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# Mitigation of Salt Stress on Basil Plant by Irrigation Technique with Magnetic Water and Spraying with Salicylic Acid under Sandy Soil Conditions at Kalabsho Region

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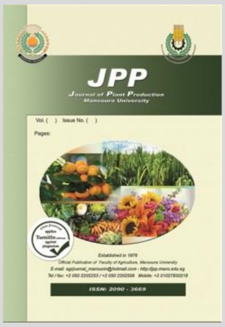


## ABSTRACT

A field experiment was conducted at a private farm in newly reclaimed sandy soil at Kalabsho, El-Dakahlia Governorate, Egypt during 2018 and 2019 seasons to evaluate the effect of irrigation water type (magnetized water and non-magnetized having 6350ppm total soluble salts), different irrigation intervals (2, 4 and 6 days) and spraying with salicylic acid (0, 50, 100 and 150 ppm) on alleviating salt stress reflecting growth, yield and metabolic characters of *Ocimum basilicum* L. The experimental design was split- split plot replicated three times. Results revealed that MW at all examined intervals gave the supreme significant increase on all studied growth parameters, herb fresh and dry yield/fed, essential oil percentage, oil yield/fed, photosynthetic pigments, carbohydrates, protein and productivity of irrigation water in the two cuts in both seasons. Appropriate irrigation interval (4 days) significantly increased herb fresh and dry yield/fed, essential oil percentage, oil yield/fed, those were higher in the 2nd cut than 1st one through both seasons while, a remarkable decrease in the 2nd cut was observed with non-MW. Spraying with SA at all levels in both water types significantly increased most of studied attributes particularly at 150ppm. It could be concluded that MW every 4 days interacted with 150ppm SA were effectively increased growth, yield, oil %, oil yield, major components linalool and 1, 8- cineol, certain metabolic characters. Consequently, MW irrigation every 4days with spraying 50ppm SA on basil under salt stress and limited water resources could be recommended for enhancing growth, qualitatively and quantitatively oil yield.

***Keywords:*** *Ocimum basilicum* L., magnetic water (MW), irrigation interval, salicylic acid (SA), yield, some physiological traits.

## INTRODUCTION

Basil (*Ocimum basilicum* L.) is a widespread herb of Labiatae grown in warm tropical climates, native to India and East Africa (Hiltunen and Holm, 2003). It is cultivated as an ornamental plant, either for culinary purposes or production of essential oil (Bączek *et al*., 2019). Approximately 60 basil species are recognized throughout the world and cultivated in Egypt, France, Russia, Indonesia, Greece and Israel (Adamović, 2012). Additionally, basil has stimulating properties and diuretic effect (Ahmed *et al*., 2014). Essential oils obtained from the leaves and flowering tops are consumed for food seasoning, dental and oral products, perfumes and in folk medicine. Basil is used in food industry as a flavoring agent and also in perfumery and medical industries (Nguyen *et al*., 2010).

Irrigation water and soil salinity have considerable effect on basil (Attia *et al*., 2011). Soil salinity resulting from natural processes or from crop irrigation with saline water, mainly occurs in arid and semi-arid regions of the world (Wu *et al.*, 2007). The deleterious effects of salinity on plant growth are associated with many factors; low osmotic potential of soil solution (water stress), nutritional imbalance, specific ion effect (salt stress), or a combination of these factors (Mahdavikia *et al*., 2019).

The availability of good quality water for irrigation becomes scarce and data on both quantity and quality is required (Fanous *et al*., 2017). Mostly, farms in the newly reclaimed soils were irrigated with saline water using magnetic water (MW) as harmless technique which improve the water quality and solubility of salts enhance seedlings development and plants become more resistant to unfavorable conditions under newly reclaimed sandy soil thus increases productivity and improves chemical composition of plants (Teixeira da Silva and Dobránszki, 2014; Samadyar *et al.*, 2014 and Hozayn *et al*., 2016). Moreover, MW and drip irrigation are more efficient approaches to save irrigation water when only saline water is the available source (Mostafazadeh *et al*., 2011). On periwinkle, the growth traits and the display life were enhanced under irrigation with MW at different irrigation period (Hashemabadi *et al*., 2015). Mahmoud *et al*., 2017 found that plants treated with 1.0 of cumulative pan evaporation (CPE) combined with silica nanoparticles at 60 ppm enhanced vegetative growth, fresh and oil yield, stomata resistance value, oil components while, decreased transpiration rate.

The effect of irrigation on herb and essential oil yield of basil has not been studied enough. Basil plants were sensitivity to water stress and irrigation could be determined by using the yield response and water use efficiency (WUE).

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Naderianfar et al. (2017) indicated that the highest water use efficiency (WUE) was obtained in terms of fresh and dry herb yield as 2.06 and 0.37 kg/m$^3$ in medium soil texture, irrigation with 75% ETc and nano fertilizer treatment, respectively. Also they found that with deficit irrigation under water restriction conditions, with the aim of maximum use of water volume unit, the optimal water consumption depth will be reduced by 20% compared to maximum irrigation mode.

Irrigation water resources are limited through Egypt as well as water budget which is 55.5 milliard cubic meter according to the international agreements with the countries of the Nile basin (1959). So, working or investigation on identified the optimum irrigation interval for basil plant considers one of the most suitable steps to make a good management for irrigation water which discussed through this paper

The use of salicylic acid (SA) and irrigation technique with magnetic water are applied to adjust plant's reaction to environmental stresses thus alleviate yield reduction and lack of water especially in arid regions where available water will be of poor quality and mostly saline in nature (Bideshkia and Arvin, 2010; Bagherifard *et al*., 2015 ). Several studies reported that SA as alleviator of the effects of saline stress (Mohammadzadeh *et al*., 2013; Angooti and Nourafcan 2015). Furthermore, SA as phytohormone regulates plant growth, yield, flowering, in addition to enhancing photosynthetic rate and chlorophyll (Bagherifard *et al*., 2015).

The main target of this work is studying the response of *Ocimum basilicum* L. to irrigation with magnetic water at different irrigation intervals and spraying with SA under North Nile Delta climatic conditions and some water relations. Obtained results could be used as a good base for basil growers in the region to optimize the use of irrigation water and mitigate salt stress. Growth, certain physiological parameters as well as yield and its components were evaluated.

# MATERIALS AND METHODS

In order to investigate the impact of irrigation water type (non-magnetized or magnetized water) at different irrigation intervals including irrigation every 2 days ($1_1$), 4 days ($I_2$) and irrigation every 6 days($I_3$) and foliar spraying of salicylic acid at 0 ($S_1$), 50 ppm ($S_2$),100 ppm ($S_3$) and 150 ppm ($S_4$) on alleviating salinity effects in relation to vegetative growth, yield and chemical composition of *Ocimum basilicum* L. under the environmental conditions of newly reclaimed sandy soil. This trial was conducted at a private farm in Kalabsho region ( Latitudes 31° 10′ and 31° 31′ N; Longitudes 31° 15′ and 31° 33 E), El-Dakahlia Governorate, Egypt during two successive seasons 2018 and 2019. The meteorological data of the experimental site during both growing seasons were recorded in Table (1). Maximum and minimum air temperature were recorded daily then calculated as mean/month.

**Table 1. The meteorological data of the experimental site during both growing seasons of 2018 and 2019.**

| Month | 1st season | | | | | | | | 2nd season | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Temp. $^0$C | | | Rh % | | | WS km d$^{-1}$ | Ep mmd$^{-1}$ | Temp. $^0$C | | | Rh % | | | WS km d$^{-1}$ | Ep mmd$^{-1}$ |
| | Max. | Min. | Mean | Max. | Min. | Mean | Mean | Mean | Max. | Min. | Mean | Max. | Min. | Mean | Mean | Mean |
| April | 30.0 | 18.9 | 24.5 | 71.6 | 41.8 | 56.7 | 105.5 | 5.9 | 27.5 | 18.9 | 23.2 | 74.0 | 42.0 | 58.0 | 90.2 | 5.9 |
| May | 31.0 | 22.9 | 27.0 | 71.0 | 45.8 | 58.4 | 112.8 | 6.4 | 29.8 | 19.7 | 24.8 | 77.5 | 45.7 | 61.6 | 92.5 | 5.3 |
| June | 33.6 | 26.4 | 30.0 | 75.7 | 46.6 | 61.2 | 87.1 | 8.0 | 31.5 | 27.0 | 29.3 | 76.9 | 45.7 | 61.3 | 84.3 | 7.3 |
| July | 33.9 | 26.1 | 30.0 | 82.7 | 56.8 | 69.8 | 82.5 | 7.8 | 32.2 | 28.7 | 30.5 | 79.8 | 44.1 | 62.0 | 83.6 | 8.7 |
| Aug. | 33.6 | 26.4 | 30.0 | 84.3 | 56.3 | 70.3 | 81.8 | 7.7 | 32.9 | 27.6 | 30.3 | 82.0 | 50.2 | 66.1 | 83.6 | 8.7 |
| Sept. | 32.9 | 24.9 | 28.9 | 83.1 | 51.8 | 67.5 | 92.1 | 5.9 | 31.5 | 26.2 | 28.9 | 82.0 | 49.9 | 66.0 | 87.4 | 7.3 |
| Oct. | 29.8 | 24.0 | 26.9 | 82.4 | 55.3 | 68.9 | 92.2 | 4.5 | 29.9 | 24.3 | 27.1 | 81.4 | 48.7 | 65.1 | 91.0 | 4.9 |

**Source: Mansoura weather station according to the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt.**

**Temp.: Air Temperature Rh: Relative humidity WS: Wind speed Ep: Pan Evaporation**

Soil samples were taken before cultivation at depths; 0-30 and 30-60 cm and analyzed physicochemically as described by (klute, 1986 and Jackson, 1973), the data are illustrated in Table (2) as mean values for both growing seasons. The texture of the experimental field soil is sand. Seeds were obtained from the Medicinal and Aromatic Plants Dept., Hort. Res. Inst., Agric. Res. Center, Egypt. The seeds were sown in the greenhouse at the beginning of March in both seasons in a mixture of vermiculite and peatmoss (2:1). Uniform seedlings 10 cm height (5-8 leaves) were transplanted in plots on April 7$^{th}$ in both seasons at 30 cm×50 cm spacing. Each plot was 4 m$^2$ and contained three rows. A guard two lines was left between each two experimental plots to avoid the overlapping infiltration. The experimental design was split- split plot arrangements with three replicates. The main plots for type of irrigation water, the sub-plots for different irrigation intervals and the sub-sub plots were concentrated for salicylic acid (SA).

**Table 2. The physicochemical properties of soil used as means of both seasons**

| Parameters | Soil fractions (%) | | | Soil texture | pH(1:2.5) soil water suspension | Ec (dSm$^{-1}$) | Available cations (meq l$^{-1}$) | | | | Available anions (meq l$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil depth | Clay | Silt | Sand | | | | $K^+$ | $Na^+$ | $Ca^{++}$ | $Mg^{++}$ | $CO_3^-$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{--}$ |
| 0-30 cm | 7.5 | 14.1 | 78.4 | Sand | 7.54 | 2.112 | 1.29 | 13.0 | 2.0 | 5.5 | 0.0 | 4.0 | 9.5 | 8.29 |
| 30-60 cm | 8.3 | 17.1 | 74.6 | sand | 7.88 | 2.406 | 1.23 | 16.0 | 1.6 | 4.9 | 0.0 | 4.0 | 7.2 | 12.53 |
| Mean | 7.9 | 15.6 | 76.5 | sand | - | 2.259 | 1.26 | 14.5 | 1.8 | 5.3 | 0.0 | 4.0 | 8.4 | 10.41 |

**Note: $So_4^{--}$ was calculated by the difference between soluble cations and anions.**

Ten days after transferring seedling were subjected to the irrigation water (IW) treatments (2, 4 and 6 day's intervals). Two types of irrigation water were used, the first was normal ordinary saline irrigation water pumped from a well (control) and the second was magnetized. Four inch water magnetized device of Nefertari Biomagnetic engineered in Germany was installed on the main irrigation line. Irrigation water (IW) was under measured through trickle irrigation system which consists of a pumped unit that contains a pump, control unit, groups of pipes which differ in its diameter and distribution lines. The control unit of the system contains a venture injector (25.4 mm), fertilizer tank, disk filters, control valves and a water flow meter. Distribution lines consists of polyethylene (PE) pipes manifolds (display and discharge) laterals of 16 mm in diameter and 40 m in length had in- line emitters spaced 0.3 m apart, each delivering 4L $h^{-1}$at a pressure of 1 bar. Drip irrigation lines were spaced 0.5 m apart equally spaced between every other row of basil. Water was applied from a pressurized hydrant and filtered through gravel and re-filtered through disk filters. The amount of applied water was measured using flow meter. Productivity of irrigation water (PIW) was calculated according to Ali *et al.*, (2007).

$$PIW = \frac{Y}{IW}$$

**Where:**

**PIW; Productivity of irrigation water (kg $m^{-3}$),**
**Y; Yield (sum yields of first cut and second cut, kg), and**
**IW; Applied irrigation water ($m^3$).**

The analysis of irrigation water for the same source using the standard method (Page *et al*., 1982) is presented in Table (3).

**Table 3. Some characteristics of the used irrigation water**

| | | Non- Magnetized water (check treatment) | Magnetized water |
|---|---|---|---|
| pH | | 8.28 | 8.36 |
| EC ($dsm^{-1}$) | | 9.92 | 9.89 |
| TSS (ppm) | | 6349 | 6328 |
| Soluble cations (meq/l ) | $Ca^{++}$ | 14.4 | 14.4 |
| | $Mg^{++}$ | 35.7 | 36 |
| | $Na^+$ | 48.0 | 47.8 |
| | $K^+$ | 0.9 | 0.9 |
| Soluble anions (meq/l ) | $CO_3^{--}$ | - | - |
| | $HCO_3$ | 13.6 | 14.0 |
| | $Cl^-$ | 60.0 | 60.0 |
| | $SO_4^{--}$ | 25.3 | 24.9 |
| Hardness (mg/l) | | 241.09 | 223.00 |
| Refractive index | | 1.33 | 1.33 |
| Surface tension( dyne/cm) | | 74.12 | 72.65 |
| Viscosity(centistoke) | | 0.76 | 0.72 |
| Density(g/ml) | | 1.00 | 1.00 |
| Turbidity (NTU) | | 885 | 790 |

Salicylic acid treatments (0,50,100 and 150 ppm) were sprayed three times; the first on May 7th, the second after one month from the first and the third on August 18th for both growing seasons. Entirely agricultural practices and fertilization through drippers under drip irrigation system were conducted as recommended by Agricultural Research Center, Egypt.

Plants were harvested twice at mid flowering stage (July 13rd and September 15th in both seasons). Random samples of five plants were taken at harvesting at 12 cm above the soil surface to evaluate the following data; Plant height (cm), Number of main branches per plant, Plant fresh and dry weight (g) as well as fresh and dry herb yield (kg $fed^{-1}$). Total leaf area per plant was calculated using leaf area-leaf weight relationship from leaf discs by a cork borer (Wallacce and Munger, 1965). Direct microscopic count for the stomatal number was carried out on stripes obtained from basil leaves. Uniformity three leaves representing the treated plants were chosen. Two epidermal stripes were taken from the leaves and on each strip two areas of about 0.25 $cm^2$ were selected for determination of three stomatal counts for each strip. The number of stomata per $mm^2$ (stomatal density) on the upper epidermis was determined using the square ocular micrometer as described by Gaber (1985). Herb oil percentage was measured by hydro distillation in Clevenger apparatus as described by British Pharmacopoeia (2000). Total oil yield was calculated by multiplying the oil yield per plant by number of plants per fed. GLC was carried out at the Medicinal and Aromatic, HRI using Varian VISIA series 6200, FID detector. The percentage of the main components was calculated by matching their retention time (RT) with those of authentic samples under the same conditions and the constituents of the essential oil were identified, according to Adams (1995). Photosynthetic pigments (chlorophyll a, b and carotenoids) were estimated spectrophotometrically according to Harborne (1984). Basil leaves was rapidly dried to constant weight then ground to a fine powder for estimation of carbohydrates and protein contents (A.O.A.C., 1980).

Data was subjected to analysis of variance (ANOVA) using (costat) statistical analysis system. Mean comparisons were performed using the least significant differences (L.S.D) method at significance level of 5 % according to Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### Growth Responses

#### Effect of irrigation water type

As apparent in Table (4), the plants irrigated with magnetic water (MW) recorded highly significant increments in all evaluated growth variables; plant height, number of branches/plant, leaf area, stomatal density, fresh and dry weights in both cuts in the two consecutive seasons comparing with non-magnetic water (control). The mean values of these parameters in the 2nd cut were higher than those in the1st cut in the two studied seasons because the environmental conditions were more suitable for basil growth. The enhancement effect of MW clearly appeared in the second season compared to the first season. Basil plants irrigated with MW understand additions over the plants irrigated with nonmagnetic in all growth criteria; the height of plant, number of branches/plant, leaf area, stomatal density, fresh and dry weights by about 30.2 ,40.1 ; 89.8, 95.8; 64.9, 78.3; 12.5, 16.1; 55.5, 67.8 and 56.5, 63.7 %, respectively, for both cuts in the first season and 37.8, 47.7; 94.9, 97.6, 64.5, 72.6; 15.7, 18.4; 56.5, 63.7 and 56.9, 63.7% respectively, in the second one. This increase in basil growth may be due to MW as the increase in pigments and protein biosynthesis. Magnetic field may be discontinuity of $H_2$ bonds of the molecule of MW and molecules become small that affected water characteristics facilitating the water passage throughout cell membrane (Grewal and Maheshwari, 2011). Also, may affect the production of IAA affecting the cell division, consequently, the increase in plant height and number of branches El-Kholy, *et al*., 2020).

Though MW has optimistic effects on the growth traits, there is no clarity to mechanisms resulted in these effects. However, many theories were suggested; Balouchi and Sanavy (2009) mentioned that the magnetic field increase the permeability of cell membranes and affect ion transport and various metabolic pathway activities. Grewal and Maheshwari (2011) described that magnetic effect on water characteristics mainly due to hydrogen bonding, polarity, surface tension, conductivity, pH and solubility of salts that influenced on plant growth. Generally, The promising effect of MW may be due to its directly effect on soil properties then indirect effect on solubility of salts and kinetic changes in salt crystallization supporting the absorption of water and availability of nutrients thus improve biological processes that resulted in development of seedlings and plants become more resistant to unfavorable conditions under newly reclaimed sandy soil (Hozayn *et al*., 2016). On the other hand, the reduction in all growth traits of basil plants due to irrigation with non-magnetic water noticed in this study may be attributed to the osmotic action and/ or ion specific effects of salinity. It was found that lower osmotic potential in the soil cause a decrease of water uptake, closure of stomata and reduction of transpiration resulting in numerous physiological disturbances (Silva *et al*., 2018). It is worthy mentioned that MW is friendly environmental performance and realized increases over the plants irrigated with nonmagnetic water. Similar enhancing effect of MW was reported on flax (Abdul Qadose and Hozayn, 2010) and on rosemary (Boix *et al*., 2018; El-Kholy, *et al*., 2020).

**Table 4. Effect of irrigation water type, irrigation intervals and salicylic acid foliar spraying and their interactions on growth responses of *Ocimum basilicum* L. in the two cuts during the two growing seasons (2018 and 2019).**

| Treatments | Plant height (cm) | | No. of branches /plant | | Leaf area ($dm^2$/plant) | | Stomatal density ($No./mm^2$) | | Plant fresh wt. (g) | | Plant dry wt. (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut |
| **1st season (2018)** | | | | | | | | | | | | |
| Irrigation water type (A) | | | | | | | | | | | | |
| Nonmagnetic | 65.27 b | 63.78 b | 6.85 b | 6.70 b | 26.73 b | 26.58 b | 156.71 b | 153.87 b | 192.31b | 185.58 b | 42.82 b | 42.30 b |
| Magnetic | 84.98 a | 89.34 a | 13.00 a | 13.12 a | 44.09a | 47.38 a | 176.28 a | 178.69 a | 299.13 a | 311.42 a | 67.00 a | 69.25 a |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.121 | 0. 104 | 0.736 | 0.124 | 0.124 | 0.078 | 2.557 | 0.249 | 0.547 | 1.114 | 0.058 | 0.145 |
| Irrigation intervals (B) | | | | | | | | | | | | |
| $I_1$ (every 2 days) | 72.65 b | 73.71 b | 9.86 b | 9.69 b | 34.47 b | 36.43 b | 165.92 b | 164.65 b | 242.62 b | 244.05 b | 54.56 b | 54.97 b |
| $I_2$ (every 4 days) | 78.17 a | 79.71 a | 10.57 a | 10.61 a | 38.78 a | 40.81 a | 170.61 a | 171.31 a | 258.44 a | 263.14 a | 57. 66 a | 59.11 a |
| $I_3$ (every 6 days) | 71.02 c | 72.28 b | 9.56 c | 9.46 c | 32.98 c | 33.70 c | 163.50 c | 162.89 b | 236.09 b | 238.32 c | 52.50 b | 53.25 c |
| F. test | ** | * | ** | ** | ** | ** | ** | ** | ** | ** | * | ** |
| L.S.D at 0.05 | 0.960 | 1.390 | 0.300 | 0.166 | 0.121 | 0.126 | 1.159 | 1.789 | 7.670 | 4.042 | 0.205 | 0.086 |
| salicylic acid (C) | | | | | | | | | | | | |
| 0 | 69.36 c | 71.04 d | 9.29 c | 9.33 d | 31.66 d | 32.98 d | 163.93 c | 163.08 c | 235.13 d | 239.13 b | 52.12 d | 52.92 b |
| 50 ppm | 74.50 b | 75.52 c | 10.03 b | 9.89 c | 35. 47 c | 36.83 c | 166.59 b | 166.75 b | 246.27 c | 248.53 a | 54.79 c | 55.83 a |
| 100 ppm | 75.59 a | 76.74 b | 10.22 b | 10. 08 b | 36.65 b | 38.24 b | 167.21 b | 166.98 b | 249.18 b | 250.77 a | 55.97 b | 56.75 a |
| 150 ppm | 76.34 a | 77.63 a | 10.46 a | 10.38 a | 37.86 a | 39.88 a | 168.25 a | 168.32 a | 252.29 a | 255.56 a | 56.53 a | 57.60 a |
| F. test | ** | * | ** | ** | ** | ** | ** | ** | ** | * | ** | * |
| L.S.D at 0.05 | 0.801 | 0.522 | 0.211 | 0.161 | 0.108 | 0.076 | 0.867 | 0.677 | 0.810 | 6.987 | 0.164 | 0.941 |
| Interactions | | | | | | | | | | | | |
| A X B | ** | ** | NS | NS | ** | ** | * | ** | * | ** | * | ** |
| A X C | * | * | ** | NS | ** | ** | ** | * | ** | ** | ** | ** |
| B X C | NS | * | NS | * | * | ** | * | ** | * | ** | * | * |
| A X B X C | ** | ** | * | ** | ** | ** | NS | * | ** | ** | ** | ** |
| 2nd season (2019) | | | | | | | | | | | | |
| Irrigation water type (A) | | | | | | | | | | | | |
| Nonmagnetic | 62.92 b | 61.13 b | 6.71 b | 6.69 b | 27.08 b | 26.64 b | 157.79 b | 155.87 b | 195.05 b | 192.70 b | 43.00 b | 42.58 b |
| Magnetic | 86.69 a | 90.38 a | 13.08 a | 13.22 a | 44.54 a | 45.99 a | 182.61 a | 184.53 a | 305.20 a | 315.46 a | 67.46 a | 69.72 a |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.067 | 0.104 | 0.93 | 0.264 | 0.108 | 0.021 | 0.248 | 0.253 | 0.258 | 0.655 | 0.057 | 2.204 |
| Irrigation intervals(B) | | | | | | | | | | | | |
| $I_1$ (every 2 days) | 75.08 b | 76.00 b | 9.61 b | 9.56 b | 34.77 b | 35.06 b | 172.07 b | 175.72 a | 248.57 b | 250.40 b | 54.92 b | 55.41 b |
| $I_2$ (every 4 days) | 79.21 a | 81.13 a | 10.78 a | 10.68 a | 39.25 a | 40.43 a | 175.23 a | 175.93 a | 262.65 a | 269.29 a | 57.80 a | 59.43 a |
| $I_3$ (every 6 days) | 73.66 c | 74.12 c | 9.43 b | 9.43 b | 33.40 c | 33.44 c | 166.80 c | 166.80 b | 239.16 c | 242.56 c | 52.63 c | 53.61 c |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.042 | 0.090 | 0.255 | 0.349 | 0.059 | 0.098 | 0.421 | 0.360 | 0.937 | 0.304 | 0.700 | 1.133 |
| salicylic acid (C) | | | | | | | | | | | | |
| 0 | 72.69 d | 72.87 d | 9.13 d | 9.11 c | 32.27 d | 32.69 d | 166.99 c | 167.80 c | 238.42 d | 241.09 c | 52.46 c | 53.29 c |
| 50 ppm | 76.41 c | 77.51 c | 10.00 c | 9.97 b | 35.79 c | 36.39 c | 170.11 b | 170.66 b | 249.59 c | 254.33 b | 54.92 b | 55.90 b |
| 100 ppm | 77.03 b | 78.69 b | 10.18 b | 10.18 a | 36.22 b | 37.31 b | 170.56 b | 170.90 b | 254.95 b | 258.52 a | 56.30 a | 57.50 a |
| 150 ppm | 77.81 a | 79.26 a | 10.44 a | 10.32 a | 38.14 a | 38.66 a | 172.24 a | 172.95 a | 257.55 a | 262.40 a | 56.67 a | 57.92 a |
| F. test | ** | * | ** | ** | * | ** | ** | ** | ** | ** | ** | |
| L.S.D at 0.05 | 0.051 | 0.055 | 0.166 | 0.150 | 0.063 | 0.074 | 0.677 | 0.521 | 0.746 | 4.368 | 0.587 | 1.143 |
| Interactions | | | | | | | | | | | | |
| A X B | ** | ** | * | * | ** | * | ** | ** | * | ** | * | * |
| A X C | ** | ** | * | NS | ** | ** | * | * | ** | ** | ** | NS |
| B X C | ** | ** | ** | * | * | ** | ** | ** | NS | * | NS | NS |
| A X B X C | ** | ** | NS | NS | ** | ** | * | * | ** | ** | ** | * |

**Means designed by the same letter at each cell are not significantly different at the 5% level, N.S.: not significant**

## Effect of irrigation intervals

Data in Table (4) showed that all growth studied criteria were significantly increased under different irrigation intervals in both seasons. The best irrigation interval was $I_2$ (every 4 days). Appropriate irrigation interval ($I_2$) resulted in the superior growth at all followed by $I_1$ and

$I_3$ with no significant differences between in many studied parameters as plant height, stomatal density in the 2nd cut and plant fresh weight in 1st cut in 1st growing season, number of branches/plant in both cuts in 2nd growing season. The increasing effects of growth under the adequate water supply may due to its effects on some metabolic processes within the cell (Sepaskhah, 1977). The decline in mentioned traits under higher irrigation interval up to 6 days may be attributable to the stomatal closure, and decrease $CO_2$ availability for the chloroplast affecting the photosynthesis rate (Leithy *et al*., 2006). Additionally, the plant senescence and the reduction of turgor pressure were causing the inhibition of cell expansion, also, the decrease of adequate moisture in the root zone affecting uptake of nutrients (Said-Al Ahl and Hussein, 2010). Obtained results showed a range of remarkable effects of irrigation intervals on basil growth; these findings are in harmony with Bahreininejad *et al*., 2013 on thyme; Abdel–kader *et al*., 2014 on lemongrass; Gerami *et al.* , 2016 on oregano and Caliskan *et al*., 2017 on sweet basil.

**Effect of salicylic acid**

The attained results in Table (4) indicated that extending of SA levels from 50 to 150 ppm statistically increased growth characteristics in terms of the plant height, number of branches/plant, leaf area, stomatal density, plant fresh and dry weights for two cutting in both seasons compared to control. The maximum promoting effect of SA was found at 150 ppm for all studied growth parameters except the 1st cut of plant height, 2nd cut of plant fresh weight and both cuts of plant dry weight in 1st growing season, 2nd cut of branches number/plant, 2nd cut of fresh and dry weight in the 2nd growing season showing the maximum values at 100 and 150 ppm SA treatments without a significant differences. SA regulate basil growth and acts as a mitigator of the effects of saline stress by increasing the resistance of the plant to System Acquired Resistance (SAR) and various physiological roles throughout the alteration of antioxidant enzyme activities as SA treatment activate some enzymes and others were inhibited such as catalase which is a fundamental enzyme in SA-induced stress tolerance (Conrath *et al*., 1995). The present results showed that SA gave an increase in all studied growth traits and increased plant tolerance for salt stress conditions. These results are in concord (Mohammadzadeh *et al*., 2013 on *Ocimum basilicum*; Abbas and Ibrahim, 2014 on *Niggella sativa* as well as Angooti and Nourafcan, 2015 on *Ocimum basilicum*.

**Effect of the interactions**

As obvious in Table (4), the interaction between water types and irrigation intervals showed a significant effect for all studied growth characters except for number of branches/ plant was non- significant for two cuts in both seasons. Also, the interactions of water types X SA exhibited a significant result for all mentioned traits except for number of branches/ plant in the 2nd cut in both seasons and plant dry weight in the 2nd cut in the 2nd growing season. Meanwhile, the interaction of irrigation intervals X SA indicated a notable effect on some experimental traits and not for others such as in the1st cut for both plant height and number of branches during the 1st developing season, plant fresh weight in the 1st cut and plant dry weight in both cuts during the 2nd one showing non- significant effect.

Results from variance analysis (Table 5) indicated that the interaction among all studied factors significantly influenced on all growth parameters except stomatal density of basil in the 1st cut during the 1st season and number of branches in both cuts during the 2nd season that showed non-significant result.

It is obvious that all growth characteristics increased due to SA application and the increase was a concentration dependent. The significant increase in the growth characters namely; the plant height , number of branches/plant, leaf area, stomatal density, plant fresh and dry weights were recorded in response to 150 ppm SA level under the appropriate irrigation interval ($I_2$) in plants treated with non MW. These increases were 16.8,17.4; 35.9, 34.4; 54.0, 53.5; 6.6, 6.2; 21.4,21.6 and 21.2, 21.7%, respectively for the two cuts in the 1st season compared to unsprayed plants while 11.1,16.6; 34.1,19.8; 52.4, 51.7; 6.0, 6.; 21.2, 21.7 and 21.2, 21.9% in that order during the 2nd season. The plants treated with MW required lower SA levels compared to the corresponding controls at all irrigation intervals through both seasons for the two cuts. The significant increases responding to the interaction treatment (MW+150ppm SA+$I_2$) determined 7.1, 8.8; 5.5, 3.6; 14.9, 9.1; 1.1, 4.3; 5.2, 5.1and 2.1, 4.8% respectively, in the two cuts during the 1st season as compared with unsprayed controls while, 6.2, 8.9; 12.6, 9.9; 10.7, 21.4; 4.3, 4.2; 2.1, 4.8 and 2.1, 4.3% in that order for both cuts in the 2nd season.

It is notably from data in Table (5) that the plants irrigated with non-MW logged minor growth characters compared to those treated with MW at all irrigation intervals. Thus MW minimized the damage effect of non-MW as well as, foliar spray with SA reduced the negative effect of non-MW treatments. Consequently, the damaging effects of salinity on the growth due to irrigation with non- MW may be mitigated by spraying of SA at high level (150 ppm) at all irrigation intervals. Regarding non-MW treatments, the interaction treatment (non-MW+ 150ppmSA+ $I_2$) recorded the top values in the experimental traits compared to the other interactions. As compared with non-MW treatments (controls), the interaction treatment of MW with spraying of SA showed highly significant increases in all verified traits under all irrigation intervals in the two cuts during both growing season. The paramount water supply for both MW and non-magnetic water is every 4 days interval ($I_2$) that realized the uppermost growth with application of SA at 150 ppm under non-MW treatments and 50, 100 or 150 ppm with non-significant differences among them under MW treatments throughout the two seasons for all cuts. The supreme vegetative growth in consequence of the interaction treatment (MW+150 ppm SA+$I_2$) for two yields in the two growing seasons paralleled to all considered treatments. This enhancement of basil growth may be owing to the effective role of MW and SA on alleviating salt stress as well as the appropriate irrigation. Applicable water in the rhizosphere simplifies nutrients absorption necessary for plant growth. Hence, it is very likely that drought conditions and water deficiency adversely affect plant growth by affecting on plant metabolism including cell wall and cell expansion. Similar enhancing effect in relation to these interactions was reported by Hashemabadi *et al*., 2015 on Periwinkle; Aly *et al*., 2015 on valencia orange and Ahmed & Abd El-Kader, 2016 on potato plants.

**Table 5. Mean comparisons for interaction effects of irrigation water type, irrigation intervals and salicylic acid foliar spraying on growth responses of *Ocimum basilicum* L. in the two cuts during the two growing seasons (2018 and 2019).**

| Treatments | | | Plant height (cm) | | No. of branches/plant | | Leaf area (dm²/plant) | | Stomatal density(No./mm²) | | Plant fresh wt. (g) | | Plant dry wt. (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water type | Irrigation interval | Salicylic acid | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut |
| **1st season** | | | | | | | | | | | | | | |
| Nonmagnetic water(non-MW) | $I_1$ (every 2 days) | 0 | 58.77 s | 58.60 p | 6.03 h | 5.83 j | 21.70 r | 21.43 u | 152.58 h | 149.89 l | 178.08 p | 173.03s | 39.27tu | 38.30w |
| | | 50 ppm | 61.70 p | 59.83m | 6.70 g | 6.07 jk | 25.37 n | 25.23 p | 158.34 f | 154.67 j | 187.20m | 180.1p | 42.62p | 42.51q |
| | | 100 ppm | 63.57 0 | 61.63 l | 7.07 fg | 6.07 jk | 27.93 m | 27.93 o | 158.39 f | 155.09 ij | 191.17 l | 183.53o | 44.05o | 42.94p |
| | | 150 ppm | 64.67 n | 61.87 kl | 7.53 ef | 6.60 hi | 29.87 l | 29.80 n | 158.45 f | 155.17 ij | 199.40k | 190.70n | 44.41o | 43.87o |
| | $I_2$ (every 4 days) | 0 | 59.83 r | 58.90 0 | 6.07 h | 5.93 k | 22.60 p | 22.60 s | 152.59 h | 150.03 l | 180.25no | 174.17rs | 39.67st | 39.45u |
| | | 50 ppm | 66.80m | 62.07 k | 7.43 f | 6.90 h | 31.13 k | 31.07 m | 158.88 f | 156.66 hi | 207.13 j | 200.28m | 46.29n | 44.91n |
| | | 100 ppm | 68.43 l | 65.17 j | 8.03 de | 7.60 g | 32.13 j | 32.07 l | 160.14 f | 157.65 h | 211.40 i | 205.08l | 47.23m | 46.61m |
| | | 150 ppm | 69.90 k | 69.17 i | 8.23 d | 7.97 g | 34.80 i | 34.77 k | 162.65 e | 159.31 g | 218.85 h | 212.75k | 48.08l | 48.03l |
| | $I_3$ (every 6 days) | 0 | 58.87 r | 58.60 p | 6.03 h | 5.83 k | 22.17 q | 21.63 t | 152.56 h | 150.00 l | 178.45op | 174.09rs | 39.26u | 38.78v |
| | | 50 ppm | 59.87 s | 59.03 0 | 6.03 h | 5.93 k | 22.83 p | 22.83 r | 152.64 h | 151.79 k | 181.90 n | 175.13r | 39.76s | 39.66t |
| | | 100 ppm | 60.90 q | 59.13 0 | 6.17 h | 6.03 jk | 24.87 o | 24.50g | 154.94 g | 151.78 k | 186.65 m | 178.06q | 41.30r | 40.99s |
| | | 150 ppm | 61.7 p | 59.50 n | 6.83 g | 6.33 ij | 25.30 n | 25.10 p | 158.33 f | 154.44 j | 187.20m | 180.06p | 41.87q | 41.56r |
| Magnetic water(MW) | $I_1$ (every 2 days) | 0 | 77.43 i | 80.30 h | 12.17 c | 12.20 f | 39.90 h | 41.10 j | 173.96 bc | 174.78 e | 288.57 f | 298.73i | 63.85j | 65.29j |
| | | 50 ppm | 84.13 f | 88.77 d | 13.13 b | 13.33 de | 43.60 de | 48.07 f | 175.16 b | 175.18 e | 298.28 d | 306.97f | 66.54g | 68.35f |
| | | 100 ppm | 85.13 e | 89.30 c | 13.13 b | 13.57 cd | 43.63 de | 48.27 e | 175.17 b | 175.34 e | 299.09 d | 307.14f | 67.73f | 68.89e |
| | | 150 ppm | 85.83 d | 89.37 c | 13.17 b | 13.87 bc | 43.73 d | 49.63 d | 175.34 b | 177.08 d | 299.15 d | 312.16e | 68.31e | 69.59d |
| | $I_2$ (every 4 days) | 0 | 85.83 d | 89.70 b | 13.17 b | 13.87 bc | 43.43 e | 49.90 c | 180.11 a | 181.62 c | 302.37 c | 318.48d | 69.20d | 71.20c |
| | | 50 ppm | 91.03 c | 97.50 a | 13.87 a | 14.07 ab | 47.77 c | 50.00c | 182.00 a | 188.02 ab | 313.05p | 328.70c | 69.82c | 73.97b |
| | | 100 ppm | 91.63 b | 97.57 a | 13.87 a | 14.17 ab | 48.43 b | 51.63 b | 182.03 a | 187.73 b | 316.50 a | 330.80b | 70.27b | 74.14b |
| | | 150 ppm | 91.90 a | 97.63 a | 13.90 a | 14.37 a | 49.90 a | 54.43 a | 182.08 a | 189.51 a | 318.00 a | 334.85a | 70.68a | 74.59a |
| | $I_3$ (every 6 days) | 0 | 75.40 j | 80.13 h | 12.27 c | 12.30 f | 40.13 h | 41.20 j | 171.78 d | 172.17 c | 283.04 g | 296.28j | 63.04k | 64.50k |
| | | 50 ppm | 83.47 h | 85.93 g | 13.03 b | 13.03 e | 42.10 g | 43.80 i | 172.50 cd | 174.17 e | 290.08ef | 300.03h | 63.71j | 65.58i |
| | | 100 ppm | 83.90 g | 87.67 f | 13.02 b | 13.07 e | 42.90 f | 45.03 h | 172.58 cd | 174.31 e | 290.27 ef | 300.04h | 65.22i | 66.92h |
| | | 150 ppm | 84.03 fg | 88.23 e | 13.10b | 13.17 e | 43.57de | 45.53 g | 172.63 cd | 174.43 e | 291.14 e | 302,84g | 65.86h | 67.97g |
| L.S.D at 5% level | | | 0.045 | 0.299 | 0.517 | 0.395 | 0.265 | 0.187 | 0.124 | 1.658 | 1.986 | 1.292 | 0.401 | 0.199 |
| **2nd season** | | | | | | | | | | | | | | |
| Nonmagnetic (non-MW) | $I_1$ (every 2 days) | 0 | 62.70 r | 59.23p | 5.27j | 5.07j | 22.10v | 21.37u | 153.81l | 151.89l | 178.90tu | 174.49w | 39.37l | 38.78m |
| | | 50 ppm | 64.03 o | 62.90m | 6.27gh | 6.17hi | 25.90p | 25.57o | 158.58j | 156.67j | 194.15p | 193.64q | 42.72k | 42.70ijk |
| | | 100 ppm | 65.47n | 65.30l | 6.57fg | 6.20hi | 28.07o | 27.97n | 159.01ij | 157.09ij | 200.67o | 195.60p | 44.16j | 43.98ij |
| | | 150 ppm | 67.97 m | 67.80k | 6.70f | 6.20hi | 29.90n | 29.83m | 159.08ij | 157.17ij | 202.34o | 199.83o | 44.52j | 44.39ij |
| | $I_2$ (every 4 days) | 0 | 62.93s | 59.80o | 5.87hi | 5.90i | 22.90t | 22.57s | 153.94l | 152.03l | 180.70st | 179.73u | 39.76l | 39.48lm |
| | | 50 ppm | 68.07m | 68.03j | 6.73f | 6.43h | 32.00m | 31.57l | 160.58hi | 158.66hi | 210.88n | 204.59n | 46.40i | 45.00hi |
| | | 100 ppm | 69.43l | 69.27i | 6.97f | 6.90g | 32.50l | 32.03k | 161.57h | 159.65h | 215.15m | 212.33m | 47.34hi | 47.25gh |
| | | 150 ppm | 69.93k | 69.73h | 7.87e | 7.07g | 34.90k | 34.23j | 163.23g | 161.31g | 219.02l | 218.80l | 48.20h | 48.11g |
| | $I_3$ (every 6 days | 0 | 62.70s | 59.27p | 5.77i | 5.23j | 22.30u | 21.63t | 153.92l | 152.00l | 178.83u | 176.67v | 39.35l | 38.94lm |
| | | 50 ppm | 63.10q | 59.93o | 5.97hi | 5.93i | 23.60s | 22.83r | 155.71k | 153.79k | 181.11s | 180.67t | 39.85l | 39.72lm |
| | | 100 ppm | 63.10q | 62.07n | 5.97hi | 6.07hi | 25.10r | 24.87q | 155.70k | 153.78k | 188.11r | 186.75s | 41.40k | 40.99kl |
| | | 150 ppm | 63.83p | 62.07n | 6.23gh | 6.13hi | 25.63q | 25.17p | 158.36j | 156.44j | 190.73 q | 189.33r | 41.97k | 41.59jk |
| Magnetic water (MW) | $I_1$ (every 2 days) | 0 | 80.77i | 84.70g | 12.07d | 12.13f | 39.93j | 42.63i | 178.69e | 180.61e | 289.66j | 297.44j | 63.74g | 65.31f |
| | | 50 ppm | 86.30e | 89.03c | 13.17bc | 13.33de | 43.60f | 44.03f | 179.10e | 181.02e | 303.12g | 311.37f | 66.70ef | 68.37de |
| | | 100 ppm | 86.53 d | 89.50b | 13.33c | 13.50d | 43.73f | 44.07f | 179.26e | 181.18e | 308.33f | 313.83e | 67.89de | 69.72cd |
| | | 150 ppm | 86.87c | 89.53b | 13.53b | 13.90c | 44.90e | 45.03e | 181.00d | 182.92d | 311.17e | 317.00d | 68.47cd | 70.04cd |
| | $I_2$ (every 4 days | 0 | 86.90c | 89.57b | 13.53b | 13.90c | 45.10d | 45.27d | 185.53c | 187.45c | 315.26d | 324.35c | 69.37bc | 71.92bc |
| | | 50 ppm | 92.00b | 97.53a | 14.83a | 14.83b | 47.80c | 51.30c | 191.93ab | 193.85ab | 318.04c | 336.95b | 69.99ab | 74.00ab |
| | | 100 ppm | 92.07b | 97.57a | 15.17a | 15.17ab | 48.90b | 51.50b | 191.64b | 193.56b | 320.12b | 337.76b | 70.45ab | 74.66ab |
| | | 150 ppm | 92.33a | 97.57a | 15.23a | 15.27a | 49.93a | 54.97a | 193.43a | 195.34a | 322.00a | 339.79a | 70.86a | 75.00a |
| | $I_3$ (every 6 days | 0 | 80.13j | 84.67g | 12.30d | 12.40f | 41.30i | 42.70i | 176.08f | 178.00f | 287.18k | 393.83k | 63.19g | 65.31f |
| | | 50 ppm | 84.97h | 87.63f | 13.03c | 13.10e | 42.50h | 43.03h | 178.08e | 180.00e | 290.21j | 298.75i | 63.86g | 65.59ef |
| | | 100 ppm | 85.57g | 88.43e | 13.07c | 13.27de | 43.20g | 43.40g | 178.23e | 180.14e | 297.10i | 304.86h | 65.38f | 68.37de |
| | | 150 ppm | 85.90f | 88.87d | 13.10c | 13.33de | 43.60f | 43.90f | 178.34e | 180.26e | 300.02h | 309.61g | 66.02f | 68.37de |
| L.S.D. at 5% level | | | 0.124 | 0.136 | 0.406 | 0.369 | 0.155 | 0.181 | 1.659 | 1.659 | 1.828 | 0.902 | 1.438 | 2.80 |

**Means designed by the same letter at each cell are not significantly different at the 5% level**

**Yield characters and essential oil production**

**Effect of irrigation water type**

Results presented in Table (6) indicated that MW caused a highly significant increment in yield characters; the fresh and dry yield per feddan in addition to the essential oil percentage besides oil yield per feddan likened with non MW during all cuts for both growing seasons. It is worthy that MW increases over the plants irrigated with non-MW in the fresh yield per fed. by about 55.5, 68.0 % in the 1st growing season and 56.4, 63.7% in 2nd season for the two cuts, respectively. Meanwhile the percentage increase in the dry yield per fed. were 57.1, 64.5% for the two yields in the1st growing season, 57.1 and 62.3% in that order in the 2nd growing seasons. Concerning on the increases in the oil %, it reached 67.3, 79.7% in the 1st season and 62.7, 81.3% in the 2nd one. The oil yield upsurges were 102, 136% in the

1st growing season while 118, 149 % in the 2nd one. The obvious increase in yield characters due to MW is a reflection of enhancement the vegetative growth**.** These results are harmony with those obtained by Hachicha *et al*., 2016 on corn and El-Kholy *et al*., 2020 on rosemary, they concluded that the irrigation with MW increased yield and the oil percentage.

**Effect of irrigation intervals**

As shown in Table (6), Irrigation every 4 days ($I_2$) produced the extreme value of fresh and dry yield per feddan, followed by irrigation every 2 days ($I_1$), then the irrigation every 6 days ($I_3$). Concerning the effect of irrigation intervals on the oil% and oil yield per fedden, $I_2$ gave the uppermost values followed by $I_1$or $I_3$ with non - significant differences in between during the two growing seasons for all cuts. Generally irrigation interval is one of the major yield constraints of basil plants, the best yield characters were obtained under the appropriate irrigation interval $I_2$ (every 4 days). Significant reduction in yield of basil under $I_3$ in relation to $I_2$ interval well demonstrated the susceptibility of basil to soil water deficiency. The increment of the essential oil yield, as a result of the formation and accumulation of essential oil, depended directly upon oil % and / or herb weight.

**Table 6. Effect of irrigation water type, irrigation intervals and salicylic acid foliar spraying and their interactions on yield of fresh herb (ton /fed), dry herb (ton /fed), Essential oil percentage (%) and oil yield (L/fed) of *Ocimum basilicum* L. in the two cuts during the two growing seasons (2018 and 2019).**

| Treatments | Yield of fresh herb (ton /fed) | | Yield of dry herb (ton/fed) | | Essential oil percentage (%) | | Oil yield(L/fed) | |
|---|---|---|---|---|---|---|---|---|
| | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut |
| **1st season (2018)** | | | | | | | | |
| Irrigation water type (A) | | | | | | | | |
| Nonmagnetic | 3.46b | 3.34b | 0.77b | 0.76b | 0.150b | 0.148b | 5.922b | 5.910b |
| Magnetic | 5.38a | 5.61a | 1.21a | 1.25a | 0.251a | 0.266a | 13.017a | 14.00a |
| F. test | ** | ** | ** | ** | * | ** | * | ** |
| L.S.D at 0.05 | 0.010 | 0.020 | 0.001 | 0.003 | 0.067 | 0.011 | 3.134 | 0.943 |
| Irrigation intervals (B) | | | | | | | | |
| $I_1$ (every 2 days) | 4.37b | 4.39b | 0.98b | 0.99b | 0.191b | 0.194b | 8.814b | 9.127b |
| $I_2$ (every 4 days) | 4.65a | 4.74a | 1.04a | 1.06a | 0.225a | 0.240a | 11.076a | 12.281a |
| $I_3$ (every 6 days) | 4.25c | 4.29c | 0.95c | 0.96c | 0.185b | 0.186b | 8.314b | 8.531b |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.012 | 0.013 | 0.004 | 0.001 | 0.018 | 0.017 | 0.970 | 0.750 |
| Salicylic acid (C) | | | | | | | | |
| 0 | 4.23d | 4.30d | 0.94d | 0.95d | 0.179b | 0.182b | 8.080b | 8.444b |
| 50 ppm | 4.43c | 4.47c | 0.99c | 1.00c | 0.203a | 0.212a | 9.535a | 10.23a |
| 100 ppm | 4.49b | 4.51b | 1.01b | 1.02b | 0.207a | 0.215a | 9.807a | 10.451a |
| 150 ppm | 4.54a | 4.60a | 1.02a | 1.04a | 0.213a | 0.218a | 10.184a | 10.793a |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.015 | 0.009 | 0.003 | 0.001 | 0.016 | 0.028 | 0.785 | 0.828 |
| Interactions | | | | | | | | |
| A X B | * | ** | NS | * | NS | * | * | ** |
| A X C | * | ** | ** | ** | NS | NS | NS | NS |
| B X C | ** | ** | ** | ** | NS | NS | NS | NS |
| A X B X C | ** | ** | ** | ** | * | * | * | * |
| 2nd season (2019) | | | | | | | | |
| Irrigation water type (A) | | | | | | | | |
| Nonmagnetic | 3.51b | 3.47b | 0.77b | 0.77b | 0.158b | 0.150b | 5.965b | 5.960b |
| Magnetic | 5.49a | 5.68a | 1.21a | 1.25a | 0.257a | 0.272a | 13.020a | 14.883a |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.005 | 0.012 | 0.001 | 0.039 | 0.007 | 0.003 | 0.518 | 0.881 |
| Irrigation intervals (B) | | | | | | | | |
| $I_1$ (every 2 days) | 4.47b | 4.51b | 0.98b | 1.00b | 0.199b | 0.201b | 9.319b | 9.672b |
| $I_2$ (every 4 days) | 4.73a | 4.85a | 1.04a | 1.07a | 0.230a | 0.240a | 11.531a | 12.563a |
| $I_3$ (every 6 days) | 4.30c | 4.37c | 0.95c | 0.96c | 0.193b | 0.191b | 8.738c | 8.931c |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.017 | 0.005 | 0.004 | 0.020 | 0.008 | 0,011 | 0.401 | 0.479 |
| Salicylic acid (C) | | | | | | | | |
| 0 | 4.29d | 4.34d | 0.94d | 0.96c | 0.183c | 0.182b | 8.421c | 8.575c |
| 50 ppm | 4.49c | 4.58c | 0.99c | 1.01b | 0.210b | 0.215a | 9.954b | 10.620b |
| 100 ppm | 4.59b | 4.65b | 1.01b | 1.03a | 0.213ab | 0.218a | 10.301ab | 10.886ab |
| 150 ppm | 4.64a | 4.72a | 1.02a | 1.04a | 0.222a | 0.228a | 10.774a | 11.473a |
| F. test | ** | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.013 | 0.007 | 0.003 | 0.021 | 0.01 | 0.014 | 0.516 | 0.714 |
| Interactions | | | | | | | | |
| A X B | * | ** | * | ** | ** | * | ** | ** |
| A X C | ** | ** | ** | NS | NS | NS | NS | NS |
| B X C | ** | ** | ** | NS | NS | NS | NS | * |
| A X B X C | ** | ** | ** | NS | * | * | * | * |

The mentioned results are in agreement with those of Ekren *et al*., 2012 reported that purple basil was very sensitive to water stress, thus the yield of dry matter was significantly decreased, Amirjani (2013) who use four different water regimes mentioned that increasing of drought level led to reduction in the growth and yield of *Catharanthus roseus*, Abedi *et al*., 2014 on basil indicated that total yield was enhanced at 1 week interval compared to 2 weeks irrigation interval. Similarly, Mohamed *et al*., 2014 concluded that the highly irrigation interval inhibited Curcuma growth and yield, its proper irrigation interval was every 7 days which enhanced the growth, the volatile oil thus increase the yield. Kalamartzis *et al*., 2020 found that water stress affected the fresh, dry matter and the essential oil depending on the proper cultivar.

**Effect of salicylic acid**

Table (6) exhibited that SA application significantly enriched basil biomass per fedden, oil % and oil yield in relation to unsprayed treatments during the two studied seasons. Application of 150ppm SA resulted in the highest fresh and dry yields compared with other levels of SA application. On the other hand, all levels of SA treatments significantly increased the oil % and oil yield with non-significant differences in between. Foliar spray of basil with SA gradually increased oil percentage compared with their corresponding controls especially with the 2$^{nd}$ cut contained increases approximately 19.8 and 20.9% in the two growing seasons, respectively. The highest mean values of fresh and dry yield per fed., essential oil percentage and oil yield per fed. of the two cuts when combined together increased significantly with about 7.1, 9.0 % in the 1st growing season and 8.5,8.4% in the 2$^{nd}$ one, 19.4 and 20% in the two growing seasons, respectively as well as 26.9 and 30.9% in the two studied seasons, in that a aforementioned order proportionate to control by application of SA at 150 ppm. The oil yield additions might be owing to the vegetative growth stimulation or the variations in oil glands of the leaf and biosynthesis of monoterpins. In conformity, Gharib (2006) found that using of SA encouraged oil yield by enhancing photosynthesis, nutrient uptake and enhanced the total free amino acid. Ghilavizadeh *et al*., 2019 showed that SA at 9 mM level stimulate the biological yield of fennel and gave the maximum yield under water stress at budding stage and 50% flowering.

**Effect of the interactions**

The results in Table (6) emphasized the significant effect of interaction between water types X irrigation intervals on the fresh and dry yield, oil% and consequently oil yield except for some slight apparent exceptions. Both treatments of the interactions between water types X SA and the interaction between irrigation intervals X anti salinity SA revealed the same significant increases on the fresh and dry yield per fed for the two growing seasons in all cuttings except the dry yield in the 2$^{nd}$ cut in the 2$^{nd}$ season whereas, they recorded a non-significant influence on the oil% and oil yield for the two studied seasons.

As regard the response of yield characters to the interaction among all studied factors, it is apparent from Table (7) that the plants irrigated with MW and sprayed with SA under all irrigation intervals caused a significantly increments on the fresh and dry yield per fed., oil % and oil yield comparable with the corresponding controls irrigated with non MW. Spraying of SA improve all mentioned characters of plants irrigated with non MW causing significant increases especially in the 2$^{nd}$ cut for both seasons equated with unsprayed controls. The maximum yield was obtained from the interaction treatment of non-MW+150ppm SA+$I_2$ that gave increases as compared with unsprayed control approximately 21.4 and 21.8% fresh and dry yield, respectively in the 1$^{st}$ season, 21.4 and 21.6%in the 2$^{nd}$ one, meanwhile 28.6, 40.7% oil percentages in the two seasons and 56.7, 70.9% oil yield during the two succeeding seasons. Results in this study showed that oil yield was higher in the 2$^{nd}$ season than the 1$^{st}$ one because of more vigorous root systems (Bowes and Zheljazkov, 2004) were established in addition to the beneficial effects of MW on soil and the plants (Hachicha *et al*., 2016).

The interactions of MW and all levels of SA under all irrigation intervals gave an increase in yield characters and this increase was significantly paralleled to owing controls of non MW. Generally, The interaction of (MW+150ppm SA+$I_{2)}$ caused the uppermost yield with significant increments, the increases in fresh yield, dry yield, oil% and oil yield were 51.2, 50.9, 77.8 and 169.5%, correspondingly in the 1$^{st}$ season and 51.3, 51.1, 71.1 and 158.9% in that order in the 2$^{nd}$ one as compared with the corresponding control of non MW. These effects in relation to these interactions were harmony with Aly *et al*., 2015 on valencia orange, Abbaszadeh *et al*., 2020 on rosemary who stated that 1mM SA upturn the oil yield and tolerance.

**Essential oil constituents**

The results of GLC analysis of the oil extracted from basil plants in the 2$^{nd}$ cut in the 2$^{nd}$ season presented in Table (8) showed a total of 7 components; Limonene, 1,8-Cineol, Linalool, 4- Terpinole, Borneol, Geranyl acetate and Eugenol. With respect to the influence of different levels of SA on plants irrigated by two types of water (MW and non-MW) under irrigation intervals, the focal components in basil oil were higher proportions of Linalool and intermediates of 1,8-Cineol. Plants irrigated with MW at 100ppm SA under $I_2$ recorded the supreme value of linalool percentage (56.89%), while the lowest linalool percentage (42.92%) was obtained from plants irrigated with non MW at 100ppm SA under $I_3$. The extreme percentage of 1,8-Cineol (21.75%) was acquired from plants irrigated with MW at 150ppm SA under $I_2$, while the treatment of (non – MW at100 ppm SA under $I_3$) recorded the minimum percentage (7.82%). Additionally, the components of basil oil comprises Limonene varied from 0.20 to 2.13% with the treatment (MW at 50ppm SA under $I_1$), 4- Terpinole ranged from 0.22- 6.37% with the treatment (MW at 50ppm SA under $I_3$), Geranyl acetate extended from 1.13 to 7.06% resulting from the treatment of (MW at 100ppm SA under $I_2$), Borneol varied from 0.29 to 1.50 % with the treatment (MW at 150ppm SA under $I_3$) and eugenol increased from 0.26 to 1.98% at maximal yield with (MW at 100ppm SA under $I_1$).

Results in the same table (8) revealed that there was a prominent difference in basil oil content due to MW treatments which improved the quality of basil oil by increasing the main components linalool and 1,8 - Cineol % compared to non MW treatments. In this concern, Gharib (2006) revealed that the major components of basil oil was linalool ranged from 46.63 to 43.32% and SA increase the production of eugenol thus basil is a good source of antioxidants in the diet.

**Table 7. Mean comparisons for interaction effects of irrigation water type, irrigation intervals and salicylic acid foliar spraying on yield of fresh herb (ton /fed), dry herb (ton /fed), Essential oil percentage (%) and oil yield (L/fed) of *Ocimum basilicum* L. in the two cuts during the two growing seasons (2018 and 2019).**

| Treatments | | | Yield of fresh herb (ton /fed) | | Yield of dry herb (ton/fed) | | Essential oil percentage (%) | | Oil yield (L/fed) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Water type | Irrigation interval | Salicylic acid | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut |
| | | | **1st season** | | | | | | | |
| Nonmagnetic water (non-MW) | I1 (every 2 days) | 0 | 3.21p | 3.11s | 0.71tu | 0.69w | 0.12j | 0.12f | 3.847h | 3.737g |
| | | 50 ppm | 3.37m | 3.24p | 0.77p | 0.77q | 0.15hi | 0.14ef | 5.057fg | 4.537fg |
| | | 100 ppm | 3.44l | 3.30o | 0.79o | 0.77q | 0.15hi | 0.15ef | 5.160fg | 4.960ef |
| | | 150 ppm | 3.59a | 3.43n | 0.80o | 0.78o | 0.16gh | 0.15ef | 5.743ef | 5.147ef |
| | I2 (every 4 days) | 0 | 3.24no | 3.16rs | 0.71 st | 0.71u | 0.14i | 0.14ef | 4.540gh | 4.380fg |
| | | 50 ppm | 3.73j | 3.60m | 0.83n | 0.81n | 0.17g | 0.17de | 6.337ef | 6.130ef |
| | | 100 ppm | 3.81i | 3.69l | 0.85m | 0.84m | 0.17g | 0.17de | 6.470ef | 6.273ef |
| | | 150 ppm | 3.94h | 3.83k | 0.87l | 0.86l | 0.18f | 0.18cd | 7.087e | 6.893e |
| | I3 (every 6 days) | 0 | 3.21op | 3.13rs | 0.71u | 0.70v | 0.13ij | 0.13ef | 4.177h | 4.077g |
| | | 50 ppm | 3.27n | 3.15r | 0.72s | 0.71t | 0.14i | o.14ef | 4.587fg | 4.413fg |
| | | 100 ppm | 3.36m | 3.21q | 0.74r | 0.74s | 0.14i | 0.14ef | 4.700fg | 4.490fg |
| | | 150 ppm | 3.37m | 3.24p | 0.75q | 0.75r | 0.15hi | 0.14ef | 5.050fg | 4.537fg |
| Magnetic Water ( MW) | I1 (every 2 days) | 0 | 5.19f | 5.38i | 1.14j | 1.18j | 0.21ef | 0.22bc | 10.907d | 11.837cd |
| | | 50 ppm | 5.37d | 5.53f | 1.20g | 1.23f | 0.24cd | 0.25b | 12.883bc | 13.817bc |
| | | 100 ppm | 5.38d | 5.53f | 1.22f | 1.24e | 0.25cd | 0.26b | 13.457bc | 14.373b |
| | | 150 ppm | 5.38d | 5.62e | 1.23e | 1.25d | 0.25cd | 0.26b | 13.463bc | 14.607b |
| | I2 (every 4 days) | 0 | 5.44c | 5.73d | 1.25d | 1.28c | 0.26bc | 0.26b | 14.140b | 14.903b |
| | | 50 ppm | 5.63b | 5.92c | 1.25d | 1.33b | 0.29ab | 0.33a | 16.330a | 19.523a |
| | | 100 ppm | 5.70a | 5.95b | 1.26b | 1.33b | 0.29ab | 0.33a | 16.523a | 19.650a |
| | | 150 ppm | 5.72a | 6.03a | 1.27a | 1.34a | 0.30a | 0.34a | 17.183a | 20.493a |
| | I3 (every 6 days) | 0 | 5.09g | 5.33j | 1.13k | 1.16k | 0.21ef | 0.22bc | 10.870d | 11.730d |
| | | 50 ppm | 5.22ef | 5.40h | 1.15j | 1.18i | 0.23cd | 0.24b | 12.017cd | 12.960bc |
| | | 100 ppm | 5.22ef | 5.40h | 1.17i | 1.20h | 0.24cd | 0.24b | 12.537bc | 12.960bc |
| | | 150 ppm | 5.24e | 5.45g | 1.19h | 1.22g | 0.24cd | 0.24b | 12.580bc | 13.083bc |
| L.S.D at 5% level | | | 0.036 | 0.023 | 0.007 | 0.004 | 0039 | 0.048 | 1.924 | 2.028 |
| | | | **2nd season** | | | | | | | |
| Nonmagnetic water (non-MW) | I1 (every 2 days) | 0 | 3.22tu | 3.14t | 0.71tu | 0.70m | 0.13g | 0.22g | 4.187k | 3.770j |
| | | 50 ppm | 3.49p | 3.49o | 0.77p | 0.77ijk | 0.16ef | 0.14ef | 5.593gh | 4.880gh |
| | | 100 ppm | 3.61o | 3.52n | 0.79o | 0.79ij | 0.17de | 0.16de | 6.140gh | 5.633gh |
| | | 150 ppm | 3.64o | 3.60m | 0.80o | 0.80ij | 0.17de | 0.17de | 6.193gh | 6.113fg |
| | I2 (every 4 days) | 0 | 3.25st | 3.24r | 0.72st | 0.71lm | 0.14fg | 0.13fg | 4.553jk | 4.207ij |
| | | 50 ppm | 3.80n | 3.68l | 0.84n | 0.81hi | 0.17de | 0.17de | 6.443fg | 6.260fg |
| | | 100 ppm | 3.87m | 3.82k | 0.85m | 0.85gh | 0.17de | 0.17de | 6.583fg | 6.503fg |
| | | 150 ppm | 3.94l | 3.94j | 0.87l | 0.87g | 0.19d | 0.19d | 7.490f | 7.483f |
| | I3 (every 6 days | 0 | 3.22u | 3.18s | 0.71u | 0.70lm | 0.13g | 0.12g | 4.187k | 3.817j |
| | | 50 ppm | 3.26s | 3.25r | 0.72s | 0.71lm | 0.15ef | 0.14ef | 4.887ij | 4.553hi |
| | | 100 ppm | 3.39r | 3.36q | 0.75r | 0.74klm | 0.15ef | 0.14ef | 5.080hi | 4.707hi |
| | | 150 ppm | 3.43q | 3.41p | 0.76q | 0.75jkl | 0.16f | 0.15fg | 5.493gh | 5.110gh |
| Magnetic water (MW) | I1 (every 2 days) | 0 | 5.21j | 5.35h | 1.15j | 1.18f | 0.22c | 0.23c | 11.470e | 12.313de |
| | | 50 ppm | 5.46g | 5.60f | 1.20g | 1.23de | 0.24bc | 0.26bc | 13.090cd | 14.570bc |
| | | 100 ppm | 5.55f | 5.65e | 1.22f | 1.25cd | 0.25b | 0.26bc | 13.880bc | 14.690bc |
| | | 150 ppm | 5.60e | 5.71d | 1.23e | 1.26cd | 0.25b | 0.27b | 14.003bc | 15.407b |
| | I2 (every 4 days | 0 | 5.67d | 5.84c | 1.25d | 1.29bc | 0.26b | 0.26bc | 14.753b | 15.180bc |
| | | 50 ppm | 5.72c | 6.07b | 1.26c | 1.33ab | 0.30a | 0.33a | 17.173a | 20.013a |
| | | 100 ppm | 5.76b | 6.08b | 1.27b | 1.34ab | 0.30a | 0.33a | 17.287a | 20.063a |
| | | 150 ppm | 5.80a | 6.12a | 1.28a | 1.35a | 0.31a | 0.34a | 17.963a | 20.797a |
| | I3 (every 6 days | 0 | 5.17k | 5.29i | 1.14k | 1.18f | 0.22c | 0.23c | 11.377e | 12.163e |
| | | 50 ppm | 5.22j | 5.38h | 1.15j | 1.18f | 0.24bc | 0.25bc | 12.540de | 13.443cd |
| | | 100 ppm | 5.35i | 5.49g | 1.18i | 1.23de | 0.24bc | 0.25bc | 12.837cd | 13.720bc |
| | | 150 ppm | 5.40h | 5.57f | 1.19h | 1.23de | 0.25b | 0.25bc | 13.500bc | 13.933bc |
| L.S.D. at 5% level | | | 0.033 | 0.033 | 0.007 | 0.050 | 0.024 | 0.035 | 1.265 | 1.751 |

**Table 8. Effect of the interaction between irrigation water type, irrigation intervals and salicylic acid foliar spraying on the essential oil components of *Ocimum basilicum* L. during the second season 2019.**

| Treatments | | | Oil Components (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Water type | Irrigation interval | Salicylic acid | Limonene | 1,8-cineol | Linalool | 4- Terpinole | Borneol | Geranyl acetate | Eugenol |
| Nonmagnetic water (non-MW) | I1 (every 2 days) | 100 ppm | 0.87 | 15.20 | 45.90 | 1.96 | 1.40 | 2.69 | 1.77 |
| | | 150 ppm | 0.31 | 19.00 | 48.00 | 0.79 | 1.90 | 5.00 | 1.77 |
| | I2 (every 4 days) | 100 ppm | 0.83 | 17.35 | 43.85 | 0.22 | 0.36 | 3.72 | 0.89 |
| | | 150 ppm | - | 16.70 | 46.11 | 0.22 | 1.00 | 3.84 | 0.26 |
| | I3 (every 6 days) | 100 ppm | 0.60 | 7.82 | 42.92 | 1.00 | 0.29 | 4.69 | 0.31 |
| | | 150 ppm | 0.20 | 9.69 | 45.02 | 0.69 | 0.51 | 1.13 | 0.75 |
| Magnetic water (MW) | I1 (every 2 days) | 50 ppm | 2.13 | 19.81 | 47.12 | 5.14 | 1.39 | 3.80 | 0.92 |
| | | 100 ppm | 1.40 | 17.60 | 51.00 | 2.22 | - | 6.02 | 1.98 |
| | | 150 ppm | 0.92 | 19.54 | 49.17 | 3.81 | 0.91 | 5.74 | 1.90 |
| | I2 (every 4 days) | 50 ppm | 0.72 | 20.72 | 55.28 | 1.03 | 0.98 | 3.84 | 1.70 |
| | | 100 ppm | 1.84 | 19.93 | 56.89 | 0.90 | 0.87 | 7.06 | 1.36 |
| | | 150 ppm | 0.85 | 21.75 | 54.97 | 1.03 | 1.42 | 5.22 | 1.92 |
| | I3 (every 6 days) | 50 ppm | 0.68 | 13.15 | 48.11 | 6.37 | 1.44 | 2.71 | 1.93 |
| | | 100 ppm | 0.72 | 9.07 | 53.15 | 4.09 | 0.99 | 5.00 | 0.87 |
| | | 150 ppm | 0.87 | 10.18 | 53.02 | 5.12 | 1.50 | 4.32 | 1.93 |

## Applied Irrigation water (IW)

Data in the Table (9) and Fig (1) illustrated that the type of water and SA treatments have not any effect on seasonal IW. The highest seasonal values for IW were recorded under $I_1$ (irrigation every two days' treatment) are 4340.70 $m^3$ $fed^{-1}$ (103.35 cm) and 4406.22 $m^3$ $fed^{-1}$ (104.91 cm) in the two growing seasons, respectively. Meanwhile, the lowest seasonal values were under $I_3$ (irrigation every six days' treatment) are 1417.08 $m^3$ $fed^{-1}$ (33.74 cm) and 1480.08 $m^3$ $fed^{-1}$ (35.24 cm) in the two growing seasons, respectively. The same table showed that, the total IW increased by decreasing irrigation interval (Number of days between the applied irrigation water) in the two growing seasons. Generally, the seasonal values of IW can be descended in order $I_1 > I_2 > I_3$. Increasing the seasonal values of IW under treatment $I_1$ in comparison with other irrigation interval treatments $I_2$ and $I_3$ might be attributed to decreasing period between irrigations and hence increasing the amount of IW. The obtained results are in agreement with those obtained by (Ekren *et al*., 2012; Mahmoud *et al*., 2017 and Pejić *et al*., 2017).

**Table 9. Irrigation water quantities added in $m^3$/fed. during the plant's growth period.**

| **Treatments** | | **Applied Irrigation Water ($m^3$ $fed^{-1}$)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1st Season 2018** | | | | | **2nd Season 2019** | | | | |
| | | **Salicylic acid (ppm)** | | | | | **Salicylic acid (ppm)** | | | | |
| **Water type** | **Irrigation interval** | **0** | **50** | **100** | **150** | **Mean** | **0** | **50** | **100** | **150** | **Mean** |
| Nonmagnetic water(non-MW) | $I_1$ | 4340.7 | 4340.7 | 4340.7 | 4340.7 | 4340.7 | 4406.2 | 4406.2 | 4406.2 | 4406.2 | 4406.2 |
| | $I_2$ | 2205.0 | 2205.0 | 2205.0 | 2205.0 | 2205.0 | 2272.2 | 2272.2 | 2272.2 | 2272.2 | 2272.2 |
| | $I_3$ | 1417.1 | 1417.1 | 1417.1 | 1417.1 | 1417.1 | 1480.1 | 1480.1 | 1480.1 | 1480.1 | 1480.1 |
| Magnetic water(MW) | $I_1$ | 4340.7 | 4340.7 | 4340.7 | 4340.7 | 4340.7 | 4406.2 | 4406.2 | 4406.2 | 4406.2 | 4406.2 |
| | $I_2$ | 2205.0 | 2205.0 | 2205.0 | 2205.0 | 2205.0 | 2272.2 | 2272.2 | 2272.2 | 2272.2 | 2272.2 |
| | $I_3$ | 1417.1 | 1417.1 | 1417.1 | 1417.1 | 1417.1 | 1480.1 | 1480.1 | 1480.1 | 1480.1 | 1480.1 |

| Treatments | Applied Irrigation Water ($m^3$ $fed^{-1}$ and cm) | | | |
|---|---|---|---|---|
| | 1st Season | | 2nd Season | |
| | $m^3$ $fed^{-1}$ | Cm | $m^3$ $fed^{-1}$ | Cm |
| Irrigation water type (A) | | | | |
| Nonmagnetic water(non-MW) | 2654.3 | 63.2 | 2719.5 | 64.75 |
| Magnetic water (MW) | 2654.3 | 63.2 | 2719.5 | 64.75 |
| Irrigation intervals (B) | | | | |
| $I_1$ | 4340.7 | 103.8 | 4406.2 | 104.9 |
| $I_2$ | 2205.0 | 52.5 | 2272.2 | 54.1 |
| $I_3$ | 1417.1 | 33.7 | 1480.1 | 35.24 |
| Salicylic acid (C) | | | | |
| 0 | 2654.3 | 63.2 | 2719.5 | 64.75 |
| 50 ppm | 2654.3 | 63.2 | 2719.5 | 64.75 |
| 100 ppm | 2654.3 | 63.2 | 2719.5 | 64.75 |
| 150 ppm | 2654.3 | 63.2 | 2719.5 | 64.75 |

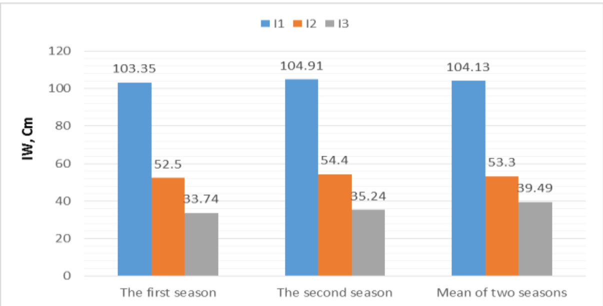


**Fig. 1. Effect of irrigation interval treatments on seasonal irrigation water applied (IW, cm) for basil in the average two growing seasons.**

**Productivity of irrigation water (PIW)**

Data presented in Table (10) and Fig (2&3) showed that productivity of irrigation water based on fresh yield ($PIW_f$) and productivity of irrigation water based on dry yield ($PIW_d$). In this study, PIW values from the irrigation interval treatment $I_3$was generally high when compared with the other treatments $I_1$and $I_2$. Productivity of irrigation water (PIW) was affected by the three studied treatments (type of irrigation water, irrigation interval and spraying of anti-salinity SA) influenced on yield.

**Table 10. Effect of water types, irrigation intervals and salicylic acid foliar spraying on productivity of irrigation water (PIW, kg $m^{-3}$) of *Ocimum basilicum* L. during the two growing seasons ( 2018 and 2019).**

| **Treatments** | | **PIW based on fresh yield (kg $m^3$)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1st Season 2018** | | | | **2nd Season 2019** | | | |
| | | **Salicylic acid (ppm)** | | | | **Salicylic acid (ppm)** | | | |
| **Water type** | **Irrigation interval** | **0** | **50** | **100** | **150** | **0** | **50** | **100** | **150** |
| Nonmagnetic water(non-MW) | $I_1$ | 1.46 | 1.52 | 1.55 | 1.62 | 1.44 | 1.58 | 1.62 | 1.64 |
| | $I_2$ | 2.89 | 3.32 | 3.40 | 3.52 | 2.86 | 3.29 | 3.39 | 3.47 |
| | $I_3$ | 4.48 | 4.54 | 4.63 | 4.66 | 4.32 | 4.40 | 4.56 | 4.62 |
| Magnetic water(MW) | $I_1$ | 2.44 | 2.51 | 2.51 | 2.53 | 2.40 | 2.51 | 2.54 | 2.57 |
| | $I_2$ | 5.07 | 5.24 | 5.28 | 5.33 | 5.07 | 5.19 | 5.21 | 5.24 |
| | $I_3$ | 7.36 | 7.49 | 7.50 | 7.54 | 7.07 | 7.16 | 7.32 | 7.41 |
| Treatments | | PIW based on dry yield (kg $m^3$) | | | | | | | |
| | | 1st Season 2018 | | | | 2nd Season 2019 | | | |
| | | Salicylic acid (ppm) | | | | Salicylic acid (ppm) | | | |
| Water type | Irrigation interval | 0 | 50 | 100 | 150 | 0 | 50 | 100 | 150 |
| Nonmagnetic water(non-MW) | $I_1$ | 0.323 | 0.352 | 0.362 | 0.366 | 0.350 | 0.384 | 0.393 | 0.397 |
| | $I_2$ | 0.644 | 0.744 | 0.766 | 0.785 | 0.691 | 0.797 | 0.819 | 0.841 |
| | $I_3$ | 0.995 | 1.009 | 1.044 | 1.059 | 1.047 | 1.061 | 1.101 | 1.115 |
| Magnetic water(MW) | $I_1$ | 0.534 | 0.560 | 0.567 | 0.571 | 0.581 | 0.606 | 0.615 | 0.620 |
| | $I_2$ | 1.147 | 1.175 | 1.179 | 1.188 | 1.223 | 1.254 | 1.259 | 1.267 |
| | $I_3$ | 1.623 | 1.644 | 1.680 | 1.701 | 1.709 | 1.730 | 1.770 | 1.790 |

**$PIW_f$ = productivity of irrigation water based on fresh yield $PIW_d$ = productivity of irrigation water based on dry yield.**


**Fig. 2. Effect of different treatments on productivity of irrigation water based on fresh yield ($PIW_f$) for basil in the average two growing seasons.**

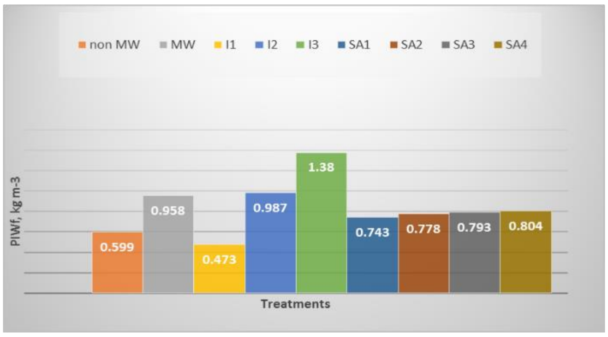


**Fig. 3. Effect of different treatments on productivity of irrigation water based on dry yield ($PIW_d$) for basil in the average two growing seasons.**

The highest values recorded under $I_3$ (irrigation every six days) in the two growing seasons were 7.54 and7.41kg $m^{-3}$ ($PIW_f$) while the values were 1.701 and 1.790 kg $m^{-3}$ ($PIW_d$) under the same treatment $I_3$, respectively. Meanwhile, the lowest values determined at $I_1$ (irrigation every two day) were 1.46 and 1.44 kg $m^{-3}$ ($PIW_f$) while the values were 0.323 and 0.350kg $m^{-3}$ ($PIW_d$) in the first and second seasons, respectively. Under these conditions, the positive effect of irrigation on yield, PIW and quality characteristics of basil have evaluated. Results were in line with findings by Ekren *et al.*, 2012. Generally, the mean values of $PIW_f$ or $PIW_d$ under type of water, irrigation interval and foliar spraying with SA treatments can be descended in order MW > non-MW, $I_3 > I_2 > I_1$ and 150 ppm SA > 100 ppm > 50ppm > 0 in the two seasons. Increasing the mean values of $PIW_f$ and $PIW_d$ under MW, $I_3$ and 150ppm SA in comparison with other treatments in the two seasons may be due to re-distribution cations and ions for salinity irrigation water resulted in adsorption and absorption nutrient elements by increasing uptake plants under MW, decreasing amount of irrigation water and increasing basil yield (under $I_3$ with 150 ppm SA) effect of increasing resistance or tolerated plants for salinity conditions. Defined as the increase in yield per unit of irrigation water applied, irrigation water use efficiency (Iwue = PIW) can be calculated if the amounts of water given by irrigation and actual yield increase from irrigation are known (Howell, 2001). Iwue provides the most realistic assessment of the irrigation effectiveness (Pejić *et al.*, 2014).

**Metabolic Responses**

**Effect of irrigation water type**

Table (11) displayed that MW caused highly significant changes in photosynthetic pigments, carbohydrate content and crude protein through the two growing seasons. chlorophylls content of leaf is a reflection of basil quality. MW treatments showed a highly significant increase in chlorophyll a, chlorophyll b, carotenoids and consequently total pigments over the non- MW treatments by about 59.6, 88.7; 50.0, 94.4; 26.1, 78.4 and 46.3, 92.8% correspondingly for the two cuttings in the 1st season while 50.3, 71.8; 52.1, 82.0; 79.3, 95.8 and 61.3, 81.4% in that order in the 2nd season. In the meantime, a significant increase on carbohydrate content and crude protein in response to MW treatments. These increases in the two cuttings were 53.6, 59.5 and 47.4, 67.4% respectively in the 1st season while 53.6, 62.2 and 56.3, 65.7% in the 2nd season over non- MW treatments. As a consequence, MW treatments enhanced all photosynthetic pigments, carbohydrate and protein contents at salt stress while non-MW caused physiological disorders. These results in contract with Trivellini *et al.*, 2014 who said that salinity influences on the rate of photosynthesis and the synthesis of hormone. Bione *et al.*, 2014 reported that under salt stress, basil plants suffer from reduction in all evaluated metabolic variables. Photosynthetic measurements increased by magnetic conducts and MW technique has a positive effect on alleviating salinity effects ( Fatahallah et al., 2014 on bean and Bseleh *et al.*, 2016 on oregano). Hassan *et al.*, 2017 stated that MW enriched the chl a, chl b and carotenoids compared with the control. The positive effect of MW on plant may be attributed to easily absorption of water and minerals leading to the improvement of assimilation of nutrients as MW expands surface tension, conductivity, $H_2$ bonding and solubility of minerals in soil. Moreover, MW affects the formation of new protein bands and growth promoters in plants causing increasing of protein contents (El-Sayed, 2014).

Effect of irrigation intervals

Data in Table (11) indicated that the irrigation intervals had a significant effect on all photosynthetic pigments, carbohydrate content and crude protein for the two cuttings in both seasons. The patterns of chlorophyll a, chlorophyll b, carotenoids and consequently total pigments as well as total carbohydrates and protein contents were elicited under the irrigation every 4 days ($I_2$) in relation to 2 and 6 days interval for two cuts in both seasons with some exceptions such as in the 1st cut in the 1st season, irrigation every 2 days ($I_1$) surpassed the other intervals where it produced the highest value of carbohydrates content in addition the 2nd cut in the 1st season and the 1st cut in the 2nd season stimulate the crude protein content. Similar results were obtained by Fakhraei Lahiji *et al.*, 2011 who reported that ten days interval enhanced the Gladiolus properties further than 15 days interval and reduce the soil evaporation. Jaberi *et al.*, 2019 on fenugreek stated that irrigation interval (every 12 days) increased carbohydrate, chlorophyll b and ash and decreased chlorophyll a and K. Increasing the mean values of the abovementioned parameters under irrigation interval ($I_2$) comparing with other irrigation treatments $I_1$and $I_3$ might be owing to that $I_2$ treatment received the appropriate amount of water applied which upturn the solubility of nutrients so the nutrients uptake by plants improved and metabolites increased. Mahdavikia *et al.*, 2019 displayed that chlorophyll content and relative water content were inhibited by water limitation, but improved carotenoids

**Effect of salicylic acid**

All metabolic patterns illustrated in Table (11) were stimulated in response to application of SA compared with their corresponding controls for the two cuttings in both growing seasons. The higher level of SA (150 ppm) in relation to respective control values had extremely significant effects on chlorophyll a, chlorophyll b, carotenoid, total carbohydrate and crude protein in both studied seasons. The percentages of increments in total pigments, total carbohydrates and crude protein of the two cuts in response to foliar spraying of 150ppm SA were 19.1, 17.6; 8.8, 7.5 and 14.4, 10.9 percentage correspondingly in the 1st growing season in relation to respective controls while upsurges in the 2nd season determined 16.7, 15.1; 8.8, 8.5 and 13.7, 12.1 percentage, respectively. These findings were in line with Gharib (2006) who quoted that applied SA ($10^{-4}$ M) increased photosynthetic pigments and carbohydrates. Jalal *et al*., 2012 noted that SA at 0.05 mM increased photosynthetic pigments. Al-Qubaie, 2013 stated that SA at 200ppm stimulates chlorophyll a, b, carotenoids and total chlorophylls, the positive effects of SA may be owing to its effect on alleviating the negative effects of salinity facilitating uptake of nutrients especially Mg and sugars biosynthesis result in enhancing pigments.

**Table 11. Effect of irrigation water type, irrigation intervals and salicylic acid foliar spraying and their interactions on the experimental traits of *Ocimum basilicum* L. in the two cuts during the two growing seasons (2018 and 2019).**

| Treatments | Chl a (mg/g fw) | | Chl b (mg/g fw) | | Carotenoids (mg/g fw) | | Total pigments (mg/g fw) | | Total Carbohydrates (%) | | Crude protein (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut |
| **1st season (2018)** | | | | | | | | | | | | |
| Irrigation water type (A) | | | | | | | | | | | | |
| Nonmagnetic | 1.41b | 1.41b | 1.24b | 1.25b | 1.15b | 1.11b | 3.80 b | 3.77b | 32.83b | 32.72b | 15.45b | 14.67b |
| Magnetic | 2.25a | 2.66a | 1.86a | 2.43a | 1.45a | 1.98a | 5.56a | 7.07a | 50.43a | 52.20a | 22.78a | 24.56a |
| F. test | * | ** | * | ** | ** | * | * | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.004 | 0.011 | 0.024 | 0.006 | 0.100 | 0.007 | 0.370 | 0.403 | 0.055 | 1.560 | 0.003 | 0.0138 |
| Irrigation intervals(B) | | | | | | | | | | | | |
| $I_1$ (every 2 days) | 1.71c | 2.10b | 1.51b | 1.81b | 1.26c | 1.46c | 4.48b | 5.37b | 44.14a | 42.65b | 19.28b | 19.86a |
| $I_2$ (every 4 days) | 2.03a | 2.35a | 1.65a | 2.01a | 1.35a | 1.70a | 5.03a | 6.06a | 41.50b | 44.75a | 19.40a | 19.88a |
| $I_3$ (every 6 days) | 1.75b | 1.96b | 1.49c | 1.70c | 1.29b | 1.48b | 4.53b | 5.14b | 39.23c | 39.97c | 18.67c | 19.11b |
| F. test | ** | * | * | * | * | * | * | ** | ** | * | * | ** |
| L.S.D at 0.05 | 0.003 | 0.151 | 0.004 | 0.009 | 0.006 | 0.006 | 0.261 | 0.442 | 0.046 | 0.971 | 0.005 | 0.081 |
| Salicylic acid (C) | | | | | | | | | | | | |
| 0 | 1.64d | 1.95d | 1.43d | 1.69d | 1.17d | 1.41d | 4.24d | 5.05d | 39.62d | 40.65d | 17.75d | 18.65d |
| 50 ppm | 1.80c | 2.11c | 1.51c | 1.80c | 1.28c | 1.54c | 4.59c | 5.45c | 41.42c | 42.38c | 18.94c | 19.28c |
| 100 ppm | 1.88b | 2.20b | 1.59b | 1.88b | 1.34b | 1.57b | 4.81b | 5.65b | 42.38b | 43.10b | 19.47b | 19.85b |
| 150 ppm | 1.99a | 2.30a | 1.67a | 1.98a | 1.40a | 1.66a | 5.06a | 5.94a | 43.09a | 43.68a | 20.30a | 20.68a |
| F. test | * | ** | * | * | * | * | ** | ** | ** | * | * | * |
| L.S.D at 0.05 | 0.009 | 0.010 | 0.008 | 0.007 | 0.007 | 0.005 | 0.016 | 0.025 | 0.042 | 1.740 | 0.010 | 0.081 |
| Interactions | | | | | | | | | | | | |
| A X B | ** | * | ** | * | ** | * | * | ** | ** | ** | * | * |
| A X C | ** | * | ** | * | * | NS | * | * | ** | * | * | * |
| B X C | ** | * | * | * | * | NS | * | * | ** | * | * | * |
| A X B X C | ** | ** | ** | * | ** | * | * | ** | ** | ** | ** | ** |
| **2nd season (2019)** | | | | | | | | | | | | |
| Irrigation water type (A) | | | | | | | | | | | | |
| Nonmagnetic | 1.93b | 1.88b | 1.56b | 1.50b | 1.21b | 1.18b | 4.70b | 4.56b | 32.85b | 32.82b | 15.78b | 15.41b |
| Magnetic | 2.90a | 3.23a | 2.51a | 2.73a | 2.17a | 2.31a | 7.58a | 8.27a | 50.46a | 53.23a | 24.67a | 25.54a |
| F. test | ** | * | ** | ** | * | ** | ** | ** | ** | ** | ** | ** |
| L.S.D at 0.05 | 0.002 | 0.016 | 0.021 | 0.090 | 0.006 | 0.017 | 0.820 | 1.00 | 0.055 | 0.055 | 0.762 | 1.232 |
| Irrigation intervals(B) | | | | | | | | | | | | |
| $I_1$ (every 2 days) | 2.26c | 2.53b | 2.01b | 2.09b | 1.64b | 1.71c | 6.03b | 6.33b | 41.53b | 42.90b | 20.49a | 20.29b |
| $I_2$ (every 4 days) | 2.59a | 2.68a | 2.23a | 2.24a | 1.77a | 1.83a | 6.59a | 6.75a | 44.17a | 45.54a | 20.39ab | 21.06a |
| $I_3$ (every 6 days) | 2.38b | 2.46c | 1.86c | 2.01b | 1.67b | 1.78b | 5.79c | 6.25b | 39.26c | 40.63c | 19.79b | 20.06c |
| F. test | * | * | * | * | * | ** | * | ** | ** | * | NS | ** |
| L.S.D at 0.05 | 0.005 | 0.012 | 0.007 | 0.096 | 0.044 | 0.038 | 0.015 | 0.019 | 0.046 | 0.046 | 0.659 | 0.137 |
| Salicylic acid (C) | | | | | | | | | | | | |
| 0 | 2.25d | 2.37d | 1.84b | 1.94c | 1.56d | 1.64d | 5.65d | 5.95c | 39.64d | 41.01d | 18.87d | 19.20d |
| 50 ppm | 2.38c | 2.55c | 1.99a | 2.09b | 1.67c | 1.77c | 6.04c | 6.41b | 41.44c | 42.81c | 19.96c | 20.30c |
| 100 ppm | 2.46b | 2.60b | 2.10a | 2.16b | 1.73b | 1.82b | 6.29b | 6.58b | 42.40b | 43.77b | 20.62b | 20.86b |
| 150 ppm | 2.56a | 2.71a | 2.21a | 2.26a | 1.81a | 1.88a | 6.58a | 6.85a | 43.12a | 44.49a | 21.45a | 21.52a |
| F. test | * | * | * | ** | ** | ** | * | * | * | * | ** | ** |
| L.S.D at 0.05 | 0.064 | 0.008 | 0.147 | 0.072 | 0.011 | 0.036 | 0.171 | 0.189 | 0.042 | 0.042 | 0.265 | 0.319 |
| Interactions | | | | | | | | | | | | |
| A X B | * | ** | * | ** | * | NS | * | * | * | * | NS | ** |
| A X C | * | ** | * | ** | * | * | * | * | * | * | ** | NS |
| B X C | * | ** | NS | ** | NS | * | NS | * | * | * | * | NS |
| A X B X C | ** | ** | ** | ** | ** | ** | ** | ** | * | ** | * | * |

**Effect of the interactions**

The interaction between water types and irrigation intervals showed a significant effect for all experimental metabolic patterns except for carotenoids in the 2nd cut and crude protein in the 1st cut throughout the 2nd season as observable in Table (11). Also, the interactions of water types X anti-salinity SA exhibited a significant result for all mentioned traits except for carotenoids in the 2nd cut in the 1st seasons and crude protein in the 2nd cut in the 2nd growing season. In the meantime, the interaction of irrigation intervals X anti-salinity SA indicated a remarkable result on some experimental traits and not for others such as carotenoids in the 2nd cut through the 1st season while chlorophyll b, carotenoids and total pigments in the 1st cut and crude protein in the 2nd cut throughout the 2nd growing season showing non-significant effect.

Results in Table (12) indicated that the interaction between all considered factors significantly encouraged all metabolic patterns in both cuts during the two studied seasons. All experimental metabolites in plants irrigated with non MW improved by increasing SA levels in relation to unsprayed treatments under all irrigation intervals.

**Table 12. Mean comparisons for interaction effects of irrigation water type, irrigation intervals and salicylic acid foliar spraying on the experimental traits of *Ocimum basilicum* L. in the two cuts during the two growing seasons (2018 and 2019).**

| Treatments | | | Chl a (mg/g fw) | | Chl b (mg/g fw) | | Carotenoids (mg/g fw) | | Total pigments (mg/g fw) | | Total Carbohydrates (%) | | Crude protein (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water type | Irrigation interval | Salicylic acid | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut | 1st cut | 2nd cut |
| | | | 1st season | | | | | | | | | | | |
| Nonmagnetic ($M_0$) | $I_1$ (every 2 days) | 0 | 1.22q | 1.22r | 1.15q | 1.12s | 1.06p | 1.02n | 3.43t | 3.36v | 30.12t | 30.10u | 13.97v | 13.95o |
| | | 50 ppm | 1.33o | 1.32p | 1.16pq | 1.17q | 1.11n | 1.03n | 3.60r | 3.52s | 31.88q | 31.78o | 15.23r | 14.15mn |
| | | 100 ppm | 1.40n | 1.40o | 1.23n | 1.21p | 1.15m | 1.05m | 3.78p | 3.66q | 32.96p | 32.59n | 15.87o | 14.44kl |
| | | 150 ppm | 1.49m | 1.53n | 1.31l | 1.32n | 1.19kl | 1.17l | 3.99n | 4.02n | 34.52o | 34.39m | 16.96m | 15.89i |
| | $I_2$ (every 4 days) | 0 | 1.27p | 1.26q | 1.17op | 1.14r | 1.09o | 1.03n | 3.53s | 3.43u | 30.18t | 30.18s | 14.22t | 14.09mno |
| | | 50 ppm | 1.51m | 1.51n | 1.29l | 1.30o | 1.18l | 1.18kl | 3.48n | 3.99o | 34.82n | 34.72l | 15.04s | 14.48k |
| | | 100 ppm | 1.65l | 1.67m | 1.33k | 1.37m | 1.20k | 1.21j | 4.18m | 4.25m | 37.73m | 37.68k | 15.23r | 14.79j |
| | | 150 ppm | 1.79k | 1.83l | 1.45j | 1.54l | 1.25j | 1.30i | 4.49l | 4.67l | 39.60l | 39.28j | 17.17l | 16.84h |
| | $I_3$ (every 6 days) | 0 | 1.23q | 1.22r | 1.15q | 1.14r | 1.06p | 1.02n | 3.44t | 3.38v | 30.13u | 30.12t | 14.18u | 14.05no |
| | | 50 ppm | 1.29p | 1.28q | 1.18o | 1.15r | 1.12n | 1.03n | 3.59r | 3.46t | 30.22t | 30.20r | 15.3q | 14.17mn |
| | | 100 ppm | 1.32o | 1.32p | 1.23n | 1.21p | 1.16m | 1.05m | 3.71q | 3.58r | 30.75s | 30.75q | 15.75p | 14.26lm |
| | | 150 ppm | 1.39n | 1.41o | 1.27n | 1.29o | 1.19kl | 1.19k | 3.85o | 3.89p | 30.99r | 30.86p | 16.44n | 14.97j |
| Magnetic ($M_1$) | $I_1$ (every 2 days) | 0 | 2.00i | 2.64l | 1.70h | 2.25i | 1.27i | 1.68h | 4.97i | 6.57j | 49.13g | 51.27f | 21.97i | 23.99d |
| | | 50 ppm | 2.08h | 2.79f | 1.78g | 2.38g | 1.42f | 1.89f | 5.28h | 7.06g | 50.75f | 53.68e | 22.89g | 24.98b |
| | | 100 ppm | 2.17f | 2.90e | 1.84e | 2.47e | 1.39g | 1.89f | 5.40g | 7.26f | 51.25e | 53.68e | 23.43d | 25.70a |
| | | 150 ppm | 2.29d | 2.99d | 1.91d | 2.59d | 1.47e | 1.97e | 5.67e | 7.55d | 51.42d | 53.70d | 23.90c | 25.79a |
| | $I_2$ (every 4 days) | 0 | 2.19f | 2.89e | 1.78g | 2.44f | 1.29h | 1.98de | 5.26h | 7.31e | 51.93c | 53.77c | 21.89j | 23.02f |
| | | 50 ppm | 2.47c | 3.15c | 1.95c | 2.63c | 1.41f | 2.23c | 5.83c | 8.01c | 52.93b | 54.13b | 23.28e | 24.13d |
| | | 100 ppm | 2.60b | 3.21b | 2.08b | 2.79b | 1.62b | 2.30b | 6.30b | 8.30b | 52.92b | 54.13b | 23.94b | 25.88a |
| | | 150 ppm | 2.74a | 3.27a | 2.16a | 2.84a | 1.73a | 2.35a | 6.63a | 8.46a | 53.04a | 54.14a | 24.39a | 25.79a |
| | $I_3$ (every 6 days) | 0 | 1.95j | 2.46k | 1.64i | 2.07k | 1.27i | 1.73g | 4.86k | 6.26k | 46.22k | 48.46i | 20.25k | 22.82g |
| | | 50 ppm | 2.10h | 2.59j | 1.70h | 2.15j | 1.42f | 1.89f | 5.22i | 6.63i | 47.89j | 49.78h | 21.89j | 23.74e |
| | | 100 ppm | 2.14g | 2.67h | 1.82f | 2.24i | 1.51d | 1.90f | 5.47f | 6.81h | 48.66i | 49.80g | 22.61h | 24.05d |
| | | 150 ppm | 2.25e | 2.75g | 1.91d | 2.32h | 1.59c | 1.99d | 5.75d | 7.06g | 48.98h | 49.80g | 22.93f | 24.78c |
| L.S.D at 5% level | | | 0.023 | 0.024 | 0.019 | 0.017 | 0.016 | 0.012 | 0.038 | 0.028 | 0.103 | 4.259 | 0.016 | 0.199 |
| | | | 2nd season | | | | | | | | | | | |
| Nonmagnetic ($M_0$) | $I_1$ (every 2 days) | 0 | 1.78t | 1.63t | 1.31u | 1.24s | 1.13q | 1.05s | 4.22u | 3.92t | 30.14t | 30.11t | 14.17m | 14.12l |
| | | 50 ppm | 1.87q | 1.84p | 1.51r | 1.41o | 1.17op | 1.10q | 4.55r | 4.35q | 31.90q | 31.87q | 15.81j | 15.03jk |
| | | 100 ppm | 1.95p | 1.91o | 1.60q | 1.49m | 1.17op | 1.13p | 4.72p | 4.53o | 32.98p | 32.95p | 16.54hi | 15.67ij |
| | | 150 ppm | 2.01n | 1.98m | 1.72 o | 1.61k | 1.24m | 1.20mn | 4.97m | 4.79m | 34.54o | 34.51o | 17.03h | 16.55gh |
| | $I_2$ (every 4 days) | 0 | 1.80s | 1.78r | 1.34t | 1.34q | 1.15pq | 1.10q | 4.29t | 4.22r | 30.20t | 30.17t | 14.63lm | 14.63kl |
| | | 50 ppm | 1.94p | 1.91o | 1.65p | 1.62k | 1.21n | 1.21m | 4.80o | 4.74n | 34.84n | 34.81n | 15.12kl | 15.62ij |
| | | 100 ppm | 2.03m | 2.02l | 1.81n | 1.70j | 1.27l | 1.26l | 5.11l | 4.98k | 37.75m | 37.72m | 15.49jk | 16.02hi |
| | | 150 ppm | 2.24l | 2.20k | 1.97m | 1.89i | 1.39j | 1.39j | 5.60k | 5.48j | 39.62l | 39.59l | 17.90g | 16.98g |
| | $I_3$ (every 6 days | 0 | 1.79st | 1.70s | 1.33tu | 1.29r | 1.13q | 1.08r | 4.25u | 4.07s | 30.15t | 30.12t | 14.30m | 14.12l |
| | | 50 ppm | 1.83r | 1.82q | 1.38s | 1.36p | 1.18o | 1.17o | 4.39s | 4.35q | 30.24t | 30.21t | 15.46jk | 15.00jk |
| | | 100 ppm | 1.88q | 1.82q | 1.49r | 1.47n | 1.22mn | 1.19n | 4.59q | 4.48p | 30.77s | 30.74s | 15.93ij | 15.00jk |
| | | 150 ppm | 1.98o | 1.96n | 1.62q | 1.58l | 1.31k | 1.29k | 4.91n | 4.83l | 31.01r | 30.98r | 16.98h | 16.12hi |
| Magnetic ($M_1$) | $I_1$ (every 2 days) | 0 | 2.67i | 3.02i | 2.34i | 2.63f | 1.93i | 2.14i | 6.94i | 7.79h | 49.16g | 51.93g | 23.90de | 24.17f |
| | | 50 ppm | 2.82g | 3.19g | 2.45g | 2.75d | 2.07h | 2.29g | 7.34g | 8.23f | 50.78f | 53.55f | 24.99b | 25.04d |
| | | 100 ppm | 2.91f | 3.28e | 2.54f | 2.75d | 2.15f | 2.37f | 7.60e | 8.40d | 51.28e | 54.05e | 25.70a | 25.83c |
| | | 150 ppm | 3.00d | 3.37d | 2.62d | 2.84c | 2.24d | 2.43d | 7.86d | 8.64c | 51.45d | 54.22d | 25.81a | 25.92c |
| | $I_2$ (every 4 days | 0 | 2.95e | 3.11h | 2.59e | 2.68e | 2.06h | 2.25h | 7.60e | 8.04g | 51.96c | 54.73c | 23.34ef | 24.25ef |
| | | 50 ppm | 3.20c | 3.40c | 2.74c | 2.83c | 2.27c | 2.13d | 8.21c | 8.66c | 52.96b | 55.73b | 24.60bc | 26.11c |
| | | 100 ppm | 3.27b | 3.48b | 2.83b | 2.90b | 2.38b | 2.49b | 8.48b | 8.87b | 52.95b | 55.72b | 25.90a | 26.99b |
| | | 150 ppm | 3.31a | 3.54a | 2.91a | 2.96a | 2.43a | 2.52a | 8.65a | 9.02a | 53.07a | 55.84a | 26.14a | 27.84a |
| | $I_3$ (every 6 days | 0 | 2.48k | 2.95j | 2.13l | 2.48h | 1.95i | 2.24h | 6.56j | 7.67i | 46.25k | 49.02k | 22.85f | 23.93f |
| | | 50 ppm | 2.61j | 3.11h | 2.22k | 2.57g | 2.12g | 2.39e | 6.95i | 8.07g | 47.92j | 50.69j | 23.79de | 25.00de |
| | | 100 ppm | 2.73h | 3.11h | 2.30j | 2.64f | 2.18e | 2.45c | 7.21h | 8.20f | 48.69i | 51.46i | 24.13cd | 25.63cd |
| | | 150 ppm | 2.81g | 3.22f | 2.39h | 2.67e | 2.26cd | 2.45c | 7.46f | 8.34e | 49.01h | 51.78h | 24.84b | 25.71cd |
| L.S.D. at 5% level | | | 0.020 | 0.019 | 0.022 | 0.020 | 0.026 | 0.019 | 0.031 | 0.038 | 0.103 | 0.103 | 0.650 | 0.781 |

The significant increase in the metabolic traits viz. total photosynthetic pigments, total carbohydrates and crude protein content induced by 150 ppm SA level under the appropriate irrigation interval ($I_2$) in plants treated with non MW determined 27.2, 36.2; 31.2, 30.2 and 20.7, 19.5%, respectively for the two cuts in the 1st season compared to unsprayed plants while 30.5, 29.9; 31.2, 31.2 and 22.4, 16.1 % in that order during the 2nd one. The treatments irrigated with MW under all irrigation intervals for the two cuts in the two growing seasons significantly surpassed total photosynthetic pigments, total carbohydrates and crude protein content in relation to the respective controls of non-MW. The significant increments in chlorophyll a, chlorophyll b, carotenoids subsequently total photosynthetic pigments induced by the MW treatments under the proper irrigation intervals (every 4 days) at 150 ppm SA over their corresponding controls were 38.0, 78.7; 49.0, 84.4; 38.4, 80.8 and 47.7, 81.2% for the two cuts respectively in the 1st season in that order of above traits, while those increments were 47.8, 60.9; 47.8, 56.6; 74.8, 81.3 and 54.5, 64.6% in the 2nd season. Additionally, the increases in total carbohydrates and crude protein content in response to the treatment of (MW+ I2+ 150ppm SA) which recorded the supreme effect were 33.9, 37.8 and 42.1, 53.7 for the two cuts in the 1st season in that order of mentioned traits while 33.9, 41.0 and 46.0, 64.0% in the 2nd season. These results on metabolic patterns induced by these interactions may be due to the effect of SA, magnetic field as helper in alleviation of saline stress effects and modification the key of cellular processes such as gene transcription (Bagherifard et al., 2015). SA is an essential signal molecule modulating plant response to water stress (Hesami et al., 2012). The recorded results were symmetry with Jalal et al., 2012 resulted that SA reduced the damage effect of water deficit thus improved photosynthetic pigments. El-Sayed (2014) concluded that chlorophyll a, b, carotenoids, total carbohydrates and protein were stimulated by irrigation with MW. In addition Bseleh et al., 2016 showed that irrigation of oregano under salinity of groundwater by MW stimulated chlorophyll content. Bagherifard et al., 2015 mentioned that SA regulates mineral absorption and photosynthetic rate. it was generally more effective in enhancing photosynthetic rate (Ghasemzadeh and Jaafar, 2013 on *Zingiber officinale* ). On the other hand, the decline under the irrigation by non MW owing to salinity disorders related to destruction of chloroplast and photosynthetic apparatus, decrease of chlorophyll biosynthesis, and the increase of activity of chlorophyllase (Kabiri *et al.*, 2014).

## CONCLUSION

Irrigation under trickle irrigation system with MW supplemented with 50 ppm SA are the most efficient approaches that mitigate the damaging effects of salinity of water and soil so, basil plants may be tolerant these environmental conditions of newly soils. These appliances stimulated plant growth, yield, production of top quantity and quality of oil and metabolites of basil. Also, irrigation interval every 4 days is the appropriate interval that saves irrigation water. This valuable modern technology was recommended to save irrigation water when only saline water is the available source under newly reclaimed sandy soils and to improve productivity of most medicinal and aromatic plants.

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## تخفيف الإجهاد الملحى على نبات الريحان بتقنية الرى بالماء الممغنط ورش حمض الساليسيلك تحت ظروف التربة الرملية بمنطقة قلابشو


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**[2]قسم بحوث المقننات المائية والرى الحقلى- معهد الاراضى والمياه والبيئة- مركز البحوث الزراعية- مصر**



أجريت تجربة حقلية في تربة رملية بمزرعة خاصة فى الاراضى المستصلحة الجديدة بمنطقة قلابشو، محافظة الدقهلية بمصر خلال الموسمين 2018و 2019 بغرض دراسة تأثير نوع ماء الرى (الماء الممغنط والماء الغير ممغنط ويصل تركيز الاملاح الذائبة الكلية فيه لحوالى6350 جزء فى المليون)، وفترات الرى المختلفة (2 و4و6يوم) و معاملة النباتات رشا بحمض السالسيلك عند مستويات (0، 50، 100و150 جزء فى المليون) على تخفيف الاجهاد الملحي والتي تنعكس بدورها على النمو، المحصول والصفات الأيضية لنبات الريحان. وقد صممت التجربة في قطع منشقة مرتين فى ثلاث مكررات.وقد أظهرت النتائج أن: الرى بالماء الممغنط عند كل فترات الرى المختبرة سجل زيادة معنوية فائقة فى جميع قياسات النمو المختبرة - محصول العشب الطازج والجاف للفدان وكذلك زيادة فى كل من النسبة المئوية للزيت العطرى ومحصول الزيت للفدان ومكوناته .اضافة الى محتوى النبات من صبغات االتخليق الضوئى والكربوهيدرات والبروتين كما أدى الى تحسين كفاءة المياه المضافة فى كلا الحشتين للموسمين. وكانت فترة الرى المثلى( كل4 يوم) قد حققت زيادةمعنوية فى محصول العشب الطازج والجاف للفدان وكذلك النسبة المئوية للزيت العطرى و ومحصول الزيت للفدان و كان أعلى فى الحشة الثانية عن الاولى في كلا الموسمين بينما قد سجل انخفاض ملحوظ فى الحشة الثانية عند الرى بالماء الغير ممغنط.كما أدى الرش بحمض السالسيلك بكل تركيزاته في نوعي المياه عند كل فترات الرى الى زيادة معنوية فى أغلب الصفات المختبرة فى كلا الموسمين وبالأخص عند تركيز 150حزء فى المليون. وخلصت النتائج الى أن التفاعل بين الرى بالماء الممغنط كل 4 أيام مع الرش بالساسليلك بتركيز 150 جزء فى المليون أدى الى زيادة معنوية فى جميع قياسات النمو والمحصول والنسبة المئوية للزيت العطرى محتوى الزيت من المكون الرئيسى الليناليول و1-8 سينول وكذلك بعض الصفات الايضية لنبات الريحان .وعليه يمكن التوصية بالرى بالماء الممغنط كل 4 أيام مع رش السالسيلك بتركيز50 جزء فى المليون عند زراعة الريحان تحت ظروف الاجهاد الملحى ومصادرمياه محدوده لتحسين النمو ،المحصول وانتاجية الزيت كما ونوعا .