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USE OF SALICYLIC ACID IN LETTUCE PLANT AGAINST INCREASING METEOROLOGICAL DROUGHT

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ABSTRACT

Climate change and related meteorological drought have been one of the most important factors limiting plant production in Turkey as well as in the whole world. Producers have to develop quick solutions for sudden drought and water shortage conditions in the field. One of these solutions is the application of various chemicals that provide resistance to drought during the growing period of plants. Since the Southeastern Anatolia Region of Türkiye is a semi-arid region, mostly irrigated agriculture is carried out from early spring to the beginning of winter. Especially in dry periods, the negative effects of drought are seen rapidly in plants such as lettuce, which are sensitive to water deficiency. In order to reduce these negative effects, different salicylic acid (SA) concentrations were tried under deficient irrigation conditions in lettuce plant grown in autumn planting in Diyarbakır. For this purpose, three different irrigation water amounts and four different SA concentrations were applied. According to these applications, the lowest leaf length was obtained from the subject where SA was not applied and the lowest dose of irrigation water. The lowest leaf width was obtained from the subject where the lowest dose of irrigation water was applied. The highest whole plant dry weight was obtained from the subject treated with the least amount of water and 0.50 mM SA. The effects of irrigation water and SA on SPAD readings and the water-soluble dry matter parameter in plants were not statistically significant.

Key words: Drought, deficit irrigation, salicylic acid, lettuce, resistance.

INTRODUCTION

Depending on climatic conditions, irrigation is the most important factor that increases crop productivity and growth in agricultural irrigation regions. Because irrigation efficiency can be increased by 1 to 5 times depending on soil characteristics, vegetative characteristics, climatic differences, irrigation method used and producer conditions. In conditions where irrigation cannot be done or it is limited, various methods are used in order to produce without reducing the yield against drought. One of them is the use of some chemicals that provide resistance to drought in plants. Salicylic acid (SA), one of these chemicals, is a plant-produced compound with different physiological and biochemical functions and evaluated as a plant growth regulator (Raskin 1995). It has been determined that the amount of intrinsic SA as a defense mechanism increases in plants exposed to biotic stress (eg pathogen attack). In recent years, both biotic, salinity, drought, low temperature etc. Studies on the role of SA in abiotic stress conditions such as It is stated that the effectiveness of SA to be applied externally in order to reduce the damage to the plant under stress conditions depends on many factors such as species, cultivar, development period of the plant, application method and concentration (Horvath et al. 2007).

This study was carried out in Diyarbakır Dicle University Faculty of Agriculture in the autumn of 2019. Yedikule type lettuce variety was used in the experiment and it was carried out to examine the effect of salicylic acid doses on the drought resistance of lettuce plant. The

main subjects of the experiment were 100% (I_1), 75% (I_2), 50% (I_3) of the amount of accumulated water evaporated from the Class A evaporation pan, and the sub-subjects of the experiment were 4 (four) different salicylic acid (SA). dose (0 mM (SA_1), 0.25 mM (SA_2), 0.5 mM (SA_3) and 0.75 mM (SA_4)). Irrigation was done with drip irrigation every 4 days, and SA applications were made 2 times with an interval of 2 weeks starting from the period when the plants had 3-4 leaves.

MATERIALS AND METHODS

Material

Research Area and Soil Properties

This study was carried out for one year in the trial area of the Faculty of Agriculture of Dicle University. The trial area where the study was carried out is located at 37°53'28.6"N latitude 40°16'24.9" east longitude and its altitude is 660 meters. The satellite photograph of the area where the study was carried out is shown in Figure 1.

Figure 1. Dicle University Faculty of Agriculture Satellite Image

The soils of the trial area are in the alluvial large soil class and generally have a clayey texture. Dry farming or fallow farming is practiced in the aforementioned lands. These lands with good drainage are named as 1st class agricultural land and there is no groundwater problem (Anonymous, 1994).

Climate Characteristics

Diyarbakir, where the experiment was conducted, has a hot and dry climate in summer and a warm and rainy climate in winter. The average annual precipitation for many years is 486.7 mm, and a significant part of it generally falls in winter and early spring.

Plant Material Used in Research

Yedikule type (cos) plain lettuce variety was used in the experiment. It has large long leaves and a large head structure. It is a tall variety with medium to dark green leaf color, capable of forming a tight and voluminous head.

Irrigation System

Since the lettuce row spacing was 30 cm (narrow row spacing), irrigation was carried out using a lateral drip irrigation method between the two plant rows. The system consists of

main pipe (Ø 50), manifold (Ø 32) and lateral (Ø 16) pipelines. The dripper spacing is 40 cm. The drip irrigation system used in the irrigation of the lettuce plant; The control unit is formed from the main, side and lateral pipeline.

Methods

Experiment Subjects and Experiment Design

The experiment was carried out according to the randomized blocks experimental design in the split plot design with 3 replications. Its main subjects are 3 (three) different amount of irrigation water (100%, 75%, 50% of the amount of accumulated water evaporated from A class evaporation pan) and its sub-topics are 4 different Salicylic Acid (SA) doses (0, 0, .25, 0.5 and 0.75 mM). Salicylic acid was applied by spraying on the leaves. Thus, the total number of parcels in the experiment was 36 (thirty-six).

Analysis and Measurements

Soil Samples and Analysis

Soil samples were obtained from the soils of the trial area for chemical and physical examinations before the trial was set up. In the experimental subjects, the change of soil water content in the root zone was monitored during the growing season. For this purpose, measurements were made during planting, before each irrigation and ended at harvest.

Soil water content was measured gravimetrically at 0–30 and 30–60 cm layers (Tüzüner, 1990). In addition, according to the trial subjects, the soil water energy was measured by tensiometers on the middle repetitions and compared with the gravimetric soil moisture levels. In addition, sensors (DECAGON (5TE)) measuring soil moisture-temperature-EC (salinity) were also driven into the middle repetitions to measure the volumetric moisture content of the soil.

Plant analyzes

In the experiment, observations and measurements were started at the same time as planting the seedlings and continued at regular intervals until the physiological maturity when the plant development completely ended.

Leaf length (cm): The length between the stem and the tip of the fruit was measured with the help of a ruler and recorded in cm.

Leaf width (cm): The diameter of the leaves taken at random will be measured from the middle parts of the fruit with a 0.1 mm caliper and recorded as cm.

Plant dry head weight (g plant^{-1}): The head weight of the harvested plants was determined by weighing in a sensitive scale sensitive to 0.01 g after the roots were cut (Korkmaz et al. 2007). The samples were dried and weighed in an oven at 65 0C until their weight remained constant (Ghoulam et al. 2002, Arfan et al. 2007).

The amount of water-soluble dry matter (%): The amount of water-soluble dry matter in the juice taken from lettuce plants was measured using ATAGO N1 (Brix 0-32%) brand hand refractometer. Two samples were taken for each plant and the % The amount of water-soluble dry matter in the lettuce juice was calculated.

Chlorophyll amount (SPAD): The relative chlorophyll content in the leaves will be measured with the Minolta SPAD-502 Chlorophyllmeter (Konica Minolta Japan Leaf Chlorophyll Meter SPAD 502) device on the 2nd and 3rd leaves of each replication, and the values obtained will be expressed as SPAD values. According to the manufacturer of the chlorophyllmeter, it will be indicated on the SPAD value scale as 1 = chlorotic or yellow color, 50 = dark green color.

RESULTS AND DISCUSSION

Irrigation Water Levels and SA Doses Applied in Different Amounts in Lettuce Leaf Effects on Width

The results of the effects of different amounts of irrigation water and different doses of SA on lettuce leaf width are given in Table 1. Twenty completed leaves were selected from ten plants taken randomly from each plot, and the lengths of these leaves were measured one by one with a ruler and average values were given (Table 1).

Leaf width values of the lettuce plant obtained depending on the different amounts of irrigation water and different doses of SA used in the experiment varied between 13.34 and 18.66 cm. The highest and lowest leaf widths were obtained from the same subject. It was obtained from the subject I_2SA_4, where 75% of the evaporation amount of the irrigation water from the A class evaporation pan was applied and the SA was applied at a dose of 0.75 mM. However, when looking at the main subject in general, the highest leaf width values are observed in the subject where 100% of the evaporation amount of the irrigation water from the class A evaporation pan is applied, while the lowest leaf width values are observed in the subject I_3 where 50% of the evaporation amount of the irrigation water from the class A evaporation pan is applied. obtained (Table 1)

Table 1. Lettuce leaf width repetition averages according to trial subjects

Main topics	Subtopics	Leaf width (cm)
I_1	SA_1	16.64
	SA_2	16.57
	SA_3	16.23
	SA_4	16.09
I_2	SA_1	15.42
	SA_2	15.14
	SA_3	15.43
	SA_4	16.07
I_3	SA_1	15.26
	SA_2	14.06
	SA_3	14.91
	SA_4	14.96

According to the results of variance analysis of the obtained data, the effects of different amounts of irrigation water on leaf width were not found to be statistically significant, while the effects of different SA doses on leaf width values of lettuce plant were statistically significant at the level of 1%. When the leaf width values of the lettuce plant were examined, it was observed that there was an insignificant increase in leaf width with the increasing amount of irrigation water. Considering the sub-topics, it will be seen that there is no noticeable difference in leaf width values in the lettuce plant. The changes that occurred depending on the amount of irrigation water and SA doses were more significant.

When the subjects and the repetition averages were examined separately, it was determined that I_1, in which 100% of the evaporation from the A class evaporation pan, gave

the highest values for the leaf width parameter, as in the majority of the other parameters examined. In addition, regardless of SA doses, the highest leaf width results were obtained from I_1 subject. The lowest leaf width was obtained from the subject I_2SA_2, where the highest leaf width was also observed, as can be seen in Figure 2.

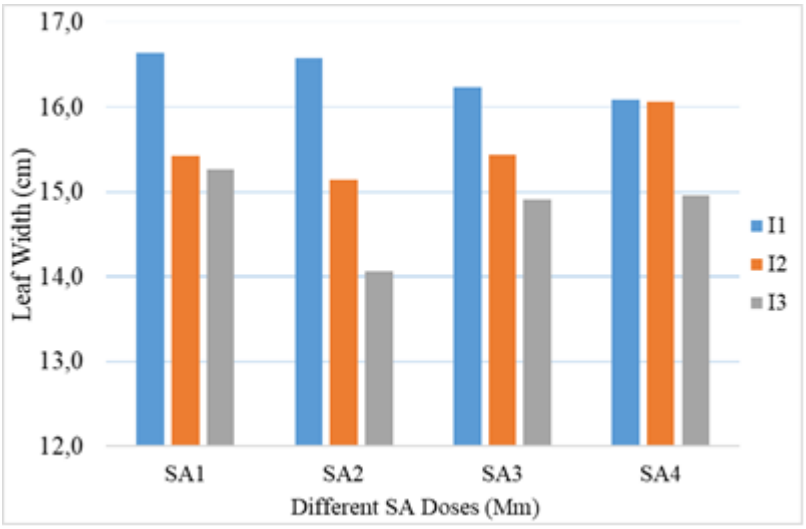

Figure 2. Leaf width change for trial year according to trial subjects

Irrigation Water Levels and SA Doses Applied in Different Amounts in Lettuce Leaf Effects on Height

The results of the effects of different amounts of irrigation water and different doses of SA on lettuce leaf length are given in Table 2. Twenty completed leaves were selected from ten plants taken randomly from each plot, and these leaves were measured one by one with a ruler and average values were given (Table 2). In Table 2 below, leaf length results are given by taking the average of the leaf length values of lettuce plants obtained from three replications and ten plants.

Leaf length of the lettuce plant obtained varied between 18.80 – 23.29 cm. The highest leaf size value It was obtained from the subject I_3SA_4, where 50% of the evaporation amount of the irrigation water from the class A evaporation pan was applied with 14.06 cm and SA was applied at a dose of 0.75 mM. The lowest lettuce plant leaf height value, 18.80 cm, was obtained from the subject I_3SA_1 where 50% of the evaporation amount of the irrigation water from the A class evaporation pan was applied and SA was not applied.

According to the results of the analysis of variance on the obtained data, the effects of different amounts of irrigation water on leaf length were not found to be statistically significant, while the effects of different SA doses on the leaf length of the lettuce plant were statistically significant at the 5% level. When the leaf length results of the lettuce plant were examined, it was observed that there was an insignificant increase in leaf length with the increasing amount of irrigation water. The highest leaf length results in the lettuce plant were determined in the application of SA_4 dose, in which SA was applied at a dose of 0.75 mM.
When the subjects and the repetition averages were examined separately, it was determined that I_1, in which 100% of the evaporation from the Class A evaporation pan was given, gave high results as in the majority of the other parameters examined. In particular, the highest leaf length was determined in the interaction between S_4 and I_3, in which SA was given as 0.75 mM. The lowest leaf length was obtained from the interaction of I_1SA_1 and I_1SA_2, as can be seen in Figure 3. In other words, regardless of the scarcity of irrigation water, low SA application doses had a reducing effect on leaf height values.

Table 2. Lettuce leaf length repetition averages according to the trial subjects

Main topics	Subtopics	Leaf length (cm)
I_1	SA_1	21.82
	SA_2	21.74
	SA_3	21.84
	SA_4	21.77
I_2	SA_1	21.48
	SA_2	20.28
	SA_3	20.92
	SA_4	22.17
I_3	SA_1	19.94
	SA_2	20.14
	SA_3	21.71
	SA_4	21.81

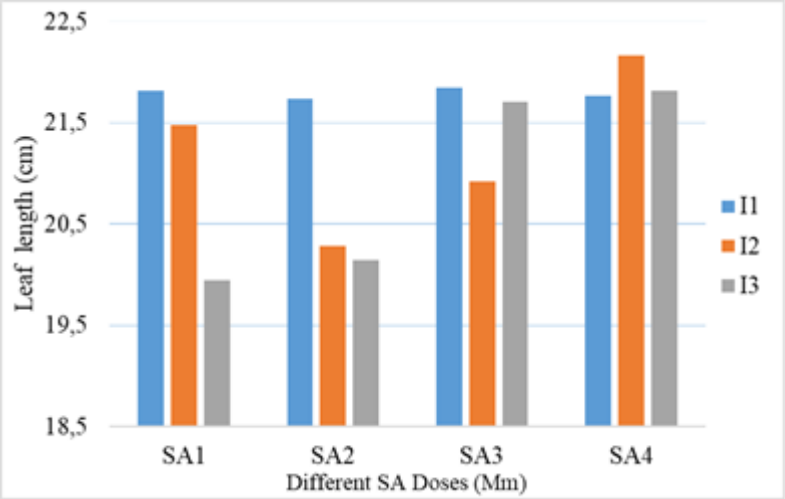

Figure 3. Leaf length change for trial year according to trial subjects

The Effects of Irrigation Water Levels and SA Doses applied in Different Amounts on the Whole Dry Weight of Lettuce Plant

All lettuce plant dry weight results of different amounts of irrigation water and different doses of SA are given in Table 3. After weighing all the plant fresh weights of the same ten plants examined for each plot, the plants were cut from their root stems and their root weights were weighed instantly on a precision scale without loss of time (without moisture loss in plants). These ten plants, whose wet weights were taken, were cut, and the upper parts and roots were weighed separately, and then dried in an oven at 65 °C for one day. The dried plants were weighed and the whole dry weight of the plant was calculated. This process was also carried out on ten random plants taken from each plot. Accordingly, a total of ten plants were taken from each experimental plot, excluding the edge effects, and evaluated.

Dry weight of the whole lettuce plant obtained depending on the different amounts of irrigation water used in the experiment and the different doses of SA. It varied between 34.35 – 48.37 g plant^{-1}. Highest dry weight of whole lettuce plant It was obtained from the subject

I_3 SA_3, in which 48.37 g of plant^{-1} and 50% of the evaporation amount of the irrigation water from the class A evaporation pan and the SA dose was applied as 0.50 mM. The lowest dry weight of whole lettuce plant was obtained from I_2SA_3 subject with 34.35 g plant^{-1} and 75% of the evaporation amount of irrigation water from Class A evaporation pan and the SA dose was 0.50 mM.

Table 3. Dry weights of whole lettuce plants by trial subjects recurrence mean

Main topics	**Subtopics**	**Plant root fresh weight (g plant $^{-1}$)**
I_1	SA_1	41.44
	SA_2	43.97
	SA_3	46.12
	SA_4	46.00
I_2	SA_1	40.68
	SA_2	41.00
	SA_3	41.94
	SA_4	43.44
I_3	SA_1	38.25
	SA_2	40.71
	SA_3	42.23
	SA_4	42.83

According to the results of variance analysis of the obtained data, the effects of different amounts of irrigation water on the dry weight of all lettuce plants were found to be statistically significant at 5%, and the effects of different SA doses on the dry weight of all lettuce plants were not statistically significant. When the dry weight results of all lettuce plants are examined, it will be seen that there is a decrease in the dry weight of the plant together with the decreasing amount of irrigation water. Likewise, the dry weight of the lettuce plant increased due to the increase in SA doses.

When the subjects and the repetition averages are examined separately, the I_1 subject, in which 100% of the evaporation from the A class evaporation container is given, and the SA_4, where the SA is applied the highest (0.75 mM), the highest dry weight of the whole lettuce plant, on the other hand, the Class A evaporation pan. It was observed that the lowest dry weight of the whole lettuce plant was obtained in the subject I_3, in which 50% of the evaporation from the evaporation pan was given, and in the subject of SA_1, in which no SA application (0 mM) was applied (Figure 4).

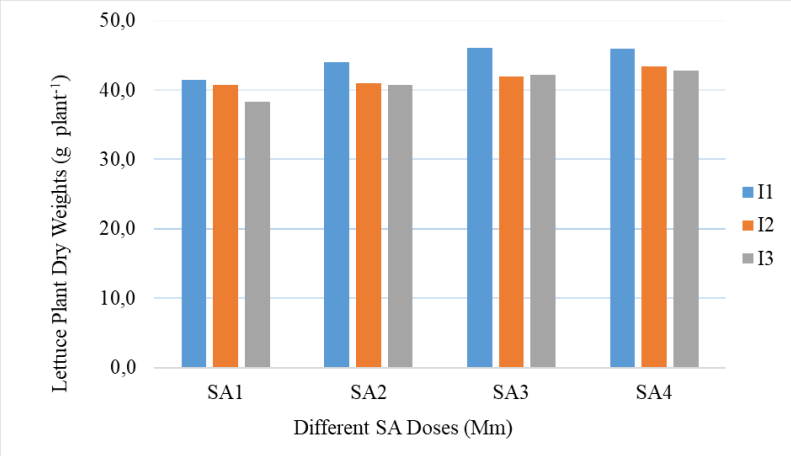

Figure 4. For the trial year by trial subjects, all lettuce plant dry weights

The Effects of Irrigation Water Levels and SA Doses Applied in Different Amounts on Water- Soluble Dry Matter (WSDM) in Lettuce

The results of the effects of different amounts of irrigation water and different doses of SA on the lettuce plant are shown in Table 4. Samples were taken from twenty different leaves of medium-grown ten plants randomly taken from each plot and measured one by one with a refractometer, and average values were given (Table 4).

values of the lettuce plant obtained varied between 3.80% and 6.85% cm. The highest WSDM value with 6.85% was obtained from I_1 SA_4 topic, and the lowest root length value was obtained from I_2SA_3 topic at a level of 0.50 mM, where the evaporation of irrigation water from Class A evaporation pan was 75% and SA application was 0.50 mM. When we look at the main subject in general, the highest WSDM values were observed in the subject where 100% of the evaporation amount of the irrigation water from the class A evaporation pan was applied, while the WSDM values were obtained in the subject I_3 where 50% of the evaporation amount of the irrigation water from the class A evaporation pan was applied (Table 4).

Table 4. The mean of WSDM recurrences in lettuce according to the trial subjects

Main topics	**Subtopics**	**WSDM**
I_1	SA_1	6.06
	SA_2	5.58
	SA_3	5.77
	SA_4	6.35
I_2	SA_1	5.27
	SA_2	5.47
	SA_3	4.66
	SA_4	5.46
I_3	SA_1	5.35
	SA_2	4.76
	SA_3	5.32
	SA_4	5.38

According to the results of the variance analysis of the obtained data, the interaction of the main topic, sub-topic, main topic and sub-topic and the effects of repetitions on the WSDM values were not statistically significant.

When the subjects and the recurrence averages were examined separately, the highest WSDM values were found in $I_{1,}$ where 100% of the evaporation of the irrigation water from the Class A evaporation pan was given in terms of irrigation water levels. In addition, very close WSDM values were determined in the subjects I_2 and I_3, which are the subjects in which 75% and 50% of the evaporation of the irrigation water from the A class evaporation container is applied. When the WSDM values were examined depending on the SA doses, the highest WSDM values were found in $SA_{4,}$ where the highest dose of 0.75 mM was applied, as in most of the other investigated parameters (Figure 5). Similarly, $SA_{1,}$ in which SA was not applied, gave values close to SA_4 as well.

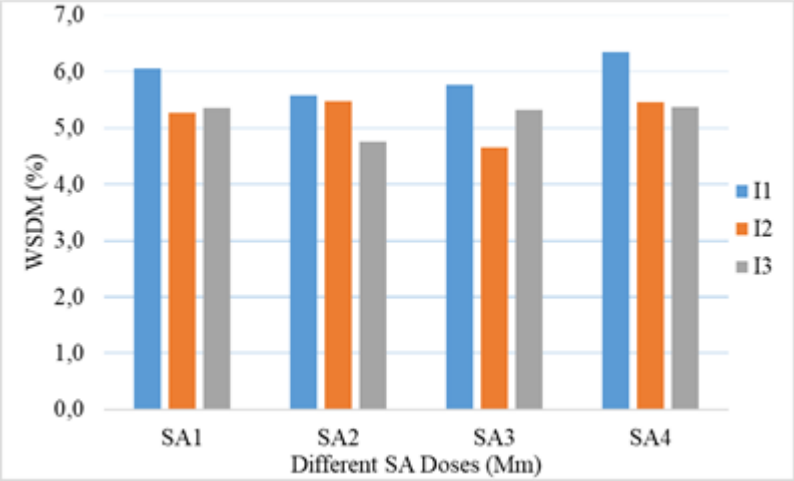

Figure 5. Change of WSDM levels according to trial subjects

Effects of Irrigation Water Levels and SA Doses applied in Different Amounts on Chlorophyll Amount

The results of the effects of different amounts of irrigation water and different doses of SA on the amount of chlorophyll in lettuce are shown in Table 5. Samples were taken from twenty different medium-grown leaves of ten plants taken randomly from each plot and measured one by one with the Chlorophyll meter SPAD-502 Plus instrument and average values were given (Table 5).

SPAD values of the lettuce plant obtained depending on the different amounts of irrigation water used in the experiment and the different doses of SA varied between 25.00 and 38.72 SPAD units. The highest SPAD value is 38.72 SPAD units with I_2SA_2 subject, and the lowest SPAD value is the main subject where 75% of the evaporation of irrigation water from Class A evaporation pan is given, and the sub-subject I, where SA is applied at a dose of 0.25 mM. 2 Obtained from SA_2 subject. The highest SPAD value was also obtained from the main subject, in which 75% of the evaporation of the irrigation water from the Class A evaporation pan, was given, and the sub-topic I_2SA_2, where SA was applied at a dose of 0.25 mM. When looking at the main subject, the highest SPAD values were observed in the subject where 50% of the evaporation amount of the irrigation water from the class A evaporation pan was applied, while the lowest SPAD values were obtained in the I_2 subject where 75% of the evaporation amount of the irrigation water from the class A evaporation pan was applied (Table 5)

Table 5. SPAD values in lettuce, mean repetitions according to trial subjects

Main topics	Subtopics	SPAD
I_1	SA_1	30.38
	SA_2	30.89
	SA_3	32.72
	SA_4	32.25
I_2	SA_1	28.27
	SA_2	32.90
	SA_3	32.27
	SA_4	29.99
I_3	SA_1	31.59
	SA_2	33.57
	SA_3	32.69
	SA_4	30.99

When the subjects and the recurrence averages were examined separately, the highest SPAD values were determined in the I_3 subject, where 50% of the evaporation of the irrigation water from the A class evaporation pan was given in terms of irrigation water levels. In addition, the subject I_2, in which 75% of the evaporation of the irrigation water from the A class evaporation pan, was applied, gave the lowest SPAD values. The lowest SPAD values were obtained in SA_1, in which SA was not applied.

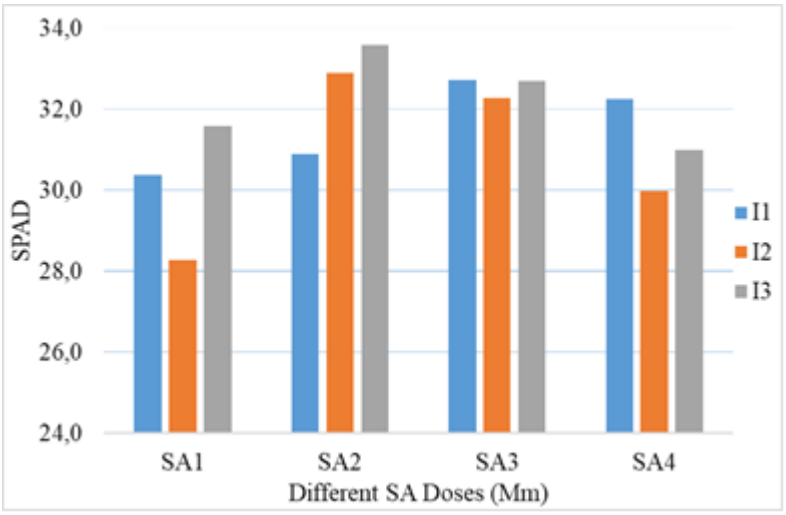

Figure 6. Change in SPAD readings by trial subjects

CONCLUSIONS

In general, the increase in the amount of irrigation water and the increase in SA doses had a positive effect on the investigated parameter. The physiology of the plant investigated in drought studies also shows different reactions to irrigation and/or chemicals used. Lettuce is a sensitive plant that reacts very quickly to dry conditions due to its physiology. Therefore, it is expected that yield and yield-related parameters will be positively affected with the increase in the amount of irrigation water or the increase in the doses of chemicals that improve resistance to drought. It may be recommended to irrigate fully and to use these

chemicals, which develop resistance to drought, in certain doses, especially in semi-arid regions such as Diyarbakır province, where rain does not fall for more than half of the growing period, since it is planted at the beginning of autumn.

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