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Research article

THE EFFECT OF SALICYLIC ACID ON PHOTOSYNTHETIC SYSTEM OF TWO VARIETIES OF GRAPES (VITISVINIFERAL L.) UNDER DROUGHT STRESS CONDITIONS

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ABSTRACT: In order to investigate the effects of treatment of Salicylic Acid on photosynthetic system of two varieties of grapes (Vitisvinifera L. and Seedless White), under drought stress conditions, a factorial experiment was performed in terms of the scheme of totally random blocks. Watering cycles included intervals of 5, 10 and 15 days, and Salicylic Acid included concentrations of zero, 1 and 2 mM. The results showed that by increasing drought stress, number parameters and leaf area, relative content of leaf water, transpiration, stomatal conductance, and pure photosynthesis had significant decrease in comparison to control treatment. And leaf thickness and stomata numbers increased significantly. Also the results revealed that the rate of leaf numbers, leaf thickness, stomata numbers, relative content of leaf water, pure photosynthesis and transpiration of Vitisvinifera L. was more than Seedless White. And the area of leaf and stomatal conductance in Seedless White grape was more than Vitisvinifera L. grape. Foliar application of Salicylic Acid resulted in increasing the number and the area of the leaf, leaf thickness, transpiration, stomatal conductance and pure photosynthesis. Generally, the results showed that Salicylic Acid can decrease drought deterrence stress effects on grape growth and VitisviniferaL. grape in comparison to Seedless white grape is more resistant to dryness.
Key words: salicylic acid, grapes (vitisviniferal l.), drought stress

INTRODUCTION

During their growth, plants continually are under effects of non-favorable elements. Some of these elements are drought stress that limit growth in plants [3]. Selection of varieties of drought tolerance is possible through investigation of their performance under stress. Since this performance is the estimation of physiological characteristics of the plant, we can use these characteristics as a tool to select tolerant plants. For this reason, usually varieties and genotypes of one plant species are investigated through physiological characteristics and its relation to drought tolerance [12]. In dry conditions the fluffs over the leaves epidermis have lower growth. Also leaf area has lower growth and the numbers of stomata in unite of leaf area increase and also leaves in dry conditions create stronger mechanical tissues. The created morphological changes because of dryness are called Xeromorphs and these changes including becoming small of the leaf area, thickening of cuticle, decreasing of cells' growth and thickening of cell membrane [18]. Relative water content (RWC), leaf water potential, stomatal resistance, transpiration ratio, leaf temperature and the temperature of plant canopy are the most important effective characteristics on water condition of the plant and are reflecting metabolic activity of tissues and proper tools in recognizing the resistance to drought [34]. Investigation of the role of water stress on physiological characteristics of grape plant has revealed that under increasing drought stress, the rate of photosynthesis (Anet), stomatal conductivity (gs) and transpiration (E) will decrease [12]. The decrease of photosynthesis under drought stress is because of stomatal and non-stomatal mechanisms.

The stomata are sensitive to lack of water and stomata being closed is the first reaction of the plant to drought stress which results in decreasing of photosynthesis speed. Closing of stomata causes the decrease of CO2levelsand assimilation of photosynthesis carbon during light respiration process and non-stomatal mechanism include creating changes in chlorophyll synthesis, performance and chloroplast structure and damage of accumulation processes, transition and distribution of synthetic materials [33]. Salicylic Acid is a phenolic compound which is known today as a semi-hormonal regulator in plants and its role is to response to defensive mechanisms against living and non-living elements [9]. Metabolic responses of the plant against Salicylic Acid are different depending on its function and type of the plant [17].

METHODS AND MATERIALS

This research two year saplings planted in plastic pots including 6 kg soil with ingredients of humus, soil and sand (1:2:1) are used. This research is performed as factorial experiment on randomized complete block design. levels of watering were 5 (control) once every 10 and 15 days [35] and levels of Salicylic Acid were zero (control) 1 and 2mM and two varieties of grapevine were Rashe and Bidane Sefid in three repetition and in two experiment unites (each experimental unite consists two pots and in every pot one sapling and totally 108 pots) in research greenhouse of Horticulture group of agricultural faculty of Urmia University. Before implanting, the root of saplings should be pruned with disinfectant scissors equally and then it is implanted in pots and after establishment level which was three months, treatment was began. The first foliar application was done simultaneously with watering cycles and in order to prevent return and also maintaining the effects of Salicylic Acid, the next foliar application was performed once every 15 days after the first foliar application. During the experiment, minimum and maximum average temperature of the greenhouse were 17 and 39 °C, respectively and the required lightness of the plant was ensured by the light of the sun. In order to measuring leaf area, of each sapling, three leaves; small, medium, big were chosen and the leaf area was measured by Leaf Area Meter Model AM200 and was multiplied by total leaves of that sapling and the final value was leaf area of the sapling. In order to measuring the number of stomata, we polish a layer of clear nail polish on underside area of the leaf and after drying, using scotch tape, we remove slowly the dried layer of the nail polish from the leaf and place it on the Lam and finally under the microscope by the help of eye lens X10 and zooming of 40X, the number of stomata from eight similar points were counted and their average were calculated. Leaf Relative water content measurement was measured with the following method [36]. Transpiration, stomatal conductance and net photosynthesis measurement were used using photosynthesis measuring machine (Model HCM-1000). Data were analyzed by using statistical software SAS series 9.1. The comparison of averages was done using Duncan multiple domain test method and Excell software was used in order to draw diagrams.

Research Findings

The effect of variety, drought stress, Salicylic Acid on the number of grape leaf

According to the results of variance analysis (Table 1), the effect of variety, drought stress levels, Salicylic Acid treatment and interaction of drought in Salicylic Acid in 1 percent level and interaction of drought in Salicylic Acid on the number of leaves in the 5% level were significant. Based on comparing the averages related to interaction of various levels of drought and Salicylic Acid on leaf numbers, by increasing watering intervals, leaf numbers have significant decrease. The number of leaves in Vitisvinifera L. was more than Seedless white grape. Salicylic Acid application increased the number of leaves, and 2 mμ density of Salicylic Acid had the most effect on increasing the number of leaves in each two varieties and increased the number of leaves in watering cycles once every 10 and 15 days. So that the results showed that the maximum number of leaves in watering cycle is in watering cycle of once every 5 days and 2 mμ density of Salicylic Acid and the minimum number of leaves in watering cycle is in watering cycle of once every 15 days and 0 mμ density of Salicylic Acid (Diagram 1). In addition, the results of comparing averages related to investigation of interaction of variety and different levels of drought on the number of leaf showed that the maximum number of leaves in Vitisvinifera L. variety with watering cycle of once every 5 and 10 days and the minimum number of leaves in Seedless White with once every 15 days was resulted (Diagram 2).

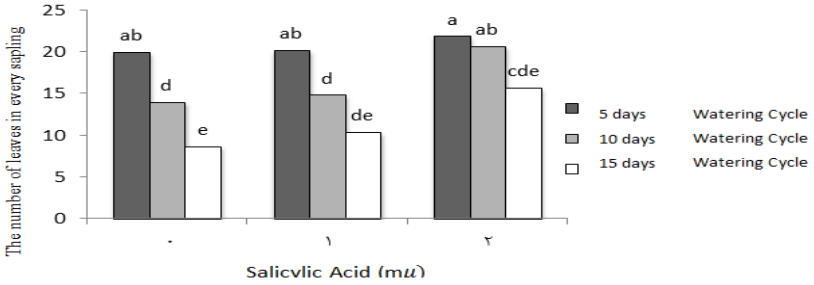

Diagram 1: The comparison between interaction of various levels of drought and Salicylic Acid on the number of leaves in each Sapling. Non-similar alphabets show significant difference in possibility level of 5% among averages, based on multiple domains Duncan test.

Table 1. Analysis of variance for effects of variety, drought stress and salicylic acid effects on some growth characteristics of the grape.

The Number of Stomata	Leaf Thickness	MS Leaf Area	Leaf Number	df	Source of variation
0.848^{ns}	0.000146^{ns}	132.175^{ns}	14.0185^{ns}	2	Block
870.272**	0.154**	11516.964**	523.370**	2	Drought Level
0.804**	0.00306**	7275.293**	422.925**	2	Salicylic Acid
533.863^{ns}	0.106**	10794.476**	1020.532**	1	Variety
0.553^{ns}	0.00890^{ns}	517.959**	20.148**	4	Drought × Salicylic Acid
42.893**	0.00707**	925.254**	26.0370**	2	Variety × drought
1.104^{ns}	0.00772^{ns}	35.670^{ns}	11.129^{ns}	2	Variety × Salicylic Acid
0.884^{ns}	0.00101**	281.502^{ns}	4.212^{ns}	4	variety × Salicylic Acid × drought
1.939	0.000307	288.887	4.605	34	Experimental error
7.150	5.921	13.699	13.665	-	cv

df: degree of freedom; MS: mean of square; *,** significant at 0.05 and 0.01 probability levels, respectively. ns; non significant.

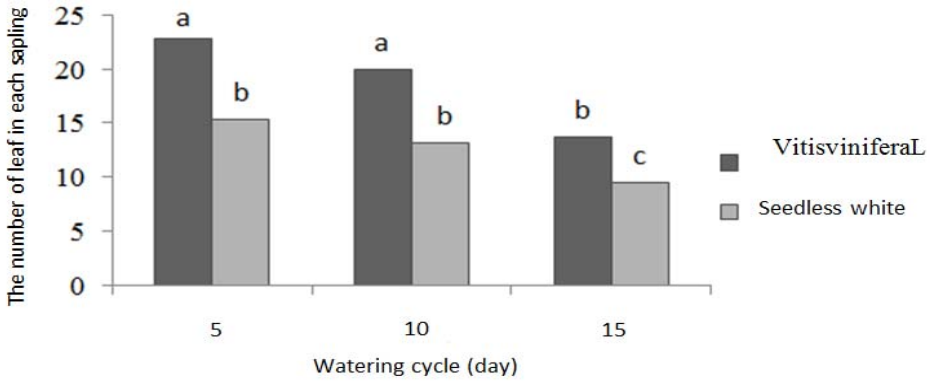

Diagram 2: The comparison between interaction of various levels of drought and variety on the number of leaves in each Sapling. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test.

The effects of variety, drought stress and Salicylic Acid on leaf area of grape

The results of variance analysis (Table 1) was the significant effect of variety, drought stress levels, Salicylic Acid treatment and interaction of drought in Salicylic Acid in 1 percent level, in addition the interaction of drought in Salicylic Acid on the number of leaves in the 5% level were significant. Based on results comparing the averages related to interaction of various levels of drought and Salicylic Acid on leaf numbers, by increasing watering intervals, leaf numbers decreased. The Area of leaf in each two varieties of Vitisvinifera L. and seedless white decreased. The area of leaf in Seedless white was more than Vitisvinifera L. grape. Salicylic Acid application increased the area of leaves in each two varieties, and Salicylic Acid treatment of 2 mμ density in watering cycles of once every 10 and 15 days increased leaf area. Based on results the maximum area leaf was in watering cycle of once every five days and 2 mμ density of Salicylic Acid and the minimum area leaf was in watering cycle of once every 5 days and 0 mμ density of Salicylic Acid (Diagram 3). In addition, the results of comparing the averages related to interaction of drought levels and variety on leaf area showed that seedless white variety with watering cycle of once every 5 days and Vitisvinifera L. variety with watering cycle of once every 15 days had the maximum and minimum leaf area, respectively (Diagram 4).

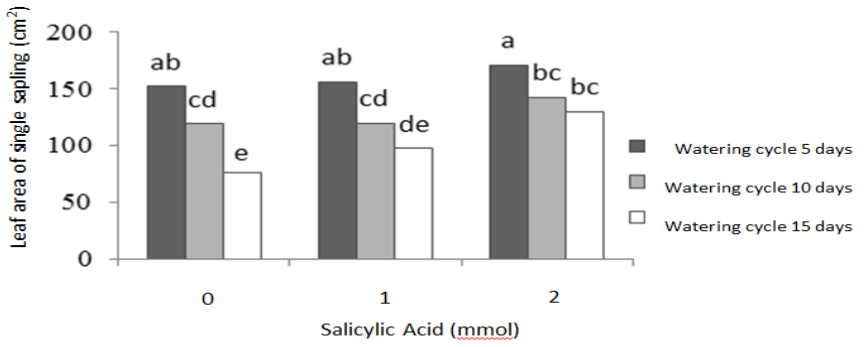

Diagram 3: the comparison of interaction of various drought levels and Salicylic Acid on leaf area of single sapling. Non-similar alphabets show significant difference in possibility level of 5% among averages, based on multiple domains Duncan test

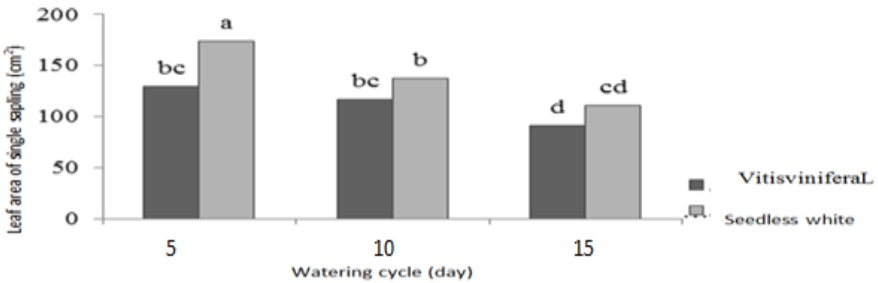

Diagram 4: the comparison of interaction of various drought levels and variety on leaf area of single sapling. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

The effects of variety, drought stress and Salicylic Acid on grape leaf thickness

The results of variance analysis (Table 1) revealed the significant effect of drought stress levels, Salicylic Acid variety, and interaction of variety in drought and triple interaction of variety, drought and Salicylic Acid on leaf thickness in area is 1%. The results of comparing averages related to interaction of variety, drought different levels and Salicylic Acid showed that by increasing watering, the leaf thickness in each two varieties; Vitisvinifera L. and seedless white varieties increased. The level of leaf thickness in Vitisvinifera L. was more than seedless white variety and Salicylic Acid application with 1 mμ density in watering cycles of once every 10 and 15 days increased leaf thickness in every two varieties. Based on the obtained results the maximum leaf thickness was in watering cycle of once every 15 days and 2 mμ density of Salicylic Acid and the minimum leaf thickness was in watering cycle of once every 5 days and 0 mμ density of Salicylic Acid (Diagram 5).

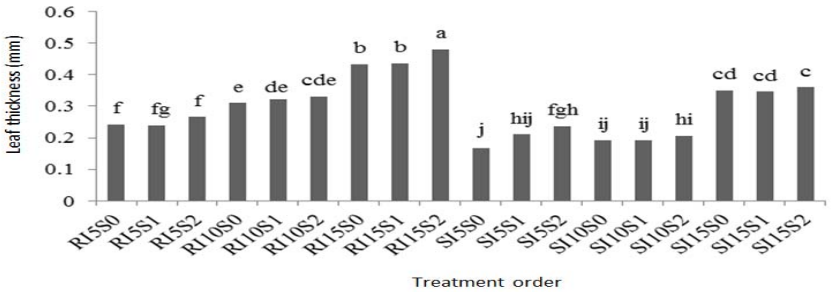

Diagram 5: the comparison of interaction of variety, various drought levels and Salicylic Acid on leaf thickness (Non-similar alphabets show significant difference in possibility level of 5% among averages, based on multiple domains Duncan test). R: Vitisvinifera L. S: white seedless; SO: Salicylic Acid zero mμ (control), S1: Salicylic Acid 1 mμ; S2: Salicylic Acid 2 mμ, I5: watering cycle of 5 days (control); I10: watering cycle of 10 days, I15: watering cycle of 15 days.

The effects of variety, drought stress and Salicylic Acid on the number of grape leaf stomata

The results of variance analysis (Table 1) revealed that the effect of drought stress levels, variety, Salicylic Acid, and interaction of variety in drought in the level of 1 % and the effect of Salicylic Acid treatment in the level of 5% on the number of stomata in leaf area unite (stomata concentration) was significant. Based on the results of comparing averages, by increasing watering intervals, the number of stomata increased so that the maximum numbers of stomata in Vitisvinifera L. was with watering cycle of once every 15 days and the minimum numbers of stomata in Vitisvinifera L. was with watering cycle of once every 5 days (Table 6) and Salicylic Acid application resulted in the decrease of the number of stomata and the density of 2 mμ of Salicylic Acid had the most effect in decrease of stomata (Diagram 7).

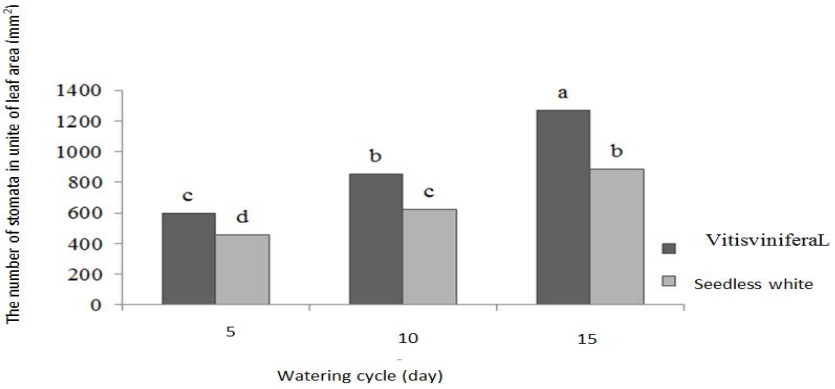

Diagram 6: the comparison of interaction of various drought levels and variety on the number of stomata. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

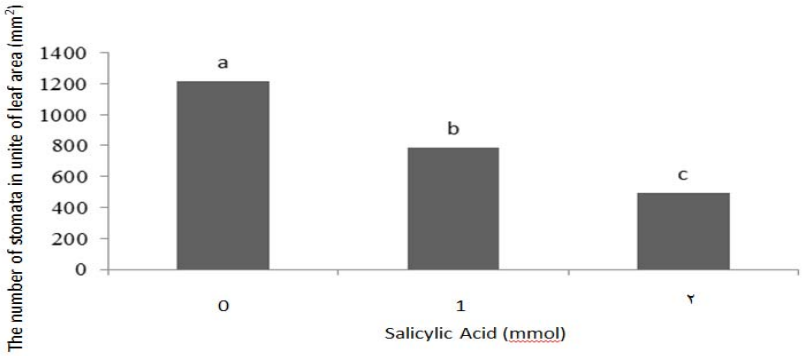

Diagram 7: the comparison of interaction of Salicylic Acid treatment on the number of stomata. Non-similar alphabets show significant difference in possibility level of 5% among averages, based on multiple domains Duncan test

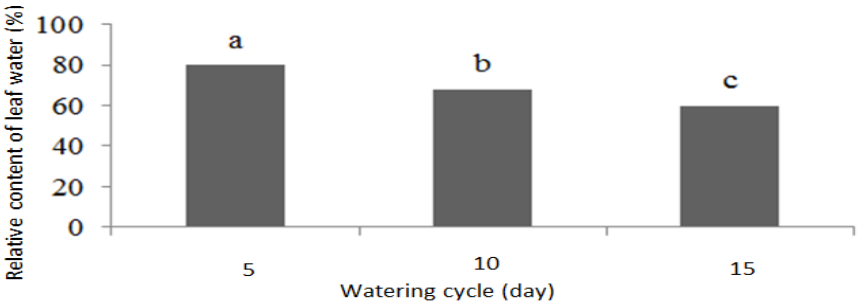

Diagram 8: the comparison of averages of effects of various drought levels on relative content of leaf water. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

The effects of variety, drought stress and Salicylic Acid on relative content of grape leaf water

The results of variance analysis (Table 2) revealed significant effect of various levels of drought on relative content of leaf water in unite was 1 %. Based on results of comparing averages, by increasing watering intervals, relative content of leaf water decreased so that the maximum relative content of leaf water was once every 5 days and the minimum amount was in watering cycle of once every 15 days (Diagram 8). Also the results of comparing the averages related to variety effect on relative content of leaf water showed that relative content of leaf water in Vitisvinifera L. Was more than white seedless variety (Diagram 9).

Table 2. Analysis of variance for effects of variety, drought stress and salicylic acid effects on some physiological characteristics of the grape.

Change sources	Freedom degree	Relative content of leaf water	Transpiration	Stomatal conductance	Pure photosynthesis
Block	2	1.0822^{ns}	$0.001.1^{ns}$	5.742^{ns}	0.404^{ns}
Drought Level	2	1825.544**	10.408**	3839.407**	12.996**
Salicylic Acid	2	13.763^{ns}	0.267*	119.949**	2.249**
Variety	1	1038.0438**	0.0864^{ns}	281.991**	3.893**
Drought × *Salicylic Acid*	4	17.860^{ns}	0.245*	21.914*	0.342^{ns}
Variety	1	1038.0438**	0.0864^{ns}	281.991**	3.893**
Drought × *Salicylic Acid*	4	17.860^{ns}	0.245*	21.914*	0.342^{ns}
Variety × drought	2	4.491^{ns}	0.460**	334.733**	0.519**
Variety × *Salicylic Acid*	2	0.519^{ns}	0.0377^{ns}	15.414^{ns}	0.103^{ns}
variety × *Salicylic Acid* × *drought*	4	30.426^{ns}	0.0586^{ns}	27.846*	0.0304^{ns}

df: degree of freedom; MS: mean of square; *,** significant at 0.05 and 0.01 probability levels, respectively. ns; non significant.

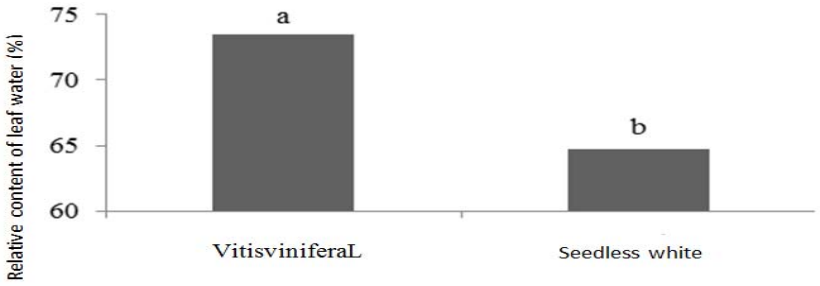

Diagram 9: the comparison of averages of effects of variety type on relative content of leaf water. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

The effects of variety, drought stress and Salicylic Acid on grape's transpiration

Based on the results of variance analysis (Table 2), the effect of various drought levels and interaction of variety in drought on transpiration in the level of 1% was significant. In addition, the results of variance analysis (Table 2) showed that Salicylic Acid treatment and interaction of drought in Salicylic Acid had significant effect in the level of 5% on transpiration. The results of comparison of averages related to interaction of variety in drought showed that by increasing watering intervals, the transpiration decreased in Vitisvinifera L. And seedless white. The maximum of transpiration in Vitisvinifera L. And seedless white is with watering cycle of once every 5 days and the minimum of transpiration in Vitisvinifera L. and seedless white is with watering cycle of once every 5 days (diagram 10). Also, based on the results of comparing averages related to interaction of various drought levels and Salicylic Acid treatment, Salicylic Acid application increased transpiration in both varieties and Salicylic Acid treatment with 2mμ density in watering cycle of once every 10 days increased transpiration.

The maximum transpiration is in watering cycle of once every 5 days and 2m$^{\mu}$ density of Salicylic Acid and the minimum transpiration is in watering cycle of once every 15 days and 1 and zero m$^{\mu}$ density of Salicylic Acid (diagram 11).

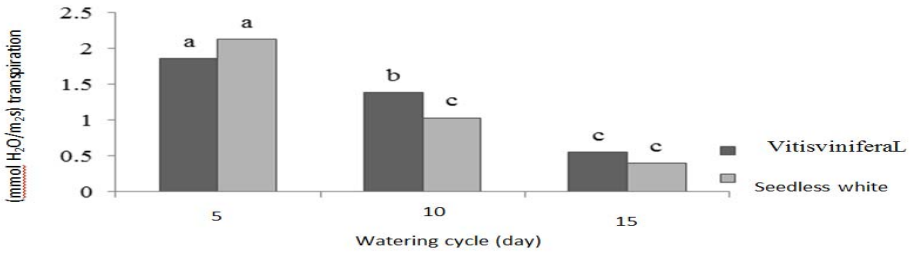

Diagram 10: the comparison of interaction of variety and various drought levels on transpiration. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

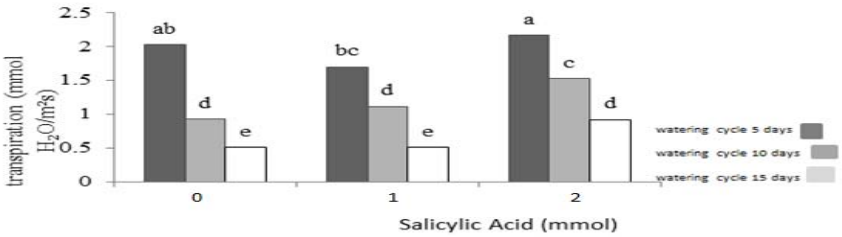

Diagram 11: the comparison of interaction of various drought levels and Salicylic Acid treatment on transpiration. Non-similar alphabets show significant difference in possibility level of 5% among averages, based on multiple domains Duncan test

The effects of variety, drought stress and Salicylic Acid on stomatal conductance

Based on the results of variance analysis (Table 2), various drought levels, Salicylic Acid treatment, variety and interaction of variety in drought on stomatal conductance in the level of 1% was significant. In addition, the results of variance analysis (Table 1) showed that interaction of drought in Salicylic Acid and triple interaction of variety, drought and Salicylic Acid in stomatal conductance was significant in the level of 5%. Based on the results of comparison of averages related to triple interaction of variety,drought and Salicylic Acid by increasing watering intervals, the stomatal conductance decreased in both varieties. The amount of stomatal conductance was more in seedless white than Vitisvinifera L.

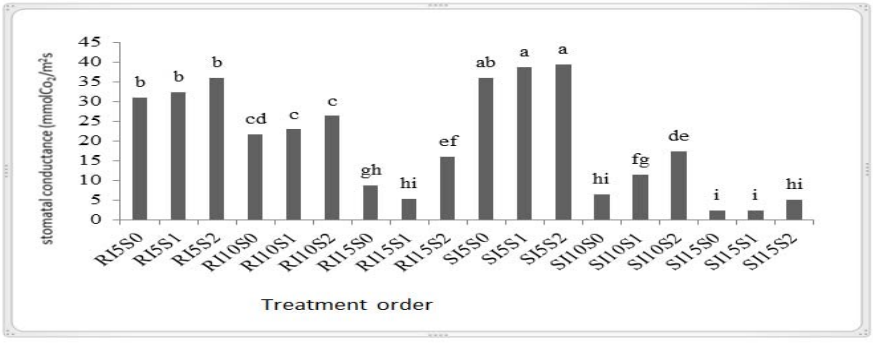

Diagram 12: the comparison of the averages of interaction of variety, various drought levels and Salicylic Acid on stomatal conductance (Non-similar alphabets show significant difference in possibility level of 5% among averages, based on multiple domains Duncan test). R: VitisviniferaL. , S: white seedless; SO: Salicylic Acid zero m$^{\mu}$ (control), S1: Salicylic Acid 1 m$^{\mu}$; S2: Salicylic Acid 2 m$^{\mu}$, I5: watering cycle of 5 days (control); I10: watering cycle of 10 days, I15: watering cycle of 15 days.

Salicylic Acid application with 2mμ in watering cycles of once every 10 and 15 days resulted in increase of stomatal conductance in both varieties. The maximum of stomatal conductance in seedless white is with watering cycle of once every 5 days and 1 and 2 mμ density of Salicylic Acid andthe minimum of stomatal conductance in seedless white is with watering cycle of once every 15 days and 1 and 2 mμ density of Salicylic Acid (diagram 12).

The effects of variety, drought stress and Salicylic Acid on pure photosynthesis

Based on the results of variance analysis (Table 2), various drought levels, Salicylic Acid, variety and interaction of variety in drought on pure photosynthesis in the level of 1% was significant.The results of comparison of averages related to the effect Salicylic Acid treatment on pure photosynthesis showed that the maximum and minimum of pure photosynthesis in Salicylic Acid treatment was with 2 and zero $m\mu$ (diagram 13). Also the results of comparing averages related to interaction of varietyin drought showed that the maximum pure photosynthesis in Vitisvinifera L.is in watering cycle of once every 5 days and the minimum pure photosynthesis in seedless white is in watering cycle of once every 15 days and (diagram 14).

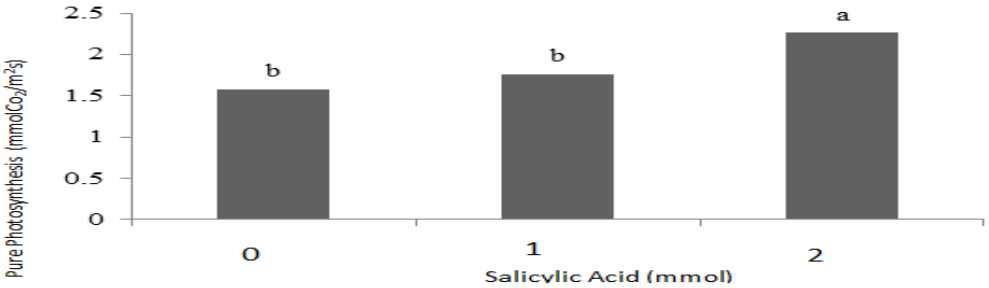

Diagram 13: the comparison of the average of the effect of Salicylic Acid treatment on pure photosynthesis. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

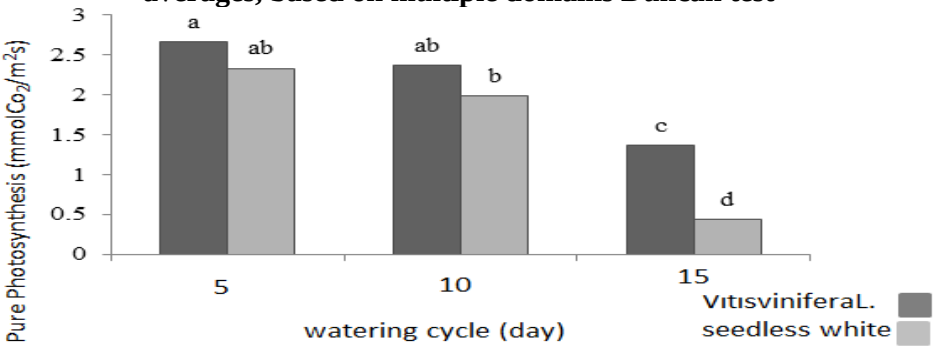

Diagram 14: the comparison of the average of interaction of variety and various drought levels on pure photosynthesis. Non-similar alphabets show significant difference in possibility level of 1% among averages, based on multiple domains Duncan test

DISCUSSION

Decrease of cell growth because of lack of water, firstly results in decrease of leaf growth, because in dehydration conditions the material and nutritive elements absorption also decrease, thus the growth and development of leaves become limited [5]. This result of decrease of numbers and leaf area is congruent with [12, 18, 20, 37, 23]. 2 mM density of Salicylic Acid results in increase of the numbers and area of leaf. That this is because Salicylic Acid with protecting root system of drought stress harmful effects, results increase of root system and the capacity of water and nutrition absorption, and finally results in the increase of plant growth, that this growth increase is associated with production of new leaves and increase of total leaf area [26]. This research is congruent with [14, 15]. Being thick of cuticle, is an important factor in maintaining the relative water content of leaves, And varieties that, they showed a greater thickness of the cuticle of leaves, in the dry conditions, retains a higher relative water content in their leaves and are more resistant against drought. The thickness of the leaf cuticle, directly correlates with drought tolerance and increases with increasing water stress and can be used as a marker for the identification of resistant varieties [30].

In this experiment the usage of Salicylic Acid resulted in the increase of Cuticle thickness of the leaf and 2 mM density of Salicylic Acid had the most effect in increasing Cuticle thickness of the leaf That this result is congruent with [18]. Salicylic Acid has direct effect on cytokinin and decrease changes of cytokine and auxin under stress and results in the increase of cell protoplast [32].The increase of drought stress results in stomata density (the numbers of stomata in unite of leaf area). The number of stomata in Rashe cv. is more than Bidane Sefid cv. Likely one cause of increased stomatal density, during drought stress is getting smaller cell size that causes will be placed more stomata per unit area [27]. By decreasing the number of stomata in unit area and length of stomata, plant's resistance to dehydration becomes more [16]. Leaf relative water content, is one of the indicators to identification resistant and susceptible varieties. Resistant strains, in the face of drought, keep water content of their cells at a higher level. [20]Being thick of cuticle, is an important factor in maintaining the relative water content of leaves, And varieties that, they showed a greater thickness of the cuticle of leaves, in the dry conditions, retains a higher relative water content in their leaves and are more resistant against drought. Increase of drought stress results in the decrease of leaf relative water content (RWC) and leaf RWC in Rashe cv. is more than Bidane Sefid cv. which is congruent with obtained results of about the decrease of leaf RWC under drought stress condition and higher leaf RWC in varieties under drought by [2, 4, 18, 19, 31]. Water deficit stress leads to closing of stomata, reduction in transpiration rates, reduced tissue water potential, and reduce photosynthesis [18]. Photosynthetic capacity of a plant, essentially, is determined by the total leaf area, and photosynthetic activity of leaves. Land substantially reduces photosynthesis through stomatal closure or by destroying the metabolic activity [24]. Evaluation of physiological responses to increasing drought stress, in some grape varieties, showed that, with increasing water stress, decreased transpiration rate, stomatal conductance and water use efficiency in grapevines [11]. Drought stress results in the decrease of transpiration which is congruent with [1, 8, 28, 29]. Also the results showed that Salicylic Acid usage increase stomatal conductivity which is congruent with [23] in corn and soybean. They, on review for corn, soybeans, concluded that, transpiration rate and stomatal conductance, increases in response to foliar spray with salicylic acid and acetyl salicylic acid. It was also reported that feeding soybean leaves with salicylic acid caused increased water efficiency, indoor concentrations of carbon dioxide and transpiration rate [22]. The effect of drought stress, abscisic acid content in leaves increases that causes stomatal closure and prevents water loss [1]. Also, studies have shown that, with reduced leaf relative water content (RWC), decreases the rate of stomatal conductance and photosynthesis [24]. Decrease in soil moisture leads to a rapid decrease in stomatal conductance, in most grape varieties [6].There is a close relationship between stomatal conductance and net photosynthetic rate in grape leaves, compared to other plant species and stomatal closure during drought leads to stimulation, decreased photosynthesis in grape [6]. Effect of water stress decreases photosynthetic rate, stomatal conductance, and photosystem II, in grapes [25].Photosynthetic capacity of a plant is determined primarily by the total leaf area, and photosynthetic activity in different leaves. Dry substantially reduces photosynthesis, stomatal closure due to, or through, the destruction of the metabolic activity [24]. In conclusion, increased stress, leads to reduction of net photosynthesis which corresponded with the results obtained by [11, 17]. The responses of healthy plants or parts of them to salicylic acid treatment, is done through their involvement in enzyme activities of different processes. Studies on mustard plants, indicating that salicylic acid at low concentrations, causes an increase of dry weight, photosynthetic rate, and efficiency carboxylation, and the activity of the enzyme nitrate reductase, and ultimately leads to increased performance mustard plants. However, the higher concentrations, it has the opposite effect And has also been shown that phenolic compounds have a chelating effect features Thus, salicylic acid can form, such as chelation, and cause better penetration and absorption of nutrients [10]. Also, the rate of photosynthesis in wheat grains treated with salicylic acid before planting time has been shown to increase significantly [15]. In both experiments, the researchers found that higher concentrations of salicylic acid leads to increased activity of the carbonic anhydrases enzyme. Salicylic acid, cause, accelerate the increase in plant dry matter And this is associated with increased enzyme ribulose bisphosphate carboxylase, which is activated by salicylic acid [13].

CONCLUSION

According to similarity of irrigation cycle in both varieties, the results showed that drought stress effects on most of morphological and physiological branches of the plant. Grape plant uses various mechanisms to confront with drought stress. Among important mechanisms in order to confront with drought stress in grape we can indicate maintaining plant relative water content (RWC), the decrease of the numbers and area of the leaf and decrease of transpiration, stomatal conductance and net photosynthesis. Rashe cv. by using most of the above mechanisms became able to reach a minimum the negative effects of drought on many morphological and physiological characteristics in comparison with Bidane Sefid CV. Generally, Salicylic Acid usage with the density of 2 mM results in the improvement of some characteristics such as the numbers and area and thickness of the leaf, leaf (RWC), stomatal conductivity, and net photosynthesis in grape.

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