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Growth, Productivity and Quality of Cucumber Plants as Influenced by Drought Stress and Salicylic Acid under Protected Condition

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DROUGHT stress is a harmful non-biological factor that reduces growth and development of plants as well as yields. Salicylic acid is a plant hormone that belongs to phenol compounds that regulate the activation of biotic and abiotic stress defense systems on the cucumber plants. In this study drip irrigation was used to investigate the impact of drought stress and salicylic acid on the growth, production, and quality of cucumber plants. The obtained results showed that the highest value of plant parameters as plant height, leaves number and leaf area, nitrogen, potassium, chlorophyll, and proline contents as well as fruit physical parameters such as fruit number, fruit length, fruit diameter, fruit yield and fruit volume and chemicals characteristics like as T.S.S., ascorbic acid and total sugar were found when the application of 80 % irrigation level. However, T.S.S. and proline contents were enhanced under 65 % irrigation level. The results showed that under 80 or 65 % irrigation level with foliar application of salicylic acid at 1.0 mM was more effective than 0.5 and 0.75 mM in improving plant growth and yield characteristics. It could be concluded that the foliar application of the salicylic acid can relax the harmful impacts under lack irrigation (drought stress) of cucumber plants.

Keywords: Cucumber, drought stress, salicylic acid, fruit yield, total sugar and proline.

1. Introduction

Cucumber (*Cucumis sativus* L.) pertain to the Cucurbitaceae family, is one of the most important greenhouse vegetables worldwide and the second better widely cultivated greenhouse vegetable crop in Egypt **(Youssef *et al.* 2018; Mugwanya *et al.*, 2023)**. In Egypt, it is planted different conditions including greenhouse, tunnels, and open fields conditions. cucumber is known that the growth and productivity of cucumber hybrids differ under various temperature and humidity and other conditions **(Abdel-Mageed *et al.*, 2024).** Nowadays, Egypt has a lot of potential for greenhouses and in recent years, the area has grown rapidly. Cucumber was ranked the first order as a cash and commercial crop of vegetables grown under the greenhouse for the local market **(Kareem *et al.*, 2023)**. It is assessed that there are 51663 greenhouses overall, each with an area of 4413 feddans (one feddan = 0.42 hectare), of which 25787 were planted with cucumber plants, occupying 2132 feddans in total, with an average productivity of 11.16 kg/m^2 based on statistics of Ministry of Agriculture and Land Reclamation (2017). When the fruits are still physiologically immature, they are typically harvested **(Nada *et al.*, 2019).** It is commonly used in salads and eaten raw. Fresh cucumber fruits still contain potassium, thiamine, vitamin B6, vitamin K, vitamin C, and vitamin A add ref. Numerous biotic and non-biotic stressors have a significant impact on the cucumber growth (**Sahin *et al.* 2015).**

Drought stress is a detrimental non-biological factor that reduced growth and development of cucumber plants beside the yield **(Rasheed *et al.* 2020).** One of the most repeated non-biotic constraints on the cucumber plant growth and development is a lack of water **(Siamak *et al.*, 2014).** According to the previous studies (**El-Gindy *et al.*, 2009; Ibrahim and Selim, 2010 on squash and Sahin *et al.*, 2015** on the cucumber, a water deficiency leads to a decreased in the leaf area, stem length, fruit number, and fruit yield. Moreover, the drought stress caused decreased chlorophyll content in the cantaloupes **(Ali, *et al.*, 2014 and Moustafa *et al.*, 2024).** In contrast, a lack of water led to an increase in the sex ratio of cucumber plants **(Kamal *et al.*, 2009)**, cantaloupe water usage efficiency (Ali *et al.*, 2014), and melon free proline **(Kavas *et al.*, 2013).** Therefore drought-resistant plants with high performance are essential **(Ding *et al.* 2015).** One of the most important scientific and economic issues in arid areas is to improve cucumber plant performance to mitigate the adverse conditions of drought stress **(Penella *et al.* 2014).**

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Salicylic acid is a plant hormone that belongt to the phenol compounds that regulated the activity of biotic and abiotic stress defense systems **(González-Villagra *et al.*, 2022 and El Refaey *et al.*, 2022).** In the presence of stress, S.A. is crucial for controlling the intake of nutrients, cell elongation, levels of photosynthetic pigment, and the activity of photosynthesis, all of which affect the growth and development of cucumber plants **(Khan *et al.*, 2022 and Rashad, 2020).** Plants can become more tolerant to abiotic stressors by increasing the efficiency of their metabolic processes with S.A**. (González Villagra *et al.*, 2022).** S.A. produces these benefits during the several processes, including enhanced carbon metabolism, antioxidant system function, cell membrane protection, stress defense, and protein modulation **(Sharma *et al.*, 2017).** The impact of salicylic acid on the cucumber plants are contingent upon the method of application, concentration, and stage of plant development (**Nóbrega *et al.*, 2020**). Numerous studies have examined the functions of S.A. in enhancing the rate of plant tolerance to abiotic stress. Deficient water decreased cantaloupe plants physical characteristics, leaf pigments, components of yield, and overall yield, and they increased even more by adding 0.30 g^{-1} of S.A **(Nada *et al.*, 2019).** When pepper plants were stressed by drought, S.A. treatment enhanced the overall yield by controlling stomatal conductance and raising the amount of chlorophyll in their leaves **(Ghahremani *et al.*, 2023).** Moreover, using S.A. as external spray stimulates plant cells to synthesize and accumulate osmo-protectants, such as proline, which provides defense from abiotic stress **(Elhakem, 2020).**

Therefore, the main aims of this study were to determine sprayed salicylic acid to improve cucumber growth, production and quality under drought stress conditions.

2. Materials and Methods

The experiment was conducted for two successive cultivation seasons of 2020 and 2021 in a plastic greenhouse on a private farm in Zawetrazin village, EL-Menofiya Governorate, Egypt. The objective is to study the impact of spraying stressed plants (irrigated with different level, factor A) salicylic acid (S.A.), and the interaction of both factors on the growth, yield and quality of cucumber (*Cucumis sativus* L.) cv. Junco F1, under greenhouse conditions during the two winter seasons of 2020 /2021and 2021/2022. The soil of experimental was categorized as clay loam and the source of irrigation water was the Nile River. The chemical and physical analyses were conducted before cultivation, as reported by **Klute (1986) and Sparks *et al.* (2020)**, the results of the analyses were in Table 1. The experiment was warily prepared with three ploughing, coordination, and separating into experimental plots. one g.r.14 mm diameter drip lines for each row with 0.50 cm spacing, 4 l h^{-1} discharge rate, and 2.00 bar operating pressure were used to apply the irrigation water. Before transplanting, irrigation water was provided to a greenhouse to ensure the optimal plant establishment. The seedling was transfer to a plastic greenhouse at 21 October with a cultivating on 50 cm distance between plants in a row and rows were 160 cm apart in the first and second seasons respectively.

2.1 Preparation of seedling

Cucumber seeds were bought from Gaara Company. Seeds were sown at 15 September in foam seedling trays (209 cells) that contained a mixture of peatmoss and vermiculite (1:1 v/v) during the two experimental seasons. Seedlings were kept for four days under a plastic sheet to the beginning of seed germination and the seedling were fertilized with N.P.K. (19:19:19) and treated with fungicide every week while, the seedling was irrigated, when necessary, that. After it is reached to 15 cm in length, 2 cm diameter and contain 3 true leaves was transferred to a plastic greenhouse.

2.2 Experimental treatments and design

The experiments used a split-plot design with four replicates. The main plots were given the different irrigation level (1200 as a control, 1080, 960, and 780 m^3/fed from Water requirement. (100 % as a control, 90 %, 80 %, and 65 %) and the foliar application with S.A. at 0, 0.50, 0.75, and 1.00 mM, as well as the control without foliar application of A.S., were given to the sub-plots (Fig. 1). Different concentrations of S.A. solutions at 0.00, 0.50, 0.75, and 1.00 mM were prepared by dissolving 0.00, 69.06, 103.59 and 138.12 mg of salicylic acid respectively in ethyl alcohol and volume was made up to 1 L with redistilled water. Foliar spraying was done four times, the first was fifteen days after transplanting, then repeated every fifteen days. The unit of experiment 32 m^2 has dimensions of 4 m for width and 8 m for length. It is made up of four dripper lines, each measuring 160 cm in width and 5 m in length. In each row, the seedling was moved to one side of drip irrigation line. The remaining irrigation water quantity (m^3/fed.) was calculated using a water counter operating at 2.0 bar and a dripper flow rate of 4 l h^{-1}. Daily irrigation was started four days after the cucumber plants were transplanted and continued until the experimental flinched. The Ministry of Agriculture and Land Reclamation recommendations for agricultural practices, including the use of mineral fertilizers, disease prevention, and pest control were performed, when necessary, of cucumber production in greenhouse.

2.3. Measurements

2.3.1. Plant characteristics

After sixty days from the transplanting date, four randomly selected and labeled plants were taken from each subplot to measure the plant parameters. The plant height was determined by the meter. Nitrogen content (%)

was determined in digestive solution by micro-Kjeldahl method as described by **Helrich (1990).** Potassium content (%) was determined by Flame photometer (Corning M 410, Germany) **(Kalra, 1998).** Leaves chlorophyll content (mg 100-1 FW) was measured by using a SPAD chlorophyll meter (Konika Minolta INC, Japan). Proline content (µg g–1 FW) was measured using the colorimetric method at wavelengths of 520 nm by spectrophotometer (6800 UV/Vis Spectrophotometer, Jenway, Bibby Scientific Ltd., Staffordshire, UK), according to **Bates *et al.* (1973).**

2.3.2. Fruit physical characteristics

The physical parameters were recorded, including fruit number per plant, fruit length (cm), fruit diameter (cm), and fruit size (cm^3). Fruit weight: The weight (kg m -1) was estimated with weighed by a digital balance.

2.3.3. Fruit chemical characteristics

Total Soluble Solid (T.S.S. %): it was measured by using digital refractometer (38-B1, Bellingham Stanley, UK). Ascorbic acid (mg100g-1 FW): it was determined by the method of titration with 2,6- dichlorophenol indophenol dye according to **A.O.A.C., (2000).** Sugars (mg100g-1 DW) content was determined in cucumber leaves according to **Mazumder and Majumder (2003).**

2.4 Statistical analyses

Data for all characters were analyzed using the analysis of variance according to **Snedecor and Cochran (1982).** The obtained data was subjected to the analyses of two-way ANOVA and L.S.D. method at 5 % level of significance for each character**.**

Table 1. The physical and chemical analyses of the soil experiment.

Physical analyses									
Clay, %	Silt, %		Sand, %		Texture			FC (%)	
65.50	20.09		14.41		Clay			41.53	
Chemical analyses									
	pH	Cation (mmolc L-^{1})				Anion (mmolc L^{-1})			
E.C (dS m^{-1})		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0.70	8.05	2.45	0.60	2.17	0.98	0.00	1.70	2.20	2.30

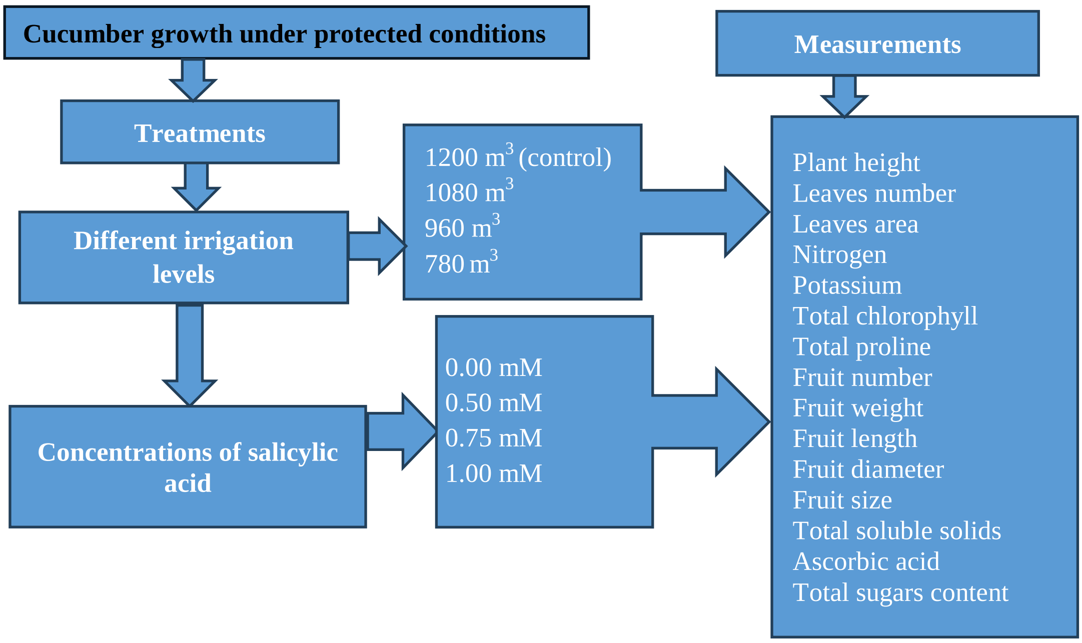

Fig. 1. Treatments used contain, the different irrigation levels, salicylic acid and the examined parameters in this study.

3. Results

3.1 Irrigation levels and salicylic acid on the plant characteristics

Data presented in Table (2) and Fig. (2) indicate the effect of different irrigation levels, salicylic acid, and their interaction on the examined parameters of cucumber including plant height, number of leaves, leaves area, chlorophyll, nitrogen, potassium and proline had significant effects during the two growing seasons of 2020/ 2021 and 2021/ 2022. The results reveal that the irrigation level 80 % demonstrated the highest values, succeeded by 90 %, 100 % and the 65 % irrigation level except the proline content which notated from the 65 % irrigation level. The foliar application of salicylic acid, 1.0 mM concentration showed the best substantial increase in plant growth parameters, followed by 0.75 mM and 0.50 mM, while the 0.0 Mm concentration recorded the lowest values of the previous parameters. The highest interaction resulted from the combined between at 80% irrigation level and 1mM of salicylic acid of all aforementioned parameters except the proline content which was found in 65 % irrigation level with all concentrations of salicylic acid. The same trend was obtained during the two examined seasons.

Table 2. Effect of irrigation levels and salicylic acid on plant height, leaves number and leaves area of cucumber in the two seasons of 2020/ 2021 and 2021/ 2022.

Irrigation treatments (factor A)	**Pant height (cm)**		**Leaves number**		**Leaves area (cm^2)**	
100% (control)	Season1	Season2	Season1	Season2	Season1	Season2
	174.22c	176.52c	37.08 c	36.88c	4209.66c	4200.00c
90 %	192.45b	194.74b	40.41b	40.24b	4574.77b	4575.44b
80 %	197.87a	200.36a	43.62a	43.48a	5075.22a	5073.55a
65 %	156.05d	158.65d	31.20d	31.08d	3271.11d	3278.77d
F- test	**	**	**	**	**	**
Salicylic acid doses (factor B)	Season1	Season2	Season1	Season2	Season1	Season2
0.00 mM (control)	173.89d	174.56d	37.01d	36.10d	4195.55d	4195.00d
0.50 mM	174.73c	177.59c	37.08c	36.84c	4237.16c	4240.25c
0.75 mM	181.28b	182.80b	38.05b	37.88b	4294.66b	4291.41b
1.0 mM	184.44a	187.28a	39.10a	39.05a	4316.25a	4314.16a
F- test	**	**	**	**	**	**
Interaction (A x B)	**	**	**	**	**	**

3.2 Irrigation levels and salicylic acid on the fruit physical characteristics

Results of Table (4, 5,6,7 and 8) illustrate effect of different irrigation levels, salicylic acid, and their interaction on the tested characteristics of cucumber including fruit number, fruit length, fruit diameter, fruit size and fruit weight had significant effects in both seasons of 2020/ 2021 and 2021/ 2022. The data show that the irrigation level 80 % exhibited the highest values, followed by 90 %, Control (100%) and the 65 % irrigation level in the first and second seasons. In terms for the foliar application of salicylic acid, 1mM concentration exhibited the best substantial increase in the fruit physical characters, followed by 0.75 mM and 0.50 mM, while the 0.00 mM concentration gave the lowest values of all parameters under this study. The interaction demonstrated that the combined between 80% irrigation level and 1mM of salicylic acid level exhibited the highest values of the previous characteristics for cucumber plants under the conditions of this experimental. Thise trend was consistent along the two cultivation seasons.

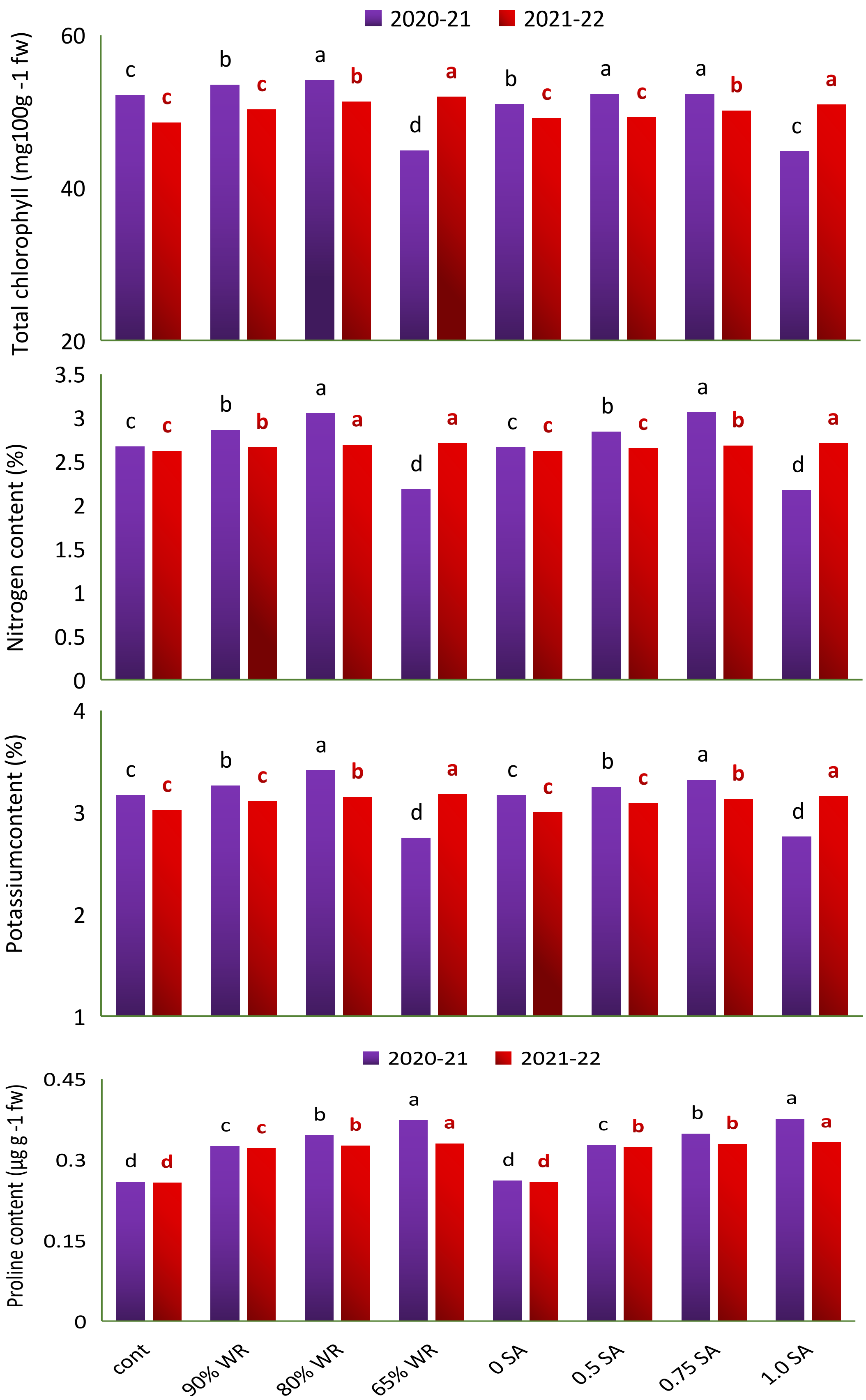

Fig. 2. Effect of irrigation levels and salicylic acid on the cucumber proline, nitrogen potassium and total chlorophyll contents in the two seasons of 2020/ 2021 and 2021/2022.

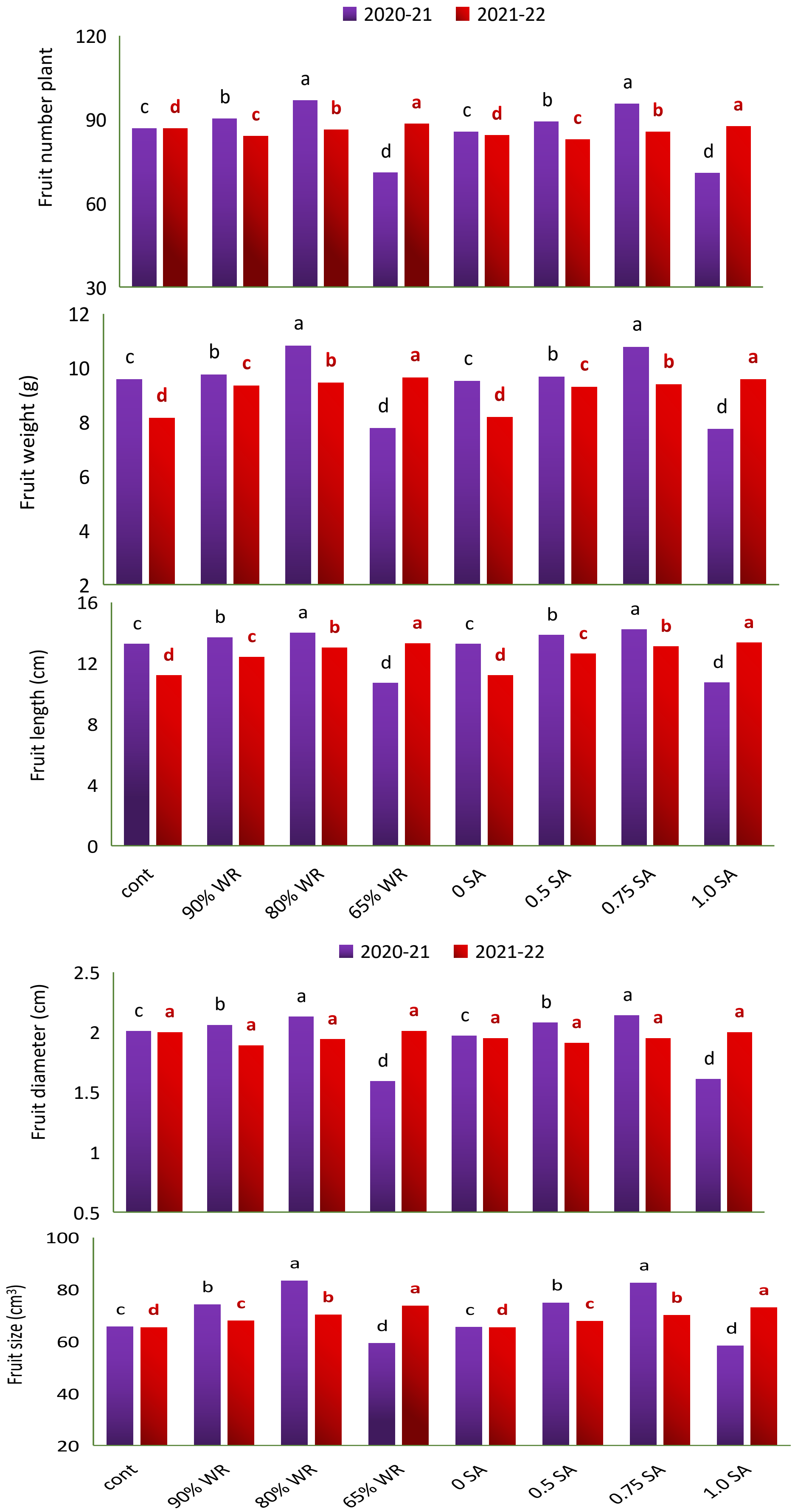

Fig. 3. Effect of irrigation levels and salicylic acid on the cucumber fruit number, fruit length, fruit diameter, fruit size and fruit weight in the two seasons of 2020/ 2021 and 2021/2022.

3.3. Irrigation levels and salicylic acid on the fruit chemical characteristics

The data illustrated in Fig. (3) showed that the impact of different irrigation levels and salicylic acid on the fruit cucumber chemical properties as T.S.S., ascorbic acid and total sugar contents during the two experimental seasons. The results indicated that 80 % irrigation level showed the highest values of fruit chemical parameters **(**ascorbic acid and total sugar) traits, followed by 90 %, Control (100%) and 65 % irrigation level except the T.S.S. which resulted from 65 % irrigation level during the investigation seasons. Regarding to, the foliar application of salicylic acid, 1mM concentration demonstrated the best substantial increase in the fruit chemical parameters, succeeded by 0.75 mM and 0.50 mM while the (0 mM) concentration of salicylic acid gave the lowest values of all fruit chemicals parameters in the two studied seasons of 2020/2021and 2021/2022. The highest value of the interaction between the irrigation levels and salicylic acid was recorded with 80 % irrigation level and 1mM of salicylic acid during the first and second seasons.

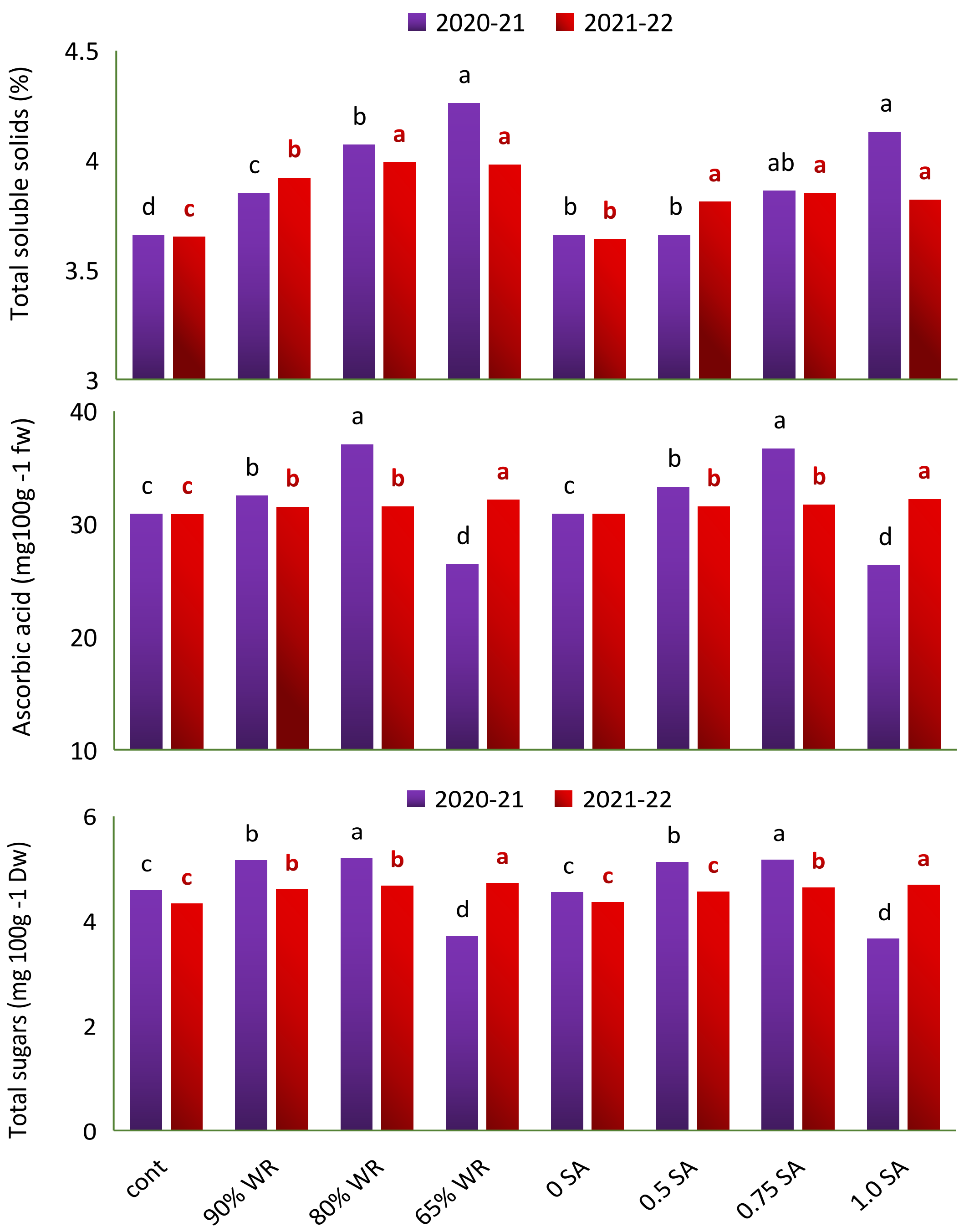

Fig. 4. Effect of irrigation levels and salicylic acid on the cucumber total sugars ascorbic acid and T.S.S. contents in the two seasons of 2020/ 2021 and 2021/2022.

4- Discussion

It is reasonably first to say that the objective goal of the present work is to have good knowledge and fully understand about the effect of different irrigation levels and salicylic acid on the cucumber plants so as to determine the optimum irrigation level and the suitable concentration of salicylic acid that give the highest quantity and the best quality of cucumber yield. The picture took out from our results on the cucumber plant reflects that the different irrigation levels and salicylic acid concentrations induced changes in the examined characteristics which are summarized in the two pictures. The first picture pointed that the cucumber plan growth characteristics such as plant height, number of leaves, leaves area, beside fruit characteristics as fruit number, fruit yield, length, diameter, and volume showed that the superior effects observed from the application 80 % irrigation level except the proline content which notated from the 65 % irrigation level. While the application of 65 % irrigation level gave the lowest value of the previous characteristics during the two cultivation seasons. Suitable irrigation level (80 %) may have stimulated growth, development, and an increase in the number of leaves per plant, which has a direct impact on the number of fruits as well as yield and volume of cucumber fruits (**Doro, 2012**). These results might be attributed to the effectiveness of the irrigation level at 80 % in promoting the vegetative development of cucumber plants growth and fruit parameters. This beneficial effect of irrigation level at 80 % may be due to better aeration in the root zone and moisture availability throughout the entire period of cucumber growth, and it is well known that water is essential for nutrient uptake and transport as well as photosynthesis, which favours growth and had an impact on fruit yield and its constituent parts. Additionally, the leading causes of leaf growth are cell division and expansion, and the turgor pressure of the cells controls the cellular expansion, so it can only take place when there is an adequate supply of water, which explains why plants with lower water availability have lower growth attributes (**Taiz and Zeiger, 2009**).

These findings, which demonstrated significantly increase plant growth such as plant height, leaves number and area as well as fruit parameters (fruit number, fruit yield, length, diameter, and size) than the other combinations, might be the consequence of interaction between 80 % irrigation levels and 1 mM of salicylic acid together. This might occur because of levels ideal for moisture and nutrients (**Mohamed *et al.*, 2018**). The available nutrients may have leached down from the root zone due to the higher irrigation level at 100 % (**Pawar *et al.*, 2018**). This may be the results of a very beneficial combination of 1.0 mM salicylic acid with 80 % irrigation level (**Shukla, 2020**). Therefore, the application of irrigation level 80 % and salicylic acid at1 mM resulted in highest significant increase of plant growth and fruit characteristics. This increase in plant growth and fruit characteristics may have been caused by water loss through evapotranspiration, which is being directly replenished by this level at the cucumber plant's root zone (**Mohammed *et al.*, 2021**). More specifically, during the crop-growing season, this state of maintaining the soil moisture regime in the root zone at low tension and closer to the field capacity ensures that plant has access to enough water, air, and nutrients in the soil of cucumber growth.

Subsequently, during the various stages of vegetative growth and ripening, the plant is shielded from moisture stress (**Ahmed *et al.*, 2012**). Additionally, an abundance of moisture in the soil produced favourable conditions for increased nutrient mobility, which in turn increased plant uptake of minerals and increased assimilation of carbohydrates required for various growth processes leading to an increase in fruit parameters and vegetative growth (**Ezzo *et al.*, 2010**). From another point of view, the superiority in the fruit yield and other characteristics of cucumber plants was attained by using the irrigation water level of 80 %. This may be related in physiological words to the favourable water supply during cell enlargement which led to turgid of the guard cells, continuity of open stomates, rapid carbon dioxide diffuses in the leaves, high rate of photosynthesis, normal rate of respiration, abundant supply of carbohydrates available for growth and excess of dry matter accumulation which reflects the best yield and quality (**Kumar, 2011**). From a chemical perspective, the prior water irrigation conditions may have increased gibberellin and auxin levels within biological concentration s, which encourage cell division and enlargement of cell size, thus increasing vegetative growth and other characteristics of cucumber plants (**Rahila, and Qanadilloba, 2015**). The previous results can be explained by proper moisture balance in plant, which produces some beneficial factors like increased photosynthetic surface area, higher pigment content, improved water status, and improved stomatal conductance, all of which can have a positive impact on these characteristics (**Abou El-Khair, 1999**). However, by using irrigation levels up to 80 % lead to increase in the cucumber content of the previous characteristics. This may be physiologically related to the favourable water supply during cell enlargement, which resulted in the guard cells becoming turgid, the continuity of open stomates, the rapid diffusion of co_2 in leaves, high rate of photosynthesis, normal rate of respiration, the abundant supply of carbohydrates available for growth, and the excess accumulation of dry matter, which reflects best vegetative growth, fruit yield and quality of cucumber (**Wang, and Xing 2016**). The lowest plant growth and fruit characteristics were resulted from the irrigation levels at 65%. This could be because the plant's capacity to absorb water from the soil decreased when high moisture tensions were present at the root zone, which meant that water and nutrients absorbed were insufficient for healthy cucumber vegetative growth and the other parameters. Concurrently, a decrease in co_2 intake due to stomata closing (**Liu *et al.*, 2005**).

Along with the decrease in net assimilation that inhibited fruit characteristics and plant growth, especially decrease in cucumber leaf area due to decrease of cell size and intercellular volume, as well as negative effects on cell turgor pressure and cell expansion rate, all contribute to a reduction in cell enlargement and growth (**Amin *et al.*, 2009**). Also, the increase in net synthesis of abscisic acid that causes the stomatal closure which decreases photosynthesis beside the decrease of net assimilation that reduced fruit parameters and vegetative growth of cucumber plants (**Ezzo, 2010**). Having to do with the reduction in the fruit yield and plant growth of cucumber due to the application of irrigation level at 65 % with 0 mM of salicylic acid, this may be attributed to the reduction in soil moisture which is responsible for the reduction in fruit parameters specially fruit volume and consequently the decrease in both the final fruit quantity and quality of cucumber (**Abou El-Khair, 1999; Leskovar and Agehara 2012**). The significant reductions in plant growth and fruit physical parameters may be due to the cucumber with 65 % irrigation level at the active root zone. These conditions are recognized to induce a wide range of molecular, biochemical, and physiological changes that impact the growth and development of plants (**Khapte *et al.*, 2019**). When plants suffer from 65 %, their growth may decline for two reasons either their cells elongate less because of the inhibiting effect of water shortage on growth-promoting hormones, or their xylem and phloem vessels become blocked, which prevents water flow and translocation (**Moustafa *et al.*, 2024**). These factors reduce cell turgor, volume, and growth (**Abdelaal, 2015**).

Furthermore, 65 % irrigation water suppresses growth parameters by lowering the relative water content of leaves, which reduces their turgor and interferes with their ability to assimilate water and nitrogen compounds, affecting cell division and enlargement (**Eltarabily *et al.*, 2019**). A lowest follow this in root formation and nutrient uptake, reducing the Fe and Mg nutrients supplied to leaves. Both are necessary for synthesizing chlorophyll pigments (**Farouk and Ramadan, 2012**). However, the reduction of chlorophyll in stressed plants is the overall indication of oxidative stress, which is linked to a reduction in chlorophyll synthesis (**Romdhane *et al.*, 2020**). Reducing chlorophyll content may result from increased pigment degradation or impair the pigment biosynthesis process (**Nematpour *et al.*, 2020**). Thereby, conditions characterized by water stress at 65 % irrigation level result in a significant reduction of plant photosynthetic efficiency (**Akács *et al.*, 2020**), and this is primarily because of stomata closing (**Putti *et al.*, 2023**), which restricts CO_2 diffusion into the leaf, Rubisco suppression and ATP synthesis reduction (**Murtaza *et al.*, 2016**). So, probable causes for our findings include a decline in nutrient uptake and inadequate photosynthate accumulation, allowing for a decrease in fruit number, length, diameter, and volume. Hence, the irrigation level at 80 % was the most suitable for crop root zone and near field capacity that led to maintain balance optimum between soil water and air around plant root zone which may be the reason for better performance of growth and fruit parameters. So, it is easy here to suggest that irrigation with level at 80 % seems to be the most favourable during the cultivation of cucumber plants.

The two-picture resulted from using the irrigation level of 80 % gave the highest value of all chemical characteristics of leaves (chlorophyll, nitrogen, potassium and proline contents) and fruits (T.S.S., vitamin C, and total sugars) except of T.S.S. and proline contents, which were obtained from at 65 % irrigation level with all concentrations 0.50, 0.75 and 1.0 mM of salicylic acid during the two cultivation seasons. The changes in these characteristics may be related to the excess of water in the soil which prevent oxygen from reaching the underground parts of cucumber resulting in reduction in the root development, induce rotting of the newly formed plant, excessive leaching in soil nutrients (**Imtiyaz *et al.*, 2000**), reduction in the translocation of assimilates to the leaves that disturb the hormonal balance (**Hartt, 1967**), confusion of the partition of assimilates among the different plant organs (**Hsiao and Acevedo, 1974**) and bring down the uptake of nutritional elements that caused a disturbance in the physiological processes needed for plant growth and quality (**Fatthallah and Gawish, 1997**). Indeed, cucumber crop does not withstand the applications of excess water (**Ahmed, *et al.*, 2007**) as excessive irrigation during the vegetative growth period can delay and reduce fruit development (**Metwally, 2011**).

However, all the previous reasons led to reduction in both plant growth and fruit parameters which in turn minimized the obtained yield (**Chala and Quraishi, 2015**). The observation that 80 % irrigation water level applied to the cucumber plants resulted in suitable water content in leaf tissues and, in turn, increased the intensity of green color of cucumber leaves (**Abou El-Khair, 1999 and Mohammed *et al.*, 2021**) may help explain the increase of T.S.S. and proline contents due to the irrigation level of 65 %. Additionally, it is showed that the application of a low irrigation water level of 65 % led to the highest accumulation of proline under these conditions. This accumulation was attributed to the inhibition of proline oxidation enzymes, specifically proline dehydrogenase, and the enhancement of proline biosynthesis enzyme activity (**Kishor *et al.*, 2005**). Furthermore, the cucumber plant may be forced to regulate specific metabolic activities in response to a water deficit by converting polysaccharides to simple sugars. This will result in an increase in the amount of total soluble solids and rate at which organic acids such as ascorbic acid, citric acid, and malic acid transform, which is crucial for osmotic adjustment in plants (**Nahar and Gretzmacher, 2002**). The minerals and other characteristics of cucumber were significantly impacted by the quantity of irrigation. At 80 % watering and a 1 mM salicylic acid treatments produced highest values of the most cucumber chemical parameters. It is feasible to suggest that 80 %

irrigation level water applications are superior for human nutrition and boost fruit mineral contents in cucumber plants (**Sahin, *et al.*, 2015**).

A decrease in soil water content usually has a negative impact on plants' ability to absorb nutrients. Furthermore, the levels of macronutrients (N, K, Ca, and Mg) in cucumber leaves were significantly reduced by water stress (**Kaya *et al.*, 2005; Kirnak and Demirtas 2006**). Under less watering circumstances we did, however, often acquire higher fruit mineral concentration s. One possible explanation is that variations in soil moisture regime can alter the chemistry of the soil solution, which in turn can alter how minerals are absorbed by plants (**Sahin, *et al.*, 2015**). The best irrigation level for crop root zones and areas close to field capacity was 80 %. This helped to maintain the ideal balance between soil water and air around plant root zones, which may have contributed to improved growth parameter performance. Therefore, it is simple to suggest that irrigation with water at an intensity of 80 % seems to be the most favorable, while the lack of water reduced cell division, roots formation, and nutrients uptake, which in turn reduced the absorption of N and Mg nutrients, which are essential for the synthesis of chlorophyll pigments (**Yavas and Unay, 2016).** Deficiency of water caused a decrease in levels of cytokines, gibberellins, elements absorbed, which impairs formation of roots, lipid peroxidation and membrane damage which raises the percentage of electrolyte leakage (**Vaisnad and Talebi 2015**).

Eventually, the results recorded of salicylic acid during the same tables and figures demonstrate that had notable disparities in the two cultivation seasons. Characteristics mentions dramatically increased with rising salicylic acid levels in both seasons. Using salicylic acid at 1 mM produced the highest values of these parameters, which was then followed by 0.75 mM and 0.50 Mm. This may be explained by the fact that a lack of water caused oxidative damage, which in turn produced reactive oxygen species (ROS), which in turn caused an oxygen shortage (**Cruz de Carvalho, 2008**). Salicylic acid inhibits excessive R.O.S. activity, promotes plant tissue elongation and cell division, activates soluble glucose translocation, ion absorption, and membrane permeability, all of which lead to increased growth and development (**Simaei *et al.*, 2012**). T.S.S., vitamin C, nitrogen, potassium, total sugar, total chlorophyll, and proline content attributes in cucumber plant leaves were significantly increased in the first and second seasons by using salicylic acid up to 1 mM, then declined at 0.00 mM, according to results shown in the previous Tables and figures. Reactive oxygen species (R.O.S.) have a disastrous effect on chlorophyll pigments when there is a water scarcity, which could be the cause of this increase. However, by improving antioxidant systems, promoting cell division and elongation, and enhancing the translocation of soluble carbohydrates, S.A. is helpful in reducing the harshest effects of R.O.S. on chlorophyll (**Fasaei, 2013)**. Furthermore, salicylic acid is known to inhibit the enzymes that oxidize chlorophyll, according to **Nazar *et al.*, (2015).**

Conclusion

From the aforementioned data, the foliar A.S. application may act positively as drought stress mitigation especially when applied as S.A. in concentrations ranged between 0.00 ,0.50, 0.75 and 1.00 mM in the foliar solution at all stages under drought stress of cucumber plants. Therefore, the study found that irrigation at 80 % significantly increases in plant height, leaves number, leaf area, nitrogen, potassium and chlorophyll contents as well as fruit number, fruit length, fruit diameter, fruit yield, fruit volume, T.S.S., ascorbic acid and total sugar contents with the exception of T.S.S. and proline contents which were noticed from 65 % irrigation level during the two cultivation seasons. The previous parameters mention increased with rising salicylic acid concentrations in both seasons. The application of salicylic acid at 1.0 mM produced the highest values of all characteristics, followed by 0.75 mM and 0.50 mM. While the concentration at control (0.0 mM) gave the lowest value of all parameters of cucumber except the T.S.S. and proline contents which was enhanced parameters with all concentrations of salicylic acid during the two growing seasons.

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