The Companion effect between Salicylic acid and Glutamine on the growth and yield of water-stressed cucumber (Cucumis sativus L.)

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Abstract. Trial was conducted in greenhouse of the Department of biology / College of Science/ University of Diyala during autumn season 2016. The study included two levels of water stress (S₁/ Irrigation for 14 minutes and S₂/ Irrigation for 7 minutes /7 ml of water per minute), three foliar application levels of Salicylic acid SA (0, 75, 150) mg. L⁻¹ and three foliar application levels of Glutamine acid G (0, 1000, 2000) mg. L⁻¹. Some growth indicators viz., (Plant height, Stem diameter, Relative growth rate and Plant Yield were registered. The experiment was designed as a factorial experiment using an RCBD design with three replicates. Water stress decreased the means of all studied indicators, Plant height record 232.44 cm, Stem diameter 8.28mm, Relative growth rate 0.019 g.day⁻¹ and yield 1358 gm plant⁻¹ at the first stress level (Irrigation for 14 minutes / S₁) while the means of the indicators decreased to 183.82 cm, 7.41 mm, 0.016 g day⁻¹ and 972 g plant⁻¹, respectively at the second stress level (Irrigation for 7 minutes / S₂). Salicylic acid and Glutamine acid increased all the studied indicators, the third level of salicylic acid and Glutamine spraying (150 mg. L⁻¹, 2000 mg. L⁻¹) has exceeded the second level (75 mg. L⁻¹, 1000 mg. L⁻¹). The role of Salicylic acid and Glutamine acid was positive to decrease the passive effect of water stress, Plant height record 236.17 cm, Stem diameter 8.57mm, Relative growth rate 0.021 g.day⁻¹ and yield 1893 gm plant⁻¹ (the percentage of increase was 37.57%, 40.95%, 50.00%, 179.62%, respectively), also the triple interaction between the second stress level(S₂) and the spraying at high levels the Salicylic acid and Glutamine SA₃ G₃ was positive to decrease the effect of water deficit stress, 262.00 cm, 9.22 mm, 0.024g.day⁻¹ and yield 2317gm plant⁻¹ (percentages of increase were 75.05%, 58.97%, 100.00% and 286.17%, respectively).

1. Introduction
Cucumber (Cucumis sativus L.) herbaceous annual plant belongs to Cucurbitaceae, which includes about 90 genera and more than 750 species. Cucumber is the most important and most widely used species [1]. India is considered the original habitat, where it was found 3,000 years ago and in overland[2].

In Iraq, Cucumber represents important economic crop, which is cultivated in spring and autumn furthermore, this plant is planting in greenhouses in winter, so it is available most of the seasons of the year, the cucumber is grown in order to fruits which have medicinal uses. Which reduces neurological disorders, purify the body of toxins, analgesic headaches and are useful in regulating blood pressure[3].
Water stress is one of the most dangerous and most significant environmental stresses on plants [4]. Water deficiency causes negative effects on most growth indicators through stimulating oxidative stress arises from the production of free radicals which have the destructive and oxidative effect on plant cells and with high concentrations of them which exacerbating damage to plants [5]. Exogenous treatment with Salicylic acid (SA) possesses the potentiality to reduce the harmful effects caused by stress that being a phenolic and non-enzymatic antioxidant compound thus contributes to elimine of free radicals. moreover, it turn them into water molecules help in reducing the severity of the shortage of water in cells [6].

Glutamine (G) is an essential amino acid in the metabolism of nitrogen. Glutamine takes place in the transferring of amino group, manufacturing of other amino acids, an energy source and this contributes to increase plant resistance to environmental stresses [7].

The exacerbation of drought stress and the lack of studies about the role of Salicylic acid and Glutamine were the reasons for conducting this study, so the aims of this experiment were to know the effect of each individual factor and the interaction between these factors in improving the cucumber plant growth.

2. Materials and Methods

2.1. Agriculture
Trial was carried out in the greenhouse of the Department of Biology, College of Science, University of Diyala, Iraq (Length: 40 m, Width: 9 m, Height: 4 m) for the autumn growth season for the period (10/10/2016 to 26/1/2017) in a clayloam soil. The experiment performed with factorial Randomized Block Complete Design (RBCD) with three replicates, the soil was plowed and divided into 54 experimental units and each experimental unit includes four plants. Fertigation with one kilogram weekly of NPK fertilizer (20:20:20) was used. (Wassim, F1) variety seeds produced from the company (VoloAgri Group Company of America) were planted on 10/10/2016. Distance between plant and another one was 40 cm, and used drip irrigation method.

2.2. Irrigation (Stress Treatments)
Two levels of water stress (S1 irrigation for 14 minutes and S2 irrigation for 7 minutes), the first level S1 was adopted as a control treatment.

S1 (S1/ Irrigation for 14 minutes/7 ml of water per minute) includes:
- Three irrigation lines, The length of each line is 15 m, Informs The number of drippers in each line (75 dripper), The total number of drippers reached (225 dripper).
- The amount of water added (S1) = 7ml*14m*225 dripper = 22.050 ml
- Number of plants for three lines = 112 plant
- The amount of water added per plant per irrigation=196.88 ml/plant
S2 (S2/ Irrigation for 7 minutes/7 ml of water per minute) includes:
- Three irrigation lines, The length of each line is 15 m, Informs The number of drippers in each line (75 dripper), The total number of drippers reached (225 dripper).
- The amount of water added (S2) = 7ml*7m*225
- Dripper = 11.025 ml
- Number of plants for three lines = 112 plant
- The amount of water added per plant per irrigation=98.44 ml/plant
- The water consumption of cucumber inside the greenhouses is 218 mm [8]

2.3. Salicylic acid and Glutamine Treatments
Three levels of Salicylic acid SA (SA1 Spray concentration 0 mg. L⁻¹, SA2 Spraying concentration 75 mg. L⁻¹ and SA3 Spraying concentration 150 mg. L⁻¹), the first level SA1 was adopted as a control treatment, which sprayed with water only. Three levels of Glutamine G (G, Spraying concentration 0
mg. L\(^{-1}\), G\(_2\) Spraying concentration 1000 mg. L\(^{-1}\) and G\(_3\) Spraying concentration 2000 mg. L\(^{-1}\)), the first level G\(_1\) was adopted as a control treatment, which sprayed with water only. Plants were sprayed in the early morning at the age of 32, 42 and 52 days respectively until completely wetness.

2.4. Studied Indicators

2.4.1. Plants height (cm)

Plants height was measured at the end of the growing season using the measurement bar from the beginning point of the stem from the soil surface to the top of the plant.

2.4.2. Stems diameter (mm)

Stems diameter was measured by Vernier Caliper at a height of 5 cm from the soil surface level.

2.4.3. Relative growth rate (g .day\(^{-1}\))

The relative growth rate was calculated according to the following equation[9] :

\[
R.G.R = \frac{(\log W_2 - \log W_1)}{T_2 - T_1}
\]

Whereas:

\[
\begin{align*}
\log W_1 &= \text{Logarithm of the vegetative weight (g) at the first measurement period (Plant age 18 days).} \\
\log W_2 &= \text{Logarithm of the vegetative weight (g) at the second measurement period (Plant age 105 days).} \\
T_1 &= \text{Plant age (day) at the first measurement period (Plant age 18 days).} \\
T_2 &= \text{Plant age (day) at the second measurement period (Plant age 105 days).}
\end{align*}
\]

2.4.4. plant yield ( g. plant \(^{-1}\))

The plant yield was calculated based on the cumulative yield of the experimental unit plants from the beginning of the harvest till the end of the season and divided on the number of plants experimental unit.

2.5. Statistical analysis

Results were statistically analyzed by the statistical program (SAS) and Duncan's multiple range test was adopted to compare the means at the probability level of 0.05[10].

3. Results and Discussions

3.1. Plant height

Results intable (1) indicate that there is a significant effect of water stress in reducing the mean plant height. At the second stress level S\(_2\), mean of plant height was decreased by 26.45% compared to the first stress level S\(_1\). It has attributed the cause of low plant height to decrease the rate of cell division and depletion and shrinkage of cells due to infiltration of cellular walls, stress urges plastids, mitochondria and peroxisome to increase the production of free radicals, which lead to the degradation of cellular membranes and oxidation of enzymes and reduce the levels of Gibberellins, Cytokinins and Auxins and oxidation of amino acids, including tryptophan, which forms the basis of building auxin especially in meristematic areas, which negatively affects the size of the shoot system[11].

The table shows significant variance in the mean plant height with an increase in the level of spraying SA, at raising the level of spraying with SA from 0 mg. L\(^{-1}\) to 150 mg. L\(^{-1}\) the mean of plant height increased by 15.82%, while increased significantly by 11.47% at the second level treatment SA2. The reason for the increase in average plant height is due to the role of SA in reduction of the concentration of Abscisic acid and the inhibition of the ethylene representation which causes the aging of the plant and the SA increases the efficiency of the photosynthesis process and increases the concentration of gibberellins, Auxins, and Cytokinins [6].
The results showed that the plant height was significantly affected by Glutamine acid treatment. Achieved a spray Glutamine direct increase in the height of the plant to the highest rate of increase at the third level G3 (2 g L⁻¹) and reached 220.94 cm, and achieved G2 (1 g L⁻¹) significant increase was recorded 213.83 cm compared to the control treatment G1 which was 189.61 cm. The increase in plant height when treated with amino acids, including Glutamine, was attributed to its role in activating vital processes, especially cellular division and elongation of the cells, and encouraging the transverse expansion and longitudinal growth of stem cells. In addition to that, the Glutamine takes part in the manufacture of tryptophan acid, which is the basis of the formation of Auxin[12], [13].

The same table showed a significant increase in plant height with increased salicylic acid and Glutamine levels. The highest value of plant height was 236.17 cm at the treatment of the third level of acids SA3 G3 while the lowest value was 171.67 cm in the treatment of control SA1 G1, the percentage of increase was 37.57%

Table .1. Effect of drought stress, Salicylic acid ,Glutamine and their interaction in Plant height (cm)

| Salicylic acid (mg. L⁻¹) | Glutamine (mg. L⁻¹) | Water Stress Level | interaction between Salicylic acid * Glutamine | effect of mean Salicylic acid | effect of mean Glutamine |
|-------------------------|---------------------|-------------------|-----------------------------------------------|-----------------------------|-------------------------|
| SA₁ 0                   | G₁ 0                | 149.67 i          | 193.67e-h                                  | 171.67 c                    |                         |
|                        | G₂ 1000             | 187.00e-h         | 224.00bcd                                  | 205.50 b                    |                         |
|                        | G₃ 2000             | 171.67 hi         | 225.00bcd                                  | 198.33 b                    |                         |
| SA₂ 75                 | G₁ 0                | 177.67ghi         | 211.67cde                                  | 194.67 b                    |                         |
|                        | G₂ 1000             | 180.67fgh         | 235.67abc                                  | 208.17 b                    |                         |
|                        | G₃ 2000             | 207.33c-g         | 249.33 ab                                  | 228.33 a                    |                         |
| SA₃ 150                | G₁ 0                | 168.00 hi         | 237.00abc                                  | 202.50 b                    |                         |
|                        | G₂ 1000             | 202.00d-g         | 253.67 ab                                  | 227.83 a                    |                         |
|                        | G₃ 2000             | 210.33c-f         | 262.00 a                                   | 236.17 a                    |                         |
| interaction between Salicylic acid * Stress | SA₁ 0 | 169.44 e      | 214.22 c                                  | 191.83 c                    |
|                                      | SA₂ 75             | 188.56 d         | 232.22 b                                  | 210.39 b                    |
|                                      | SA₃ 150            | 193.44 d         | 250.89 a                                  | 222.17 a                    |
| interacion between Glutamine*Stress | G₁ 0               | 165.11 d         | 214.11 b                                  | 189.61 b                    |
|                                      | G₂ 1000            | 189.89 c         | 237.78 a                                  | 213.83 a                    |
|                                      | G₃ 2000            | 196.44 c         | 245.44 a                                  | 220.94 a                    |
| Stress effect of mean Water         |                   | 183.82 b         | 232.44 a                                  |                              |

The tripartite interactions between (SA, G, S) possessed significant effect on the increase of the plant height, it has reached the highest mean 262.00 cm at the third level of acids SA3 G3 within the first level of stress S1 and reached the lowest mean of plant height 149.67 cm for the control treatment SA1 G1 and the second level of stress S2 and recorded a percentage increase in the mean of height with acids spray in the presence of stress 75.05%

3.2. Stem diameter

The results in Table (2) indicate a significant decrease in the diameter of cucumber stems due to water stress. The second stress level S₂ resulted in a decrease of 11.74% compared to the first stress level S₁. The reason for the decrease in mean stem diameter is due to drought of the lack of intermediate distances in the cells of the mesophyll tissue, which in turn leads to a significant decline in the delivery of this tissue [14].

The results of the table showed that the addition of Salicylic acid has a role in increasing the mean diameter of the stem. When the spray level is increased from 0 mg. L⁻¹ to mg. L⁻¹, the mean
diameter of the stem increased by 17.77% and the treatment of 75 mg L\(^{-1}\) was significantly increased in stem diameter by 14.25% compared to control treatment, the reason for increasing stem diameter with spraying treatments is due to the SA role in maintaining auxins from oxidation and inhibit IAA oxidase activity and increased levels of Gibberellins and cytokines and inhibition of ethylene representation also has a role in increasing divisions in metastatic regions [15].

The results of the same table show that the stem diameter was significantly affected by the Glutamine spray treatments causing a direct increase in stem diameter to the highest increase rate at the G3 level it was 8.39 mm and percentage increase 15.56%, thus exceeding the G2 and G1 levels recorded 7.90 mm and 7.26 mm respectively, the reason for this increase is the role of amino acids including Glutamine in stimulating physiological and biochemical processes and their participation in the construction of proteins and the manufacture of carbohydrates by contributing to the construction of chlorophyll, which improves the growth of plant tissues and thus reflected positively in the stem diameter [16].

The table shows that the interaction between Salicylic acid SA and Glutamine G had a significant effect on the stem diameter, where SA\(_3\) G\(_3\) and SA\(_3\) G\(_2\) treatment recorded the highest increase in mean stem diameter 8.57 mm while the control treatment SA\(_1\) G\(_1\) decreased to the lowest value in the stem diameter 6.08 mm with an increase of 40.95% compared to control treatment.

The significant overlap between the experimental factors (SA, G, S). It was noticed that the increase in the diameter of the stem with increased the level of acids spraying within the same stress level, where the increase rate was 58.97% and the highest value was in the first level of stress S\(_1\) in SA\(_3\) G\(_2\) treatment was 9.22 mm followed by an SA\(_3\) G\(_3\) treatment recording of 9.21 mm compared to the control treatment at the second level of stress S\(_2\), which recorded a minimum value of stem diameter 5.80 mm.

Table 2. Effect of drought stress, Salicylic acid, Glutamine and their interaction in the stem diameter (mm).

| Salicylic acid (mg. L\(^{-1}\)) | Glutamine (mg. L\(^{-1}\)) | Water Stress Level | interaction between Salicylic acid * Glutamine | Effect of mean Salicylic acid | Effect of mean Glutamine |
|-------------------------------|--------------------------|-------------------|---------------------------------------------|-------------------------------|---------------------------|
| SA\(_1\) 0                    | G\(_1\) 0                | Irrigation for 7 minutes | 5.80 h | 6.36 gh | 6.08 e |
|                               | G\(_2\) 1000             |                   | 6.82 fg | 7.30 ef | 7.06 d |
|                               | G\(_3\) 2000             |                   | 7.53 def | 8.73 abc | 8.13 abc |
| SA\(_2\) 75                   | G\(_1\) 0                | Irrigation for 14 minutes | 7.45 def | 8.14 cde | 7.79 c |
|                               | G\(_2\) 1000             |                   | 7.88 cde | 8.25 bcd | 8.07 abc |
|                               | G\(_3\) 2000             |                   | 7.89 cde | 9.02 ab | 8.46 ab |
| SA\(_3\) 150                  | G\(_1\) 0                |                   | 7.51 def | 8.29 bcd | 7.90 bc |
|                               | G\(_2\) 1000             |                   | 7.93 cde | 9.22 a | 8.57 a |
|                               | G\(_3\) 2000             |                   | 7.92 cde | 9.21 a | 8.57 a |
| Interaction between Salicylic acid * Stress | SA\(_1\) 0 | Irrigation for 7 minutes | 6.72 d | 7.46 c | 7.09 b |
|                               | SA\(_2\) 75              |                   | 7.74 c | 8.47 b | 8.10 a |
|                               | SA\(_3\) 150             |                   | 7.78 c | 8.91 a | 8.35 a |
| Interacion between Glutamine* Stress | G\(_1\) 0                | Irrigation for 14 minutes | 6.92 d | 7.60 c | 7.26 c |
|                               | G\(_2\) 1000             |                   | 7.54 c | 8.26 b | 7.90 b |
|                               | G\(_3\) 2000             |                   | 7.78 c | 8.99 a | 8.39 a |
| Effect of mean Water Stress    |                          |                   | 7.41 b | 8.28 a |         |
3.3. Relative growth rate

The results (Table 3) showed a significant effect of water stress on the relative growth rate. The relative growth rate decreased from 0.019 g day$^{-1}$ at the first stress level $S_1$ to 0.016 g day$^{-1}$ at the second stress level $S_2$ and a decrease of 18.75% due to the negative effects which is caused by the drought in many characteristics of the plant, including the effect of root growth and poor absorption of essential nutrients from the soil and the consequent lack of elements in the plant, causing a decrease in the rate of construction of biological components and the weakness or discontinuation of metabolic processes and thus get weakness in plant growth and low absolute and relative growth rate.

Salicylic acid spraying significantly increased the relative growth rate with increased levels of acid spray. The growth rate increased from 0.016 g day$^{-1}$ at control treatment $SA_1$ to 0.018 g day$^{-1}$ at the treatment of the second level of $SA_2$ and the highest relative growth rate was 0.020 g day$^{-1}$. The ratio of increase in the relative growth rate was 12.5% and 25.00% for the levels of $SA_2$ and $SA_3$ respectively, the reason for the increase in the relative growth rate was due to the role of salicylic acid in raising the ratio of auxin and cytokine and increasing the cellular divisions, in addition to his role in increasing leaf area, plant height and stem diameter is therefore reflected in the increase in vegetative growth of the plant[17].

Moreover, The Glutamine acid caused a significant increase in the relative growth rate by 11.76%. The highest relative growth rate was 0.019 g day$^{-1}$ at the treatment of the third level of G3 compared to the control G1 0.017 g day$^{-1}$, the cause of the increase is that the amino acids, including Glutamine, promote the biological activities and source of nitrogen, carbon and energy and thus regulate the internal structure of the plant, which leads to an increase in the building of proteins and carbohydrates and thus contribute to increase the length of the plant and the leaf area and the number of leaves, as a result, increasing the total vegetative weight, causing the increase of the relative growth rate of the plant[18].

The results of the table showed significant differences due to Salicylic acid and Glutamine interaction and their effect on the relative growth rate. The relative growth rate increased significantly with the increase in the levels of acidic spraying together with an increase of 50.00%. The highest value was 0.021 g day$^{-1}$ on the $SA_3 \times G_3$ treatment, fell to the lowest value of the growth rate of 0.014 g day$^{-1}$ at the treatment of control $SA_1 \times G_1$.

The results showed that there were significant differences in the relative growth rate due to the triangular interference between the experiment factors, namely, acids spraying and drought stress, the relative growth rate increased by 100.00%. The growth rate increased from 0.012 g day$^{-1}$ in control treatment $SA_1 \times G_1$ and the second stress level $S_2$ to its highest value in the table amounted to 0.024 g day$^{-1}$ when spraying the third level of acids $SA_3 \times G_3$ and within the level of the first stress $S_1$. 


### Table 3. Effect of drought stress, Salicylic acid, Glutamine and their interaction in the relative growth (g. day\(^{-1}\)).

| Salicylic acid \(\text{(mg. L}^{-1}\) | Glutamine \(\text{(mg. L}^{-1}\) | Water Stress Level | interaction between Salicylic acid * Glutamine | effect of mean Salicylic acid | effect of mean Glutamine |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| \(\text{SA}_1\) | 0               | \(G_1\)        | 0.012 \(i\)    | 0.016 \(fg\)   | 0.014 \(f\)   | \(0.018\)        |
|                 |                 | \(G_2\)        | 0.014 \(h\)    | 0.018 \(def\)  | 0.016 \(e\)   | \(0.018\)        |
|                 |                 | \(G_3\)        | 0.015 \(g\)    | 0.018 \(de\)   | 0.017 \(e\)   | \(0.017\)        |
| \(\text{SA}_2\) | 75              | \(G_1\)        | 0.017 \(efg\)  | 0.019 \(bcd\)  | 0.018 \(d\)   | \(0.018\)        |
|                 |                 | \(G_2\)        | 0.017 \(ef\)   | 0.019 \(cd\)   | 0.018 \(d\)   | \(0.017\)        |
|                 |                 | \(G_3\)        | 0.018 \(de\)   | 0.020 \(bc\)   | 0.019 \(bc\)  | \(0.019\)        |
| \(\text{SA}_3\) | 150             | \(G_1\)        | 0.018 \(def\)  | 0.019 \(cd\)   | 0.018 \(d\)   | \(0.018\)        |
|                 |                 | \(G_2\)        | 0.019 \(cd\)   | 0.020 \(b\)    | 0.020 \(b\)   | \(0.020\)        |
|                 |                 | \(G_3\)        | 0.019 \(cd\)   | 0.024 \(a\)    | 0.021 \(a\)   | \(0.021\)        |

| interaction between Salicylic acid * Stress | \(\text{SA}_1\) | 0               | 0.014 \(c\)     | 0.017 \(d\)    | 0.016 \(c\)   | \(0.016\) |
|                                              | \(\text{SA}_2\) | 75              | 0.017 \(d\)     | 0.019 \(b\)    | 0.018 \(b\)   | \(0.018\) |
|                                              | \(\text{SA}_3\) | 150             | 0.018 \(c\)     | 0.021 \(a\)    | 0.020 \(a\)   | \(0.020\) |

| interaction between Glutamine* Stress | \(\text{G}_1\) | 0               | 0.015 \(c\)     | 0.018 \(c\)    | 0.017 \(c\)   | \(0.017\) |
|                                       | \(\text{G}_2\) | 1000            | 0.016 \(d\)     | 0.019 \(b\)    | 0.018 \(b\)   | \(0.018\) |
|                                       | \(\text{G}_3\) | 2000            | 0.017 \(c\)     | 0.021 \(a\)    | 0.019 \(a\)   | \(0.019\) |

| Effect of mean water stress | 0.016 \(b\) | 0.019 \(a\) |

#### 3.4. Plant yield (g plant\(^{-1}\))

Table (4) shows a significant decrease in plant yield due to the reduction in the duration of irrigation. The average plant yield decreased from 1358 g plant\(^{-1}\) at the first stress level \(S_1\) to 972 g plant\(^{-1}\) at the second stress level \(S_2\) with a decrease of 28.42%. As a result of the lack of absorbed water and elements and their transport, which reduces the activity of the vital activities in the vegetative range, which is reflected in the quantity of the yield [19].

Salicylic acid spraying resulted in a significant increase in the average plant yield. Increased from 769 g plant\(^{-1}\) in the control treatment \(\text{SA}_1\) to 1127 g plant\(^{-1}\) in the treatment \(\text{SA}_2\) and the highest mean 1599 g plant\(^{-1}\) in the treatment \(\text{SA}_3\) with an increase of 107.93%. The effect of acids spraying was significantly increased by 179.62%, the mean value of the \(\text{SA}_3\) \(G_3\) was 1893 g plant\(^{-1}\) compared to the control treatment \(\text{SA}_1\) \(G_1\), which recorded 677 g plant\(^{-1}\). The results indicated in the table showed a significant overlap between the three experimental factors. The acids spraying resulted in an increase of 286.17% under the effect of drought stress, the \(G_3\) \(\text{SA}_3\) \(S_1\) treatment achieved the highest mean of 2317 g plant\(^{-1}\), while it decreased to 600 g plant\(^{-1}\) in the treatment \(\text{SA}_1\) \(G_1\) \(S_2\).
Table 4. Effect of drought stress, Salicylic acid, Glutamine and their interaction in the plant yield (gm).

| Salicylic acid (mg. L⁻¹) | Glutamine (mg. L⁻¹) | Water Stress Level | interaction between Salicylic acid * Glutamine | effect of mean Water Stress | effect of mean Salicylic acid |
|--------------------------|---------------------|-------------------|-----------------------------------------------|---------------------------|----------------------------|
| SA1                      | 0                   | G1 0              | 600 j                                         | 755 ij                    | 677 f                      |
|                          |                     | G2 1000           | 623 j                                         | 827 hij                   | 725 f                      |
|                          |                     | G3 2000           | 770 ij                                        | 1042 fgh                  | 906 e                      |
| SA2                      | 75                  | G1 0              | 813 hij                                        | 1015 f-i                  | 914 e                      |
|                          |                     | G2 1000           | 942 ghi                                        | 1283 def                  | 1112 d                     |
|                          |                     | G3 2000           | 1166 efg                                       | 1543 c                    | 1354 c                     |
| SA3                      | 150                 | G1 0              | 1129 fg                                        | 1405 cde                  | 1267 cd                    |
|                          |                     | G2 1000           | 1240 def                                       | 2033 b                    | 1636 b                     |
|                          |                     | G3 2000           | 1468 cd                                        | 2317 a                    | 1893 a                     |
| interaction between       | SA1 0               |                   |                                               |                           | 769 c                      |
| Salicylic acid * Stress   | SA2 75              |                   |                                               |                           | 1127 b                     |
|                          | SA3 150             |                   |                                               |                           | 1599 a                     |
| interaction between       | G1 0                |                   |                                               |                           | 953 c                      |
| Glutamine*Stress          | G2 1000             |                   |                                               |                           | 1158 b                     |
|                          | G3 2000             |                   |                                               |                           | 1384 a                     |

4. Conclusions
We conclude from this study that water stress, especially at the second level, resulted in a decrease in all growth indicators and negatively. Also spraying salicylic acid and Glutamine at increasing levels reduced the effect of water stress on the triangular interference between the experimental factors. The effect of acids was clear in reducing the effect harmful to water stress so we recommend spraying higher concentrations and studies on other environmental stresses and other plants.

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