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RESEARCH PAPER

INFLUENCE OF SALICYLIC ACID ON LEAF AREA INDEX, CHLOROPHYLL AND RELATIVE WATER CONTENT ON SESAME (*Sesamum indicum L.)* UNDER DROUGHT STRESS

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A B S T R A C T:

Drought is an important factor that could restrict plants growth and productivity through several biological and physiological processes. Salicylic acid (SA) has a key role in many physiological processes of plants and stimulate specific responses against various biotic and abiotic stress factors, in some of plants. In order to evaluate the effect of foliar application by salicylic acid (SA) under drought stress on some morphological characteristics of sesame crop, a RCBD experiment with a with three replications .The experimental included irrigation treatment based on principal development stages according to the general BBCH (Biologische Bundesanstalt, and Chemische Industrie) scale, with three irrigation levels: control (normal irrigations), water stress (stop irrigation at flowering stage (65BBCH) and water stress (stop irrigation at seed production stage (79 BBCH) . Four levels of Salicylic acid (0 as control, 100, 200, 300 ppm). Result indicated that the effect of water stress (stop irrigation at flowering stage (65BBCH) greater than water stress (stop irrigation at seed production stage (79 BBCH), which stop irrigation at flowering stage (65BBCH) decreased photosynthetic pigments, leaf area index and relative water content more than stop irrigation at seed production stage (79 BBCH) under drought stress. Application of salicylic acid significant effect of chlorophyll pigment leaf area index and relative water content while the high level of concentration salicylic acid (SA)(300ppm) caused increases all parameter study and decreases the effect of water stress compared to plant spring only by water.

KEY WORDS:Drought; Salicylic Acid (SA); LA; Chlorophyll content; RWC.
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1. INTRODUCTION

Sesame from the Pedaliaceae family (*Sesamum indicum* L.) is one of the world's oldest crops has been grown tropical and subtropical countries in Asia and Africa for more than 5000 years (Gouveia et al., 2016 and Pham et al., 2010). Sesame seeds play a significant role in human health (Bagheri et al., 2013). The lack of water sources is a primary factor preventing the production of agricultural systems in dry and semidry environments through a number of physiological processes. Environmental stress like drought and high temperatures have a negative impact on the growth and production of agricultural crops (Araus, 2004).

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Drought is a meteorological term that refers to absence of sufficient rainfall, that may limit plant growth and productivity. It is the primary factor stifling the majority of crop plant growth and causing crop loss (Anjum, 2011). Sesame is typically planted in arid and semi-arid regions of the world because it is highly adaptable to unfavorable conditions and abiotic factors. Despite its reputation as a drought-tolerant crop (Poor-Esmaeil et al., 2014). Oxidative damage which is the biochemical change that plants undergo in response to abiotic stresses like drought. This damage can cause an imbalance between the levels of antioxidant defenses and reactive oxygen species (ROS) (Noreen et al., 2009). Although sesame is more drought-tolerant than many other crops, it is particularly susceptible to drought during the germination stage (Athari and Reza, 2014). Germination can be inhibited, or completely stopped by water stress (Turk et al., 2004). It is essential to identify crucial sesame crop growth stages that are impacted by a lack of water supply (Richards et al., 2002). Drought stress alters plant morphology, physiological function, biochemistry, and molecular structure (Harfi, 2016). Drought stress is a major environmental factor that inhibits growth and crop production worldwide, particularly in arid and semi-arid regions (Kadkhodaei et al., 2014). The most cost-effective strategy for reducing agricultural use of irrigation water resources and increasing agricultural productivity would be to strengthen plant resistance to drought stress (Hussain et al., 2008).

Salicylic acid is a potential plant growth regulator and a non-enzymatic antioxidant (Salarizdah et al., 2012), which regulate seeds germination, some physiological processes in plants, such as photosynthesis, flowering, growth, and maturity (Hanan, 2007). Exogenous SA application was found to be very effective in reducing the negative effects of drought stress, enhancing growth, photosynthetic activity, leaf turgor, and relative water content (Hussain et al., 2008). Salicylic acid is an endogenous plant growth regulator of a phenolic nature involved in plant deference mechanisms, so plant exposure to environmental stresses leads to the activation of various deference mechanisms that may be modified by certain chemicals applied to the plants (Hayat et al., 2010).

Foliar application of salicylic acid is an efficient strategy during plant growth, mitigating the negative effects of drought stress and increasing crop yield (Kazemi, 2014). The goal of this study was to investigate the effect of different salicylic acid concentrations on sesame plants leaf area, chlorophyll content, and relative water content under drought stress in two different environments.

2.MATERIALS AND METHODS

2.1 (Seed source)

Seeds of local sesame (Somar) were received from Anbar Research Directorate field

2.2(Study Site)

The experiment was conducted in two different environments; Grdarasha field of Erbil Research Directorate field (Latitude: 36° 4’ N and Longitude: 44° 2’ Elevation 415 Meters above sea level), and the second experimental site was in kifri district (Latitude: 34° 4’ N and Longitude: 44° 5’ Elevation 219 Meters above sea level) in Garmean.

2.3 (Experimental Design)

A factorial experiment arranged in Completely randomized block design with three replications. The plot size was 6 m^2 (2 x 3 m) keeping 50 cm within plots and 100 cm between blocks. Each plot consisted of 5 rows with 40 cm row-to-row distance, and 20 cm within plants. There were three levels of irrigation studied: control (normal irrigation), stop irrigation during flowering growth stage (65BBCH), and stop irrigation during seed production stage (79 BBCH). Four concentrations of salicylic acid: 0 ppm (sprayed with water), 100, 200, and 300 ppm were applied.

2.4 (Crop management)

Study plots were plowed by two crossed plowing, rotator land levelling, then rows were established by chisel plow. Sowing date was on the 1st of May 2021 in Research center nurseries, then homogenized seedlings were transplanted on the 24th of May 2021 in kifri site and the 26th of May in Grdarasha site. Two doses of nitrogen fertilizer were applied (80 kg ha^{-1}): first at the time of transplanting and the second was applied 45 days from the first application. Phosphorus fertilizer was applied at the rate of (80 kg ha^{-1}) with planting the seedlings. Hand weeding was conducted each 20 days to exclude any weed and crop competition.

2.5 (Salicylic Acid Treatment)

Four levels of Salicylic acid 0 ppm (only water recognized as control), 100, 200, and 300 ppm). Sesame plants were sprayed three time (36, 46, and 56 days) after sowing for spraying, 2 L knapsack sprayer was calibrated to insure the complete plant wetting. The spray process was conducted in the evening to avoid any high temperatures or excessive light duration.

2.6(Experiment Parameters)

2.6.1. Plant Leaf Area (PLA) (cm^2)

Leaf area were measured after five days from stopping irrigation, using (image J software) where one plant was chosen randomly form each plot for leaf area (Easlon and Bloom, 2014 and Mohammed and Amin, 2019).

2.6.2. Leaf Area Index (LAI)

Leaf area index was calculated according to below equation

$$LAI = \frac{\textbf{Plant total leaf area}}{\textbf{Average land area occupied by plant}} \ldots (1)$$

2.6.3. Water Content (WC)

Relative water content (RWC) was determined in leaves of a similar age. Leaves were excised before dawn, then recording the fresh weight (FW) and placed in distilled water at 40°C in the dark refrigerator for 24 hours to rehydrate. The following morning, leaf turgid weight (TW) was indicated after that leaves were dried at 70°C for 48h and the dry weight (DW) was determined (Barrs, 1968). Finally, the relative water content (RWC), Initial water content (IWC), and Plant water content (PWC) were figured according to below equation (Lonboni and Arzani, 2011).

$$\boldsymbol{RWC}\% = \frac{\boldsymbol{Fw - Dw}}{\boldsymbol{Tw - Dw}} \times \mathbf{100} \quad \ldots\ldots (\mathbf{2})$$

$$\boldsymbol{IWC}\% = \frac{\boldsymbol{Fw - Dw}}{\boldsymbol{Dw}} \quad \ldots\ldots\ldots\ldots (\mathbf{3})$$

$$\boldsymbol{PWC}\% = (\boldsymbol{Fw - Dw}) \quad \ldots\ldots\ldots. (\mathbf{4})$$

2.6.4. Total Chlorophyll content

Total chlorophyll content was conducted after 10 days from stopping irrigation by using chlorophyll meter instrument SPAD-502 which estimated the chlorophyll content from mature leaves from the fourth or fifth node of each plant at different time intervals (Ling et al, 2011).

2.7Statistical analysis

All recorded data were subjected to standard analysis of variance and means were compared using Duncan Multiple Range Test (DMRT) at 5% of probability using SPSS computer analysis according to (Field, 2005 and Weinberg, and Abramowitz, 2008).

3.RESULTS

3.1Influence of salicylic acid and drought stress on some vegetative traits of sesame in kifri location

Table (1) indicated significant differences on plant leaf area and leaf area index within four concentrations of salicylic acid SA for both time intervals. The highest values of plant leaf area and leaf area index (2120.85cm^2 and 2.65) respectively were recorded in (300ppm) concentration compared to the lowest values of (1603.65cm^2 and 2) for both plant leaf area and leaf area index respectively were recorded in (100ppm) for the first data recording. While in second data the highest values for leaf area and leaf area index were (1438 cm^2 and 1.80) respectively recorded when sprayed with water (control) but the lowest values of (819cm^2 and 1.02) for both plant leaf area and leaf area index respectively recorded at (300ppm) concentration, the highest SA concentration caused lowest data for leaf area and leaf area because salicylic acid (SA) plays an important role in abiotic stress tolerance, during the second data recording, plant leaves were characterized by smaller leaves and a thicker cuticle to mitigate the effect of drought effect on plant.

Table (1) shows clearly significant differences on plant leaf area and leaf area index within the three levels of water stress at two growth stages, whereas at the first stage the maximum values of plant leaf area and leaf area index were (1962.42 cm^2 and 2.45) respectively measured in control treatment, and the minimum value were (1772.85cm^2 and 2.22) respectively obtained from stop irrigation at flowering stage (65BBCH) while at the second growth stage the maximum values of plant leaf area and leaf area index were (1205 cm^2 and 1.51) respectively obtained from at seed production stage (79 BBCH) but the minimum values were (770.26cm^2 and 0.96) respectively obtained from stop irrigation at flowering stage (65BBCH).

The interaction between concentration of SA and drought stress caused significant differences within plant leaf area and leaf area index at two investigated growth stages. At first stage the highest values of plant leaf area and leaf area index were (2266.05cm^2 and 2.83) respectively obtained from control treatment and the SA(100ppm), whilest the minimum values were (1335.94cm^2 and 1.67) respectively obtained from seed production stage (79 BBCH) and SA(200ppm). At the second stage the highest values of plant leaf area and leaf area index were (1529.06cm^2 and 1.92) respectively obtained from control treatment and the SA(0ppm) while the minimum values were (432.26cm^2 and 0.54) respectively obtained from stop irrigation flowering stage (65BBCH).

Table (1) clearly shows significant differences on chlorophyll pigments under four concentrations of salicylic acid application within both data collecting processes. The highest values of chlorophyll pigment (48.17) was recorded for plants under the concentration (100ppm) of SA and the lowest value (45.75) was measured in control plant treatment. In second data recording the highest values of (27.64) was measured for plants under the application of SA (300ppm) and the lowest value (25.40) was measured for plants under concentration of (200ppm) SA.

Also the table (1) shows significant differences on chlorophyll pigment under drought stress at the three levels of water stress for the two growth stages. At both time intervals the highest chlorophyll content values of (47.65 and 44.12) were recorded in plant under control treatment but the lowest values (45.46 and 0) were recorded for plants in stop irrigation at flowering stage (65BBCH).

The interaction between concentration of salicylic acid and drought stress imposed significant differences on chlorophyll pigment. In the first growth stage the highest value of total chlorophyll (49.93) was measured in the concentration (100 ppm) and at seed production stage (79 BBCH) but the lowest value (44.33) was recorded in stop irrigation at flowering stage (65BBCH) while in second stage the highest value of total chlorophyll (45.57) was measured in control treatment but the lowest value (0) was recorded in stop irrigation at flowering stage (65BBCH) for all concentrations used.

3.2 Influence of salicylic acid and drought stress on relative water content (RWC), initial water content (IWC) and plant water content (PWC) of sesame crop in kifri

Table (2) indicated significant differences between RWC and IWC within four concentrations of salicylic acid for two data recording interval whereas in the first data recording the highest values were (63.90% and 4.52) for RWC and IWC respectively recorded in the spray with only water treatment but the lowest values were (51.06% and 4.07) for RWC and IWC respectively recorded in the concentration of SA (100ppm and 200 ppm) compared to second interval which showed non-significant differences between RWC and IWC except PWC which was significant within four concentrations the highest value of (0.43) was recorded in control treatment and the lowest value of IWC (0.38) was recorded in SA (200ppm).

Drought stress for the three levels of water stress shows clearly significant differences on RWC and IWC except PWC within the three levels of water stress at two data recording whereas at the first data recording the maximum values for RWC and IWC were (60.67% and 4.40) respectively measured for full irrigation but the minimum values RWC and IWC respectively measured for stop irrigation at flowering stage (65BBCH). However, at second data recording shows significant differences between RWC, PWC and IWC under the three levels of water stress where the maximum values were (55.15%, 0.43 and 3.28) for RWC, IWC and PWC respectively were measured in control treatment and stop irrigation at seed production stage (79 BBCH) while the minimum values were (50.01%, 3.09 and 0.38) for RWC, IWC and PWC respectively measured in stop irrigation at flowering stage (65BBCH).

According to the results in table (2) the interaction between concentration of salicylic acid SA and drought stress caused significant differences within RWC, and IWC at two growth stages. At first data recording the highest value (73.34%)for RWC respectively was recorded in (control) treatment and SA (0ppm but the lowest value (46.21%) for RWC was recorded in the 100ppm and stop irrigation at seed production stage (79BBCH). However the maximum values for IWC (4.82) was recorded in stop irrigation at seed production stage (79BBCH) and SA(0ppm)While at second data recording also imposed significant differences within RWC, IWC and PWC, the highest values of (RWC and PWC) were (65.77% and 0.49) recorded in the absence of SA and control treatment but IWC was (3.59) recorded in the 300ppm and at seed production stage (79 BBCH) whereas the lowest values for RWC, PWC (43.19%, and 3.01) respectively were recorded in the concentration of SA (0 and 200ppm) at seed production stage (79 BBCH) and (0.36) for IWC was recorded in the no SA spray and at flowering stage (65BBCH).

3.3 Influence of salicylic acid and drought stress on some vegetative traits of sesame in Erbil location

Table (3) indicated significant differences on plant leaf area and leaf area index within four studied concentrations of salicylic acid at both time intervals whereas the highest value for plant leaf area and leaf area index were (2353.46cm^2 and 2.94) respectively recorded with SA (300ppm) and the lowest values were (2126.75 cm^2 and 2.66) respectively recorded with

SA(100ppm) for the first data recording. The second data recording elucidated that the highest values for plant leaf area and leaf area index were (2250.19cm^2 and 2.81) respectively SA (100ppm) and the lowest values were (1545.32cm^2 and 1.93) respectively recorded when sesame plants sprayed only with water due to SA application with the doses (0 to 300ppm) increase plant resistant under unfavorable condition due to decrease leaf area index to minimize respiration process in plant.

Drought stress imposed significant differences on the monitored data for the three levels of water stress in the two growth stages at the first stage the maximum values for plant leaf area and leaf area index were (2415.13 cm^2 and 3.02) for leaf area and leaf area index respectively in control treatment. Whilest minimum values were (2076.82cm^2 and 2.60) for leaf area and leaf area index respectively measured in stopping irrigation at flowering stage (65BBCH). At second stage the maximum values were (2252.73cm^2 and 2.82) for leaf area and leaf area index respectively measured in stop irrigation plots in flowering stage (65BBCH) but minimum values were (1810.17cm^2 and 2.26) for leaf area and leaf area index respectively in stop irrigation at seed production stage (79BBCH). Application of SA increases plant resistance for drought stress.

The interaction between concentration of SA and drought stress caused significant differences within plant leaf area and leaf area index at two investigated growth stages. At first stage the highest value of plant leaf area and leaf area index were (2581.56 cm^2 and 3.23) respectively in the concentration of 200ppm in stop irrigation at flowering stage (65BBCH) plots, but lowest values were (1679.84cm^2 and 2.10) for leaf area and leaf area index recorded with the concentration 100ppm in stop irrigation at flowering stage (65BBCH). Second stage data showed the highest values of plant leaf area and leaf area index were (2682.06 cm^2 and 3.35) respectively recorded in the concentration 100ppm when irrigation stopped at flowering stage (65BBCH), but the lowest values were (1274.16cm^2 and 1.59) for leaf area and leaf area index respectively recorded in plant under control treatment.

Table (3) shows significant differences between chlorophyll pigment and salicylic acid at two studied growth stages. At the first data recording the highest values of chlorophyll content was (51.68) recorded in concentration of SA (300ppm) and the lowest values of chlorophyll was (49.23) recorded in the concentration of SA (100ppm). At the second data recording the highest value was (29.52) recorded in the concentration of SA(200ppm) and the lowest value was (26.59) recorded in the concentration of SA (100ppm).

According to table (3) the significant differences between chlorophyll pigment within drought stress at three levels of water stress for two growth stages. The highest values were reported (51.77 and 45.24) for both growth stage respectively measured at normal irrigation but the lowest values were reported (49.07and 0) for both growth stage respectively were measured at stop irrigation at flowering stage (65BBCH). Also table (3) shows significant differences of the interaction between concentration of salicylic acid and drought stress on chlorophyll pigment at two growth stages where the highest value was (53.36) recorded in the concentration of SA(300ppm) and normal irrigations while the lowest value was (44.15) recorded in the concentration of SA(100ppm) and stop irrigation at flowering stage (65BBCH) for the first stage data recording. While at second stage the highest value was (46.97) recorded in the concentration of SA (300ppm) in control treatment while the lowest value (0) was shown in the all of the concentration of salicylic acid in stop irrigation at flowering stage (65BBCH).

3.4Influence of salicylic acid and drought stress on relative water content (RWC), plant water content (PWC) and initial water content (IWC) of sesame leaves in Erbil

Table (4) indicated significant differences between RWC, IWC and PWC within salicylic acid concentrations at two growth stages. At the first data recording significant differences between RWC and IWC except PWC (non-significant) the highest values were (61.23% and 4.22) for both RWC and IWC respectively in the concentration of SA(300ppm) but the lowest values (51.67% and 3.99) respectively recorded from SA (0ppm and 200 ppm).

At second data recording indicated non-significant differences between RWC and IWC but significant differences between PWC within four concentration of salicylic acid, the highest value of PWC (0.46) was recorded in concentration of SA(300ppm) but the lowest value (0.37) was recorded in concentration of SA(100ppm).

However, in the table (4) shows that drought stress imposed significant differences between RWC and IWC but (non-significant) with PWC for two data recording. At the first data the maximum values were (61.60% and 4.19) for both RWC and IWC respectively recorded in the control treatment and stop irrigation at seed production stage (79 BBCH) but the minimum values were (49.67% and 3.94) for both RWC and IWC respectively recorded in stop irrigation at flowering stage (65BBCH) while at second data recorder shows significant differences between RWC and PWC except IWC non-significant differences the highest values were (55.35% and 0.46) for both RWC and IWC respectively recorded in control treatment but the minimum values were (46.73 and 0.37) for both RWC and IWC respectively recorded in stop irrigation at flowering stage (65BBCH).

The interaction between SA concentrations and drought stress caused significant differences on RWC, IWC and PWC. At the first growth stage significant differences were found within RWC and IWC where maximum values were (65.12% and 4.42) for both RWC and IWC respectively measured in the concentration 300ppm at control treatment while minimum values were (43.29% and 3.98) for both RWC and IWC respectively recorded in only water spraying (0ppm) and 200ppm at and at control and stop irrigation flowering stage (65BBCH).

While at the second data recording significant differences were shown between RWC, IWC and PWC within concentrations of SA and drought stress the maximum values were (60.38%, 3.79, and 0.53) for RWC, IWC and PWC respectively measured in the concentration (200ppm and 300ppm) in control treatment while the minimum values were (42.91%, 2.92 and 0.33) for RWC, IWC and PWC respectively registered with the concentration (300ppm and 100ppm) at flowering stage (65BBCH).

Table 1. Influence of salicylic and drought stress on some vegetative traits of sesame in kifri location

Treatment	**Plant leaf area 1 (cm^2)**		**Leaf area index (LAI)**		**Total Chlorophyll content (Spad)**	
	1st Data Recording	**2nd Data Recording**	**1st Data Recording**	**2nd Data Recording**	**1st Data Recording**	**2nd Data Recording**
Concentration						
C0(water)	2063.79 a	1438 a	2.58 a	1.80 a	45.75 b	26.24 b
C1(100ppm)	1603.65c	883.05 bc	2 c	1.10 bc	48.17 a	25.92 b
C2(200ppm)	1780.82 b	910.62 b	2.23 b	1.14 b	46.76 ab	25.40 b
C3(300ppm)	2120.85 a	819c	2.65 a	1.02 c	46.41 b	27.64 a
Stress						
S0	1962.42 a	1062.09 b	2.45 a	1.33 b	47.65 a	44.12 a
S1	1772.85 b	770.26 c	2.22 b	0.96 c	45.46 b	0 c
S2	1941.56 a	1205.65 a	2.43 a	1.51 a	47.21 a	34.79 b
Con. * Stress						
C0S0	2065.74 a-d	1529.06 a	2.58 a-d	1.92 a	47.05 a-c	45.57a
C0S1	2266.05 a	1249.68 bc	2.83 a	1.56 bc	44.53 c	0 e
C0S2	1859.58 de	1535.24 a	2.32 de	1.91 a	45.67 bc	33.17d
C1S0	1617.07 f	811.25 d	2.02 f	1.01 d	48.73 ab	43.9 ab
C1S1	1508.41fg	522.23 e	1.89 fg	0.65 e	45.85 bc	0 e
C1S2	1685.47 fe	1315.66 b	2.11 ef	1.64 b	49.93 a	33.87d
C2S0	1988.2 cd	1092.99 c	2.48 cd	1.37 c	46.57 bc	41.93 b
C2S1	1335.94 g	876.87 d	1.67 g	1.10 d	47.13 a-c	0 e
C2S2	2018.31 b-d	761.99 d	2.52 b-d	0.95 d	46.57 bc	34.27 d
C3S0	2178.67 a-c	815.06 d	2.72 a-c	1.02 d	48.24 ab	45.07 a
C3S1	1981cd	432.26 e	2.48 cd	0.54 e	44.33 c	0 e
C3S2	2202.89 ab	1209.69 bc	2.75 ab	1.51 bc	46.67 bc	37.87 c

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

Table 2. Influence salicylic and drought stressed on relative water content, initial water content and plant water content of sesame crop in kifri

Treatment	Relative water content1st	Initial water content1st	Plant water content1st	Relative water content 2st	Initial water content 2st	Plant water content 2st
Concentration						
C0(water)	63.90 a	4.52 a	0.74 a	52.38 a	3.20 a	0.43 a
C1(100ppm)	51.06 c	4.38 ab	0.76 a	50.76 a	3.08 a	0.39 c
C2(200ppm)	55.61b	4.07 b	0.71 a	52.52 a	3.12 a	0.38 c
C3(300ppm)	56.31b	4.22 ab	0.74 a	52.24 a	3.25 a	0.41b
Stress						
S0	60.67 a	4.40 a	0.71 a	55.15 a	3.12 b	0.43 a
S1	51.37 c	4.06 b	0.68 a	50.01 b	3.09 b	0.38 b
S2	58.13 b	4.44 a	0.75 a	50.77 b	3.28 a	0.39 b
Con.* S						
C0S0	73.34 a	4.42 a-d	0.72 a	65.77 a	3.21bc	0.49 a
C0S1	53.94 d	4.31 a-d	0.68 a	48.19 f	3.01 c	0.41 b-d
C0S2	64.42 b	4.82 a	0.82 a	43.19 g	3.4 ab	0.38ef
C1S0	56.4 cd	4.59 a-c	0.91 a	50.34 c-f	3.17bc	0.41bc
C1S1	50.57 e	3.93 cd	0.66 a	49.55 d-f	3.05 c	0.37ef
C1S2	46.21 f	4.61 ab	0.70 a	52.4 b-e	3.04 c	0.38 d-f
C2S0	56.3 cd	3.93 cd	0.67 a	51.41 b-f	3.08bc	0.39 c-e
C2S1	47.28 f	4.08 b-d	0.74 a	53.68bc	3.17bc	0.38ef
C2S2	63.25 b	4.21 a-d	0.73 a	52.47 b-e	3.10bc	0.36 f
C3S0	56.64 cd	4.65 ab	0.83 a	53.07 b-d	3.03 c	0.41bc
C3S1	53.68 d	3.91 d	0.65 a	48.62 ef	3.12bc	0.38ef
C3S2	58.63 c	4.10 b-d	0.74 a	55.03 b	3.59 a	0.42b

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

Table 3. Influence of salicylic and drought stress on some vegetative traits of sesame in Erbil location

Treatment	Plant leaf area (cm^2)		Leaf area index (LAI)		Total Chlorophyll content (Spad)	
	1st Data Recording	2st Data Recording	1st Data Recording	2st Data Recording	1st Data Recording	2st Data Recording
Concentration						
C0(water)	2198.58 bc	1545.32 c	2.75 bc	1.93 c	50.84 ab	26.79 c
C1(100ppm)	2126.75 c	2250.19 a	2.66 c	2.81 a	49.23 c	26.59 c
C2(200ppm)	2255.15 ab	2041.91 b	2.82 ab	2.55 b	49.92 bc	29.52 a
C3(300ppm)	2353.46 a	2220.08 a	2.94 a	2.77 a	51.68 a	28.13 b
Stress						
S0	2415.13 a	1980.23 b	3.02 a	2.48 b	51.77 a	45.24 a
S1	2076.82 c	2252.73 a	2.60 c	2.82 a	49.07 c	0.0 c
S2	2208.51 b	1810.17 c	2.76 b	2.26 c	50.41 b	38.03 b
Con.* Stress						
C0S0	2337.23 b-d	1274.16 f	2.92 b-d	1.59 f	50.62 c	44.20 b
C0S1	2107ef	1732.81 e	2.63 ef	2.16 e	50.99bc	0 e
C0S2	2151.51 de	1629 e	2.69 de	2.04 e	50.90bc	36.17 cd
C1S0	2259.10 c-e	2295.77bc	2.83 c-e	2.87bc	50.44 cd	44.77 b
C1S1	1692.65 g	2682.06 a	2.12 g	3.35 a	48.74 de	0 e
C1S2	2428.49 a-c	1772.74 e	3.04 a-c	2.22 e	48.51 e	35 d
C2S0	2504.07 ab	2315.74bc	3.13 ab	2.90bc	52.67 ab	45.03 b
C2S1	2581.56 a	2079.67 cd	3.23 a	2.60 cd	46.12 f	0.0 e
C2S2	1679.84 g	1730.31 e	2.10 g	2.16 e	50.97bc	43.53 b
C3S0	2560.10 a	2035.25 d	3.20 a	2.54 d	53.36 a	46.97 a
C3S1	1926.08 f	2516.37 ab	2.41 f	3.14 ab	50.43 cd	0 e
C3S2	2574.19 a	2108.62 cd	3.22 a	2.64 cd	51.26bc	

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

Table 4. Influence of salicylic acid and drought stress on relative water content, plant water content and initial water content of sesame leaves in Erbil

Treatment	Relative water content1st	Initial water content1st	Plant water content1st	Relative water content 2st	Initial water content 2st	Plant water content 2st
Concentration						
C0(water)	51.67 d	4.05 ab	0.74 a	53.31 a	3.40 a	0.40 b
C1(100ppm)	58.82 b	4.09 ab	0.75 a	51.18 a	3.20 a	0.37 c
C2(200ppm)	57.4 c	3.99 b	0.67 a	51.30 a	3.55 a	0.45 a
C3(300ppm)	61.23 a	4.22 a	0.73 a	53.85 a	3.53 a	0.46 a
Stress						
S0	60.58 b	4.19 a	0.74 a	55.35 a	3.60 a	0.46 a
S1	49.67 c	3.94 b	0.70 a	46.73 b	3.35 a	0.37 c
S2	61.60 a	4.13 a	0.73 a	55.15 a	3.31 a	0.42 b
Con.*Stress						
C0S0	57.15 d	4.13 ab	0.77 a	55.97 a-c	3.52 ab	0.45 b-d
C0S1	43.29 g	3.91 b	0.67 a	50.49 b-e	3.55 ab	0.35 fg
C0S2	54.57 e	4.10 ab	0.78 a	53.47 a-d	3.12 ab	0.40 c-f
C1S0	62.87 bc	4.22 ab	0.72 a	54.96 a-c	3.43 ab	0.39 d-f
C1S1	51.55 f	3.89 b	0.78 a	44.95 de	3.24 ab	0.33 g
C1S2	62.06 c	4.15 ab	0.74 a	53.62 a-d	2.92 b	0.39 ef
C2S0	57.19 d	3.98 b	0.67 a	50.08 b-e	3.79 a	0.48 ab
C2S1	49.89 f	3.90 b	0.65 a	49.07 c-e	3.19 ab	0.40 d-f
C2S2	65.12 a	4.08 ab	0.70 a	54.74 a-c	3.67 a	0.46 bc
C3S0	65.12 a	4.42 a	0.80 a	60.38 a	3.66 a	0.53 a
C3S1	53.94 e	4.05 ab	0.70 a	42.41 e	3.41 ab	0.41 c-f
C3S2	64.63 ab	4.19 ab	0.69 a	58.76 ab	3.52 ab	0.44 b-e

Values with different letters within columns indicate significant differences at 5% of probability according to Duncan's multiple range test.

4.DISCUSSION

Crop plants show a variety of morphological responses in response to a lack of water. The majority of these responses are adaptive mechanisms designed to resist water deficits and ensure survival and reproduction in these conditions. Drought has a major impact on three aspects of plant morphology: Modulation of Root Growth (Jackson et al., 2000), leaf size modulation, and leaf orientation changes (Chaves et al., 2003). Drought stress results in shorter internodes, possibly due to a reduction in leaf area and decrease in light interception, thereby leading to reduced dry mater production and reduced growth. The decrease in shoot length in response to drought may be either due to decrease in cell elongation resulting from water deficit which led to a decrease in each of cell turgor, cell volume and eventually cell growth and/or due to blocking up of xylem and phloem vessels thus hindering any translocation through (Ajithkumar and Panneerselvam, 2013). The reduction of shoot length may protect the loss of water by mechanisms of mitigate drought stress. The interaction between SA concentration and drought stress imposed significant differences within plant leaf area and leaf area index. Salicylic acid (SA) plays an important role in abiotic stress tolerance, and more interests have been focused on SA due to its ability to induce a protective effect on plants under unfavorable environmental conditions. According to Shakirova et al., (2003) Salicylic acid's positive influence on development can be attributed to its influence on other plant hormones; SA altered auxin, cytokinin, and ABA balances and increased growth under normal conditions, while improving growth and drought tolerance under drought conditions. This result agrees with (Bagheri et al., 2013., Kazmi, 2014, Athari and Talebi, 2014). Leaf area was higher in its data recording due to the plant age, while during the second data recording, plant leaves were characterized by smaller leaves and a thicker cuticle to mitigate the drought effect on leaves. Effect of drought stress at flowering stage was greater than drought stress at seed production stage and control (normal irrigation) this result agrees with (Hussen et al., 2015, Khatiby et al., 2016). Chlorophyll decrease may be due to water which is essential for plant growth and survival, and its absence disrupts many physiological processes, including photosynthesis. Water stress can reduce soil moisture availability, affecting plant root uptake of water and nutrients. When plants are stressed by a lack of water, the stomata close to conserve water and reduce transpiration. This reduction in stomatal opening leads to a decline in CO_2 uptake, which in turn reduces the availability of CO_2 for photosynthesis and, as a result, a reduction in chlorophyll synthesis. Plants also activate their stress response mechanisms under water stress, which can include the breakdown of chlorophyll to conserve energy. While treatment by hormonal salicylic acid with different concentrations enhanced growth parameters of sesame plants grown under drought stress at vegetative stages, under water-stressed conditions, SA applications may help reduce the negative effects of drought and may increase sesame vegetative growth. In many study found that significant effect of concentration of salicylic acid and drought stress on chlorophyll pigment high level of concentration salicylic acid cause increasing of chlorophyll pigment due to salicylic acid plays an important role to decrease the effect of drought stress on plant under water stress. The results in table (1,3) similar to those obtained by Hussain *et al.,* (2008) they found that exogenous SA application was very effective in reducing hateful effects of drought stress and improved the growth, enhanced photosynthetic, water use efficiency, leaf turgor and relative water content. This result, similar to the results of (Raskin,1992, Hussain et al., 2008, Bidabadi, 2012 and Kazemi, 2014) were found that SA improves leaf water status under water deficient condition. Plants treated with SA had a slower decrease in RWC during drought stress. RWC was found to be positively related to proline concentration. As a result, the increase in RWC caused by exogenous SA application may be due to osmotic adjustment caused by the accumulation of osmotic adjustment such as proline. This result is consistent with the findings (Kadioglu et al.,2011, Afshari et al.,2013 and Athari and Talebi, 2014)

5.CONCLUSIONS

In our study it was clear that the effects of water stress and concentration of salicylic acid were more prevalent when used during vegetative growth stage. Salicylic acid (SA) application can help reduced the negative impacts of drought and promote sesame growth under drought conditions.

Exogenous salicylic acid application shows benefits under both normal and stress conditions. However, the plants mitigation by SA application were better when imposed to water stress at flowering stage than those water stress at seed production stage.

Overall, it is concluded that lack of irrigation during the flowering and seed production stages affects growth and yield of sesame and application of salicylic acid mitigated the effects of drought stress. In a water-stressed situation, foliar application of (50,100,150 ppm) SA and drought stress was beneficial in reducing the adverse effects of water stress in sesame.

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