The physiological effect of soaking seeds with ascorbic acid on some growth characteristics of sweet corn under water stress condition

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Abstract

A field experiment was conducted in the experimental field of the Crop Sciences Department at the College of Agricultural Engineering Sciences (Al-Jadriyah) - University of Baghdad. The aim was to study the physiological effect of soaking seeds in ascorbic acid on some vegetative growth traits of sweet corn (*Zea mays* L. var saccharata) under water stress conditions for the fall seasons of 2021 and 2022 respectively. A randomized complete block design (RCBD) according to the split-plot arrangement was used with three replications. The main plot included three levels of water stress, which were irrigation after depleting 40%, 60%, and 80% of the available water, coded W1, W2, and W3, respectively. The seed soaking concentrations of ascorbic acid at 50, 100, and 150 mg L^{-1}, coded A1, A2, and A3, respectively, in addition to the control treatment (dry seeds), coded CO allocated to the sub-plots. The seeds were soaked for 24 hours, then dried to their original moisture content. The results showed no significant differences between the two water stress treatments when depleting 40% and 60% of the available water regarding the number of days from planting until 75% of male flowering, plant height, leaf number, leaf area, leaf area index, dry weight of plants, and crop growth rate for the two seasons. The irrigation treatment when depleting 80% caused a significant decrease in all studied traits. On the other hand, the soaking treatments with ascorbic acid significantly affected most of the studied traits, with the soaking treatment with 50 mg L-1 of ascorbic acid performing significantly with the highest average plant height of 145.01 and 143.91 cm, stem diameter of 2.55 and 2.54 cm, leaf number of 13.61 and 13.64 leaves $plant^{-1}$, leaf area of 4672.30 and 4634.00 cm^2 $plant^{-1}$, leaf area index of 2.49 and 2.47, dry weight of plants of 162.41 and 162.29 g $plant^{-1}$, and crop growth rate of 3.44 and 3.37 g m^{-2} day^{-1} compared to the control treatment for both seasons, respectively. The soaking treatment with 150 mg L^{-1} of ascorbic acid gave the lowest average number of days from planting until 75% of male flowering of 46.67 and 46.89 days compared to the control treatment, which gave the highest average number of days from sowing up to 75% male flowering, 50.44 and 52.44 days, respectively, for the two seasons. The interaction between water stress and ascorbic acid significantly affected most of the studied traits for the two seasons. Therefore, we recommend that, in the case of limited irrigation water, the possibility of irrigation by depleting 60% of the available water without a significant decrease in the vegetative growth characteristics of the sweet corn crop when the seeds were soaked in ascorbic acid at a concentration of 50 mg L^{-1} to improve their ability to withstand water stress.

Keywords: Sweet corn, water stress, ascorbic acid, vegetative growth rate.
*Part of PhD dissertation of first author.

Introduction

Water resources are considered as one of the main and effective foundations in agricultural development plans in terms of production and agricultural expansion. Therefore, the development of these resources remains one of the most complex problems in achieving and sustaining food security at the international and local levels. It should be noted that Iraq is located in arid and semi-arid regions, and currently faces a range of challenges related to the scarcity of water resources due to the decline in the quantities of water flowing through the Dijlah and Euphrates rivers, accompanied by a weakness in the irrigation management process, with a decrease in rainfall rates in recent years, in addition to the increasing population growth and raising the standard of living of the individual, which has led to an increase in demand for water for all the sectors used, requiring researchers to work on developing possible means for wise management of these resources in order to use them optimally in response to this circumstance that will affect the productivity of all field crops.

Water stress is one of the most important types of non-biological environmental stress, which occurs when the soil moisture decreases due to the absence of rainfall, lack or reduction of irrigation water, or when the amount of water lost through transpiration is greater than the amount of water that plants can absorb through their roots. This leads to changes in the plants' physiological and biochemical functions (13 and 8). Water stress on plants is a result of either water shortage or when the added amount of water does not meet the plant's needs to complete all biological processes that require water (31). Water stress, defined more precisely by(30), is the shortage of available water in terms of quantity and distribution during the plant's growth season. Several studies have indicated that water stress causes a decrease in the vegetative growth characteristics of maize crops.(2) results showed that water stress had a significant effect on reducing growth standards for maize, including plant height, leaf area, and yield, when irrigated at 25% of the control treatment. While, irrigating with 50% of the available gave the highest average plant height and plant diameter compared to control treatment. Additionally, the results of (27), (3), (17), (4), and (14) indicated that water stress significantly reduced the number of days to male flowering, the number of leaves, leaf area, leaf area index, dry weight of plants, and crop growth rate for maize and pop corn in successive seasons (21) study confirmed a reduction in plant height, diameter, dry weight, and crop growth rate of sweet corn, with increased water stress in the early growth stages for two consecutive seasons.

The ascorbic acid, which is one of the non-enzymatic antioxidants that works within cells to remove toxins and deposit heavy metals, this acid is considered the first line of defense for plants by protecting metabolic processes from hydrogen peroxide and other toxic oxygen derivatives (7) Additionally, it promotes plant growth by playing a role in cell division and expansion and is also an active component in plant metabolism, increasing the availability of water and nutrients (23 ; 29). It also regulates the onset of flowering and delays leaf aging, as its effect is similar to that of plant growth regulators (35 ; 5).

The results of. (26) showed that soaking seeds in ascorbic acid concentrations of 0, 100, and 200 mg L^{-1}, the 200 mg L^{-1} concentration outperformed in all growth characteristics and properties. Similarly, the results of. (28) indicated that soaking sweet corn seeds in ascorbic acid at a concentration of 100 mg L^{-1}, in addition to the control treatment (without soaking) under drought conditions, the 100 mg L^{-1} concentration gave the highest significant increase in all growth parameters compared to the control treatment.

Materials and methods

A field experiment was carried out in the research fields of the Department of Field Crop Sciences - College of Agricultural Engineering Sciences - University of Baghdad (Al-Jadriyah) for the fall seasons 2021 and 2022, with the aim of studying the effect of soaking seeds with ascorbic acid under water stress conditions on some vegetative growth characteristics of sweet corn crop. A randomized complete block design (RCBD) according to the split-plot arrangement was used with three replications. The main plot included three levels of water stress, which were irrigation after depleting 40%, 60%, and 80% of the available water, coded as W1, W2, and W3, respectively. The seed soaking concentrations of ascorbic acid at 50, 100, and 150 mg L^{-1}, coded A1, A2, and A3, respectively, in addition to the control treatment (dry seeds), coded CO allocated to the sub-plots. The seeds were soaked for 24 hours, then dried to their original moisture content. The experimental land was plowed with two perpendicular plows with Moldboard plows to a depth of 50 cm. It was smoothed with disc harrows and leveled accurately. After the leveling process was carried out, the experimental land was divided into blocks according to the aforementioned design. The experimental unit had an area of 9 square meters, containing four lines of plants, each 3 meters long with a spacing of 75 cm between lines and 25 cm between plants to achieve a plant density of 53,333 plants per hectare. A distance of 2 meters was left between the main treatments and the same was done between the replicates to prevent water from seeping from irrigated plots to non-irrigated plots for two seasons.

Seeds of the American hybrid sweet corn (CASAH F1) from Snowy River Seeds company were planted manually on 3/8/2021 for the first season and 1/8/2022 for the second season, with three seeds per hill. Thinning was carried out one week after emergence to leave one plant per hill, and replanting was done for failed hills after 75% of the seedlings emerged for both seasons. The experimental land was fertilized with urea (46% N) at a rate of 174 kg ha^{-1}, added in two doses; the first at the stage of 6 true leaves and the second before male flowering. Triple superphosphate (46% P_2O_5) was added at a rate of 109 kg ha^{-1} in a single dose mixed with soil before planting during land preparation (25). Weeding was carried out manually whenever needed to control weeds, and preventive control of corn stalk borer (*Sesamia cretica*) was performed using the insecticide granular diazinon applied in two doses; the first at the stage of 4-5 leaves and the second at the beginning of male flowering (6). The experimental plants were harvested at full maturity on 7/11/2021 for the first autumn season and on 5/11/2022 for the second autumn season.

The relationship between volumetric moisture content and water tension of a soil sample sieved from a sieve with holes of 2 mm in diameter and volumetric moisture content at tensile strengths 0, 3, 5, 7 and 15 bar in the laboratory of the College of Agricultural Engineering Sciences - University of Baghdad for the purpose of estimating the water retention capacity of the soil to a depth of 0- 40 cm, including the determination of the available water content of the soil through the difference between the volumetric moisture content at the field capacity and the permanent wilting point, which was determined through the moisture description curve (Fig. 1).

The volumetric method was adopted to measure the moisture content of the soil, follow up the moisture changes in the soil, and determine the irrigation date according to the depletion level of the irrigation treatments. Samples of soil were taken near the root zone using an Auger to preserve the roots from damage, one day before and two days after irrigation, at depths of 0-20 cm and 0-40 cm for each depletion level, whether 40%, 60%, or 80% of the available water.

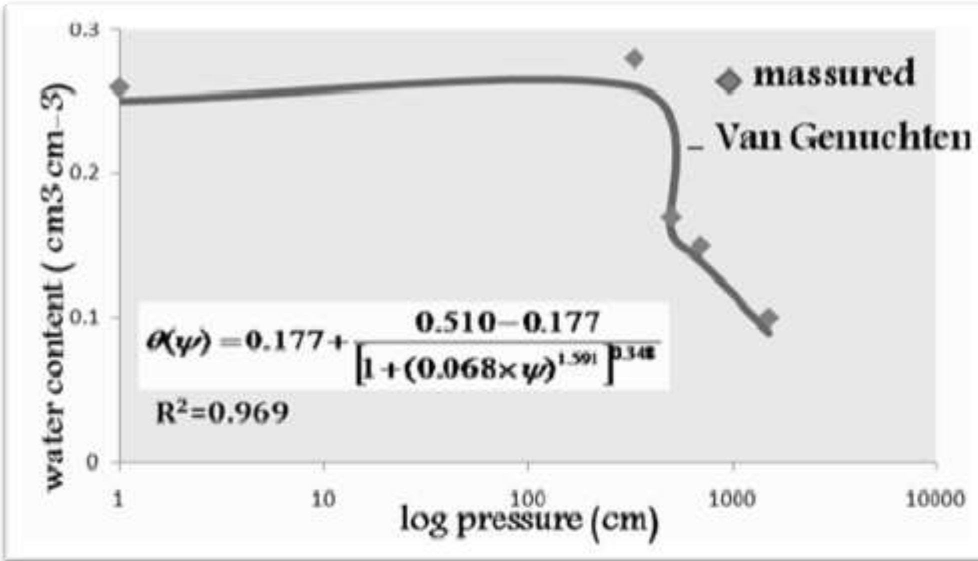

Figure 1. Moisture characteristic curve

It was placed in an aluminum container with a known weight and closed directly to prevent water loss from the sample. Wet weight taken, then placed in a microwave oven for twelve minutes, after the drying time was measured with samples dried in the electric oven at a temperature of 105 °C for a period of 24 hours according to the method proposed by. (34) for drying samples. The dry weight of the sample was then measured, and its moisture content was calculated using the equation provided by (18).

$$P_w = \left(\frac{M_{sw} - M_s}{M_s}\right)100 \quad \ldots\ldots\ldots\ldots (1)$$

Where:

P_w = percent moisture content.

Msw = mass of wet soil (g)

Ms = dry soil mass (g)

Then calculate the volumetric moisture content based on the bulk density of the soil, as in the following equation:

$Q = P_w \times P_b$ …………….(2)

Where: Q = moisture content based on volume ($cm^3\ cm^{-3}$).

Pw = moisture content based on weight gm gm^{-1}.

P_b = bulk density of soil (μg m^{-3}).

The irrigation process is carried out using flexible plastic pipes connected to a pump that operates on gasoline and has a fixed discharge (3 liters sec^{-1}) and is provided with a counter to measure the quantities of water added to each experimental unit for the purpose of controlling the amounts of water calculated based on the depletion of water content for the two autumn seasons. Equal quantities of irrigation water were added at planting to the field capacity of all experimental units to ensure field emergence. Water stress treatments were carried out at 40, 60 and 80% of the available water when the plant reached the stage of 6 complete true leaves (15).

The amounts of irrigation water to a depth of 20 cm per irrigation for depletion treatments were (129, 194, and 259) liters per experimental unit, respectively. As for the quantities of irrigation water to a depth of 40 cm per irrigation, they were (258, 388, and 518) liters for each experimental unit respectively, until the last irrigation when the plant reached the stage of physiological maturity respectively for the two seasons. The depth of water added to compensate for the depleted moisture was calculated according to the following equation (Allen *et al*., 1998).

$\boldsymbol{d} = \boldsymbol{D} \times (\boldsymbol{\theta fc} - \boldsymbol{\theta}_d)$

$\boldsymbol{\theta}_d = \boldsymbol{\theta fc}$ - depletion rate × available water

Where : d : = depth of irrigation water added (cm).
D = soil depth at effective root system (cm).
θfc = volumetric moisture at field capacity (cm3 cm^{-3}).

After that, the volume of water to be added to each experimental unit is calculated according to the following equation:
V = d x A ………………(3)
Where: V = The volume of water to be added in liters per irrigation.
A= Irrigated area (m^2)

Preparation of ascorbic acid solutions (AsA)
Ascorbic acid ($C_6H_8O_6$) was supplied from the American company Reagent World, and the standard solution was prepared by dissolving 1g of ascorbic acid in 1 liter of distilled water (1000 ml) to obtain a concentration of 1000 mg L^{-1} as a standard solution. Then, the required soaking concentrations of 50, 100, and 150 mg L^{-1} are prepared to soak the seeds for 24 hours, according to the following dilution equation:
$N_1 \times V_1 = N_2 \times V_2$ …………….(4)
N1 = concentration of the original (standard) solution
V1 = the volume to be taken
N2 = desired concentration
V2 = required volume

Characters studied

1. **The period from planting until 75% male flowering (day)**

It was calculated from the date of planting (the date of the first irrigation) to the appearance of 75% male flowering of ten plants for each experimental unit, according to field observation.

2. **Plant height (cm)**
   It was calculated from the soil surface level to the lower node of the male inflorescence of an average of ten randomly selected plants from the two middle lines of each experimental unit after the completion of male flowering.

3- Stem diameter (cm)
The measurement was taken from the middle of the internode that bears the upper ear of the plant for the average of ten randomly selected plants from the two middle lines of each experimental unit using Vernier's.

4- Number of leaves (leaf $plant^{-1}$)
The total number of leaves was calculated from the first green leaf at the bottom of the plant to the highest leaf in the plant for an average of ten randomly selected plants from the two middle lines of each experimental unit.

5- Total leaf area of the plant (cm^2 $plant^{-1}$)
It was calculated at the stage of 75% male flowering for ten randomly selected plants from the two middle lines of each experimental unit according to the following equation (10).
Leaf area = square of the length of the leaf under the leaf ear x 0.75

6- Leaf Area index
It was calculated by dividing the leafy area per plant by the land area occupied by the plant.

7- Dry weight (g $plant^{-1}$)
Five plants were weighed at the stage of 75% male flowering, and they were randomly taken with all their components except roots. They were air drying with continuous turning the plants until the weight was stable, and the average dry weight was calculated.

8. - Crop growth rate (g m^{-2} day^{-1}) at the stage of 75% male flowering
According to the following equation (Hunt, 1982):
CGR = 1/A x W2 - W1 / T1 - T2 / …………..(5)
Where: A: represents the land area occupied by the plant sample.
W1: represents the dry weight of the sample at the beginning of the period T1.

W2: represents the dry weight of the sample at the end of the period T2.

The data were analyzed statistically according to the aforementioned design for the two seasons using the Genstat program, and the averages of the treatments were compared using the Least Significant Difference (L.S.D) test at a probability level of 5% (33).

Results

The results of tables (1, 2, 3, 4, 5, 6, 7, and 8) indicated a significant effect of water depletion treatments on all studied characteristics, including the number of days from sowing to 75% male flowering, plant height, stem diameter, number of leaves, leaf area, leaf area index, plant dry weight, and crop growth rate for the two successive seasons. Treatments W1 and W2 (after depleting 40% and 60% of the available water outperformed in the average number of days to 75% male flowering (49.00, 49.83, 48.83, and 49.25 days for two seasons , respectively), plant height (145.85, 146.08, 145.11, and 141.75 cm), stem diameter (2.66, 2.65, 2.41, and 2.44 cm), number of leaves (13.62, 13.60, 13.32, and 13.42 leaves plant-1), leaf area (4752.80, 4706.00, 4721.70, and 4681.00 cm^2), leaf area index (2.53, 2.51, 2.52, and 2.49) , plant dry weight (164.59, 165.77, 163.69, and 165.41 g $plant^{-1}$) , and crop growth rate (3.36, 3.34, 3.35, and 3.37 g m^{-2} day^{-1}) , for the two seasons, respectively. There was no significant difference between W1 and W2 in most of the mentioned characteristics, except for the average stem diameter. while, the water stress treatment (W3) with 80% depletion of the available water had the lowest average for all studied characteristics, which were 46.67 and 47.17 days, 124.90 and 125.15 cm, 2.10 and 2.13 cm, 11.33 and 11.47 leaves plant-1, 3428.90 and 3458.00 cm2 plant-1, 1.83 and 1.84, and 125.43 and 127.95 g plant-1, and 2.70 and 2.72 g m-2 day-1 for the two seasons, respectively.

As indicated by the results of Tables (1, 2, 3, 4, 5, 6, 7, and 8), there is a significant effect of soaking seed treatments with ascorbic acid on all the studied traits respectively over the two seasons. Increasing the AsA concentration in seed soaking reduced the number of days from planting to 75% male flowering, with the A3 treatment (at a concentration of 150 mg/L) having the lowest mean of 46.67 and 46.89 days compared to the other concentrations. while, the CO treatment (dry seeds) recorded the highest mean for the number of days, with a mean of 50.44 and 52.44 days respectively over the two seasons (Table 1). Seed soaking with ascorbic acid before planting led to an increase in the mean plant height (Table 2), with the A1 treatment (at a concentration of 50 mg L^{-1}) outperforming the other soaking treatments, with the highest mean plant height at 145.01 and 143.91 cm and a percentage increase of 11.13 and 9.61% compared to the control treatment (CO), which gave the lowest mean plant height at 130.48 and 131.29 cm respectively over the two seasons. The results in Table (3) showed that soaking the seeds with AsA led to an increase in stem diameter, with the A1 treatment having the highest mean stem diameter at 2.55 and 2.54 cm and a percentage increase of 14.86 and 14.41% compared to the CO treatment, which gave the lowest mean at 2.22 cm for both seasons respectively. The results in Table (4) indicated that the A1 treatment achieved the highest mean number of leaves, with an average of 13.61 and 13.64 leaves $plant^{-1}$ respectively over the two seasons, which was significantly different from the A2 and A3 treatments, with a percentage increase of 13.03 and 12.82 compared to the control treatment (CO), which gave the lowest mean for this trait at 12.04 and 12.09 leaves $plant^{-1}$ respectively over the two seasons. The results in Table (5) also showed that the highest mean leaf area was achieved by the A1 treatment at 4672.30 and 4634.00 cm^2 per plant respectively over the two seasons compared to the other soaking treatments. while, the CO treatment recorded the lowest mean of 3776.60 and 3772.00 cm^2 per plant respectively over the two seasons. The results in Table (6) indicated that the average leaf area index was affected by pre-sowing seed soaking treatments with AsA, where treatment A1 recorded the highest average at 2.49 and 2.47, respectively, with a percentage increase of 23.88% and 22.88% compared to the control treatment (CO), which had an average of 2.01 for both seasons. Additionally, the results in Table (7) indicated that seed soaking with AsA led to a significant increase in plant dry weight, with the highest average of 162.41 and 162.29 g plant^{-1} for the A1 treatment, with a percentage increase of 15.18% and 15.41% compared to the control treatment (CO), which recorded the lowest average at 141.00 and 140.61 g plant^{-1} for both seasons, respectively. Moreover, the results in Table (8) showed that crop growth rate was affected by seed soaking treatments with AsA, where treatment A1 recorded the highest average for crop growth rate at 3.44 and 3.37 g m^{-2} day^{-1} for both seasons, respectively, compared to the control treatment (CO), which recorded the lowest average at 2.78 and 2.68 g m^{-2} day^{-1} for both seasons, respectively.

The results also indicated that there was a significant interaction between the depletion treatments of the available water and the ascorbic acid soaking treatments (the characteristic of stem diameter, leaf area and leaf area index, plant dry weight and crop growth rate) respectively for the two seasons.

Discussion

The results of tables (1, 2, 4, 5, 6, 6, 7, and 8) showed no significant effect between the W1 (40% of the available water) and W2 (60% of the available water) moisture depletion treatments on the growth characteristics of sweet corn plants. This may be attributed to the availability of soil moisture content, which plays an influential role in the growth and depth of roots and, therefore, in the absorption and distribution of water and nutrients to plant parts, resulting in cell growth and division, enzyme activity, and regularity of carbon assimilation, leading to an increase in dry matter accumulation in the plant and, in turn, positively impacting the growth characteristics. This is consistent with the results of (16). However, the W3 irrigation treatment (depletion 80% of the available water) recorded the lowest averages for all growth indicators in the aforementioned tables, reducing the number of days from planting to 75% male flowering (Table 1). This may be due to the lack of water in the plant's environment, which increases the effectiveness of aging hormones such as ethylene and abscisic acid while reducing the effectiveness of growth hormones such as auxin, gibberellin, and cytokinin, thus causing early flowering (12 ; 1). It may also be due to a lack of water combined with high temperatures and low relative humidity, which increases the speed of physiological processes inside the plant, pushing it towards early flowering, which is a mechanism that plants follow to escape from drought by completing their life cycle before being exposed to severe water stress, and is an indicator of drought tolerance. This is consistent with the findings of (3) , (17), and (4), who pointed out that plants exposed to water stress conditions tend to reach the male flowering stage early. The morphological traits were also affected by water stress, as the plant height (Table 2) was reduced due to the shortening of the period from planting to 75% male flowering (Table 1), which includes the stage where the plant elongates. In addition to reducing the number of leaves and their area (Tables 4 and 5), which allows light to penetrate into the plant vegetation and prevents the growth hormone auxin from elongating the internodes, thereby affecting plant height, these results are consistent with those of (2016), Abduladheem (27), and (11), who found a decrease in average plant height for maize under water stress conditions. Whereas, for the reduction in stem diameter with increased water stress (Table 3), the reason may be that water stress affects the dry weight of the root system, causing a decrease in root nutrient uptake by the shoot due to a decrease in carbon metabolism rates. A decrease in root growth rates also causes a decrease in cytokinin production levels, which are primarily produced in the roots that aid in stem diameter division, this results in an increase in stem thickness and thus an increase in plant thickness, which coincides with a decrease in elongation levels due to the reduced turgor pressure resulting from a decrease in relative water content (unpublished data). This leads to a reduction in stem diameter with increased water stress, which is consistent with (22) and (21), who found that water stress caused a reduction in stem diameter for maize and sweet corn. The reduction in the number of plant leaves (Table 4) when exposed to water stress can be attributed to a decrease in the difference in duration from planting until 75% male flowering (Table 1), and the growth and expansion of the affected leaf due to soil moisture deficit and the increase in temperature, which varied between seasons, in addition to the decrease in plant height at the depletion treatment W3, resulting in a reduction in the number of leaves in the plant. This confirms the results reached by researchers such (19),. (32), (3), (17), and (4), who indicated a reduction in the number of plant leaves under water stress. Leaf area, which is considered a basic factor in the process of carbon metabolism is reduced when the plant is exposed to water stress (Table 5), which can be attributed to a reduction in the number of days from planting to 75% male flowering (Table 1), when the leaf growth and expansion stage occurs, or perhaps the reason for the decrease is due to water stress, which reduces the levels of the growth regulator auxin responsible for regulating growth in leaves and cell division and elongation in leaf sheaths, or perhaps due to the degradation of auxin due to increased IAA-oxidase enzyme activity as a result of water stress, which has a negative impact on leaf area (24). This result agrees with the results of (2),. (19),. (32), (3), (17), and (4), who found that water stress causes a reduction in leaf area in the plant. The results in Table 6 also show a reduction in leaf area index when sweet corn plants are exposed to water stress, which can be attributed to a low number of leaves and leaf area (Tables 4 and 5). This result agrees with the results of (2) and (32), who indicated that water stress causes a reduction in leaf area index. The decrease in green growth indicators, including plant height, number of leaves, leaf area, and index, in the aforementioned tables resulted in a decrease in plant dry matter yield (Table 7) for sweet corn plants when exposed to water stress due to a low photosynthetic rate and reduced assimilation surface area. This had a negative impact on the accumulation of dry matter, resulting in its reduction, which in turn affected the amount of surface area exposed to solar radiation. This surface area is a fundamental part of the carbon-building process, this was the main reason for the decrease in the crop growth rate by increasing water stress (Table 8), which depends on the formation of cells and their expansion to form plant parts, which is strongly affected by water stress and dry weight. This result is consistent with the findings of (3), (17), (4), and Iedan and Alag (21), and (14) who all reported a decrease in crop growth rate with increased water stress.

The results indicate that soaking sweet corn seeds in ascorbic acid caused a significant increase in all the studied vegetative growth traits. This may be due to the positive role of ascorbic acid in improving vegetative growth by increasing cell size and expansion, as well as its role in activating the plant's metabolic process, where it increases the availability of water and nutrients (23) and regulates flowering initiation, delays leaf aging, and promotes root development because its effect is similar to that of plant growth regulators (35). This is reflected in the increase in vegetative growth indicators, such as plant height, stem diameter, number of leaves, cell division, leaf elongation, and hence an increase in leaf area and leaf area index, dry weight, crop growth rate (Table 2, 3, 4, 5, 6, 7, 8) respectively. This is evident in the treatment of soaking with A1, which gave the highest means for the mentioned traits in the tables shown later, superior to the other soaking treatments A2 and A3, as well as the treatment of CO, which gave the lowest means for most of the studied traits in both seasons, while increasing the soaking concentrations of AsA reduced the number of days for 75% male flowering. The concentration of A3 recorded the lowest mean number of days for male flowering at 46.67 and 46.89 days respectively, compared to CO, which recorded the highest number of days for male flowering at 50.44 and 52.44 days respectively for both seasons. The reason for this may be attributed to the role of ascorbic acid in regulating the flowering process and plant hormonal signals to stimulate flowering during the transition from the vegetative stage to the reproductive stage, allowing the plant to withstand water stress and accelerate flowering.

As indicated by the results in the aforementioned tables, there was a significant interaction between the study factors in some vegetative growth characteristics (stem diameter, leaf area, leaf index, dry weight of plants, and crop growth rate). The role of ascorbic acid in reducing the damage caused by water deficit was evident, as it reduces the reduction in vegetative growth characteristics by decreasing leaf expansion and carbon assimilation. Furthermore, the presence of ascorbic acid led to a reduction in the negative effects of water deficit, as the treated plants increased their ability to absorb water and nutrients. This is necessary to improve the overall vegetative growth in order to enable the plants to survive under water stress conditions (23 and 28).

Conclusions

We conclude from this that the W2 treatment (60% of the available water has been depleted) gave the same effect on the studied vegetative growth characteristics without any significant differences from the W1 treatment (40% of the ready water has been depleted). This is due to the technology of soaking the seeds with ascorbic acid in reducing the damage caused by water stress by improving the vegetative growth indicators represented by (number of days 75% male flowering, plant height, stem diameter, number of leaves, leaf area and leaf area index, dry weight and crop growth rate). As a result, this is reflected in the formation of an in-depth root system to absorb more water and nutrients and transfer them to the plant.

Table 1. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the number of days from sowing up to 75% male flowering (day) for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water (W)	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	51.00 53.67	48.67 49.33	48.33 48.67	48.00 47.67	49.00 49.83
W_2 60%	51.33 53.00	47.67 49.00	49.00 48.00	47.33 47.00	48.83 49.25
W_3 80%	50.00 50.67	45.00 45.67	46.00 46.33	45.67 46.00	46.67 47.17
Mean	50.44 52.44	46.78 48.00	47.44 47.67	46.67 46.89	
L.S.D $_{0.05}$	W 0.23 0.65		AsA 0.95 0.69		Interaction N.S N.S

Table 2. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the plant height (cm) for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	137.73 141.20	152.67 151.40	148.47 147.93	144.53 143.80	145.85 146.08
W_2 60%	137.07 135.60	149.93 147.27	149.77 143.10	143.67 141.03	145.11 141.75
W_3 80%	116.63 117.07	132.43 133.07	127.87 128.00	122.67 122.47	124.90 125.15
Mean	130.48 131.29	145.01 143.91	142.03 139.68	136.96 135.77	
L.S.D $_{0.05}$	W 2.71 5.12		AsA 1.91 2.82		Interaction N.S N.S

Table 3. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the stem diameter (cm) for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	2.51 2.48	2.82 2.83	2.69 2.61	2.63 2.66	2.66 2.65
W_2 60%	2.19 2.18	2.56 2.61	2.48 2.49	2.41 2.50	2.41 2.44
W_3 80%	1.97 2.01	2.26 2.18	2.14 2.16	2.03 2.17	2.10 2.13
Mean	2.22 2.22	2.55 2.54	2.44 2.42	2.36 2.44	
L.S.D $_{0.05}$	W 0.062 0.063		AsA 0.027 0.067		Interaction 0.047 0.117

Table 4. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the leaf number plant^{-1} for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	13.03 12.93	14.50 14.33	13.67 13.73	13.30 13.40	13.62 13.60
W_2 60%	12.67 12.87	14.27 14.13	13.40 13.47	12.97 13.20	13.32 13.42
W_3 80%	10.43 10.47	12.07 12.47	11.63 11.67	11.20 11.27	11.33 11.47
Mean	12.04 12.09	13.61 13.64	12.90 12.96	12.49 12.62	
L.S.D $_{0.05}$	W 0.348 0.272		AsA 0.270 0.339		Interaction N.S N.S

Table 5. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the leaf area (cm^2 plant^{-1}) for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	4243.30 4166.00	5150.00 5100.00	4871.70 4857.00	4746.30 4701.00	4752.80 4706.00
W_2 60%	4218.30 4134.00	5117.30 5048.00	4846.70 4845.00	4704.30 4697.00	4721.70 4681.00
W_3 80%	2868.00 3016.00	3749.70 3754.00	3574.70 3517.00	3523.30 3545.00	3428.90 3458.00
Mean	3776.60 3772.00	4672.30 4634.00	4431.00 4406.00	4324.70 4314.00	
L.S.D $_{0.05}$	W 45.81 33.30		AsA 52.52 70.60		Interaction 90.96 122.30

Table 6. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the leaf area index for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	2.26 2.22	2.75 2.72	2.60 2.59	2.53 2.51	2.53 2.51
W_2 60%	2.25 2.21	2.73 2.69	2.58 2.58	2.51 2.50	2.52 2.49
W_3 80%	1.53 1.61	2.00 2.00	1.91 1.87	1.88 1.89	1.83 1.84
Mean	2.01 2.01	2.49 2.47	2.36 2.35	2.30 2.30	
L.S.D $_{0.05}$	W 0.024 0.020		AsA 0.028 0.037		Interaction 0.048 0.064

Table 7. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on the dry weight (gm) for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	152.71 150.28	177.32 176.31	166.88 168.74	161.45 167.76	164.59 165.77
W_2 60%	151.11 150.22	176.22 175.79	166.33 168.01	161.08 167.60	163.69 165.41
W_3 80%	119.19 121.32	133.69 134.76	128.05 130.80	120.79 124.91	125.43 127.95
Mean	141.00 140.61	162.41 162.29	153.75 155.58	147.77 153.42	
L.S.D $_{0.05}$	W 1.113 0.511		AsA 0.667 0.934		Interaction 1.155 1.619

Table 8. Effect of water stress treatments and seed soaking in ascorbic acid and their interaction on crop growth rate (gm m^{-2} day^{-1})) for the two autumn seasons 2021 (the highest) and 2022 (the lowest).

Depletion of available water	Ascorbic acid conc. (mg L^{-1})				Mean
	Control CO	A_1 50	A_2 100	A_3 150	
W_1 40%	2.99 2.78	3.64 3.58	3.45 3.47	3.36 3.52	3.36 3.34
W_2 60%	2.94 2.83	3.69 3.59	3.39 3.50	3.40 3.57	3.35 3.37
W_3 80%	2.39 2.39	2.97 2.95	2.79 2.82	2.64 2.71	2.70 2.72
Mean	2.78 2.68	3.44 3.37	3.21 3.26	3.14 3.26	
L.S.D $_{0.05}$	W 0.023 0.047		AsA 0.059 0.042		Interaction 0.103 0.073

References:

1-Abdul Basir, A., M. Khan, I. Khan, M. Adnan, S. Fahad, A .l S. Shah, I.Ur-Rehman, M. Noor and A. Rahman .2018. Phenology and growth traits response of maize (*Zea mays* L.) genotypes to semi-arid conditions. Pure and Appl. Bilogy., *7*(1): 169-173.

2-Abduladheem , M. S.2017. Effect of water stress and Ascorbic acid on growth and yield of Maize Athesis to coll. of Agric. at Univ . of Baghdad. pp:122.

3-Abdulameer , O. Q.A., and S.A. A. Ahmed .2018. Anti-transpirants role in improving the morphological growth traits of maize plants subjected to water stress. Research on Crops.19(4) pp593-603.

4-Abdulameer, O. Q ,S.A. Ahmed. 2019 . Role of humic acid in improving growth characters of corn under water stress.Iraqi Journal of Agricultural Science, 50 (1) pp 420-430.

5-Abed .Z.E., R.W.Jessup,M.H.E.Al-Issawi.2018. Irragation intervals affect dhn1expresssion and some physiological parameters in stay green and non stay green sorghum . Biochmeical and cellular Archive , 18 :1043-1047.

6-Al-Ameri, N. M. 2011. The effect of chemical control of the stalk corn digger Sesamia cretica Led on the growth and productivity of the maize crop. *Zea mays* L. in Qadisiyah province.

7-AL-Behadili , A. J .and Z.A.Abed .2019. effectiveness of oxidantion enzymes in the ratio of gluten of wheat bread via different treatments of weeds control . Indain Journal of Ecology 46(8):119-122.

8-Al-Fatlawi, Sanaa Khadem Abdel-Amir. 2013. Effect of spraying with abscisic acid on the tolerance of wheat plant (*Triticum aestivum* L.) growing under different levels of water stress College of Education for Pure Sciences-Department of Life Sciences-Karbala University.

9-Allen, R.G. , L. S. Pereira, D. Raes and M. Smit. 1998. Crop Evapotranspiration FAO Irrigation and drainage paper. Food and Agriculture Organization of the United Nations, 56(97): 156.

10-Al-Sahoki, Medhat Majeed and Saddam Hakim Jiyad. 2103. Tables for estimating the leaf area of maize based on the length of one leaf. Iraqi Journal of Agricultural Sciences- 44 (2):164-167.

11-Amin, M ., R., Ahmad , A ., Ali , I ., Hussain , R ., Mahmood , M ., Aslam , and D. J.Lee .2018. Influence of silicon fertilization on maize performance under limited water supply Silicon , 10 (2) , 177-183.

12-Atta, M., M. Hamza and A. M. Gohar. 2017. Tolerance of ten yellow corn hybrids to water deficit at flowering and grain filling. Egypt. J. Plant Breed. 21(1):179 – 198.

13-Awad, Hassan Odeh. 2009. Inheritance and Breeding of Crops for Environmental Stres Distribution. Alexandria, Arab Republic of Egypt.

14-Ghazi, T. M., and Abed, Z. A. 2021. Role Of Selection And Irrigation Periods In Improving Some Sunflower Characteristics Related With Drought Tolerance. Plant Archives, 21(1), 1681-1687.

15-Hanway , J .J .1971 . How a com plant develops . Iowa state Univ ., Cooperative Ext .Serv. Spec .Rep .Ames, Iowa , U.S.A No.48.

16-Hashim., E.K.and S.A.Ahmed. 2017. Response of some field traits of wheat to ABA under effect of water stress.The Iraqi J of Agric Sci. (4) 48 pp 957-971

17-Hassan, A. A. H., Ahmed.S.A. A.H .2018. Role of plant growth-promoting rhizobacteria in reduchng the harmful effect of water stress on some physiological traits of popcorn .Research on Crops ,19(3), pp398-404.

18-Hillel , D. 1980. Application of soil physics.Academic press.Inc. pp:116-126.

19-Huang, S .; L. Lv; J .Zhu; Y. Li;H. Tao and P.Wang .2018. Extending growing period is limited to offsetting negative effects of climate change on maize yield in the north china plain . Field Crops Res.21 (5) :66-75.

20-Hunt , R. 1982. Plant growth curves : the functional approach to plant growth analysis .London , Fdward Amold . pp: 248 .

21-Iedan , S. F. and M, K. Alag . 2021. The role of priming seeds with salicylic acid in improving some vegetative growth charcteristics of swett corn under water stress conditions.The J. of Plant Archives,vol.pp1548- 1554.

22-Karasu, A; K. Hayrettin and O . Mehmet .2015. Yield and economic return response of silage Maize to different of irrigation water in a sub –huimid zone . Zemdirbyste – Agriculture 102 (3) 313-318.

23-Khan,T. A.,M. Mazid and F. Mohammad .2011. A review of ascorbic acid potentialities against oxidative stress induced in plants .J. Agrobiol 28(2):97-111.

24-Majda , M . and S . Robert .2018. The Role of auxin in cell wall expansion. J. Mol .Sci 19 (6) 95 -111.

25-Ministry of Agriculture.2011. Guidance in agriculture and the production of maize, The General Authority for Agricultural Guidance and Cooperation Guidance of Iraq.

26-Mohammed .Labed Shareef , Kotada Ibrahim Abdulla and Ather Saber Mustafa .2019. Effect of Ascorbic Acid concentration and harvesting date on growth and yield of three corn Varieties (*Zea mays L*.). *Plant Archives* Vol. 19, Supplement 2, pp2390-2395

27-Mohammed, Nj,Ahmed, S.A. 2016. Importance of Kinetin for some growth characters of *zea ma*ys L.under water stress condition.Iraqi Journal of Agricaltural Scitences ,47(1) pp.259-270.

28-Naglaa, Loutfy,. M.M. Azooz , Mona. Abou Alhamd .2020. Exogenously-applied

Salicylic Acid and Ascorbic Acid Modulate some Physiological Traits and Ant oxidative Defense System in (*Zea mays* L.) Seedlings under Drought Stress. Egypt. J. Bot. Vol. 60, No.1. pp 313-324.

29-Okab, S.I. and Z.A.Abed.2022. Effect of nitrogen fertilizer on growth and yield traits of maize . Iraqi journal of Market research and consumer protection. 14(2)40-49.

30-Sarwata M, Tuteja N., .2017. Hormonal signaling to control stomatal movement during drought stress. Plant Gene;11:143–53.

31-Shinozaki, K., Uemura, M., Bailey-Serres, J., Bray, E. A. and Weretilnyk, E., .2015. Responses to abiotic stress. In Biochemistry and Molecular Biology of Plants (eds. Buchanan, B. B. et al.) 1051−1100.

32-Song, H .; Y . Li ; L . Zhou ; Xu and G. Zhou .2018. Maize leaf functional responses to drought episode and rewatering. Agri. and Forest Meteorology. (4): 57 -70.

33-Steel, R. and J. Torrie. 1980. Principles and procedures of statics.2nd edition, McGrew-Hillbook. Newyork. USA.pp194.

34-Zein , A, K. 2002. Rapid determination of soil moisture content by the microwave oven drying method. Sudan Eng .Soci . j., 48 (40) : 43-54.

35-Zhang, Y. 2012. Ascorbic Acid in Plants: Biosynthesis,Regulation and Enhancement. Springer New York Heidelberg Dordrecht London pp1-117.