Life Science Informatics Publications
Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences
Journal Home page http://www.rjlbpcs.com/
RJLBPCS
ISSN 2454-6348

Original Research Article **DOI: 10.26479/2018.0403.42**

EFFECT OF SALICYLIC ACID AND WATERING REGIME ON GROWTH, WATER STATUS, VOLATILE OIL COMPOSITION OF THYME PLANT

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ABSTRACT: The experiment was conducted during two successive growing seasons at green house of National Research Centre to investigated the effect of water regime (10,15 and 20 days irrigation intervals),salicylic acid (0,100 and 200 ppm) and their interaction on growth, water status, some chemical constituents and volatile oil composition of thyme plant. The main results could be summarized as follows: 1. The treatment of 10 days irrigation intervals provided plants with adequate supply of water and recorded highest increments in (plant height, fresh and dry weight of leaves and branches) and osmotic pressure (O.P. %).Extending irrigation intervals more than 10 days caused decrease in O.P. %, relative water content (R.W.C. %), antioxidant activity and total phenolic. Salicylic acid application did not significantly affect growth parameters and oil%, in most cases, while lows concentrations 100 ppm resulted in the higher R.W.C. %. 2. The interaction between 10 days interval and 100 and/or 200 ppm salicylic application increased dry mater, R.W.C. %, oil %. Increasing the irrigation time from 10 to 15 days affected the concentration of total phenolic which reduced from 57.32 to 49.55 mg GAE/g, respectively. While, the highest total flavonoid content was found in the essential oil of plants collected after 10+SA with concentration of 48.26 mg QE/g, the least value was obtained after irrigation of 15 days "39.59 mg QE/g". The analysis of GC and GC-MS identified 26 volatile compounds in the essential oil. Thymol was the main volatile compound in thyme essential oil which varied from 57.42% to 61.49% in the plant essential oil after 10 days of irrigation and interaction of SA, respectively, followed by γ – Terpinene and carvacrol.

KEYWORDS: thyme plant, water regime, salicylic acid, antioxidants, volatile oil

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1. INTRODUCTION:

Thyme is used in Egypt as ornamental plants and as appetizer, it belong to family labiatae. The species of the family are aromatic herbaceous, annual or perennials. Many number of the family have been employed as flavoring agents, spices and in the manufacture of perfumes and primitive medicinal practice. The family is rich in essential oil. Salicylic acid plays important roles in a biotic stress tolerance and considerable interest have focused on salicylic acid due to its ability to induce a protection effect on plant under stress drought. Salicylic acid also shown to influence a number of physiological processes [1]. Salicylic acid considered as a hormone like substances, which plays an important role in photosynthetic rate, stomatal conductance and transpiration [2]**.** In these connection [3] also mentioned that salicylic acid acts as antioxidants, further more [4], concluded that, salicylic acid can ameliorate the oxidative stress in barley stressed plants. The essential oil and extracts isolated from T. daenensis have been shown to have biological and pharmacological activities, including anti-bacterial [5], anti-fungal, antioxidant [6]. The aerial parts and volatile constituents of thyme are commonly used as a medicinal herb. Thymus species are commonly used as herbal tea, flavouring agents (condiments and spices) and medicinal purposes [7]**.** Infusion and decoction of aerial parts of Thymus species are used to produce tonic, carminative, digestive, antispasmodic, anti-inflammatory, and expectorant and for the treatment of colds [8],[9]**.** The aromatic and medicinal properties of the genus Thymus have made it one of the most popular medicinal plants [8]. The essential oil and extracts from the aerial parts of T. daenensis contain mainly monoterpenes, sesquiterpenes, phenolic compounds and flavonoids [10]. Earlier studies have identified thymol, carvacrol, p-cymene and γ-terpinene as the major constituents of the essential oils of T. daenensis [8], [6]**.** Aim of the work is to investigate the role of salicylic acid as antioxidants to avoid the hazard effect of shortage of water (drought) on growth, photochemical and volatile oil of thyme.

2. MATERIALS AND METHODS

Thyme (*Thymus valgaris* L.) was grown in a greenhouse of the National Research Centre Egypt, Cairo. The experiments carried out two successive seasons aimed to evaluate the effect salicylic acid on growth, oil and oil component of thyme plants grown under different water regime. For cultivation plastic pot (30 cm in diameter and 50 cm depth) were used in this experiment. Each pot was filled with media containing mixture of sand and loam 1:1 by volume. The experiment in both seasons included nine treatments in which the combination of three watering intervals 10,15 and 20 days and three levels of salicylic acid 0,100 and 200 ppm. Old homogeneous terminal cutting of thyme 3-5 cm length with 3-4 leaves were transplanting on 2015-2016 in both seasons. Phosphorus fertilizer was added before transplanting and all pots received the recommended dose according to the ministry of agriculture, Egypt. The irrigation regime was applied after 42 days from transplanting. Further 44 days from transplanting the plants were twice sprayed with salicylic (SA), 0,100 and 200 ppm. The other sprays were 30 days later starting from 48 hours from the irrigation intervals. Treatments were distributed in a complete randomized with 4 replicates for each treatment and the irrigation intervals were carried out- every 10, 15 and 20 days alone or in combination with the different salicylic treatments. For first cut representative plant sample was taken from three replicates randomized for each treatment after five month from transplanting and the second cut were taken five month later. In both cutting, the growth parameters included plant height, number of leaves and branches fresh weight of both leaves and branches, dry weight of both leaves and/or branches. In both cuttings fresh leaves g/plant were sampled to determine relative water content according to [11] and osmotic pressure according to [12].Another sample of leaves were taken to determine oil % according to [13].

Extraction of volatile oils

The leaves of thyme were subjected to hydro distillation using a Clevenger-type apparatus for 3 hrs. After decanting and drying the oil over sodium sulfate anhydrous. The oils in selected treatments were stored in sealed vial in a refrigerator (6°C) before being analyzed by GC and GC/MS.

Determination of total phenolic content (TPC)

The TPC was determined using the Folin-Ciocalteu reagent [14]**.** Accordingly, the reaction mixture contained 200 µL of a diluted thyme extract, 800 µL of freshly prepared and diluted Folin-Ciocalteu reagent and 2 mL of 7.5% sodium carbonate (Na_2CO_3). The final mixture was diluted to a final volume of 7 mL with deionized water. The obtained mixture was kept in the darkness at ambient conditions for 2 h to complete the reaction. In the next step, the absorbance of the solutions were measured at 765 nm. In our evaluations, gallic acid was used as the standard and the results were expressed as mg gallic acid (GAE)/g.

Determination of total flavonoid content (TFC)

Total flavonoid content (TFC) was determined using the aluminum chloride ($AlCl_3$) method according to a reliable approach using quercetin as the standard [15]**.** In this regard, the plant extract (0.1 mL) was added to 0.3 mL of distilled water followed by addition of 0.03 mL of $NaNO_2$ (5% w/v). After 5 min. at 25 ºC, $AlCl_3$ (0.03 mL, 10%) was added. After further 5 min., the reaction mixture was treated with0.2 mL of NaOH (1 mM). Finally, the reaction mixture was diluted to 1mL with water and the absorbance was measured at 510 nm. The results were expressed as mg quercetin (QE)/g.

The DPPH assay for evaluation of antioxidant activity

The antioxidant capacity of the essential oils was evaluated by the method of [16]**.** The essential oils at different concentrations (150–450 ug/ml) were mixed with the same volume of 0.2 mM methanol solution ofDPPH^0. The disappearance of DPPH^0 by essential oils after30 min of incubation at room temperature was determined spectrophotometrically at 515 nm. Methanol was used tozero spectrophotometer. The absorbance of the DPPH radical without antioxidant, i.e. the control was measured daily using UV-Vis Shimadzu (UV-1601, PC) spectrophotometer at 515 nm against a blank, i.e. withoutDPPH^0.

Scavenging activity (%) was calculated using the following formula:

% Inhibition = [(A $_{control}$ – A $_{treatment}$/=A $_{control}$)] X 100

Where: A $_{control}$: is the absorbance of the control; A $_{treatment}$: is the absorbance of the treatments. Butylated hydroxyl anisol (BHA) and *tert*-Butylated hydroxyl qunione (TBHQ) were used as positive controls. All tests were run in triplicate and an average was used.

β-Carotene Bleaching assay

The assay was carried out according to the method of [17]**,** β -carotene (2 mg)was dissolved in 20 mL chloroform, then, linoleic acid (40 mg) and Tween 40 (400 mg) were added to 4 mL of this mixture. After, the chloroform was evaporated at 40°C under vacuum. The mixture was supplemented with 100 mL of oxygenated water and then shacked vigorously. Samples (10 μL) with different concentrations (150-450 ug/mL) of oils extracts in methanol/water (90:10, v/v) were added to an aliquot (150 μL) of the -carotene/linoleic acid emulsion. The mixture was stored for 120 minutes at 50°C, and the absorbance was measured at 470 nm by a microtitre reader (model EAR 400, Lab systems Multi-skan MS). Readings of all samples were performed immediately (t= 0min) and after 30 or 120 minutes of incubation. The antioxidant activity (%) of oils methanolic extracts was evaluated in terms of β-carotene bleaching inhibition using the following formula:

% Inhibition= $[(A_t-C_t)/ (C_0-C_t)]\times 100$

Where, A_t and C_t are the absorbance values measured for the test sample and control, respectively, after incubation for 120minutes, and $C_0$is the absorbance values for the control measured at zero time during the incubation. All experiments were carried out in triplicate.

Gas chromatography–mass spectrometry analysis

Gas chromatography–mass spectrometry (GC–MS) analysis were performed with an HP Agilent 2890 plus gas chromatograph (GC) equipped with a HP-5MS column (a length of 60 m × internal diameter of 0.25 mm, and 0.25 mm film thickness). The column oven temperature was set at 60 ^{0}C for 8 min, and then increased to 250 ^{0}C at rate of 2 ^{0}C/min. The injector and detector temperatures were kept respectively at 250 and 270 ^{0}C. Carrier gas was helium, the flow through the column was1ml/min, and the split ratio was set to 50:1 with injection of (0.2) µl of oil sample. The GC/ mass spectrometry (MS) analysis was performed with a Quadrupole mass spectrometer that operated at 70 eV. Constituent's identification was based on comparison of retention times with those of corresponding reference standards using the NIST and WILEY libraries. Percentage compositions of essential oils were calculated according to the area of the chromatographic peaks.

Compound identification

Identification of EO constituents was made by matching their recorded mass spectra with those stored in the Wiley/NBS mass spectral library of the GC-MS data system and other published mass spectra. Retention index was calculated for each compound using the retention times of a homologous series of C_6 - C_{22}*n*-alkanes [18]**.** The recorded data, mean of the two growing season were statistically analyzed using the complete randomized design in factorial arrangement [19] where the means of the studied treatments were compared using L.S.D test at 0.05 probability.

3. RESULTS AND DISCUSSION

Effect of irrigation regime

It could be observed from table (1) that, the greatest plant growth expressed in plant height, fresh weight of leaves and branches as well as dry weight of leaves in the 1st and 2nd cut were recorded from plants irrigated every 10 days, and the difference between 10 and 15 days were enough to reach the level of significance in some cases. These mean that, the treatment of 10 days provided plants with adequate supply of water. Similar results were obtained on different crops by [20], [21],[22],[23][24],[25],[26],[27]. Prolong irrigation intervals from 10 up to 20 days induced significant reduce in previous mentioned parameters. These are true in both cuts. Thus the drought showed adverse effect on growth and consequently the plant requires more water and sensitive to drought. From the previous results it could be concluded that drought depressed growth of thyme plant but the magnitude of the depression differ with the irrigation frequencies, where short irrigation intervals 10 days favors the growth while extending irrigation intervals more than 10 days cause a progressive and constant. Increase in osmotic pressure of the soil solution. These will be cause a decrease in syntheses of metabolites, reduction in translocation of nutrients from the soil to plant and within plant, decrease in cell division and cell elongation. All of this probability could consider as a main course of the depression in the vegetative growth. In this respect [28] reported that drought stress affect both elongation and expansion of growth. Also, [29] reported that the reduction in plant height was associated with a decline in cell elongation and more leaf senescence. Osmatic pressure in both cuts gradually decreased insignificantly with drought treatments 15 and 20 days the reduction respectively reached 22.26 % and 27.51 % in the first cut and 26.05% and 28.85% in the 2nd cut. In this respect [30] mentioned that higher osmotic potential is the driving face for cell elongation and cell division. Relative water content (RWC) % decreased by increasing irrigation intervals Table (1). Thyme plants exposed to drought 20 days irrigation intervals decreased by about 32.46 and 17.33 in the 1st and 2nd cut compared with these plants. These results may be due to the higher osmatic pressure of the cell sap which favor water uptake and water retention in the cell of plants irrigated every 10 days. These results are in agreement with [25] on *Custer bean* and [31].

Effect of Salicylic acid

Results in table (2) reveal that, the growth parameters, expressed in number of leaves, fresh weight of branches and leaves as well as dry weight as affected by salicylic acid (SA) application were not significantly affected in most cases. However there were very different trends towards a decreasing in growth parameters by increasing the (SA) concentration compared with the control. These results hold true in both cuts.

Relative water content (R.W.C.) %

There are negative correlation between (R.W.C.) % and concentration of salicylic acid, where Lowes concentration 100 ppm resulted in the higher (R.W.C.)% in both cuts compared with the control plants.

Osmotic potential: O.P. %

Osmotic potential insignificantly in most cases affected by (SA) application, increasing (SA) from 100 up to 200 ppm has drusting effect on osmotic potential, the reduction reached 2.28 % and 3.68 % in the 1st and 39.99 and 32.0 in the 2nd cuts respectively.

Interaction effect between irrigation regime and salicylic acid:

With regard to the interaction effect between levels of salicylic acid as foliar spry and irrigation intervals, it is clear from Table (3) that the more pronounced effect on increasing plant height in the 1stcut was recorded when plants irrigated every 15 days with 0 level of (SA) and/or 15 days intervals sprayed with 200 ppm (SA) in the 2nd cut. In both cuts branches number was increased by irrigation every 10 days and sprayed with 100 ppm (SA). It also noticed that number of leaves in both cutting when 10 days irrigation interval interacted with zero SA had the pronounced effect on previous parameters. However, it worth noting that Thyme plants which were sprayed with 100 ppm SA and irrigated every 10 days accumulated the highest dry matter amount in the leaves. Table (3) also showed that, drought stress decreased relative water content in Thyme leaves was achieve in plants irrigated every 10 days and sprayed with 100 ppm salicylic acid and/or 200 ppm. The lowest RW.C.% were recorded with 20 days irrigation intervals and sprayed with tested level of SA. It is event that Table (3) 15 days irrigation intervals interacted with 100 ppm SA recorded the highest Osmotic Potential whereas 20 days intervals interacted with 200 ppm SA gave the lowest Osmotic Potential. The differences are not significant in most cases. Essential oil percent were affected with the different water regime. Spraying 100 and/or 200 ppm salicylic acid interacted with 10 days irrigation intervals resulted in the highest value of oil % in the first cut. Increasing irrigation intervals up to 15 and 20 days the oil % showed a drusting decreasing effect, which 100 ppm salicylic acid with 20 days irrigation intervals has a slight promoting effect on oil percent.

Table: (1) Effect of Irrigation intervals on Thyme plant (mean of the two seasons)

Chac.	Plant height (cm)		Leaves No		Branches No		F.W. of leaves (g/plant)		F.W of branches (g/plant).	
Treat.	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
10 days	28.00	46.33	91.88	184.00	7.11	11.55	159.66	179.22	41.11	124.80
15 days	59.00	61.33	84.11	186.22	76.6	7.22	166.22	201.22	53.00	148.88
20 days	25.44	54.55	80.77	137.56	7.33	8.66	140.77	137.56	43.33	134.66
L.S.D. (0.05)	5.23	8.73	16.57	70.86	1,29	4.07	53.29	70.68	21.45	38.20

No= number, F.W. = fresh weight.

Continued of Table (1)

Chac. Treat.	D.W. of leaves		D.W. of branches		R.W.C.%		O.P.%	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
10 days	8.61	1085	3.18	8.89	55.32	59.37	2.38	2.98
15 days	6.75	9.88	3.53	13.00	47.25	59.08	1.85	2.16
20 days	7.50	7.27	3.09	8.94	37.36	49.08	1.76	2.12
L.S.D.(0.05)	3.18	3.41	1.62	3.62	3.92	17.31	0.19	0.36

D.W. = Dry weight, R.W.C. = Relative water content, O.P.=Osmotic potential

Table 2: Effect of Salicylic acid on Thyme plant (mean of the two seasons)

Chac. Treat.	Plant height (cm)		Leaves No		Branches No.		F.Wof leaves(g/plant)		F.W of branches (g/plant)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
SA 0 ppm	28.88	58.66	100.11	199.67	7.33	10.11	194.77	199.67	53.33	153.77
SA 100 ppm	31.11	55.44	95.00	176.66	8.66	11.00	184.44	176.66	52.11	148.11
SA 200 ppm	32.44	44.66	61.66	131.44	6.11	6.33	87.44	131.44	32.00	104.55
L.S.D.(0.05)	8.70	8.95	17.02	41.53	3.27	2.98	85.39	41.53	10.00	29.64

SA= Salicylic acid. No= number, F.W. = fresh weight.

Continued of Table: (2)

Chac. Treat.	D.W. of leaves 1st	D.W. of leaves 2nd	D.W. of branches 1st	D.W. of branches 2nd	R.W.C.% 1st	R.W.C.% 2nd	O.P.% 1st	O.P.% 2nd
SA 0 ppm	10.46	8.49	4.18	12.66	42.98	64.97	2.02	2.03
SA 100 ppm	8.27	9.59	3.21	10.47	54.69	58.95	2.11	2.60
SA 200 ppm	4.12	9.93	2.41	7.70	42.25	46.05	1.85	2.47
L.S.D. (0.05)	2.64	2.63	0.52	4.25	8.70	7.39	0.15	0.58

D.W.= Dry weight, R.W.C. = Relative water content, O.P.=Osmotic potential

Table 3: Effect of interaction between irrigation water intervals and salicylic acid on Thyme plant (mean of the two seasons)

Treat Charc.		10 days +0 SA	10 days +100 SA	10 days +200 SA	15 days +0 SA	15 days +100 SA	15 days +200 SA	20 days +0 SA	20 days +100 SA	20 days +200 SA	L.S.D. (0.05)
Plant height (cm)	1st	32.oo	40.00	12.00	43.33	35.66	38.00	29.66	28.00	18.66	9.15
	2nd	58.66	51.33	30.66	53.66	61.33	63.00	57.66	53.66	40.33	15.50
Leaves No	1st	101.60	117.33	56.66	98.66	82.66	71.00	100.00	85.00	57.33	28.60
	2nd	239.00	201.00	112.00	190.67	192.00	176.00	169.33	137.00	106.33	71.90
Branches No.	1st	6.66	9.66	5.00	8.33	7.33	7.33	7.00	9.60	6.00	2.24
	2nd	12.67	14.33	7.17	9.67	6.67	5.33	8.00	12.00	6.00	5.16
F.W. of leaves (g/plant)	1st	190	212.33	70.66	183.66	192.66	122.33	210.66	142.33	69.33	92.00
	2nd	222.67	210.67	104.33	230.67	174.00	199.00	234.67	217.00	167.67	38.44
F. W. of branches (g/plant)	1st	176.66	49.66	27.00	56.33	54.00	48.66	57.00	52.66	20.33	17.32
	2nd	152.66	151.66	70.33	168.33	133.66	138.66	140.33	159.00	104.66	51.39

SA= Salicylic acid. No= number, F.W. = fresh weight.

Continued of Table: (3)

Treat Charc.		10 days +0 SA	10 days +100SA	10 days +200SA	15 days +0 SA	15 days +100 SA	15 days +200 SA	20 days +0 SA	20 days +100 SA	20 days +200 SA	L.S.D. (0.05)
D W. of leaves (g/plant)	1st	10.49	9.33	6.02	10.13	6.29	2.82	10.27	8.71	3.58	4.58
	2nd	9.10	13.39	10.08	9.72	9.73	10.19	6.65	6.61	9.59	4.55
D.W.of branches (g/plant)	1st	3.44	3.60	2.50	2.34	4.76	3.49.	8.83	4.18	1.25	0.91
	2nd	13.86	8.22	4.61	13.79	11.60	13.61	10.33	11.59	4.89	7.36
R.W.C%	1st	48.62	66.17	51.18	54.55	49.56	37.62	25.77	48.36	37.95	15.07
	2nd	65.07	39.53	73.50	61.16	66.48	49.59	68.68	40.81	69.07	12.79
O.P.%	1st	2.38	2.36	2.38	1.59	2.38	1.59	2.11	1.59	1.59	0.85
	2nd	2.98	2.64	2.44	2.12	2,78	1.59	1.59	2.38	2.38	0.96
Oil %	1st	0.07	2.22	2.08	0.04	0.36	1.00	0.53	1.13	0.52	-
	2nd	0-12	0.84	0-18	1.30	0.34	0.42	0.36	1.44	0.18	-

D.W.= Dry weight, R.W.C. = Relative water content, O.P.=Osmotic potential SA= Salicylic acid

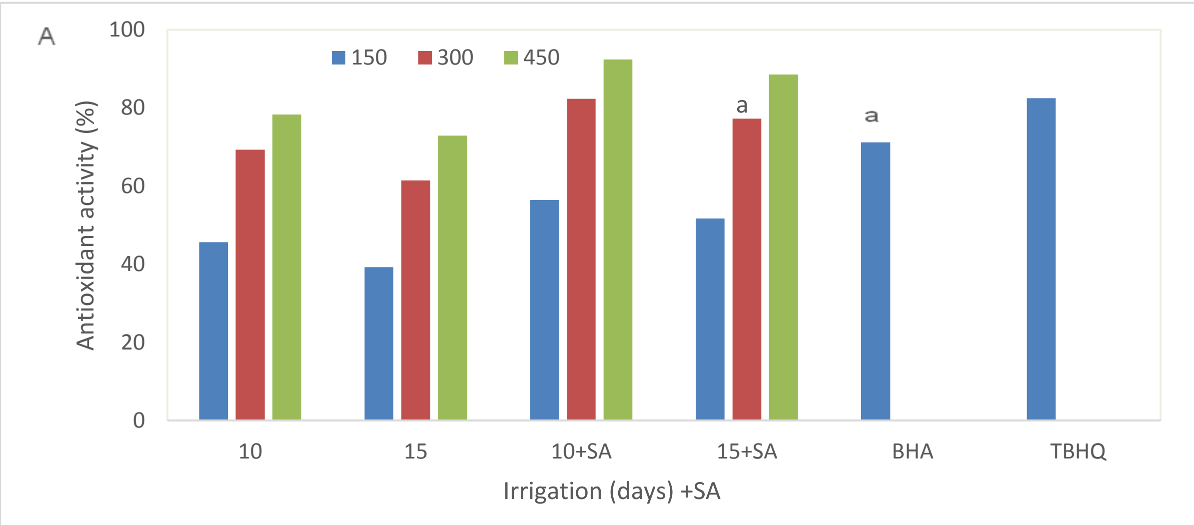
Effect of irrigation intervals and salicylic acid on phytochemical and antioxidant of thyme essential oil The changes in total phenolic and flavonoid contents in thyme essential oil were followed by the assay of folin-ciocalte and aluminum chloride respectively and the obtained data are given in Table (4). The results revealed that increase the irrigation time from 10 to 15 days affected the concentration of total phenolic which reduced from 57.32 to 49.55 mg GAE/g, respectively. The same trend was observed after interaction of irrigation time with SA, since the reduction was 67.31 after 10+SA to 61.84 after 15+SA. While, the highest total flavonoid content was found in the essential oil of plants collected after 10+SA with concentration of 48.26 mg QE/g, the least value was obtained after irrigation of 15 days "39.59 mg QE/g" (Table 4).

Table 4: Effect of irrigation intervals and salicylic acid (SA) on total phenolic, flavonoids contents of thyme

Treatment	Phenolic content (mg GAE/g)	Flavonoids content (mgQE)/g)
10	57.32±0.23*	42.67±0.19
15	49.55±0.17	39.59±0.31
10+SA	67.31±0.14	48.26±0.17
15+SA	61.84±0.27	44.72±0.26

*Values are expressed as mean± SD

The antioxidants play an important role in the inhibition of deleterious effect of free radicals role in food technology, pharmaceutical industry and biological system. In the current study the antioxidant activity were determined by DPPH^0 and β-carotene methods and the results are given in (Fig. 1). Results of our study indicated that elongation the irrigation time caused a signification reduction in antioxidant activity. The interactions of SA minimize the reduction of antioxidant activity (Fig. 1). The reduction of antioxidant activity was confirmed by the data of total phenolic as well as flavonoid contents in (Table 4). The antioxidant activity of thyme essential oil correlated well with the presence of phenolic compound like, thymol, carvacrol, γ-terpinene [32]. The obtained results in contrast with those obtained by [33],[34] who observed that an increase in total phenolic content in thymus plants treated with GA_3 and citrus fruits treated with SA, respectively. These variations may be due the difference in applied concentrations and species of thyme under investigation.



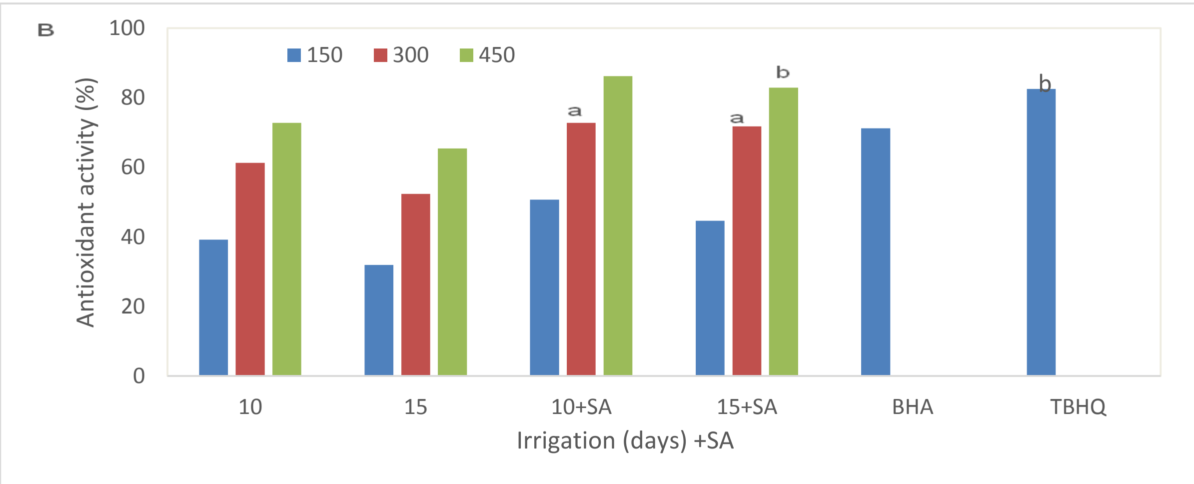


Fig. 1 Effect of irrigation intervals and salicylic acid (SA) on antioxidant activity of thyme essential oil determined by DPPH^0 (A) and β-carotene assays (B). Columns with the letter are not significant ($P \leq 0.05$).

Table 5: Effect of irrigation interval and salicylic acid (SA) at 200 ppm on essential oil composition of *T. Vulgaris*

		Irrigation interval (days)			
Volatile compound	RI [a]	10	15	10+SA	15+SA
α-Thujene	926	0.92[b]	0.85	0.52	0.49
α-Pinene	931	1.16	1.24	2.03	1.74
Camphene	948	0.84	0.95	0.13	0.08
1-Octen-3-ol	965	n.d	0.63	0.09	0.75
3-Octanone	968	0.37	0.06	0.17	0.34
β-Pinene	975	1.98	2.09	1.12	0.72
Myrcene	987	0.71	0.57	0.03	0.25
Sabinene	998	0.64	0.16	1.07	1.03
α-Phellandrene	1008	0.95	1.12	0.85	1.14
α- Terpinene	1017	0.74	0.08	1.19	0.58
P-Cymene	1024	3.17	0.62	0.07	0.83
Limonene	1031	1.09	0.93	0.27	0.31
1,8-Cineole	1037	0.63	0.58	1.32	0.46
(Z)- β- Ocimene	1041	1.78	n.d	0.63	0.04
Benzen acetaldehyde	1048	0.19	1.17	1.15	0.19
(E)- β- Ocimene	1051	0.38	0.24	0.28	0.35
γ- Terpinene	1064	7.45	5.36	8.26	8.41
Cis- Sabinene hydrate	1071	1.16	2.28	2.05	1.37
Terpinolene	1088	0.67	0.61	0.71	0.23
Linalool	1103	2.46	3.19	1.13	1.08
Camphor	1142	3.13	2.25	4.19	2.15
Terpinene-4-ol	1179	0.49	1.13	0.53	0.48
Thymol	1302	57.42	59.41	61.49	60.42
Carvacrol	1316	6.37	8.12	7.13	8.97
Eugenol	1365	0.18	0.09	0.03	0.06
(E)- Caryophyllene	1423	1.73	2.45	1.13	1.51

[a]: RI retention indices determined on DB-5 capillary column; n.d - not detected

The selected treatments were subjected to extraction of essential oil by hydro distillation and analysis by GC and GC/MS. The analysis identified 26 volatile compounds in the essential oil and the obtained results are given in Table (5). It showed that thymol is the main volatile compound in thyme essential oil which varied from 57.42% to 61.49% in the plant essential oil after 10 days of irrigation and interaction of SA, respectively followed by γ-Terpinene and carvacrol with concentration of 7.45% and 6.37%, respectively in collected plants after 10 days of irrigation. These results in were demonstrated by the findings of [6], [35]. While the elongation irrigation time from 10 to 15 days showed increase in thymol content from 57.42% to 59.41%, respectively, the interaction of SA showed a nonsignificant decrease from 61.49% to 60.42% after 10 and 15 days of irrigation respectively. This observation may be due to the transformation of p-cymene to thymol or carvacrol [36].

4. CONCLUSION

Thyme plant needs more water and sensitive to drought stress. The treatment of 10 days irrigation intervals provided plants with adequate supply of water and recorded highest increments in plant growth parameters. Salicylic acid treatments had no or insignificant effect under drought on growth as well as oil percent. The interaction of SA with elongation irrigation time may reduce the reduction in total phenolic, antioxidant activity and the main volatile compounds in thyme essential oil.

5. ACKNOWLEDGEMENT

I extend my sincere thanks and appreciation and gratitude for the National Research Centre to provide support to complete this work.

6. CONFLICT OF INTEREST

The authors have no conflict of interest.

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