J. Plant Production, Mansoura Univ., Vol. 6 (10):1733 -1754,2015

EFFECT OF IRRIGATION LEVELS AND SOME TREATMENTS TO REDUCE WATER LOSSES ON THE GROWTH AND YIELD OF TOMATO PLANTS GROWN UNDER NORTH SINAI CONDITIONS

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ABSTRACT

The experiment was conducted during the two successive seasons of 2013 and 2014 at the Agriculture Research Station, in El- Arish, North Sinai Governorate, Egypt. Tomato "GS12" hybrid was used in the experiment to study the effect of three water irrigation levels ,.i.e. 100 %, 75 % and 50 % from water requirements of tomato plants under foliar spray with two materials, i.e Dodouxil Benzene Sulphonate "DBS" and Potassium silicate "PS" at two rates 2 and 6 cm/liter on the growth, fruit yield and its quality as well as some water irrigation relationship. Split plot design was used in the experiment. The results showed that, irrigation at the level 100% from tomato requirements with foliar spray by any one of the materials used, i.e. (DBS) or (PS) at the concentration of 6 cm/liter then the concentration of 2 cm/liter recorded the high values of growth parameters, i.e. dry weight of tomato plant organs (roots, leaves and stem). The superior total yield was obtained from the same treatment. The same treatment hassend also, physical and chemical fruit quality. While irrigation tomato plants with 75% from its requirement led to reduction in fruit yield by 25% but in the same time saved 33.6% from water irrigation, moreover irrigation tomato plants with 50% levels saved about 43% from water irrigation and induced 50%reduction from tomato yield. Foliar spray with potassium silicate or Dodouxil Benzene Sulphonate showed significant values in tomato growth, fruit yield and its quality and increased the water use efficiency of tomato plants grown under the condition of North Sinai.

INTRODUCTION

Water supply is a major constraint factor to crop production in the north Sinai region. The dependence of crop yield on water supply is a critical issue because of the increasing limited water resources for irrigation. The underground water is the main source of irrigation through using drip irrigation system. It is known that, the soil of north Sinai characterized with low holding water capacity and coarse-textured type, moreover, its weather characterize with high temperature in the summer, that is induce low water use efficiency and this reflect on crop water requirements.

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important and has the highest acreage of any vegetable crop in the world (Jensen et al., 2010). In 2010, its global production was approximately 145.6 million tons of fresh fruit (Matos et al., 2012). The tomato is an important global vegetable crop (Berova and Zlatev, 2000), and require a high water potential for optimal vegetative and reproductive development (Waister and Hudson, 1970). Arid and semi-arid regions are characterized by unreliable rainfall, high radiation load and high evaporative demand, with soils generally of poor structural stability, low water holding capacity and low fertility (Monteith and Virmani, 1991). Water is the solvent in which gasses, minerals, and other solutes enter plant cells and move from organ to organ. It is a reactant in many important biochemical processes, including photosynthesis and hydraulic processes. Another role of water is in the maintenance of turgor, which is essential for cell enlargement and growth (Kramer and Boyer,1995). Stated that irrigation water should be applied adequately during plant growth stages (Ahmed, 1991). Delaying or reduction in water irrigation causes shortage vegetative growth falling of the flowers, reduces early-formed fruit size as well as total yield. While Increasing irrigation will increase the vegetative growth. However, it can increase water-use efficiency of a crop by reducing evapotranspiration and minimizing leaching into groundwater. On the other hand, silicon (Si) is not recognized an essential element for the growth of higher plants, it has been proved that Si is beneficial or quasi-essential to plants. Several investigators showed that silicon supplementation affects the plant growth, yield and fruit quality, in addition (Si) has been shown to improve stimulates photosynthesis, reduces transpiration rate by decreasing stomatal resistance leaves or maintaining plant water balance and erectness of leaves and structure of xylem vessels under high transpiration rates, and enhances plant resistance to a series of both abiotic and biotic stresses such as water and chemical stresses, nutrient imbalances, metal toxicities, diseases and pests problems (Cherif *et al*., 1992; McAvoy and Bible, 1996; Liang *et al*., 2001; Lu and Cao, 2001; Ma and Takahashi, 2002; Zhou et *al*., 2002; Hodson and Sangster, 2002). It was found that addition silica deposition on the leaves limits transpiration in *Prosopis juliflora* and wheat, in addition,(Yeo *et al*., 1999) Found that the mode of action of silica in rice is by partial blockage of the transpirational bypass flow. (Trenholm et al., 2004) have suggested that silicate crystals deposited in epidermal cells form a barrier that reduces water loss through the cuticles. Foliar application by Si cause formation of double layer cuticle'-Si in the leaf cause increasing of thickness this layeres and thus cuticular transpiration in the leaf was decreased too much and RWC (Relative water content) was increased (Romero-Aranda *et al.,* 2006). Application of Si or $K_2 SiO_3$ to several crops through sub-irrigation or foliar spray has enhanced vitamin C, leaf chlorophyll "a" and total chlorophyll in the leaves, and contents of beta-carotene also, total solid solutes were observed in tomato plants. These results produced by many of the researchers, Respectively (Stamatakis *et al.*, 2003 and Silva *et al.,* 2012;). Regarding, Potassium (K) is an essential nutrient that affects on most of the biochemical and physiological processes that influence plant growth and metabolism. Also, K plays essential roles in enzyme activation, protein synthesis, photosynthesis, osmoregulation, energy transfer, phloem transport, cation-anion balance, one of the major functions of the stomata is to control plant water loss via transpiration and stress resistance (Mengel, 2001; and Marschner and Marschner 2012). The objective of this research was to study the effect of irrigation levels and some foliar spray treatments, i.e Dodouxil Benzene Sulphonate as well as Potassium Silicate to reduce water losses and it's reflict on the growth and yield of tomato plant.

MATERIALS AND METHODS

The present work was carried out during the two successive seasons of 2013 and 2014 at the Agriculture Research Station, in El- Arish, North Sinai Governorate, Egypt. Tomato "GS12" hybrid was used in the study. The seeds were sown in the 10th May in the nursery. Uniform Seedlings were selected and transplanted on 5th and 10th Jun in 2013 and 2014 seasons, respectively. Seedlings were transplanted besides dripper lines, the distance between every two dripper lines in each row were 120 cm. The distance between plants in the same line was 40 cm. The plot area was 12 m^2 (10 m long and 120 cm between each two dripper lines in each row).

The objective of this experimental was to study the effect of three irrigation levels (namely, 100 %, 75 % and 50 % of water requirements (WR) for tomato plants) add the irrigation water using gage (2310,1733 and 1155 m^3/fed. for 100, 75 and % of WR respectively). With three levels of foliar spray (without, 2 cm/l and 6 cm/l) of Dodouxil Benzene Sulphonate "DBS" 22% under Commercial name Volume which contains (N 5%, P 15% and K 9.5%), and Potassium silicate "PS" which contains (Potassium Oxide 10% and Silicon Oxide 25%) Solutions for both" DBS" and "PS" Foliar spraying took place after 20, 40, 60 and 80 days from transplanting) on growth, yield and fruits quality of tomato.

Treatments were arranged randomly in a split-plot design, wherein the three irrigation levels were randomly arranged in the main plots and the foliar spraying treatments for both" DBS" and "PS" beside control treatment were randomly distributed in the sub plots with four replicates, in a completely randomized block design.

Some physical and chemical properties of the experiment soil used and chemical analysis of irrigation water were presented in Tables 1 and 2 respectively, according to the stander by Ryan *et al.* (1999).

Table 1: Mechanical and chemical properties of the experimental soil.

<table>
<tr><th colspan="3">Mechanical analysis %</th><th colspan="14">Chemical analysis (soluble ion in (1:5 extract)</th><th rowspan="4">Organic matter %</th></tr>
<tr><th>sand</th><th>silt</th><th>clay</th><th colspan="4" rowspan="2">Total (ppm)</th><th colspan="8">meq./l</th><th rowspan="3">ECe</th><th rowspan="3">pH</th></tr>
<tr><td rowspan="2">88.7</td><td rowspan="2">4</td><td rowspan="2">7.3</td><th colspan="3">Cations</th><th colspan="5">Anions</th></tr>
<tr><th>N</th><th>P</th><th>K</th><th>Ca^{++}</th><th>Mg^{++}</th><th>Na^+</th><th>K^+</th><th>$So^{--}4$</th><th>Cl-</th><th>Co_3</th><th>Hco_3</th><th>$Ca Co_3$</th></tr>
<tr><td colspan="3">Soil texture (Sand)</td><td>10</td><td>57.6</td><td>26</td><td>2.0</td><td>2.0</td><td>0.82</td><td>0.23</td><td>2.4</td><td>2.4</td><td>-</td><td>0.2</td><td>0.2</td><td>0.5</td><td>7.9</td><td>0.08</td></tr>
</table>

Table 2: Chemical analysis of irrigation water.

<table>
<tr><th rowspan="3">pH</th><th rowspan="3">EC (dSm^{-1})</th><th colspan="8">Soluble ions($meq.1^{-1}/L$)</th><th rowspan="3">S.S.P %</th><th rowspan="3">S.A.R</th><th rowspan="3">R.S.C</th></tr>
<tr><th colspan="4">Cations</th><th colspan="4">Anions</th></tr>
<tr><th>Ca^{++}</th><th>Mg^{++}</th><th>Na^+</th><th>K^+</th><th>Cl^-</th><th>HCO_3^-</th><th>CO_3^{--}</th><th>SO_4^{--}</th></tr>
<tr><td>7.86</td><td>8.28</td><td>15.4</td><td>14.6</td><td>45.2</td><td>0.2</td><td>47.5</td><td>2.6</td><td>-</td><td>25.93</td><td>12.9</td><td>64.3</td><td>25.7</td></tr>
</table>

Data recorded

1. Water relations

Soil parameters were determined before conducting the experiments as the following:

a. Particles size distribution: It was determined using the international A.C.A. Pippete method (Piper, 1950).

b. Bulk density:It was determined using J.R.H. Coutts cylinder (Piper, 1950).

c. Calcium carbonate:It was determined as $CaCO_3$ % by means of Collin's calcimeter (Jackson, 1967).

d. Soil pH value: It was determined in 1:2.5 soil water suspension.

e. Water holding capacity, field capacity and wilting point They were determined by the weighing method using the pressure cocker and pressure membrane method (Richard, 1954).

The soil, water extract from the 1:5 soil, water ratio was chemically analyzed for:

1) Electrical conductivity (E.C), conductimetrically using Radiometer Copenhagen N.V. Type CDM 2d, Jackson (1967).

2) Carbonate and bicarbonate, titremetrically using H_2SO_4 and phenophthalein and bromocresol green as indicators.

3) Chloride following Mohr's method, Richard (1954).

4) Soluble sulfate was taken by the difference between the sum of soluble cations and anions.

5) Soluble potassium and sodium, by the flame photometer, Richard (1954).6) Calcium and magnesium, by the versenate method using ammonium purpurate as an indicator for Ca^{++} and Eriochrome black T for Ca^{++} plus Mg^{++}, Jackson (1967). Soil moisture was determined by the weighing method after and before irrigation, Richard (1954). Air temperature and relative humidity were recorded from the meteorological station at El-Arish, North Sinai Governorate.

Water Use Efficiency (WUE)

The consumed water by sugar beet, fodder beet and wheat plants were calculated according to Yaron *et al.* (1973a) as follows:

$$\text{W.U.E.} = \frac{Y}{Eta}$$

Where:

Y = Crop yield in kg fed^{-1}

ETa = Evapotranspiration in m^3 fed^{-1}

The actual evapotranspiration, ETa, is assumed to be synonymous with the calculated consumptive use of water (CU). Consequently, daily and monthly consumptive use of water were calculated, for specified soil depths, for all treatments.

The reductions in yield and water saving were calculated from the following equations Ismail, (2010):

$$\text{Reduction in yield} = 100 - \frac{(\text{Yield of 75 \% of WR or 50\% of WR})}{\text{Yield of 100 \% of WR}} \times 100$$

$$\text{Water saving} = 100 - \frac{\text{(Water consumption of 75 \% of WR or 50\% of WR)}}{\text{Water consumption of 100 \% of WR}} \times 100$$

2. Vegetative growth

A random sample of 5 plants from each plot was taken at 70 days after transplanting and vegetative characters were recorded, i.e fresh weight of roots, stems, leaves, clusters (g), and dry weight of root, stem, as well as leaves (g), and total fresh and dry weight/plant (g) were calculated.

3. Fruit yield

Fruit yield was divided into two grades (grade A: fruits weights more than 100g, and weights grade B: fruits weights less than 100g). The following measurements were studied:

a. Early yield per plant (g), early yield per fed. (ton) and average fruit weight (g). Early yield was calculated from the first three harvestings, and

b. Total yield per plant (g) total yield per fed. (ton) as well as average fruit weight (g) were calculated.

4. Fruit quality

At the red ripe stage of the third picking samples of ten fruits were randomly taken from each sub plot and the following data were recorded**:**

a.Ascorbic acid (V.C)

It was determined in fruit juice (as mg/100ml juice) using 2,6 diclorophenol endophenol as described in A.O.A.C. (1990).

b. Titratable acidity

It was determined by titration against Na OH using phenolphthalein as indicator according to the method described in A.O.A.C. (1990).

c. Fruit total soluble solids (TSS %)

It was measured using a hand refractometer A.O.A.C. (1990).

5. Statistical analysis

Statistical analysis of the obtained data was carried out according to statistical analysis of variance according to Snedecor and Cochran (1980). Duncan's multiple range tests was used for comparison among the means (Duncan, 1958). The M stat C program was used for analysis.

RESULTS AND DISCUSSION

1. Water use efficiency (WUE)

The water use efficiency for irrigation treatments are presented in Table (3). Reveal that a highly significant differences among the irrigation levels. Increasing the irrigation deficit was met by a high increase in the WUE. The highest value of WUE was obtained from 50% of WR treatment, while the lowest one was recorded from 100% of WR treatment. Data presented in Table (4) show that, the effect of the interaction between the irrigation levels and foliar spray treatments, it showed highly water use efficiency with the irrigation 50% of WR with PS 6 cm/l in the both seasons, while the lowest values were with the irrigation 100% of WR with without foliar spray by anyone of the material used in the both seasons.

Table 3 Effect of irrigation levels and foliar spray with PS and DBS on tomato total yield and some watering relationship during 2013 and 2014 seasons.

Characters / Variables	Yield (ton/fed.)	Water consumptive use (m^3/fed.)	Water use efficiency (kg/m^3)
Irrigation Levels	**Season2013**		
100%	23,72	2100,34	11,29
75 %	15,75	1484,53	10,61
50%	13,32	989,54	13,46
	Season2014		
100%	24,66	2098,45	11,75
75 %	18,13	1475,23	12,29
50%	15,97	985,87	16,20

100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

Table 4 Effect of the interaction between irrigation levels and foliar spray with PS and DBS on tomato total yield and some watering relationship during 2013 and 2014 seasons.

Characters / Variables		Yield (ton/fed.)	Water consumptive use (m^3/fed.)	Water use efficiency (kg/m^3)
Irrigation Levels	**FoliarSpray treatments**			
Season 2013				
100%	Without	20,93	2100,34	9,97
	PS 2cm/ l	22,2	2100,34	10,57
	PS 6cm/l	26,35	2100,34	12,55
	DBS 2cm/l	22,18	2100,34	10,56
	DBS 6cm/l	26,96	2100,34	12,84
75 %	Without	13,52	1484,53	9,11
	PS 2cm/ l	14,94	1484,53	10,06
	PS 6cm/l	17,45	1484,53	11,75
	DBS 2cm/l	15,51	1484,53	10,45
	DBS 6cm/l	17,34	1484,53	11,68
50%	Without	12,21	989,54	12,34
	PS 2cm/ l	13,52	989,54	13,66
	PS 6cm/l	14,22	989,54	14,37
	DBS 2cm/l	12,55	989,54	12,68
	DBS 6cm/l	14,11	989,54	14,26
Season 2014				
100%	Without	21,27	2098,45	10,14
	PS 2cm/ l	23,01	2098,45	10,97
	PS 6cm/l	27,58	2098,45	13,14
	DBS 2cm/l	23,57	2098,45	11,23
	DBS 6cm/l	27,86	2098,45	13,28
75 %	Without	15,38	1475,23	10,43
	PS 2cm/ l	17,13	1475,23	11,61
	PS 6cm/l	20,15	1475,23	13,66
	DBS 2cm/l	18,05	1475,23	12,24
	DBS 6cm/l	19,93	1475,23	13,51
50%	Without	14,34	985,87	14,55
	PS 2cm/ l	16,03	985,87	16,26
	PS 6cm/l	17,4	985,87	17,65
	DBS 2cm/l	15,58	985,87	15,80
	DBS 6cm/l	16,49	985,87	16,73

100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

A sharp increase in water use efficiency was obtained by deficit irrigation. The total dry mass of fruit may be slightly affected by deficit irrigation (Dorji, et al., 2005). This indicates that water movement into fruit may have decreased with progressive development of water deficit without affecting the translocation of dry matter into the fruit and resulted in an increase in mass production per unit of water, which led to high water use efficiency.

The amount of water saving due to deficit irrigation is shown in Table 5. Obviously deficit irrigation saves water but reduces the yield. Irrigating tomato plants with 75% of irrigation requirements during the complete growing season reduced the total yield by 25% and saved about 33.60% of irrigation water. Increasing the deficit irrigation resulted in a severe yield reduction which giving 50% of irrigation water reduced the fresh fruit yield by 50 %, but increased the water saving to be about 43% of irrigation water.

Table 5. Irrigation efficiency and water saving in relation to irrigation deficit.

Characters / Variables	Water consumption (m^3/fed.)	Yield (ton/fed.)	Reduction in yield due to deficit irrig. (%)	Water saving due to deficit irrig. (%)
Irrigation levels		Season 2013		
100%	23,72	2100,34	0,00	0,00
75 %	15,75	1484,53	25,00	33,60
50%	13,32	989,54	50,00	43,84
		Season 2014		
100%	24,66	2098,45	0,00	0,00
75 %	18,13	1475,23	25,00	26,48
50%	15,97	985,87	50,00	35,24

100%,75% and 50% from water requirements

2. Vegetative growth

Data in Table (6) Show that significant effects on most studied traits of fresh and dry weight in tomato plants. Water application level 100% of irrigation requirements gave the highest values in all fresh and dry weight of tomato plant organs expressed in roots, leaves, stem, as well as the cluster fresh weight, in both seasons. The increment in tomato plant organs due to application of 100% of irrigation requirements might be to the appropriate balance of moisture content in plant tissues. This moisture balance creates promising conditions for nutrient uptake, photosynthesis and metabolites translocation, which eventually hastened the rate of plant growth Ezzo et al. (2010). These results are in harmony with El-Zeiny and Ibrahim (2006) They illustrated that tomato plants grown with 80 and 100% ETc provided the vigorous growth compared to lower irrigation levels at 40 % of the calculated water requirement.

Data in the same Table show that, foliar application with PS or DBS concentration rate 2, 6 cm per liter indoced significant effects on fresh and dry weight of tomato plant organs than without spray, in the both seasons. The highest effects were due to the foliar application with PS followed by

DBS at a rate 6 cm per liter; data show that application of PS and DBS had the highest values from total fresh and dry weight of tomato organs (2016.14; 1924 &283.65; 267.20 gm. /plant), and (2059, 79; 1966.95& 282.56; 279.39 gm. /plant) in first and second season, respectively, while the lowest value was recorded with control treatment (without) in the both seasons.

Foliar application by using PS had a positive effect on plant growth., i.e fresh and dry weight per plant. Increasing in growth might be due to increases in photosynthetic activity of plant, water metabolism, chlorophyll content, more formation of carbohydrates, membrane lipid peroxidation, protective enzymes under drought condition and more uptake of essential nutrients Yasuto and Eiichi(1983). Similar results were noticed by Nesreen et al.(2011) in beans and Ma et al. (2004) in cucumber.These results confirm other reports evidencing that silicon application in plant nutrition increases dry matter content in plants (Junior *et al.,* 2010 and Jarosz, 2013).Potassium silicate at 8 ml per liter improving growth of sapota Lalithya et al., (2014).The increment in plant growth due to foliar application with DBS might be due to make in emulsion polymerization on leaves and content of micronutrients namely, asN, P, K and S they are effects on function and metabolism of tomato plant.Increases in structure of chemicals are anionic surfactants used to lower the surface tension of water USEPA (2006).

Table 6. Effect of irrigation levels and foliar spray with PS and DBS on fresh and dry weight of tomato plants at 70 days from transplanting during 2013 and 2014 seasons.

Characters Variables	Root	leaves	Stem	Clusters	Total	Root	Leaves	Stem	Total
	Fresh weight (g)					Dry weigh (g)			
Irrigation Levels	Season 2013								
100 %	31.90a	513.79a	215.66a	1474.37a	2235.74a	16.62a	210.82a	55.60a	283.05a
75%	20.98ab	399.51b	162.55b	1178.22b	1761.26b	12.78b	198.81a	43.83b	255.43b
50%	17.71b	296.99c	139.54c	1005.28b	1459.55c	8.34c	160.33b	35.18c	203.86c
	Season 2014								
100 %	34.05a	518.79a	220.82a	1479.11a	2252.78a	19.52a	208.96a	59.74a	288.22a
75%	23.22b	377.72b	170.89b	1195.24b	1767.09b	15.68b	201.74a	48.07b	265.50b
50%	18.65c	331.73c	145.09c	1022.90c	1518.38c	11.57c	164.70b	39.49c	215.76c
Foliar Spray	Season 2013								
without	18.64c	361.08b	149.48c	1038.31d	1567.52d	10.48d	170.02b	35.66d	216.17d
PS 2cm/l	20.13c	415.16a	163.87bc	1170.62c	1769.80c	12.21c	177.98b	40.44c	230.64c
PS 6cm/l	27.83a	441.18a	188.54a	1358.58a	2016.14a	14.51a	213.93a	55.21a	283.65a
DBS 2cm/l	24.29b	376.34b	175.76ab	1239.73bc	1816.133c	12.19c	183.62b	43.75c	239.57c
DBS 6cm/l	26.76ab	423.39a	185.27a	1289.23ab	1924.66b	13.51b	204.39a	49.28b	267.20b
	Season 2014								
without	20.38c	365.82d	157.52d	1043.63d	1587.37d	13.01d	171.91b	39.63c	224.56b
PS 2cm/l	22.13c	388.64c	172.85cd	1174.64c	1758.29c	15.30c	184.04ab	45.44b	244.80b
PS 6cm/l	29.48a	457.71a	192.79a	1379.79a	2059.79a	17.82a	205.68a	59.051a	282.56a
DBS 2cm/l	26.12b	405.963	181.66bc	1244.29bc	1858.04bc	15.32c	188.67ab	47.16b	251.15b
DBS 6cm/l	28.42ab	428.95b	189.84ab	1319.73ab	1966.95ab	16.48b	208.69a	54.21a	279.39a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

The results of the interaction between irrigation levels with foliar spray by PS and DBS at the concentration rate 2, 6 cm per liter on fresh and dry weight of tomato plants are presented in Table (7).The data show significant effects of the interaction between irrigation levels (100, 75 and 50%), and foliar spray with SP or DBS at the concentration rate 2, 6 cm per liter on most studied traits,i.e fresh and dry weight of tomato plants. In general, the highest values were recorded with water application levels 100% of requirements and foliar spray with PS by followed by which DBS at the rate concentration of 6 cm per liter for total fresh weight, were (2524.23, 2542.13&2411.68, 2426.33 gm. /Plant), and dry weight were (333.26, 317.99& 311.47, 324.58 gm. /Plant)as well as the cluster fresh weight(1658.45, 1664.01&1618.78, 1622.84 gm. /Plant) in first and second season, respectively.

This sufficient requirement water for tomato plant promising conditions for nutrient uptake, photosynthesis and metabolites translocation, which eventually hastened the rate of plant growth El-Zeiny and Ibrahim (2006).These results are in harmony with Ezzo et al.(2010) The Superior vegetative growth was obtained with the highest irrigation level (100% ETc). In this respect Gorecki et al. (2009) revealed that, silicon might help in cell division, more nutrient and water uptake them may increase plant growth. Concerning, Data in The same Table7. show that, the highest total dry weight (296.80, 293 &278.17, 289.45 gm. /Plant) were recorded by adding 75% of irrigation levels with SP or DBS in both foliar spray applications at the concentration 6 cm per liter respectively, in the first and the second seasons. As compared to addition of water application levels 100% without spray (241.14, 246.41 g.) for total dry weight in both seasons and 100% with PS or DBS (258.83, 270.57 &270. 45, 281.58 g.)for total dry weight in both concentration rates 2 cm per liter in both seasons respectively. The increment of plant growth (fresh and dry weight of different plant organs) as a result to PS or DBS which application may be due tostimulate nutrient uptake, photosynthesis and reduce transpiration rate and this reflect on encouraging the fresh and dry weight of the plant. Ascribed this effect to the formation of a silica-cellulose layer beneath the cuticle layer of leaves, which reduces transpiration. High silica uptake has been shown to improve drought resistance and increase resistance (Belanger *et al.* 1995., Marschner, 1995 and Epstein, 1999).

Table 7. Effect of the interaction between irrigation levels and foliar spray with PS and DBS on fresh and dry weight of tomato plants at 70 days from transplanting during 2013 and 2014 seasons

Variables	Characters	Root	leaves	Stem	Clusters	Total	Root	Leaves	Stem	Total
		Fresh weight (g)					Dry weigh (gm)			
Irrigation Levels	Foliar Spray treatments	Season 2013								
100%	without	26.92c	427.21e	194.69cd	1213.98cd	1862.81de	13.93de	184.02d-f	43.18e	241.14g
	PS 2cm/l	30.48b	489.45c	205.81bc	1304.01bc	2029.76c	15.83c	194.53cd	48.47d	258.83ef
	PS 6cm/l	35.40a	597.13a	233.24a	1658.45a	2524.23a	19.51a	244.24a	69.51a	333.26a
	DBS 2cm/l	32.85ab	525.18b	215.51ab	1576.66a	2350.22b	16.31a	200.27c	53.96c	270.54de
	DBS 6cm/l	33.85a	529.97b	229.07a	1618.78a	2411.68b	17.53b	231.06ab	62.87b	311.47b
75%	without	15.43fg	332.30fg	139.72g	1080.40ef	1567.86g	11.06g	177.76a-g	35.29hi	224.11hi
	PS 2cm/l	17.18ef	434.89de	150.36fg	1183.72de	1786.16e	12.56f	182.09d-f	38.88f-h	233.53gh
	PS 6cm/l	26.04c	418.68e	180.52de	1323.61b	1948.85cd	14.53d	225.36b	56.63c	296.52c
	DBS 2cm/l	20.96d	353.87f	168.07ef	1145.44de	1688.35f	12.05f	191.70c-e	41.04ef	244.80fg
	DBS 6cm/l	25.29c	457.80d	174.06de	1157.93de	1815.09e	13.72e	217.14b	47.31d	278.17d
50%	without	13.58g	323.73g	114.02h	820.54g	1271.88i	6.46j	148.27j	28.51j	183.25k
	PS 2cm/l	12.74g	321.14g	135.44g	1024.14f	1493.48gh	8.25i	157.33ij	33.99i	199.57j
	PS 6cm/l	22.07d	307.72gh	151.87fg	1093.68ef	1575.34g	9.51h	172.18fh	39.49e-g	221.18hi
	DBS 2cm/l	19.04de	249.97i	143.70g	997.09f	1409.82h	8.21i	158.89hj	36.27gi	203.37j
	DBS 6cm/l	21.14d	282.41h	152.69fg	1090.97ef	1547.22g	9.29h	164.99gi	37.66f-i	211.95ij
	Season 2014									
100%	without	28.60d	432.64d	200.33de	1219.78d	1881.36de	16.65e	181.90d-h	47.85d-f	246.40e-g
	PS 2cm/l	32.98c	496.31c	212.88cd	1308.43bc	2050.61c	18.51cd	199.01b-e	53.05cd	270.57c-e
	PS 6cm/l	38.02a	602.07a	238.03a	1664.01a	2542.13a	22.68a	220.99ab	74.31a	317.99ab
	DBS 2cm/l	34.51bc	529.24b	219.26bc	1580.48a	2363.50b	19.49bc	206.993b-d	55.09c	281.58cd
	DBS 6cm/l	36.14ab	533.72b	233.61ab	1622.84a	2426.33b	20.27b	235.90a	68.40b	324.58a
75%	without	17.88g	336.83ef	153.29ij	1085.68f-h	1593.68gh	13.78gh	181.67d-h	38.95h	234.41f-h
	PS 2cm/l	19.49g	339.34ef	164.56g-i	1188.31de	1711.71f	15.65ef	191.73c-g	46.07e-g	253.46ef
	PS 6cm/l	27.78d	437.02d	185.79ef	1329.71b	1980.31cd	17.76d	218.74a-c	57.28c	293.78bc
	DBS 2cm/l	23.86e	357.49e	172.38f-h	1147.70d-f	1701.43fg	14.65fg	195.29b-f	46.44ef	256.39d-f
	DBS 6cm/l	27.09d	417.94d	178.47fg	1224.83cd	1848.35e	16.56e	221.27ab	51.62c-e	289.45c
50%	without	14.673h	327.99f	118.953k	825.45i	1287.07i	8.59k	152.17i	32.10i	192.87i
	PS 2cm/l	13.93h	330.28f	141.13j	1027.20gh	1512.54h	11.76j	161.38hi	37.21hi	210.36hi
	PS 6cm/l	22.65e	334.04ef	154.57h-j	1145.66d-f	1656.93fg	13.04hi	177.32e-i	45.56e-g	235.9f-h
	DBS 2cm/l	19.99fg	331.16f	153.36ij	1004.69h	1509.20h	11.81j	163.72g-i	39.96gh	215.49hi
	DBS 6cm/l	22.04ef	335.18ef	157.44h-j	1111.51e-g	1626.18fg	12.63ij	168.90f-i	42.60f-h	224.14gh

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

3. Yield parameters

Early yield parameters:

Data presented in Table (8).Indicated that water application levels 100% from water requirements of tomato plants recorded the highest values on most studied traits of early yield ., i.e the number of fruits per plant (5.43&6.53), average fruit weight for grade A per plant (118.57&123.66g), early yield for grade A/fed. (3.85&4.87ton.), and total early yield grade A+B/fed.(6.94&8.08ton).In both seasons. The same data also illustrate that there were no significant differences between water application levels 100,75%and 50% of irrigation water requirements on other studied early yield components such as number of fruits/plant, average fruit weight, early yield /plant g., and total early yield for grade B/fed. For perspective to the high total early yield/fed. Which was obtained might be due to the increases caused increased fruit weight of tomato plants for grade A with the highest water levels led to also derived from the highest produced increased of the high values of clusters weight and dry matter, content as shown on Table (3) Also, These results agree well with the findings of Kere et al., (2003).

Data in the same Table shows that, foliar application with PS at ther ate of 6 cm per liter had significant effects on most early yield parameters; viz, number of fruits (5.95 &6. 05) and early yield /plant (655.55&746.25g.) for grade A in both seasons, while there were no significant effects on average fruit weight to early yield in grade A of the both seasons. It is noticed also that, the average fruit weight and fruit weight /plant of grade B were recorded by PS spray at a rate of 6 cm per liter in the first season. On the other hand, there were no significant differences in the number of fruits/plant, average fruit weight /plant and fruit weight /plant for grade B by all spray treatments in the second season.

Concerning early yield as well as grade A per fed. (3.93, 4.47 &3. 47, 4.29 ton.)and total grade A+B (7.12, 7.50 & 6.40, 7.42ton) data in Table (8) show significant effects to the two materials used in both seasons. The highest values were obtained with PS then DBS spray at a rate of 6cm per liter .According to The same data in Table (8) show that there are no significant effects due the control or with foliar spraying on grade B parameters as well as the number of fruits /plant, average fruit weight g. and yield/plant. in the second season. The increment in total early yield was owing to the increment of yield in grade A per fed, these results might be due to the increment in dry weight of tomato plants and consequently the increment in total fruit weight for grad A and total early yield. This results may be due to the foliar application of potassium silicate at 6 ml per liter, which increased photosynthetic activity and induced translocation of metabolites. The results are in accordance with Nam Sangyoung et al. (1996) and Nesreen et al.(2011). Silicon might help in cell division, more nutrient and water. Similar observations were mentioned by Gorecki and Danielski Busch (2009) in greenhouse cucumber, Nesreen et al.(2011) in beans and Stamatakis et al.(2003) in tomato.

Table 8. Effect of irrigation levels and foliar spray with PS and DBS on early yield parameters of tomato plants during 2013 and 2014 seasons.

Characters Variables	Early Yield Parameters						Early Yield/fed.(ton)		
	Grade A			Grade B					
	No. of fruits/ plant	Average Fruit weight (gm)	Yield/ Plant (gm)	No. of fruits /plant	Average Fruit weight (gm)	Yield/ Plant (gm)	Grade A	Grade B	Total Grade (A+B)
	Irrigation Levels Season 2013								
100 %	5.43a	118.57a	642.11a	6.67a	77.73a	515.39a	3.85a	3.092a	6.94a
75%	4.11b	102.42a	415.11b	6.87a	69.44a	468.37a	2.49b	2.81a	5.30ab
50%	3.92b	95.15b	366.94b	6.14a	68.21a	419.29a	2.20b	2.51a	4.71b
	Season 2014								
100 %	6.53a	123.66a	812.36a	6.81a	78.69a	534.71a	4.87a	3.21a	8.08a
75%	4.21b	114.05a	478.00b	6.85a	75.11a	511.66a	2.86b	3.07a	5.93b
50%	3.86b	111.74a	432.41c	6.00a	70.19a	419.78a	2.59b	2.52a	5.11b
Foliar Spray	Season 2013								
without	3.05c	100.85a	307.82d	5.74b	70.42a	403.96b	1.84d	2.42b	4.27d
PS 2cm/ l	3.66bc	104.85a	380.43cd	6.96ab	74.60a	513.58a	2.28cd	3.08a	5.36c
PS 6cm/l	5.95a	108.68a	655.55a	6.97ab	76.29a	532.27a	3.93a	3.19a	7.12a
DBS 2cm/l	4.42b	103.34a	450.89c	5.66b	71.45a	400.58b	2.70c	2.40b	5.10c
DBS 6cm/l	5.38a	109.18a	578.91b	7.48a	66.21a	488.00ab	3.47b	2.92ab	6.40b
	Season 2014								
without	3.72b	106.72a	396.62c	6.22a	71.87a	448.38a	2.38c	2.69a	5.07b
PS 2cm/ l	4.00b	121.06a	481.62bc	7.00a	76.64a	535.38a	2.89bc	3.21a	6.10b
PS 6cm/l	6.05a	120.85a	746.25a	6.58a	76.40a	503.88a	4.47a	3.02a	7.50a
DBS 2cm/l	4.72ab	113.06a	531.17b	6.12a	71.84a	433.75a	3.18b	2.60a	5.78b
DBS 6cm/l	5.85a	120.73a	715.63a	6.85a	76.57a	522.19a	4.29a	3.13a	7.42a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

Data in the Table 9. shows significant effects due to the interaction between water irrigation levels 100, 75% and 50% of irrigation water requirements and foliar spray with PS and DBS on all studied traits, except the average fruit weight of grade A and B as well as the number of grade B in the second season. In general, data show that irrigation with 100%of water requirements for tomato plants with spray PS followed by spray DBS had the highest early yield and its components., i.e the number of fruits(8.13,8.83& 5.90,8.92),average fruit weight (120.79,138.04&131.72,130.04), yield/plant of grade A was (975.00,1195.00&763.63,1152.39) and B was (557.36,507.50&588.45,576.25) in the two seasons, respectively, while the early yield ton./fed viz, of grade A was (5.85,7.17&4.58,3.46), grade B was (3.34,3.04&3.53,3.46g.)and total grade A+B was (9.19,10.21&8.11,10.37g.), except application 100% of water requirements with application foliar spray SP at the concentration of 2cm per liter was recorded the highest values for fruit weight for grade Bwas (3.77&3.93 ton/fed). in both seasons respectively. Concerning, addition 75% of irrigation water requirements of tomato plants by spray DBS or PS at the concentration rate 2 or 6 cm per liter then 100% of water requirements without spray was the best in most parameters for early yield and its components in both seasons.The increase in total early yield might be owing to the increase of average fruit weight and yield per plant for grade A. On the other hand, water application levels 75% with DBS or PS of the concentration rate 2 or 6 cm per liter significant increase yield more than addition 100 % of water requirements without spray for tomato plants. The favorable effects of DBS or PS might be to their effect on formation of double layer cuticle- Si in the leaf which cause of increasing the thickness of this layer and thus cuticular transpiration in the leaf was decreased too much and the RWC (Relative water content)was increased(Romero-Aranda et al. 2006). Also, DBS play vital role in reflect sun solar on tomato leaves hence induce low evapotranspiration. Additionally, its content from N, P, K and S mineralswhich effects in tomato plant growth and yield. The physical-chemical properties of the DBS category affect partitioning between air and water and water, water solubility and partitioning coefficient are the main drivers. Because of the relatively narrow range of carbon chain lengths of chemicals in the category USEPA (2006).

Table 9. Effect of the interaction between irrigation levels and foliar spray with PS and DBS on early yieldparameters of tomato plants during 2013 and 2014 seasons.

Variables / Characters		Early Yield Parameters						Early Yield/fed.(ton)		
		Grade A			Grade B					
		No. of fruits/ plant	Average Fruit weight (gm)	Yield/ Plant (gm)	No. of fruits/ plant	Average Fruit weight (gm)	Yield/ Plant (gm)	Grade A	Grade B	Total Grade (A+B)
Irrigation Levels	Foliar Spray Treatments	Season 2013								
100%	without	3.73ef	111.04ab	410.66e	5.70cd	73.82a	417.66e-g	2.46ef	2.50e-g	4.97e-g
	PS 2cm/ l	3.83ef	118.51ab	450.63de	8.21a	78.52a	629.20a	2.70de	3.77a	6.48c
	PS 6cm/l	8.13a	120.79ab	975.00a	6.82a-d	81.68a	557.36a-c	5.85a	3.34a-d	9.19a
	DBS 2cm/l	5.58bc	110.70ab	610.63c	5.17d	75.04a	384.28e-g	3.66c	2.30e-g	5.97cd
	DBS 6cm/l	5.90b	131.716a	763.63b	7.48a-c	79.62a	588.45ab	4.58b	3.53ab	8.11b
75%	without	2.95fg	99.66ab	292.23gh	5.84cd	72.31a	422.20e-g	1.75gh	2.53e-g	4.28gh
	PS 2cm/ l	3.58ef	100.69ab	356.90fg	6.75a-d	74.59a	498.53b-e	2.14fg	2.99b-e	5.13ef
	PS 6cm/l	4.85cd	108.6ab	522.50d	7.42a-c	76.45a	569.83a-c	3.13d	3.42a-c	6.55c
	DBS 2cm/l	4.01d	102.20ab	394.94e	6.33b-d	73.48a	456.53d-g	2.36ef	2.74d-g	5.10ef
	DBS 6cm/l	5.18bc	100.94ab	509.00d	8.00ab	50.37b	394.77e-g	3.05d	2.37e-g	5.42de
50%	without	2.46g	91.86a	220.55h	5.69cd	65.14ab	372.03fg	1.32h	2.23fg	3.55i
	PS 2cm/ l	3.56ef	95.36a	333.76fg	5.92cd	70.69ab	413.03e-g	2.00fg	2.47e-g	4.48f-h
	PS 6cm/l	4.86cd	96.61a	469.16de	6.67a-d	70.74ab	469.63c-g	2.81de	2.81c-g	5.63de
	DBS 2cm/l	3.66ef	97.06a	347.11fg	5.48d	65.84ab	360.95g	2.08fg	2.16g	4.24h
	DBS 6cm/l	5.06bc	94.84a	464.10de	6.98a-d	68.66ab	480.80b-f	2.78de	2.88b-f	5.67de
	Season 2014									
100%	without	4.33b-d	107.63a	467.33c-e	7.00a	72.67a	508.66ab	2.80c-e	3.05ab	5.857d
	PS 2cm/ l	4.66bc	125.21a	574.16bc	7.96a	83.64a	655.33a	3.44bc	3.93a	7.38b
	PS 6cm/l	8.83a	138.043a	1195.43a	6.00a	83.21a	507.50ab	7.17a	3.04ab	10.21a
	DBS 2cm/l	5.90b	116.95a	672.50b	5.60a	76.51a	425.83b	4.03b	2.55b	6.59bc
	DBS 6cm/l	8.92a	130.47a	1152.39a	7.50a	77.44a	576.25ab	6.91a	3.46ab	10.37a
75%	without	4.00cd	103.69a	407.12e	6.08a	72.35a	440.00b	2.44ef	2.64b	5.08de
	PS 2cm/ l	3.66cd	121.46a	443.55c-f	7.04a	75.05a	523.33ab	2.66c-f	3.14ab	5.80cd
	PS 6cm/l	5.06bc	109.42a	556.62b-d	7.16a	76.82a	550.83ab	3.34b-d	3.30ab	6.64bc
	DBS 2cm/l	4.00b-d	121.23a	484.92c-e	7.00a	71.29a	483.37ab	2.90c-e	2.90ab	5.80cd
	DBS 6cm/l	4.35d	114.46a	497.81c-e	7.00a	80.03a	560.83ab	2.98c-e	3.36ab	6.35bc
50%	without	2.83d	108.85a	315.43f	5.60a	70.60a	396.50b	1.89f	2.38b	4.27e
	PS 2cm/ l	3.66cd	116.52a	427.14d-f	6.00a	71.25a	427.50b	2.56d-f	2.56b	5.13de
	PS 6cm/l	4.26b-d	115.09a	486.70c-e	6.60a	69.17a	453.33b	2.92c-e	2.72b	5.64cd
	DBS 2cm/l	4.26b-d	101.00a	436.11c-f	5.76a	67.71a	392.08b	2.61c-f	2.35b	4.96de
	DBS 6cm/l	4.30b-d	117.26a	496.69c-e	6.06a	72.25a	429.50b	2.98c-e	2.58b	5.56cd

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

Total yield

Data in Table 10.shows that the highest values of total yield parameters were obtained with water application levels 100 % of water requirements, in the both seasons. The same data in the same table reveal also that, the highest values of total yield parameters, i.e. number of fruits and average fruit weight for grade A and B per plant as well as grade A was (10.90, 12.24 &10.58,12.41&) and B was (8.76 ,9.30 &856, 9.18)and total yield per fed. was (19.34, 21.71 &19.47,21.42 ton./fed). These values recorded when plants received foliar spray with DBS or PS at therate of6cm per liter in both seasons respectively, while the lowest values were recorded by the control treatment (15.55 &16.99 ton./fed.).

Table 10.Effect of irrigation levels and foliar spray with PS and DBS on total yield parameters of tomato plants during 2013 and 2014 seasons.

Characters / Variables	Total Yield Parameters						Total Yield/fed.(ton)		
	Grade A			Grade B					
	No. of fruits/ plant	Average Fruit weight (gm)	Yield/ Plant (gm)	No. of fruits/ plant	Average Fruit weight (gm)	Yield/ Plant (gm)	Grade A	Grade B	Total Grade (A+B)
Irrigation Levels	Season 2013								
100 %	14.90a	128.02a	1898.28a	24.60a	83.75a	2056.40a	11.32a	12.33a	23.72a
75%	10.70b	103.04b	1089.98b	19.24b	79.34b	1536.19ab	6.53b	9.21ab	15.75b
50%	9.39b	101.89b	946.40b	19.70b	68.18b	1274.32ab	5.67b	7.64b	13.32b
	Season 2014								
100 %	15.83a	123.80a	1943.86a	27.06a	80.30a	2166.74a	11.66a	13.15a	24.66a
75%	12.08b	98.06ab	1185.77b	23.13b	79.72a	1836.00b	7.11b	11.01b	18.13b
50%	11.15b	93.83b	1028.69c	24.59ab	67.34b	1633.06b	6.17c	9.79b	15.97c
Foliar Spray	Season 2013								
without	11.06b	103.25ab	1157.89b	20.83ab	71.34a	1434.74b	6.84b	8.609b	15.55b
PS 2cm/ l	11.68b	109.45ab	1295.04ab	18.82ab	80.15a	1519.96ab	7.77ab	9.12ab	16.89ab
PS 6cm/l	12.63a	113.95a	1460.45a	22.02a	79.67ab	1763.80a	8.76a	10.58a	19.34a
DBS 2cm/l	11.01b	109.31ab	1216.58ab	19.44ab	80.41a	1574.99ab	7.29ab	9.45ab	16.74ab
DBS 6cm/l	11.94b	118.96a	1427.81ab	24.81a	73.87b	1818.02a	8.56a	10.90a	19.47a
	Season 2014								
without	11.75b	100.56b	1198.79b	23.00b	71.74a	1634.33b	7.19ab	9.80b	16.99c
PS 2cm/ l	12.64ab	106.72ab	1365.26ab	22.55b	78.41a	1756.40b	8.19ab	10.53b	18.72c
PS 6cm/l	14.37a	106.46ab	1550.72a	26.83a	77.55a	2068.441a	9.30a	12.41a	21.71a
DBS 2cm/l	12.17ab	104.65b	1285.25ab	24.77ab	76.85a	1892.96ab	7.71ab	11.35ab	19.06bc
DBS 6cm/l	14.17ab	107.74a	1530.51a	27.48a	74.39a	2040.87a	9.18a	12.24a	21.42ab

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

The results of the interaction between water irrigation levels and foliar spray on the total yield of tomato are presented in Table (11). All measured parameters gave highly significant differences among the treatments. Water application levels 100 % of the water requirements with spray by DBS or PS atthe rate2 and 6 cm per liter gave the highest values from the number of fruits and average fruit weight for grade A and B per plant as well as grade A and B and total yield per fed. (ton). Whereas, the lowest values were recorded in the check treatment in the both seasons. Regarding,the addition 100% of irrigation requirements with spray by DBS or PS at the concentration 6 cm per liter was recorded the highest significant values on number of fruits and average fruit weight for grade A which it was (147.56, 133.23 & 133.69, 127.38g.) and B was (84.51, 82.49 &80. 94,82.44g.) per plant as well as grade A was (12.44, 12.45 &12.83, 12.92ton./fed.) and B was (14.52, 13.81 &15. 03,14.66ton. /Fed.) and total yield Grade A+B per fed.was (26.96, 26.35

&27.86,27.58 ton/fed.) in both seasons respectively.Potassium silicate had a positive effect on growth and yield. The Increasing yield might be attributed due to increases in photosynthetic activity of plants, water metabolism, chlorophyll content, which reflected in more formation of carbohydrates, membrane lipid peroxidation, protective enzymes under drought condition and more uptake of essential nutrients (Yasuto and Eiichi, 1983). Lalithya et al. (2014) noticed similar results on sapota**,** Nesreen et al.(2011) in beans and Ma et al. (2004) in cucumber.

Table 11. Effect ofthe interaction between irrgation levels and foliar spray with PS and DBS on total yield parameters of tomato plants during 2013 and 2014 seasons.

Characters / Variables		Total Yield Parameters						Total Yield/fed.(ton)		
		Grade A			Grade B					
		No. of fruits /plant	Average Fruit weight (gm)	Yield/ Plant (gm)	No. of fruits /plant	Average Fruit weight (gm)	Yield/ Plant (gm)	Grade A	Grade B	Total Grade (A+B)
Irrigation Levels	Foliar Spray treatment	season 2013								
100%	without	15.46a	110.75bc	1708.65b	23.000a-d	77.49ab	1780.12cd	9.95b	10.68cd	20.93b
	PS 2cm/ l	14.80a	125.34a-c	1840.61ab	21.38b-d	87.03a	1860.58cd	11.04ab	11.16cd	22.20b
	PS 6cm/l	15.66a	133.69a	2090.20a	28.00ab	82.49a	2302.68ab	12.54a	13.81ab	26.35a
	DBS 2cm/l	14.51a	122.69a-c	1777.86b	22.12a-d	87.27a	1920.78bc	10.66b	11.52bc	22.18b
	DBS 6cm/l	14.06ab	147.65a	2074.08a	28.66a	84.51a	2420.95a	12.44a	14.52a	26.96a
75%	without	9.56d-f	99.46c	951.86cd	17.32d	75.31ab	1302.24f	5.71cd	7.81f	13.52de
	without	10.46c-e	101.67bc	1058.92cd	18.44cd	77.10ab	1431.86d-f	6.35cd	8.59d-f	14.94c-e
	PS 2cm/ l	12.23bc	104.67bc	1255.71c	20.23cd	81.75a	1654.58c-f	7.53c	9.92c-f	17.45b
	PS 6cm/l	10.25c-f	103.06bc	1028.63cd	19.66cd	79.05ab	1556.53c-f	6.17cd	9.34c-f	15.51cd
	DBS 2cm/l	11.03cd	106.36bc	1154.79c	20.57cd	83.47a	1736.36c-e	6.92c	10.42c-e	17.34c
50%	without	8.17f	99.55c	813.15d	22.17a-d	61.22bc	1222.03f	4.88d	7.33f	12.21e
	PS 2cm/ l	9.78d-f	101.35bc	985.59cd	16.65d	76.32ab	1268.03f	5.91cd	7.60f	13.52de
	PS 6cm/l	10.00d-f	103.49bc	1035.46cd	17.83d	74.78ab	1335.47ef	6.21cd	8.01ef	14.22de
	DBS 2cm/l	8.26ef	102.19bc	843.24d	16.67d	74.927ab	1248.45f	5.06d	7.49f	12.55e
	DBS 6cm/l	10.73cd	102.87bc	1054.58cd	25.20a-c	53.64c	1297.70f	6.32cd	7.78f	14.11de
		Season 2014								
100%	without	15.46bc	112.93ab	1741.99b	25.66b-d	70.30ab	1803.33c-f	10.45b	10.82c-f	21.27bc
	PS 2cm/ l	14.80b-d	127.38ab	1873.94ab	23.66cd	83.07ab	1962.53b-d	11.24ab	11.77b-d	23.01b
	PS 6cm/l	18.22a	120.54ab	2153.53a	30.00ab	82.44ab	2444.65a	12.92a	14.66a	27.58a
	DBS 2cm/l	14.51b-d	124.91ab	1811.23ab	25.00a	84.76a	2117.21b	10.86ab	12.70b	23.57b
	DBS 6cm/l	16.39ab	133.23a	2138.64a	31.00a	80.94ab	2505.96a	12.83a	15.03a	27.86a
75%	without	10.33fg	94.98ab	977.78de	20.66d	78.11ab	1586.66ef	5.86de	9.52ef	15.38ef
	PS 2cm/ l	11.66e-g	97.31ab	1132.62c-e	21.66cd	80.00ab	1723.33c-f	6.79c-e	10.34c-f	17.13e
	PS 6cm/l	13.43c-e	101.54ab	1360.12c	24.16cd	82.88ab	1998.33b-d	8.16c	11.99b-d	20.15cd
	DBS 2cm/l	11.66e-g	98.77ab	1153.70c-e	23.33cd	79.89ab	1855.00b-e	6.92c-e	11.13b-e	18.05de
	DBS 6cm/l	13.33c-e	97.68ab	1304.65cd	25.83b-d	77.72ab	2016.66bc	7.83cd	12.11bc	19.93cd
50%	without	9.46g	93.78ab	876.61e	22.66cd	66.80ab	1513.00f	5.26e	9.07f	14.34f
	PS 2cm/ l	11.46e-g	95.48ab	1089.22c-e	22.33cd	72.16ab	1583.33ef	6.53c-e	9.50ef	16.03ef
	PS 6cm/l	11.73e-g	97.31ab	1138.53c-e	26.33a-c	67.32ab	1762.33c-f	6.83c-e	10.57c-f	17.40e
	DBS 2cm/l	10.33fg	90.27b	890.87e	26.00bc	65.91ab	1706.66d-f	5.34e	10.24d-f	15.58ef
	DBS 6cm/l	12.84d-f	92.31b	1148.24c-e	25.63b-d	64.53b	1600.00ef	6.88c-e	9.61ef	16.49ef

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS=Potassium silicate
DBS=Dodouxil Benzene Sulphonate

4. Fruit quality

Tomato chemical constituents did not reflect any significant effects due to the water application levels 100, 75 and 50% of irrigation water requirements in both seasons, except the titratable acidity showed the highest content (0.31%)in the second season only, when tomato plant received 100% of the water irrigation requirementsas shown in the Table 12. Data in the same table shows significant effect of foliar spray with PS and DBS on tomato chemical constituents. Concerning,the contentof titratable acidity data shows that without spray had the highest values (0.32%) in the two studied seasons.Regarding the content of tomato fruits from V.C and T.s.s the favorable values were obtained by the foliar spray withPS at 6cm per liter in the both seasons. While, the lowest values obtained fromwithout spray.

Silicon might help in improving fruit quality and this may be due to suppression of respiration and reduction in ethylene evolution and thus minimized physiological loss in weight of the fruit. The results are in conformity with Babak and Majid (2011). Potassium silicate also help in the synthesis of more sugar content in fruit and thus resulted in increasing maximum total soluble solids. The results are in accordance with Stamatakis et al.(2003); Increase in TSS content in fruit grown under soil, water deficit condition was related primarily to decrease in fruit water content.

Table 12. Effect of irrigation levels and foliar spary with PS and DBS on fruit quality of tomato plants during 2013 and 2014 seasons.

Characters / Variables	Titratable Acidity (%)	V.C (mg /100ml Juice)	T.S.S	Titratable Acidity (%)	V.C (mg/100 ml Juice)	T.S.S
Irrigation Levels	Season 2013			2014Season		
100 %	0.30a	23.45a	6.18a	0.31a	22.65a	5.72a
75%	0.29a	22.46a	6.23a	0.28b	24.01a	5.80a
50%	0.29a	23.50a	6.26a	0.28b	25.88a	5.80a
Foliar Spray						
without	0.32a	19.267b	5.86b	0.32a	21.91c	5.37c
PS 2cm/l	0.29b	24.35a	6.31ab	0.29b	26.55a	6.23a
PS 6cm/l	0.29b	25.86a	6.64a	0.29b	27.57a	6.86a
DBS 2cm/ l	0.28b	23.22ab	6.41a	0.28b	22.11ab	5.97ab
DBS 6cm/l	0.28b	24.00ab	5.90b	0.28b	23.75a-c	5.45b

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

Concerning to the effect of the interaction between water application levels 100, 75 and 50% of irrigation water requirements and the foliar spray with PS and DBS on tomato chemical constituents, the results are presented in the Table 13. for the analysis of titratable acidity, vitamin C and T.S.S. The results were similar in most treatments. However, Application of 100, 75, and

50 % levels of the water requirements of tomato plants and without spray gave the highest values from titratable acidity compared to the other treatments in the both seasons. Furthermore, data were recorded the best values to increase vitamin C and T.S.S by addition of 100, 75, and 50% levels of the water requirements of the tomato plants and spray with PS a rate of 2 and 6 cm per liter, respectively. in the both seasons. These results agree with Petersen et al. (1998) attributed the enhancing contents of vitamin C and total soluble solids in tomato fruit with increased salinity to concentration effects originating from reduced fruit water content due to adaptation of the plant to salinity.

Table 13. Effect ofthe interaction between irrigation levels and foliar spray with PS and DBS on fruit quality of tomato plants during 2013 and 2014 seasons.

Variables / Characters		Titratable Acidity (%)	V.C (mg/100 ml Juice)	T.S.S	Titratable Acidity (%)	V.C (mg/100 ml Juice)	T.S.S
Irrigation Levels	Foliar Spry treatments	Season 2013			Season 2014		
100%	without	0.34a	18.33bc	5.53f	0.35a	22.60ab	5.06e
	PS 2cm/l	0.29de	26.86a	6.66a	0.31b	26.06ab	6.20a
	PS 6cm/l	0.31bc	25.53a	6.63ab	0.31b	26.73ab	6.20a
	DBS 2cm/ l	0.29de	21.93a-c	6.46a-c	0.30b-d	21.26bc	5.96ab
	DBS6cm/l	0.30cd	24.60a	5.60ef	0.30bc	16.60c	5.16de
75%	without	0.32b	16.86c	6.10cd	0.31b	23.06ab	5.63b-d
	PS 2cm/l	0.27e	23.26ab	6.16b-d	0.26f	25.93ab	5.73a-c
	PS 6cm/l	0.27e	24.33a	6.66a	0.26f	23.66ab	6.20a
	DBS 2cm/ l	0.30cd	23.00a	6.16b-d	0.29c-e	23.40ab	5.76a-c
	DBS6cm/l	0.29de	22.86ab	6.06cd	0.27ef	23.00bc	5.66b-d
50%	without	0.31bc	22.60ab	5.96d-f	0.31b	28.06a	5.43c-e
	PS 2cm/l	0.30cd	24.86a	6.66a	0.28d-f	27.66a	6.66a
	PS 6cm/l	0.28e	24.73a	6.63ab	0.27ef	24.33ab	6.20a
	DBS 2cm/ l	0.30cd	22.73ab	6.60ab	0.29c-e	21.66bc	6.20a
	DBS6cm/l	0.30cd	22.60ab	5.03c-e	0.29c-e	27.66a	5.53b-e

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.
100%,75% and 50% from water requirements
PS= Potassium silicate
DBS=Dodouxil Benzene Sulphonate

CONCLUSION AND RECOMMENDATIONS

According to the obtained results, it can be said that, the superior treatments for produce high fruit yield with best quality were from irrigate tomato plants with 100% of the water irrigation requirement per feddan and foliar spray by Dodouxil Benzene Sulphonate "DBS" or Potassium Silicate "PS" at the rate of 6 cm/liter from anyone of each, but under water deficit it can irrigate tomato plants with 75% from its water irrigation requirement and spray the plants with any one of the mentioned treatment (DBS or PS) with the same concentration (6cm/liter), but under these condition it can save 33.6% from water irrigation and reduce tomato yield by 25%.

REFERENCES

A.O.A.C. 1990. Official Methods of Anlysis. 15th ed. Pp. 123-126. Associaioon of Offficial Analytical Chemists, Washington DC. U.S.A.

Ahmed, A. H.,. 1991.Peppers. In: Vegetables Crop Production. 1st Edition. Cairo, Egypt.

Babak .J., andR. Majid. 2011. Carnation flowers senescence as influenced by nickel, cobalt and silicon. *J. Biol. Environ. Sci.,* 5(15): 147-152.

Belanger, R.R., P.A. Bowen, D.L. Ehret and J.G. Menzles, 1995. Asoluble silicon: Its role in crop and disease management of greenhouse crops. Plant Dis., 79:329-336.

Berova, M. and Z. Zlatev.2000. Physiological response and yield of paclobutrazol treated tomato plants and Plant Growth Reg. 30(2): 117-123.

Cherif, M., Benhamou, N. Menzies, J. G. and R. R. Belanger. 1992. Silicon induced resistance in cucucmber plants against Pythium ultimum. Physiological and Molecular Plant Pathology. 41:411-425.

Dorji, K., M.H. Behboudian, and J.A. Zegbe-Dominguez,. (2005) Water relations, growth, yield, and fruit quality of hot pepper under deficit irrigation and partial root zone drying, Sci. Hortic., 104: 137-149.

Duncan, D.B. 1958. Multiple range and multiple F test. Biometrics 11:1-42.

El-Zeiny O.H, KA.Ibrahim. 2006 Response of tomato plants (*Lycopersicon esculentu*m L.) to different levels of water irrigation under sand and clay soil conditions. Egypt J Appl Sci.; 21(12 A):154-171.

Epstein, E., 1999. Silicon. Annu. Rev. Plant Physiol, *Pl. Mol. Biol.*, 50: 641-644.

Ezzo, M.I., A.A. Glala, H.A. Habib, and A.A. Helaly. 2010. Response of sweet pepper grown in sandy and clay soil Lysimeters to water regimes. Amer- Euras J Agric & Environ Sci., 8(1):18-26.

FAO, 1998. Vapotranspiration. irrigation and drainage,paper 56, rome, Italy.

FAO. 1999. Production Yearbook; Food and Agriculture Organization; Rome, Italy.

Gorecki, R.S., and W. Danielskibusch. 2009, Effect of silicate fertilizers on yielding of greenhouse cucumber (*Cucumis sativus* L.) in container cultivation. *J. of Elementology,* 14(1): 71-78.

Hodson, M.J., and A.G. Sangster. 1999. Aluminum/silicon interactions in conifers. Journal of inorganic biochemistry.Vol.76 (2), pp. 89-98.

Ismail, S. M.2010. Influence of Deficit Irrigation on Water Use Efficiency and Bird Pepper Production (*Capsicum annuum* , JKAU: Met., Env. & Arid Land Agric. Sci., Vol. 21, No. 2, pp: 29-43.

Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall, Inc., Engle wood cliff, N.J.

Jarosz, Z., . 2013. The effect of silicon application and type of substrate on yield and chemical composition of leaves of cucumber. J. Elem., 18(3), 403–414, DOI: 10.5601/jelem.2013.18.3.05

Jensen, C.R.; Battilani, A.; Plauborg, F; Psarras, G.; Chartzoulakis, K.; Janowiak, F. Stikic, R.; Jovanovic, Z. Li; G. Qi, X. Liu, F. Jacobsen and S. Andersen. 2010. Deficit irrigation based on drought tolerance and root signalling in potatoes and tomatoes. Agricultural Water Management, V .98, P.403-413.

Junior, L.A.Z., R.L.F. Fontez, J.C.L. Nevez, G.H. Korndorfer, and V.T. Avila. 2010. Rice grown in nutrient solution with doses of manganese and silicon. R. Bras. Ci. Solo, 34, 1629–1639.

Kafkafi, U.1990. The functions of plant K in overcoming environmental stress situations. In: Proc. 22nd colloquium of IPI, pp. 81-93, held in Soligorsk, USSR, IPI, Bern.

Kere G.M.; M.O. Nyanjage, G. Liu and S.P. Nyalala. 2003.Influence of drip irrigation schedule and mulching material on yield and quality of greenhouse tomato (*Lycopersicon esculentum* Mill. 'Money Maker'). Asian J Plant Sci 2 (14):1052-1058.

Kramer, P.J. and J.S. Boyerb.1995. Water Relations of Plants and Soils. Academic Press, San Diego.

Lalithya, K.A., H.P. Bhagya, and C.Raveendra. 2014 Response of silicon and and micro nutrients on character and nutrient content leaf of sapota. (2):593-598.www.biolifejournal.com

Lalithya, K.A., H.P. Bhagya,K.Bharthi, and H.Kulapati .2014.Response of soil and foliar application of silicon and micro nutrients on leaf nutrient status of sapota. . an international quarterly journal of life sciences 9(1): 159-162. (E-mail: kalalithya0@gmail.com)

Liang, Y., C.Y. ang, and H. Shi.2001. Effects of silicon on growth and mineral composition of barley grown under toxic levels of aluminum. Journal of Plant Nutrition.Vol. 24(2), pp. 229-243.

Lu, G., and J. Cao.2001. Effects of silicon on earliness and photosynthetic characteristics of melon. Acta Horticulturae Sinica. Vol.28, No. 5, pp.421- 424.

Ma, J.F, .2004. Role of silicon in enhancing the resistance of plants to biotic and abiotic stresses. Soil Sci plant Nutr; 50:11-8.

Ma, J.F., and E. Takahashi.2002. Soil, fertilizer, and plant silicon research in Japan. Elsevier, Amsterdam. The Netherlands. P 1-200.

Marschner, H., 1995. Mineral nutrition of higher plants. Academic press.

Marschner, P., and S. Marschner. 2012.Mineral Nutrition of Higher Plants, 3rd ed.; Academic Press: London, UK., pp. 178–189.

Matos, E. S.; F. H. Shirahige and P. C. T. Melo 2012.Desempenho de híbridos de tomate de crescimento indeterminado em função de sistemas de condução de plantas. Horticultura Brasileira. v.30, p.240-245.

McAvoy, R.J., and B.B. Bible.1996. Silica sprays reduce the evidence and severity of bract necrosis in poinsettia. HortScience. 31(7):1146-1149.

Mengel, K. Principles of Plant Nutrition. 2005.5th ed.; Kluwer Academic Publishers: Dordrecht, the Netherlands., pp. 481–509.

Monteith, J.L., and S.M.Virmani. 1991. Quantifying risk in the semi-arid tropics: ICRISAT experience. p. 183-204.

Nam Sang young ; Kim Kyoungmi:; Lim Sangcheol, and,Parkjongchun. 1996. Effects of lime and silica fertilizer application on grape cracking. *RDA J. Agric. Sci., Soil & Fert.,* 38(1): 410-415.

Nesreen, H., Abou-Baker, Abd-El-Adl M., Mohsen, M. Abbas. 2011. Use of Silicate and Different Cultivation Practices in Alleviating Salt Stress Effect on Bean Plants. *Australian J. Basic & Applied Sci.*, 5(9): 769-781.

Petersen, K.K., Willumsen, J. and K .Kaack. 1998. Composition and taste of tomatoes as affected by increased salinity and different salinity sources. J. Hort. Sci. 73:205-215.

Piper, C.S. 1947. Soil and plant analysis.The University of Adelaide (Australia) pp: 59- 74.

Richards, L.A. 1954. Diagnosis and improvement of saline and alkaline soils. U.S.D.A. Handbook No.60.

Romero-Aranda M.R., O. Juardo, and J. Cuartero.2006. Silicon alleviates the deleterious salt effect on tomato plant growth by improving plant water status. Journal of plant Physiology 163: 847-855.

Ryan, J.; Garabet S.; Rashid A. and El-Garous M. 1999. Assessment of Soil and Plant Analysis. Laboratories in the West Asia North African region. Commun. Soil Sci. Plant Analysis 30: 885-894.

Silva, O.N., A.K.S. Lobato, F.W. Avila, R.C.L. Costa and C.F. Oliveira Neto et al. 2012. Silicon-induced increase in chlorophyll is modulated by the leaf water potential in two water-deficient tomato cultivars. Plant soil Environ., 58; 481-486.

Snedecor, G.W., and W.G. Cochran. 1980. Statistical Methods 7th ed. Iowa State Univ., Press. Ames. Iowa, USA.

Stamatakis, A., Papadantonakis N., Lydakis-Simantiris N., Kefalasm, P. and Savvas D. 2003. Effects of silicon and salinity on fruit yield and quality of tomato grown hydroponicalll. Acta Hort., 609: 141-147.

Trenholm L.E., Datnoff, L.E. and Nagara R.T. 2004. Influence of silicon on drougth and shade tolerance of St. Augustinegrass. HortTechnology14:487–90.

USEPA, United States Environmental Protection Agency. Reregistration Eligibility Decision for Alkylbenzene Sulfonates, July 2006. EPA 739-R-06-006.

Waister, P.D. and J.P. Hudson.1970. Effect of soil moisture regimes on leaf deficit, transpiration and yield of tomatoes. J Hort Sci. 45, 359–370.

Yaron, B.; E. Danfors, and Y. Vaddia. 1973. Arid zone irrigation. Springer-Verlag Berlin, Heidelberg, New York.

Yasuto Mitake, and Eiihi Takahashi..1983. Effect of silicon on the growth of cucumber plant in soil culture. *Soil Sci. Pl. Nutri.,* 29(4): 463-471.

Yeo A.R., S.A. Flowers, G. Rao, K. Welfare, N. Senanayake and T.J. Flowers.1999. Silicon reduces sodium uptake in rice (Oryza sativa L.) in saline conditions and this is accounted for by a reduction in the transpirational bypass flow. Plant Cell Environ; 22:559–65.

Zhou, Q., G. Pan, Z. Shi, Y. Meng and Y. Xie. 2002. Effects of Si fertilizer application on maize yield and on quality of maize population. J. of Maize Sci. 10(1): 81-93.

تأثير مستويات الري وبعض معاملات تقليل فقد الماء على النمو والمحصول لنباتات الطماطم الناميه تحت ظروف شمال سيناء.

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**** اقسام بحوث الخضر-معهد بحوث البساتين-مركز البحوث الزراعية-الجيزة-مصر.**

*****قسم الاراضي والمياه-كلية العلوم الزراعية البيئيه بالعريش-جامعة قناة السويس-مصر.**

اجريت تجربه حقليه خلال موسمين صيفيين متتالين، ٢٠١٣ و ٢٠١٤ م في محطة البحوث الزراعية - العريش- شمال سيناء. واستخدم في الدراسة هجين الطماطم جى اس ١٢ لدراسة تأثير ثلاثة مستويات من الري هما ١٠٠٪ و ٧٥٪ و ٥٠٪ من الاحتياجات المائية لنباتات الطماطم ، مع ثلاثة مستويات من الرش الورقي وهى، 2سم / لتر و ٦ سم / لتر وبدون رش من مادتين هما سيليكات البوتاسيوم ومادة دودوكسيل بنزين سلفونات على النمو والمحصول وجودة الثمار وكفاءة استخدام الماء. واستخدم فى تصميم التجربه نظام القطع المنشقة مره واحده. وأظهرت النتائج أن: الرى عند مستوى ١٠٠٪ من الاحتياجات المائيه لنباتات الطماطم مع الرش الورقى باى من سيليكات البوتاسيوم او مادة دودوكسيل بنزين سلفوناتبتركيز ٦ سم من اى منهما/ لتر ماء يلى ذلك تركيز ٢سم/لتر ماء قد اعطى اعلى القيم للنمو الخضرى ممثلا فى الوزن الطازج والجاف لمكونات نبات الطماطم (الجذور والاوراق والسيقان والوزن الطازج والجاف الكلى(، كذلك زيادة المحصول الثمرى ومكوناته وكانت افضل معامله لانتاج اعلى محصول مبكر وكلى ومكونات المحصول هى الرى بمستوى ١٠٠٪ من الاحتياجات المائيه لنباتات الطماطم مع الرش باى من المادتين المستخدمتين عند تركيز ٦سم/لتر- اما عند الرى بمستوى ٧٥% من الاحتياجات المائيه لرى الطماطم فقد ادت الى توفير ٣٣.٦% من الاحتياجات المائيه مع نقص فى المحصول بمعدل ٢٥% وذلك تحت ظروف الرش بنفس المعاملات اما معاملة الرى بمستوى ٥٠% من الاحتياجات المائيه مع الرش بنفس المعاملات فقد ادى الى توفير ٤٣% من الاحتياجات المائيه مع نقص فى المحصول بمعدل ٥٠% كما ادى الرش باى من مادتى سليكات البوتاسيوم او دودوكسيل بنزين سلفونات بتركيز ٦سم/لتر الى تحسين كفاءة استخدام المياه تحت ظروف شمال سيناء.