to receive soil organic conditioners application, i.e., control, 5 t ha^{-1} VC, 10 t ha^{-1} of Bio, (2.5 t ha^{-1} VC + 5 t ha^{-1} Bio). The total number of the experimental units for each season was; 3 (irrigation treatments) × 3 (anti-transpiration concentration) × 4 (soil organic conditioners applications) × 3 (replicates) **=** 108 experimental units. The statistical design used in this study was a split split-plot system in a randomized complete blocks design **(Snedecor and Cochran, 1980)**. The main plots (irrigation treatments) were isolated by a dike of 2 m in width to avoid the horizontal movement of water between irrigation treatments. Some chemical analysis of the VC and Bio conditioners are presented in Table 1. The anti-transpiration (K_2SiO_3, solution) (30% SiO_2 + 18% K_2O) was purchased from Chem. Tech. for Chemicals, the K_2SiO_3 was sprayed to corn plants in two equal doses, the first dose was applied after 35 days of planting, and the second dose added after 25 days of first dose.

2.2. *Irrigation water applied (IWA)*

Class A Pan method used to estimate the ETo (reference evapotranspiration, mm day^{-1}**),** using the available meteorological data of Fayoum Governorate (Table, 2), and the ETo values were calculated from the following Eq. according **Allen et al. (1998)**:

$$ETo = E_{pan} \times K_{pan}$$

Where: E_{pan} = pan evaporation, mm day^{-1}, and K_{pan} = pan coefficient (equal = 0.85).

The crop evapotranspiration (ETc) values were calculated from the following Eq. according **(Doorenbos and Pruitt, 1992)**:

$$ETc = ETo \times Kc$$

Where: Kc is the crop coefficient.

The amounts of irrigation water applied (IWA, m^3) values of each plot through the irrigation regime were calculated by using the following Eq. **(Keller and Karmeli, 1975)**:

$$IWA = \frac{A \times ETc \times Ii}{Ea \times 1000}$$

Where: A = the soil area (m^2), ETc = the crop evapotranspiration (mm day^{-1}), Ii = the irrigation intervals (day), and Ea = the application efficiency of irrigation (60%).

The amount of IWA was controlled by spiles (plastic pipes) of 5.08 cm in diameter and 90 cm in length. One spile per plot used to convey the irrigation water from irrigation channel to plot. The discharge values of irrigation water (Q, L $Sec.^{-1}$) were calculated from the following Eq. **(Israelsen and Hansen, 1962)**:

$$Q = C\,A\,\sqrt{2gh} \times 10^{-3}$$

Where: A is the pipe area (cm^2), g = gravity acceleration (cm Sec^{-2}), h = the average of effective head of water (cm) above pipe surface, and C is the constant.

2.3. Corn planting and plant evolution conditions

Corn (*Zea maize* L.) (hybrid and single cross, Hytech 2031) was planted in two successive summer seasons of (2020 and 2021) to investigate the effect of soil organic conditioners application, deficit irrigation, and their interaction on some soil characteristics. Corn grains was planted manually in 10th of May in the 1st season and in 2nd of May in the 2nd season, respectively, in hills 20 cm apart from each to other, and the distance between rows was 60 cm, and keeping two plants per hill. Harvesting of the corn plants was after 120 days of the planting date for each season. Some growth and physiological parameters, yield and economical income of corn crop were measured. Soil organic conditioners were applied before planting. Corn plants received NPK fertilizers requirements as 119 kg N, 31 kg P_2O_5 and 24 kg K_2O units which equal to 250 kg ha^{-1} of urea fertilizer (46% N), 200 kg ha^{-1} of the calcium super phosphate fertilizer (15.5%, P_2O_5), and 50 kg ha^{-1} of potassium sulphate fertilizer(48% K_2O), respectively. Nitrogen fertilizer was applied in two equal doses. The application of the first dose was after thinning

Table 1. The chemical analysis of the organic soil conditioners (vermi-compost and biochar) used in the field experiment

Organic conditioners	OC (%)	TN (%)	C/N ratio	pH, in (1:2.5) of suspension	ECe, (dS m^{-1}) in the extract	$CaCO_3$ (%)	P (%)	K (%)
Vermi-compost	41.36	1.28	32.31	7.15	2.78	1.64	0.922	0.695
Biochar	44.17	0.98	45.07	7.83	3.88	1.32	0.316	0.484

Where: OC = organic carbon, TN = the total nitrogen.

Table 2. Monthly mean climatically data values for two seasons were obtained from Fayoum Agricultural Department, Fayoum, Egypt.

Month	Year	Temperature (°C)			Relative humidity (%)	Wind speed, (km h^{-1})	Number of sunshine hours	Class A pan evaporation, (mm/day)
		Max.	Min.	Mean				
May	2020	32.30	18.60	25.45	38	2.0	10.43	5.50
	2021	18.60	21.60	20.10	39	1.9	10.38	5.45
Jun.	2020	28.10	15.60	21.85	41	1.9	9.05	6.33
	2021	26.60	13.40	20.00	42	1.7	8.02	6.31
Jul.	2020	23.60	12.70	18.15	42	1.9	7.79	6.78
	2021	21.10	9.50	15.30	43	1.8	7.78	6.76
Aug.	2020	21.30	9.40	15.35	43	2.2	8.59	6.10
	2021	20.29	9.50	14.90	43	2.1	8.60	6.10
Sep.	2020	23.40	9.70	16.55	41	2.0	9.46	5.45
	2021	22.90	9.50	16.20	42	1.9	9.44	5.44

Where: Kc = the crop coefficient

operation which conducted at four leaves stage of the plant, and keeping two plants per hill. The second dose was added after four weeks of the first one. Also, supper phosphate was added before planting. Potassium sulfate fertilizer was applied after thinning. Agronomic practices were performed according to the recommendations of the Egyptian Ministry of Agricultural and land reclamation.

2.4. Soil analysis

Undisturbed and disturbed soil samples were collected from the experimental site, at two depths: 0-20 and 20-40 cm, before and after application of the studied treatments. Some physical determinations of the soil were carried out according to the methods described and outlined by **Klute (1986).** Also, chemical properties of the soil were obtained by using the methods outlined and described by **Page *et al.* (1982).** Table (3) show the initial values of some of the soil physical and chemical characteristics. Soil texture is heavy clayey, and the soil is calcareous. The clay fraction values increased with depth increment. The soil under study has decreases in pore spaces between the soil particles, low permeability, poor soil structure, and the subsurface layer more compacted, due to is low available water content and the soil have a high content of the clay fraction. These soils require the correctly integrated management of water and soil to get the highest productivity. Soil pH values ranged between (7.35-7.52), and the ECe values ranged between 3.66 dS m^{-1} at surface layer of the

Table 3. Some soil physical and chemical characteristics of the experimental field (as mean values of two seasons).

Soil properties	Soil layer depth, cm	
	0-20	20-40
Soil physical characteristics		
Particle size distribution, %		
Sand	7.0	7.2
Silt	32.9	27.3
Clay	60.1	65.5
Texture class	Clay	Clay
Soil particle density, g cm^{-3}	2.64	2.65
Soil dry bulk density, g cm^{-3}	1.41	1.43
Total porosity (%)	46.59	46.04
Air porosity (%)	29.82	26.87
Void ratio	0.87	0.85
Hydraulic conductivity, cm h^{-1}	0.10	0.09
Field capacity, %	37.80	36.90
Wilting point, %	25.50	25.80
Available water content, %	12.30	11.10
Soil chemical characteristics		
pH	7.35	7.52
EC, dS/m	3.66	5.51
Soluble cations (meq. L^{-1})		
Ca^{++}	10.28	15.42
Mg^{++}	5.84	9.66
Na^{+}	20.07	34.9
K^{+}	0.51	0.62
Soluble anions (meq. L^{-1})		
CO_3^{--}	--	--
HCO_3^{-}	1.5	2.2
Cl^{-}	9.01	17.78

SO_4^{--}	26.19	40.62
$CaCO_3$, %	10.25	15.43
Organic matter, %	1.89	1.06

3. Results and Discussion

3.1. Some growth and physiological parameters of corn plants

3.1.1. Plant height

Table (4) showed the effect of anti-transpiration concentrations and soil organic conditioners application on the height of corn plants grown under deficit irrigation treatments. The highest value of the plant height was 2.17 m and it was recorded at full irrigation I_1 (100% of ETc) with VC application (5 t ha^{-1}) and highest concentration of anti-transpiration (10 mM ha^{-1}). The mean values of the plant height significantly decreased by 5.19 and 12.74% when the deficit irrigation treatments increased from full irrigation (I_1) to I_2 and I_3 (severe irrigation), respectively. The plant height values of corn plants grown in the heavy clayey soil were significantly increased under full irrigation I_1 as compared to deficit irrigation treatments I_2 (80% of ETc) and I_3 (80% of ETc). These results might be attributed to the improving in the physical, chemical and biological properties in the soil under irrigation treatment I_1, which received the optimum irrigation water quantity. The mean values of the plant height significantly increased by 2.04 and 2.55% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the plant height significantly increased by 1.44 and 2.39% at full irrigation I_1, and by 2.54 and 3.55% at deficit irrigation I_2, and by 1.64 and 2.73% at deficit irrigation I_3, when anti-transpiration (K_2SiO_3) application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. These results are compatible with those observed by **Teixeira *et al.* (2022)** who reported that Si mitigated the harmful effects caused by severe deficit irrigation in maize plants.

The mean values of the plant height significantly increased by 3.06, 1.53, and 2.04% when the application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The mean values of the plant height were significantly increased by 2.88, 1.44 and 2.40% for full irrigation I_1 and by 3.55, 1.52 and 2.54% for deficit irrigation I_2 and by 2.73, 0.55 and 1.64% for deficit irrigation I_3 with application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. These results are in agreement with those observed by (**Meron, 2023).**

3.1.2. 100-grain weight

Table (4) showed that the highest value of the weight of 100 grains of corn was 45.61 g, it was recorded at full irrigation I_1 (100% of ETc) with VC application (5 t ha^{-1}) and the highest rate of K_2SiO_3 (10 mM ha^{-1}). The mean values of the weight of 100 grains significantly decreased by 11.06 and 23.39% when the deficit irrigation treatments increased from I_1 to I_2 and I_3, respectively. The weight of 100 grains values of corn plants grown in the heavy clayey soil were significantly increased under full irrigation I_1 compared to deficit irrigation I_2 and I_3. These results might be due to the improvement occurred in the soil physical, chemical and biological properties under irrigation treatment I_1, which received the optimum irrigation water quantity.

The mean values of the weight of 100 grains significantly increased by 9.59 and 14.66% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the weight of 100 grains significantly increased by 8.28 and 12.10% at full irrigation I_1, and by 8.57 and 14.16% at deficit irrigation I_2, and by 12.61 and 18.80% at deficit irrigation I_3 when anti-transpiration rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. These results are compatible with those observed by **Farhan *et al.* (2019).**

The mean values of the weight of 100 grains significantly increased by 14.40, 4.58, and 7.88% when the application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The mean values of the weight of 100 grains were significantly increased by 13.67, 4.60 and 7.41% at full irrigation I_1 and by 13.42, 4.31 and 6.99% at deficit irrigation I_2 and by 15.74, 4.89 and 9.57% at deficit irrigation I_3 when application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The increases in the weight of 100 grains values of corn attributed to the improvement effect of the soil organic conditioners application and potassium silicate as anti-transpiration on the physicochemical properties of the heavy clayey soil. These results are in agreement with those found by **(Kiran, 2019).**

3.1.3. Relative water content (RWC)

Table (4) showed that the effect of anti-transpiration rates and soil organic conditioners application on the RWC of corn plants grown under deficit irrigation treatments. The highest value of the RWC was 81.30%, recorded at full irrigation I_1 (100% of ETc), with VC application rate (5 t ha^{-1}) and the highest rate of anti-transpiration (10 mM ha^{-1}).

The mean values of the RWC significantly decreased by 7.30 and 12.02% when deficit irrigation increased from I_1 to I_2 and I_3, respectively. The RWC values of corn plants grown in the heavy clayey soil were significantly increased under full irrigation I_1 as compared to deficit irrigation treatments I_2 (80% of ETc) and I_3 (60% of ETc). These results might be attributed to the improvement occurred in the soil physical (soil structure, soil permeability and macro pores), chemical (soil pH, soil salinity) and biological properties under irrigation treatment I_1 which received the optimum irrigation water quantity. These results are in agreement with those concluded by **Abdou *et al.*** (**2024).**

The mean values of the RWC significantly increased by 3.79 and 9.21% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the RWC significantly increased by 4.93 and 10.15% at full irrigation I_1, and by 3.48 and 9.19% at deficit irrigation I_2, and by 2.84 and 8.16% at deficit irrigation I_3 when anti- transpiration rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. These results are in compatible with those observed by **(Karvar *et al.*, 2023).** The mean values of the RWC significantly increased by 9.36, 4.05, and 7.01% when the application each of VC, Bio and

(½VC + ½ Bio), respectively, as compared to the control. The mean values of the RWC were significantly increased by 10.32, 4.85 and 7.67% at full irrigation I_1 and by 8.16, 3.12 and 6.36% at deficit irrigation I_2 and by 9.61, 4.18 and 6.99% at deficit irrigation I_3, when application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The increases in RWC of values attributed to the improvement effect of soil organic conditioners application on the physicochemical properties of the heavy clayey soil, and enhancing the plant growth. These results are in agreement with those concluded by **Din *et al.* (2023)** who showed that the combined addition of compost and Bi improved the values of RWC, MSI and SPAD and they increased by 18.6%, 22.7% and 26.2%, respectively, as compared to control.

3.1.4. Membrane stability index (MSI)

Table (4) showed that the highest value of the MSI was 71.86% and it recorded at full irrigation I_1 (100% of ETc), with VC application (5 t ha^{-1}) and the highest rate of anti-transpiration application (10 mM ha^{-1}).

Table 4. Effect of deficit irrigation, anti-transpiration and soil organic conditioners applications on plant height, 100 grains weight, relative water content (RWC) and membrane stability index (MSI) of corn crop (as mean values of two seasons)

Treatment	Plant height, m	100 grains weight, g	RWC, %	MSI, %
Irrigation (I)	**	**	**	**
$I_{100\%}$	2.12±0.006c	40.49±0.458c	74.38±0.679c	64.57±0.678c
$I_{80\%}$	2.01±0.006b	36.01±0.438b	68.95±0.560b	61.79±0.586b
$I_{60\%}$	1.85±0.005a	31.02±0.472a	65.44±0.521a	58.75±0.572a
Anti-transp. (Ant)	**	**	**	**
Ant_0	1.96±0.018a	33.16±0.760a	66.70±0.678a	58.73±0.473a
$Ant_{5\ mM\ ha-1}$	2.00±0.019b	36.34±0.710b	69.23±0.753b	60.50±0.513b
$Ant_{10\ mM\ ha-1}$	2.01±0.019c	38.02±0.691c	72.84±0.796c	65.88±0.580c
Soil conditioner (SC)	**	**	**	**
Control (C)	1.96±0.020a	33.60±0.877a	66.21±0.852a	59.19±0.684a
Vermicompost (VC)	2.02±0.022d	38.37±0.877d	72.41±0.940d	63.93±0.839d
Biochar (Bio)	1.99±0.022b	35.14±0.855b	68.89±0.847b	60.86±0.746b
VC + Bio	2.00±0.022c	36.25±0.833c	70.85±0.896c	62.82±0.813c
Interaction	**	**	**	**
I_{100} × Ant_0 × C.	2.05±0.006p	35.04±0.061i	66.16±0.066h	59.32±0.081hij
I_{100} × Ant_0 × VC	2.11±0.006t	40.62±0.168n	74.57±0.115r	63.67±0.070nop
I_{100} × Ant_0 × Bio	2.09±0.003s	37.40±0.127l	69.94±0.095l	59.73±0.287ij
I_{100} × Ant_0 × VC + Bio	2.10±0.006st	38.61±0.230m	72.59±0.086p	62.45±0.035lmn
I_{100} × $Ant_{5\ mM}$ × C.	2.08±0.006r	38.63±0.123m	70.33±0.070m	61.34±0.080kl
I_{100} × $Ant_{5\ mM}$ × VC	2.15±0.006x	43.51±0.118q	77.00±0.032w	65.13±1.953qrs
I_{100} × $Ant_{5\ mM}$ × Bio	2.12±0.003u	40.65±0.092n	74.62±0.075r	62.10±0.444lm
I_{100} × $Ant_{5\ mM}$ × VC + Bio	2.14±0.006wx	41.44±0.070o	75.31±0.078s	64.02±1.402op
I_{100} × $Ant_{10\ mM}$ × C	2.10±0.003s	40.48±0.192n	74.60±0.075r	66.08±0.041st
I_{100} × $Ant_{10\ mM}$ × VC	2.17±0.006y	45.61±0.177r	81.30±0.076y	71.86±0.050x

I_{100} × $Ant_{10\ mM}$ × Bio	2.13±0.003uw	41.36±0.185o	76.74±0.042u	68.45±0.054u
I_{100} × $Ant_{10\ mM}$ × VC + Bio	2.14±0.006wx	42.57±0.104p	79.39±0.094x	70.67±0.061w
I_{80} × Ant_{0} × C.	1.95±0.003k	30.67±0.022e	62.58±0.073c	56.04±0.058bcd
I_{80} × Ant_{0} × VC	2.00±0.003m	36.40±0.180k	68.09±0.041j	61.41±0.049kl
I_{80} × Ant_{0} × Bio	1.96±0.003k	32.72±0.193g	66.36±0.064h	58.50±0.070ghi
I_{80} × Ant_{0} × VC + Bio	1.98±0.006l	34.10±0.107h	67.59±0.080i	60.210.038jk
I_{80} × $Ant_{5\ mM}$ × C.	1.98±0.003l	34.64±0.143i	66.16±0.046h	57.64±0.035efg
I_{80} × $Ant_{5\ mM}$ × VC	2.05±0.003op	38.61±0.211m	70.62±0.067n	63.14±0.048mno
I_{80} × $Ant_{5\ mM}$ × Bio	2.01±0.003m	35.79±0.359j	67.74±0.076i	60.08±0.046j
I_{80} × $Ant_{5\ mM}$ × VC + Bio	2.04±0.003no	36.30±0.213k	69.33±0.038k	62.33±0.027lm
I_{80} × $Ant_{10\ mM}$ × C	1.99±0.003l	36.41±0.247k	69.39±0.099k	62.49±0.064lmn
I_{80} × $Ant_{10\ mM}$ × VC	2.07±0.003q	40.38±0.207n	75.59±0.082t	68.15±0.048u
I_{80} × $Ant_{10\ mM}$ × Bio	2.03±0.003n	37.61±0.185l	70.20±0.046m	64.55±0.041pqr
I_{80} × $Ant_{10\ mM}$ × VC + Bio	2.05±0.003op	38.43±0.159m	73.79±0.035q	66.95±0.050t
I_{60} × Ant_{0} × C.	1.80±0.003a	25.50±0.084a	60.42±0.093a	54.49±0.076a
I_{60} × Ant_{0} × VC	1.86±0.003fg	30.65±0.209e	65.57±0.041g	57.14±0.050def
I_{60} × Ant_{0} × Bio	1.82±0.003b	27.67±0.079b	62.51±0.067c	55.27±0.043ab
I_{60} × Ant_{0} × VC + Bio	1.84±0.003cd	28.48±0.207c	64.00±0.068d	56.53±0.071bcde
I_{60} × $Ant_{5\ mM}$ × C.	1.83±0.006bc	29.40±0.098d	61.37±0.058b	55.74±0.047bc
I_{60} × $Ant_{5\ mM}$ × VC	1.89±0.003i	33.89±0.121h	67.73±0.040i	59.51±0.026ij
I_{60} × $Ant_{5\ mM}$ × Bio	1.84±0.003de	30.52±0.268e	64.37±0.050e	56.82±0.038cde
I_{60} × $Ant_{5\ mM}$ × VC + Bio	1.87±0.003gh	32.67±0.113g	66.23±0.027h	58.12±0.032fgh
I_{60} × $Ant_{10\ mM}$ × C	1.85±0.003ef	31.62±0.160f	64.85±0.047f	59.58±0.094ij
I_{60} × $Ant_{10\ mM}$ × VC	1.90±0.006j	35.61±0.208j	71.26±0.061o	65.38±0.058rs
I_{60} × $Ant_{10\ mM}$ × Bio	1.87±0.003h	32.56±0.228g	67.55±0.048i	62.27±0.050lm
I_{60} × $Ant_{10\ mM}$ × VC + Bio	1.88±0.003hi	33.64±0.206h	69.44±0.032k	64.10±0.038opq

The mean values of the MSI significantly decreased by 4.31 and 9.01% when the deficit irrigation increased from I_1 to I_2 and I_3, respectively. The MSI values of corn plants grown in the heavy clay soil were significant increased under full irrigation I_1 as compared to deficit irrigation treatments I_2 (80% of ETc) and I_3 (60% of ETc). These results might be attributed to the improving in the plant growth parameter under irrigation treatment I_1 which received the optimum irrigation water quantity. These results are in agreement with those found by **Abdou *et al.* (2024)** who reported that there are decreasing in RWC, MSI and SPAD values by 8.96, 5.91 and 14.67%, respectively, under deficit irrigation (I_{60}) as compared to full irrigation.

The mean values of the MSI significantly increased by 3.14 and 12.17% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the MSI significantly increased by 3.03 and 13.02% at full irrigation I_1, and by 2.98 and 11.01% at deficit irrigation I_2, and by 3.03 and 12.48% at deficit irrigation I_3 when anti-transpiration rate increased from zero to 5 mM ha^{-1} h^{-1} and 10 mM ha^{-1} h^{-1}, respectively. The anti-transpiration addition led to reduce the amount of water lost by transpiration. These results are compatible with those found by **Teixeira *et al.* (2022)** who reported that Si mitigated the harm caused by severe deficit irrigation in maize plants.

The mean values of the MSI significantly increased by 8.01, 2.82, and 6.13% when the application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The mean values of the MSI were significantly increased by 7.45, 1.90 and 5.54% at full irrigation I_1 and by 9.38, 3.95 and 7.56% at deficit irrigation I_2 and by 7.21, 2.69 and 5.27% at deficit irrigation I_3 when application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The increases in MSI of corn values attributed to the improvement effect in physicochemical properties when soil organic conditioners application in the heavy clayey soil which led to enhancing the plant growth parameters. These results are compatible with those found by **Abdou *et al.* (2024)** who concluded that the soil achieved with a high rate of Bi_{20}, contributed to significant increases in RWC, MSI and SPAD values by 5.94, 5.71 and 8.87%, respectively, as compared to control.

3.2. Grains and biomass yield of corn crop

3.2.1. Grains yield of corn crop

Table 5 and Figure 1 showed the effect of anti-transpiration rates and soil organic conditioners application on the grains yield of corn crop grown under deficit irrigation treatments. The highest value of the grains yield was 9.948 t ha^{-1} and recorded at full irrigation I_1 (100% of ETc), with VC application (5 t ha^{-1}) and the highest rate of anti-transpiration application (10 mM ha^{-1}). The mean values of the grains yield significantly decreased by 10.58 and 29.85% when the deficit irrigation treatments increased from I_1 to I_2 (80% of ETc) and I_3 (60% of ETc), respectively. The full irrigation I_1 had a superior effect on the grains yield values of corn crop as compared to other deficit irrigation I_2 and I_3. These results are in agreement with those concluded by **Ibrahim *et al.* (2020)**.

The mean values of the grains yield of corn crop significantly increased by 11.29 and 17.96% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the grains yield significantly increased by 6.06 and 19.21% at full irrigation I_1, and by 6.06 and 15.79% at deficit irrigation I_2, and by 14.62 and 18.79% at deficit irrigation I_3 when anti-transpiration rate increased from zero to 5 and 10 mM ha^{-1}, respectively. K_2SiO_3 application as foliar spraying led to decrease the adverse effect of deficit irrigation, and increased the grains yield due to it enhance the RWC, MSI, stomata conductance, transpiration rate, chlorophyll content, and photosynthesis rate. These results are compatible with those observed by **Teixeira *et al.* (2022).**

The mean values of the grains yield of corn crop significantly increased by 51.47, 42.01, and 46.88% when the application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The mean values of the grains yield of corn crop were significantly increased by 50.88, 43.11 and 47.24% at full irrigation I_1 and by 44.25, 34.00 and 38.42% at deficit irrigation I_2 and by 64.73, 56.00 and 59.00% at deficit irrigation I_3, when application each of VC, Bio and

(½VC + ½ Bio), respectively, as compared to the control. The increases in grains yield of corn might be due to the improvement occurred in the physical and chemical properties of heavy clay soil, which led to enhancing in the plant growth and yield. These results are in agreement with those concluded by **Arabi *et al.* (2023).**

3.2.2. Biomass yield of corn crop

Table (5) and Figure (1) showed that the highest value of the biomass yield was 73.728 t ha^{-1} and it recorded at full irrigation I_1 (100% of ETc), with VC application (5 t ha^{-1}) and the highest rate of K_2SiO_3 application (10 mM ha^{-1}). The mean values of the biomass yield significantly decreased by 12.06 and 18.45% when the deficit irrigation treatments increased from I_1 to I_2 and I_3, respectively. The full irrigation I_1 had a superior effect on the biomass yield values of corn crop as compared to other deficit irrigation treatments I_2 (80% of ETc) and I_3 (60% of ETc). These results are similar with those concluded by **Wani *et al.* (2021)**.

The mean values of the biomass yield of corn crop significantly increased by 6.72 and 12.80% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the biomass significantly increased by 3.83and 8.67% at full irrigation I_1, and by 8.30 and 13.26% at deficit irrigation I_2, and by 8.70 and 17.55% at deficit irrigation I_3 when anti-transpiration rates increased from zero to 5 and 10 mM ha^{-1}, respectively. The K_2SiO_3 application as foliar spraying effectively decreased the adverse effect of deficit irrigation, which led to increases in the biomass yield of corn crop values.

Table 5. Effect of deficit irrigation, anti-transpiration and soil organic conditioners applications on grains yield, biomass yield and water productivity of corn crop (as mean values of two seasons).

Treatment	Grains yield, t ha^{-1}	Biomass yield, t ha^{-1}	Water productivity, kg m^{-3}
Irrigation (I)	**	**	**
$I_{100\%}$	8.51±0.245c	63.53±1.60c	1.13±0.014a
$I_{80\%}$	7.61±0.189b	55.87±2.11b	1.24±0.015b
$I_{60\%}$	5.97±0.195a	51.81±2.09a	1.35±0.016c
Anti-transp. (Ant)	**	**	**
Ant_0	6.68±0.254a	53.58±1.97a	1.14±0.015a
$Ant_{5\ mM\ ha-1}$	7.53±0.269b	57.18±2.07b	1.26±0.017b
$Ant_{10\ mM\ ha-1}$	7.88±0.264c	60.44±2.13c	1.31±0.020c
Soil conditioner (SC)	**	**	**
Control (C)	5.44±0.214a	38.09±1.42a	1.18±0.023a
Vermicompost (VC)	8.24±0.239d	65.23±1.04d	1.22±0.023b
Biochar (Bio)	7.78±0.233b	61.67±1.03b	1.25±0.023c
VC + Bio	7.99±0.243c	63.27±1.07c	1.29±0.023d
Interaction	**	**	**
I_{100} × Ant_0 × C.	5.33±0.006e	45.76±0.0017g	1.02±0.0012b
I_{100} × Ant_0 × VC	8.55±0.008y	68.14±0.0020f	1.06±0.0009d
I_{100} × Ant_0 × Bio	8.11±0.006u	63.89±0.0009x	1.00±0.0006a

I_{100} × Ant_0 × VC + Bio	8.31±0.008w	66.16±0.0015b	1.03±0.0006c
I_{100} × $Ant_{5\ mM}$ × C.	6.67±0.003k	47.62±0.0012h	1.10±0.0006f
I_{100} × $Ant_{5\ mM}$ × VC	9.85±0.003f	70.02±0.0020i	1.22±0.0003o
I_{100} × $Ant_{5\ mM}$ × Bio	9.46±0.006b	67.13±0.0009d	1.17±0.0006i
I_{100} × $Ant_{5\ mM}$ × VC + Bio	9.67±0.008d	68.51±0.0017g	1.20±0.0009m
I_{100} × $Ant_{10\ mM}$ × C	6.85±0.008m	49.96±0.0017i	1.11±0.0009g
I_{100} × $Ant_{10\ mM}$ × VC	9.95±0.008g	73.73±0.0006k	1.23±0.0012r
I_{100} × $Ant_{10\ mM}$ × Bio	9.55±0.006c	69.47±0.0028h	1.18±0.0012k
I_{100} × $Ant_{10\ mM}$ × VC + Bio	9.77±0.006e	71.94±0.0009j	1.21±0.0009n
I_{80} × Ant_0 × C.	5.26±0.006d	33.60±0.0038c	1.09±0.0012e
I_{80} × Ant_0 × VC	7.93±0.003t	62.00±0.0015r	1.23±0.0006q
I_{80} × Ant_0 × Bio	7.49±0.003r	55.58±0.0015m	1.16±0.0006h
I_{80} × Ant_0 × VC + Bio	7.69±0.003s	57.29±0.0019o	1.19±0.0012l
I_{80} × $Ant_{5\ mM}$ × C.	5.93±0.011g	34.69±0.0036e	1.18±0.0006j
I_{80} × $Ant_{5\ mM}$ × VC	8.54±0.003y	65.05±0.0015z	1.32±0.0003u
I_{80} × $Ant_{5\ mM}$ × Bio	7.70±0.008s	62.36±0.0013t	1.19±0.0012l
I_{80} × $Ant_{5\ mM}$ × VC + Bio	7.92±0.006t	63.68±0.0015w	1.23±0.0006pq
I_{80} × $Ant_{10\ mM}$ × C	6.49±0.003i	36.97±0.0012f	1.19±0.0009l
I_{80} × $Ant_{10\ mM}$ × VC	9.05±0.008a	67.75±0.0017e	1.40±0.0009a
I_{80} × $Ant_{10\ mM}$ × Bio	8.45±0.006x	64.96±0.0015y	1.31±0.0012t
I_{80} × $Ant_{10\ mM}$ × VC + Bio	8.87±0.006z	66.45±0.0020c	1.37±0.0012y
I_{60} × Ant_0 × C.	3.46±0.003a	29.08±0.0059a	1.18±0.0012j
I_{60} × Ant_0 × VC	6.25±0.008h	55.12±0.0018l	1.29±0.0012s
I_{60} × Ant_0 × Bio	5.81±0.008f	52.54±0.0009j	1.20±0.0006m
I_{60} × Ant_0 × VC + Bio	5.93±0.008g	53.80±0.0012k	1.22±0.0013p
I_{60} × $Ant_{5\ mM}$ × C.	4.32±0.008b	31.44±0.0021b	1.35±0.0012w
I_{60} × $Ant_{5\ mM}$ × VC	6.98±0.003o	59.86±0.0009q	1.44±0.0012d
I_{60} × $Ant_{5\ mM}$ × Bio	6.58±0.003j	57.02±0.0019n	1.36±0.0006x
I_{60} × $Ant_{5\ mM}$ × VC + Bio	6.71±0.006l	58.81±0.0013p	1.38±0.0009z
I_{60} × $Ant_{10\ mM}$ × C	4.63±0.008c	58.81±0.0021d	1.41±0.0009b
I_{60} × $Ant_{10\ mM}$ × VC	7.06±0.008q	65.43±0.0015a	1.46±0.0009f
I_{60} × $Ant_{10\ mM}$ × Bio	6.89±0.003n	62.11±0.0017s	1.42±0.0013c
I_{60} × $Ant_{10\ mM}$ × VC + Bio	7.01±0.011p	62.81±0.0009u	1.45±0.0003e

These results are compatible with those observed by **Karvar *et al.* (2023).**

The mean values of the biomass yield of corn crop significantly increased by 71.25, 61.91, and 66.11% when the application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The mean values of the biomass yield of corn were significantly increased by 47.83, 39.87 and 44.14% at full irrigation I_1 and by 85.05, 73.76 and 78.04% at deficit irrigation I_2 and by 91.59, 82.30 and 86.28% at deficit irrigation I_3, when application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The increases in biomass yield of corn might be attributed to the improvement occurred in the physical and chemical properties in the heavy clayey soil after organic conditioners application, which led to increases in the plant growth and yield. These results are in parallel with those concluded by **Neupauer *et al.* (2023) and Park *et al.* (2023).**

3.3. Irrigation water applied (IWA)

The amounts of irrigation water applied values at the three irrigation treatments I_1, I_2 and I_3 were 8076.88, 6461.50 and 4846.13 m^3 ha^{-1}, respectively. When decreasing the IWA value by 20% (deficit irrigation, I_2), the grains yield andbiomass yield of corn crop decreased by 10.58% and 12.06%. While, when decreasing the IWA value by 40% (deficit irrigation, I_3), the grains and biomass yields of corn crop decreased by 29.85% and 18.45%. The relationship between each of grains and biomass yields of corn crop and IWA was plotted, and the results showed that there are a positive significantly correlation between IWA and each of grains and biomass yields. The simple regression equations between IWA and each of grains and biomass yields of corn crop as the following:

$Y_1 = 2.269 + 0.0008\ X$ $\quad\quad R^2 = 0.9716$

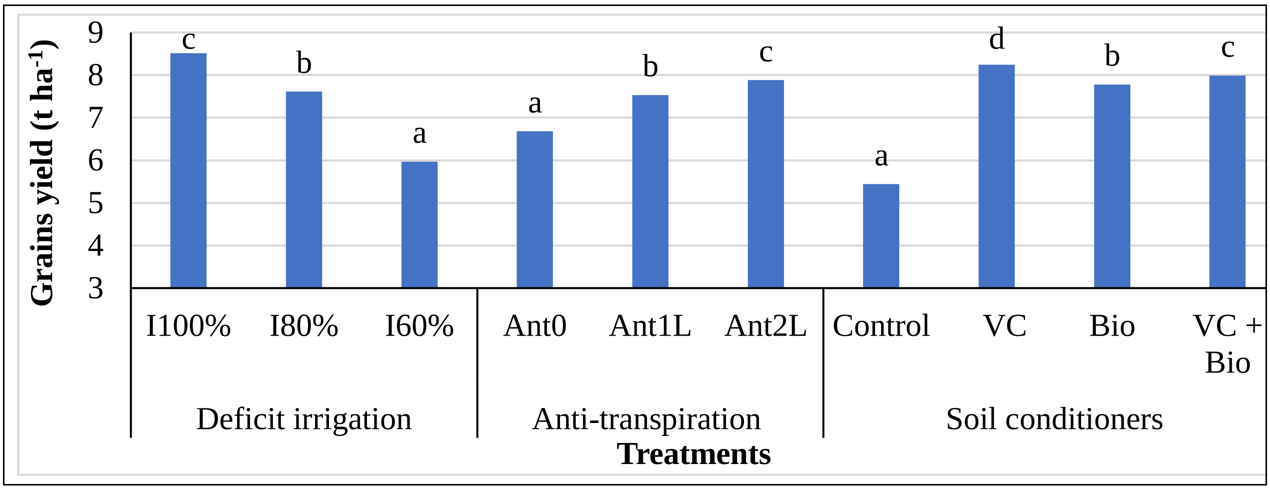
$Y_2 = 33.62 + 0.0036\ X$ $\quad\quad R^2 = 0.9695$

Where: Y_1 is the grains yield of corn crop (t ha^{-1}), Y_2 is the biomass yield of corn crop (t ha^{-1}), and X is the IWA (m^3 ha^{-1}).

From the aforementioned regression equations, we could predict of the yield of corn crop (grains or biomass) when the irrigation water amounts is scarcity.

3.4. Water productivity (WP) of corn crop

Table (5) and Figure (1) showed that the effect of anti-transpiration rates and soil organic conditioners application on the WP values of corn crop grown under deficit irrigation treatments. The highest value of the WP was 1.457 kg m^{-3} and it recorded at irrigation treatments I_3 (60% of ETc), with VC application (5 t ha^{-1}) and the highest rate of anti-transpiration application (10 mM ha^{-1}). The mean values of the WP significantly increased by 9.73 and 19.47% when the deficit irrigation treatments increased from I_1 to I_2 (80% of ETc) and I_3.



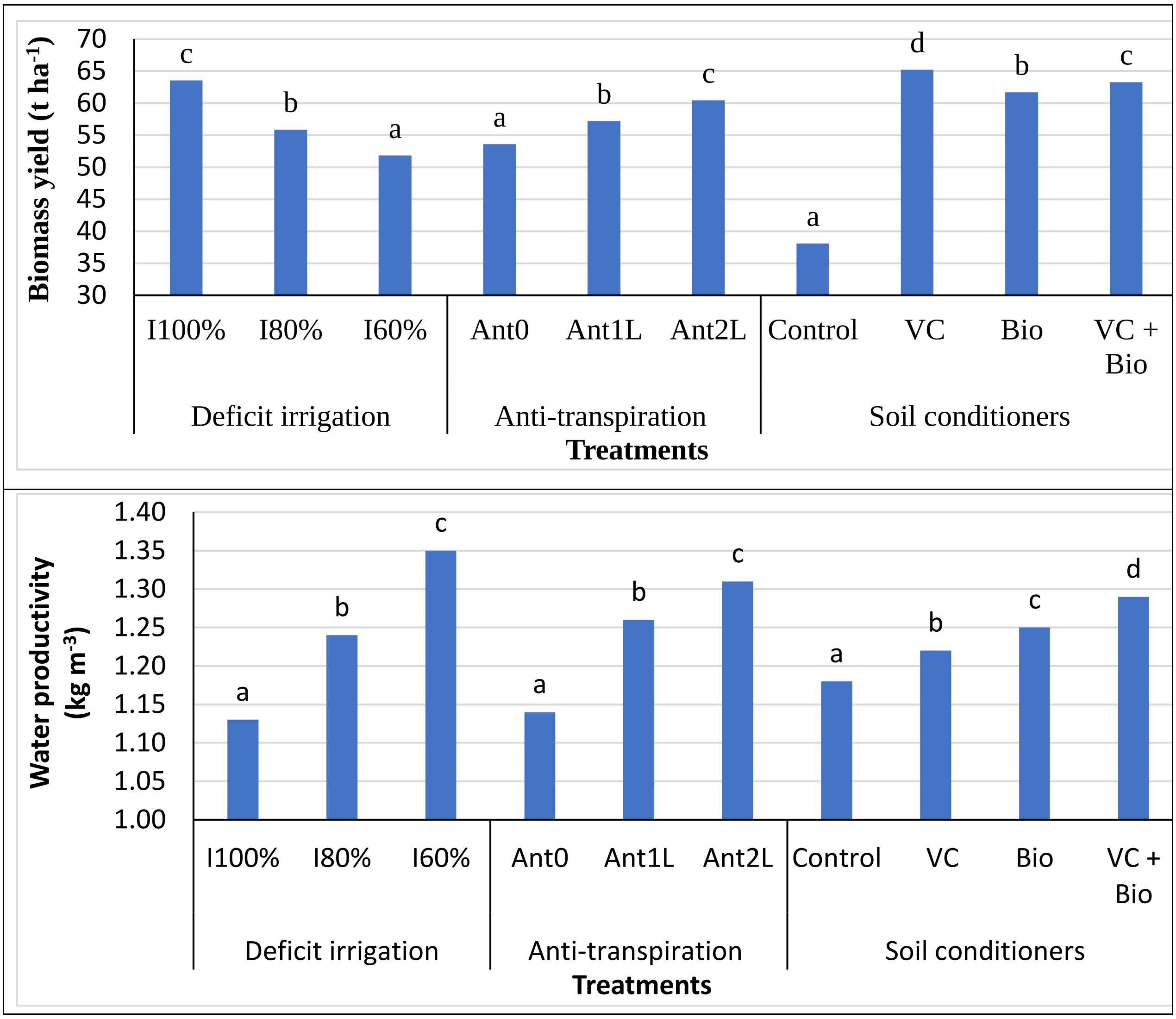


Fig. 1. Effect of deficit irrigation, anti-transpiration and soil organic conditioners applications on each of grains yield (t ha^{-1}), biomass yield (t ha^{-1}) and water productivity (kg m^{-3}) of corn crop (as mean values of two seasons).

(60% of ETc), respectively. These results might be attributed to the increases in the grains yield of corn crop under deficit irrigation treatment I_3 due to the application of anti-transpiration which decreased the water losses by transpiration. These results are in similar with those concluded by **Wang *et al.* (2023)** who found that under deficit irrigation, the WP value of maize crop was increased (> 2.7 kg m^{-3}).

The mean values of the WP of corn crop significantly increased by 10.52 and 14.91% when the K_2SiO_3 application rate increased from zero to 5 mM ha^{-1} and 10 mM ha^{-1}, respectively. The mean values of the WP significantly increased by 14.01 and 15.08% at full irrigation I_1, and by 5.31 and 12.85% at deficit irrigation I_2, and by 13.00 and 17.17% at deficit irrigation I_3 when anti-transpiration rate increased from zero to 5 and 10 mM ha^{-1}, respectively. Anti- transpiration application improved the physiological parameters in the plants. These results are similar with those concluded by **Ulameer and Ahmed (2018)** who found that spraying anti-transpiration agents led to increases in the growth parameters under deficit irrigation condition.

The mean values of the WP of corn crop significantly increased by 3.39, 5.93, and 9.32% when the application each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The mean values of the WP values of corn crop were significantly increased by 8.84, 4.09 and 6.51% at full irrigation I_1 and by 14.14, 5.72and 9.54% at deficit irrigation I_2 and by 6.40, 1.07 and 2.97% at deficit irrigation I_3, when addition each of VC, Bio and (½VC + ½ Bio), respectively, as compared to the control. The effect of soil organic conditioners on each of plant height, weight of 100 grains, RWC, MSI, grains and biomass yields and WP of corn values could be havetake the following descending order: VC > (½VC + ½ Bi) > Bi > control. It could be reported that the increases in the WP values of corn crop due to the improvement effect of the soil organic conditioners application to the heavy clayey soil. These results are in agreement with those observed by **Alghamdi *et al.*** (**2021**).

3.5. Economic income and net profit of corn crop

Table (6) showed the effect of anti-transpiration rates, deficit irrigation treatments and soil organic conditioners application on the economic income and net profit of corn crop grown in heavy clayey soil. The highest value of economic income of corn crop was 95148 L.E. ha^{-1} and it recorded at full irrigation treatment I_1 with VC and highly application rate of K_2SiO_3 (10 mM ha^{-1}). While, the highest value of the net profit of corn crop was 56079 L.E. ha^{-1} and it recorded at full irrigation treatment I_1 with Bio application (10 t ha^{-1}) and high application rate of K_2SiO_3 (10 mM ha^{-1}). The net profit values were highly with Bio. application due to low cost of Bio. conditioner as compared to VC conditioner. The increases in the values of economic income and net profit attributed to the perfection occurred in the physiochemical properties of heavy clayey soil which resulted improvement in yield of the corn crop.

Increasing deficit irrigation treatments from I_1 to I_2 and I_3 led to decreases in the mean values by 10.05 and 29.94% for total economic income and by 17.00 and 43.88% for net profit values of corn, respectively.

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Table (6). Economic income and net profit values (L.E. ha^{-1}) of corn crop as affected by anti-transpiration rates and soil organic conditioners application under different irrigation treatments (as mean values of two seasons) *

Anti-transpi-ratio (Anti-T)	Soil organic condit.	Full irrigation (I_1,100% of ETc)				Deficit irrigation (I_2, 80% of ETc)				Deficit irrigation (I_3, 60% of ETc)			
		Total costs, L.E. ha^{-1}	Total income, L.E. ha^{-1}	Profit net., L.E. ha^{-1}	Mean Profit net., L.E. ha^{-1}	Total costs, L.E. ha^{-1}	Total income, L.E. ha^{-1}	Profit net., L.E. ha^{-1}	Mean Profit net., L.E. ha^{-1}	Total costs, L.E. ha^{-1}	Total income, L.E. ha^{-1}	Profit net., L.E. ha^{-1}	Mean Profit net. L.E. ha^{-1}
Cont. (Anti-T_0, 0 L ha^{-1})	Cont.	14453	53475	39022	41189	14453	48170	33717	34457	14453	34482	20029	21254
	VC	44453	83707	39254		44453	77152	32699		44453	63312	18859	
	Biochar	34453	79054	44601		34453	71635	37182		34453	59348	24895	
	½VC+½Bi	39453	81331	41878		39453	73684	34231		39453	60686	21233	
Anti-T_1 (5 mM ha^{-1})	Cont.	14603	63056	48453	50805	14603	53042	38439	41236	14603	41102	26499	28774
	VC	44603	93032	48429		44603	82349	37746		44603	69998	25395	
	Biochar	34603	89302	54699		34603	85200	50597		34603	69610	35007	
	½VC+½Bi	39603	91240	51637		39603	77765	38162		39603	67796	28193	
Anti-T_2 10 mM ha^{-1})	Cont.	14753	65208	50455	52605	14753	57636	42883	44318	14753	44042	29289	31118
	VC	44753	95148	50395		44753	86816	42063		44753	72782	28029	
	Biochar	34753	90832	56079		34753	81723	46970		34753	70304	35551	
	½VC+½Bi	39753	93244	53491		39753	85108	45355		39753	71355	31602	
		Mean	81552	48199		Mean	73357	40004		Mean	60401	27048	

Where: The total costs = 13025 L.E. ha^{-1} = {1700 L.E. preparing the soil + 1200 L.E. planting + 1200 L.E. hoeing + 500 L.E. weeds protection + 600 L.E. insects protection + 1200 L.E. harvesting + fertilizers (12 Urea bags × 300 L.E. = 3600 L.E. + 9.5 superphosphate bages × 150 = 1425 L.E. + 50 kg potassium sulphate = 1600 L.E.)}. 1 ton vermi-compost = 6000 L.E., 1 ton biochar = 2000 L.E., One irrigation = 178.5 L.E. ha^{-1}, 1 ton of corn grains yield = 7000 L.E., 1 ton of corn shoots yield = 400 L.E.

Topak *et al*. (2011) found that 25% deficit irrigation saving of irrigation water, caused 6.1% reduction in the net income. Increasing application rate of K_2SiO_3 from zero to 5 and 10 mM ha^{-1} resulted significant increases in the mean values of the net profit

of corn crop by 23.34 and 27.72% at full irrigation (I_1), and by 19.67 and 28.62% at deficit irrigation (I_2), and by 35.38 and 46.41% at deficit irrigation (I_3), respectively. The increases in the economic income and net profit values, which resulted from soil organic conditioners were superior as compared with resulted from K_2SiO_3 applications.

It could be recommended that, when irrigation water is adequate, using spray application of K_2SiO_3 (10 mM ha^{-1}), and VC application (5 t ha^{-1}) under full irrigation treatment (I_1), which resulted improvement in the properties of the heavy clayey soil and enhancing the growth and physiological parameters, grains and biomass yields, and economic income of corn crop. While, under scarcity of water resources, deficit irrigation treatment (I_2) can be applied with VC application (5 t ha^{-1}) and spray application of K_2SiO_3 (10 mM ha^{-1}), this will save about 20 % of the IWA (about 1615 m^3 ha^{-1}) with low decreasing in the grains or biomass yields of corn crop (< 10 %). Also, when the aim is reach to the highest values of net profit and water productivity, Bio (5 t ha^{-1}) should be added to this soil with deficit irrigation (I_2) and anti-transpiration rate 10 mM ha^{-1}.

4. Conclusion

The aim of this study is to evaluate the effect of anti-transpiration (K_2SiO_3), deficit irrigation (DI) and soil organic conditioners (SOC) on yield and water productivity of corn. Results indicated that, the highest values of growth and physiological parameters, grains and biomass yield and economic income of corn were recorded at full irrigation (I_1) with VC (5 t ha^{-1}) and K_2SiO_3 rate (10 mM ha^{-1}). The highest value of water productivity was recorded at DI I_3 with VC (5 t ha^{-1}) and K_2SiO_3 rate 10 mM ha^{-1}. The effect of SOC application on the yield and economic income betake the descending order: VC > (½VC + ½ Bi) > Bi > control. It could be recommended that, under scarcity of irrigation water, it could be use K_2SiO_3 (10 mM ha^{-1}) and VC (5 t ha^{-1}) under DI treatment (I_2) to save 20% of the irrigation water applied with low decrease in corn yield.

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