Available online at sjuoz.uoz.edu.krd

Science Journal of University of Zakho
Vol. 12, No.2, pp.250–256 April-June, 2024

journals.uoz.edu.krd

p-ISSN: 2663-628X
e-ISSN: 2663-6298

DIFFERENT LEVELS OF SALICYLIC ACID AND DROUGHT IMPACTS ON MAIN PHYTOCHEMICAL COMPOUNDS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Received: 5 Jan., 2024 / Accepted: 28 Apr., 2024 / Published: 23 June., 2024. https://doi.org/10.25271/sjuoz.2024.12.2.1249

ABSTRACT

This study covered 2 locations, using 3 replications with randomized complete block design (RCBD) as a split-plot factorial arrangement, to determine the effect of both irrigation (I_1, I_2, & I_3) and salicylic acid application (S_1), and non-SA (S_0) treatments, respectively, on sunflower seed oil % and main phytochemical components %, at ache-forming, flowering, and vegetative stages, compared to complete irrigation (I_4). SA applied with full irrigation resulted in the highest values of seed oil % and overwhelming majority phytochemical components. On the contrary, the lowest values were noted by none (SA) application with skipping irrigation at the flowering-stage (I_2S_0).

KEYWORDS: Phytochemicals, Sunflower oil, Abiotic stress, Salicylic acid.

1. INTRODUCTION

For vegetable oil, sunflower is the best source after rapeseed, soybean and oil palm (Rauf *et al*., 2017). Also, sunflowers are used as a human snack and baking (Kiani *et al*., 2007). It has a high amount of unsaturated fatty acids and 0 cholesterol level (Alberio & Aguirrezábal, 2014).

Flavonoids, sugars, saponins, tannins, alkaloids, phytosterols, fixed oils, and active proteins are some of the most important phytochemicals obtained from *H. annuus* (Hamad, 2017; Bashir *et al*., 2021). Sunflower seeds contain proteins, peptides, amino acids, carbohydrates, lipids, palmitic acid, linoleic acid, vitamins, carotenoids, chlorogenic acid, caffeic acid and quinic acid, as well as S, K, Na, Mg, Ca and P (Boriollo *et al*., 2014). The flavonoids, quercetin, kaempferol, luteolin, apigenin, and kaempferol were found in the seeds' chemical composition. For flavonoids, the common substitution patterns include 3,5,7,3,4, pentaoxygenation and 3,5,7,4, tetraoxygenation (Guo *et al*., 2017).

The phytochemical components are greatly affected by ater availability during sunflower growth stages (Anastasi *et al*., 2010). At every stage of development and growth, deficit irrigation has an impact on oil phytochemicals (El Midaoui *et al*., 2001).

SA has effects on enzymes such as peroxidases and catalases, as well as regulators (glycine, proline and ameliorates) on the drought stress (Pancheva *et al*., 1996). Antioxidant capacity is increased by SA which enhances leaf peroxidase activity (Noreen *et al*., 2012). In the stress, SA helps to keep stress effects to a minimum (Gharib, 2006). SA regulates physiological function in plants (Moghaddam *et al*., 2011). After the application of SA, the leaves of rapeseed rose made Glucosinolate from thioglucoside (Hayat *et al*., 2007). When plant tissues are damaged, the hydrolysis of glucosinolates releases a variety of compounds that shield plants from pests and pathogens (Hamad, 2021; Hamad *et al*., 2023). Its impact on oil and seed yields is significant, when SA is employed at a limiting concentration (Bapir and Hamad, 2022).

The effect of (SA) with various skipping irrigation on sunflower oil % and seed main chemical compounds % was the study main objective.

2. MATERIALS AND METHODS

2.1 The Experimental Site Location

Both locations are located in Sulaimani Governorate in northeastern Iraq. The 1st location (Ranya City) is located in Sulaimani northwest (607 masL, Longitude: 44° 51' 29 E Latitude: 36° 16' 30 N). The 2nd location (Qaldza City) is located in Sulaimani northwest (612 masL, Longitude: 45° 06' 29 E, Latitude: 36° 11' 34 N) (Google Earth, Version 9.154 2/2022) (Figure 1).

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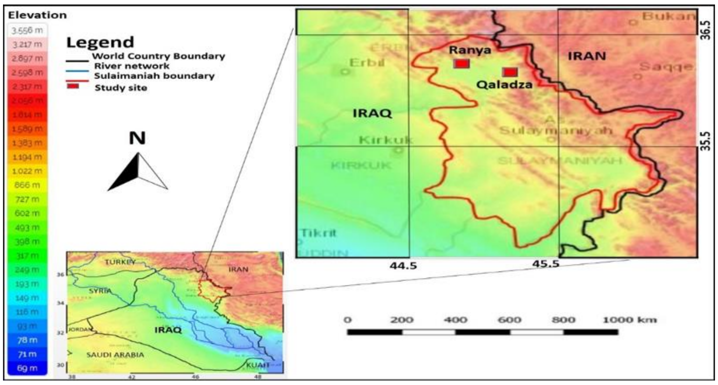

Figure 1: The study locations

2.2 Climatic Conditions of the Region:

Table 1 illustrates 2021 agrometeorological parameters during the experiment season (summer) at Ranya and Qaladza locations.

Table 1: Agrometeorological parameters during summer season 2021 at Ranya and Qaladza locations

Locations	**Month**	**Air temperature °C**		**Average humidity (%)**	**Average wind speed (ms^{-1})**	**Precipitation (mm)**
		Minimum	**Maximum**			
Ranya	June	22.3	39.83	15.2	1.7	0
	July	26.96	43.26	17.4	1.4	0
	August	26.2	42.36	18.1	1.6	0
	September	19.9	36.63	20.4	1.7	0
Qaladza	June	17.3	38.86	15.0	1.9	0
	July	21.73	41.56	16.4	1.6	0
	August	23.03	41.43	18.4	1.7	0
	September	16.36	35.33	19.7	2	0

2.3 Irrigation and Salicylic treatments

Each location includes 4 full and skipped irrigation treatments with 2 (SA) with 200 mg L-1 and non-applied SA (Noreen *et al*., 2012; Bapir & Hamad, 2023). SA was sprayed on leaves at different stages. DW was sprayed on leaves on both locations at the same time. More details are in Table (2).

Table 2: Details of irrigation and (SA) treatments at both locations

symbols	**Description**
I_1	The vegetative stage skipping irrigation
I_2	The flowering stage skipping irrigation
I_3	The achene formation stage skipping irrigation
I_4	Non-skipping irrigation (full irrigation)
S_0	Non-applied (SA) (spry distil water on leaves)
S_1	(SA) applied

2.4 Experimental Design

Randomized complete block design (RCBD) was used with 3 replications, as split-plot factorial arrangement with the irrigation treatments as the primary plots (I_1, I_2, I_3, and I_4), and the sub-plot factorial included S_0 and S_1 to AS treatments.

2.5 Field Preparation and Layout

After soil surface leveling, for each location, the field was divided into 3 main plots and 8 subplots with 9 m^2 (3 x 3 m^2) for each replication. In each subplot, 4 rows were planted, spaced 0.75 m, and sunflower seeds were placed at 4-6cm depths, 3 seeds $hole^{-1}$, with 0.30 m plant spacing. Across all treatments, the plant population were 44400 plants ha^{-1}. To 1 plant $hole^{-1}$ they were thinned after seedlings. As needed, weeding by hand was conducted without the application of fertilizer and pesticides. To protect from bird attacks, sunflower heads were covered with a specific screen.

2.6 Hybrid Description

The first generation of NS Leviathan was produced at Novi Sad-Serbia by Field Crop Institute, in May 2021 (Bapir & Hamad, 2022).

2.7 Sowing Date

It was sown on June 21 and 22 , 2021 on the line, at Ranya via Qaladza locations, respectively.

2.8 Watering and Restrictions

A drip irrigation system was used that received water from a tank, and it was closed through drip irrigation tubes to irrigate each sunflower plant in the various treatments, equally. At different growth stages, to skip irrigation, the dripper points were closed (Bapir & Hamad, 2022).

2.9 Analytical Methods

2.9.1 Soil Analysis

For both locations (Ranya & Qaladza), at different depths (30, 60, and 90 cm), 5 kg of soil samples were taken. After cleaning and crushing, use a 2 mm stainless-steel sieve for soil sieving.

To textural class determination used (2.00, 0.05 and 0.002 mm) sieves (international sieve method). The electrical conductivity (EC) and (pH) of water and soil solution (1:10) were determined using the pH model WTW 330i. Walkley-Black method was used to determine the soil organic matter % (O.M. %), with this formula: Organic matter % = Organic carbon % X (1.724 (factor)). $CaCO_3$ was determined using a 23c method (The United States Salinity Laboratory). Staff developed this method in 1954. The soil moisture content (on a weight basis) was determined gravimetrically with Equation 1 (Bapir & Hamad, 2022; Smith *et al*., 1997), and Table 3 shows the soil data results.

$$\text{Soil moisture \%} = \frac{\text{Wet weigh} - \text{Oven dry weigh}}{\text{Oven dry weigh}} \text{ X } 100 \text{ …… (1)}$$

Table 3: Physicochemical properties of the soil samples for both experiment locations

Physicochemical properties		Locations	
		Ranya	Qaladza
Particles size distribution %	Sand	5.8	4.5
	Silt	59.7	62.6
	Clay	34.5	32.9
	Texture	Silty loam	Silty loam
pH		7.60	7.49
ECe (dc m^{-1}) or (DS m^{-1})		0.5	0.5
O.M. %		0.5	0.4
$CaCO_3$ %		8.2	7.9
Soil moisture content %		5.7	4.8

2.9.2 Extraction of seed oil and phytochemical components

From each treatment the seed sample was taken with an Electric Blender. Then dissolved with petrol ether. The crude fat was utilized by a Soxhlet (Instruction Manual Soxtherm S306 A. 2000).

Twenty-five g of the sunflower seed air-dried powder were extracted (through maceration) by adding ethanol 99.8% (225) mL and shaking at 85 rpm for 24 hours at 25 °C. In a Buchner funnel, used (Whatman No. 1) filter paper to the extract filtration and it was dried with a rotatory vacuum evaporator (Heidolph, North America, Wood Dale, IL) (Kryuchkov *et al*., 2022). The dried extracts were stored at 4°C in the dark until GC-MS analysis.

2.9.3 Seed oil % and phytochemical components % determination:

Agilent 7890A Gas Chromatograph (GC-MS) with a silica column (19095-400) fused and an electron impact quadrupole (MD 800) mass spectrometer detector (30 m length and 0.25 µm inner-diameter) and the 0.25 µm thick stationary phase was used. Set the injection column temperature to 35 °C /2.50 min, then progressively increase to 280 °C in 7°C increments for 20 minutes. Using computer matching (NIST) to volatile oil identity. Equation 2 is used to determine the oil %.

$$\text{Oil \%} = \frac{\text{The oil extracted with the flask's weight} - \text{Empty flask weight}}{\text{The sample's weight}} \text{ X } 100 \text{ ….. (2)}$$

Statistical analysis

The IBM SPSS (version26) was used to examine statistically the parameters. To determine significant effects, using the $P \leq 0.05$ significance criterion with the analysis of variance (ANOVA), an approach to split-plot in RCBD with Duncan's multiple-range test.

3. RESULTS AND DISCUSSION

3.1 Effect of irrigation treatments on main phytochemical components % and oil at both locations (Ranya and Qaladza):

As indicated in Table 4, the irrigation treatments effect was of significant differences for all characters 8,11-Octadecadiynoic acid, methyl ester % (OAME%), 2,4-Decadienal, (E,E)- % (DEE%), Ascaridole epoxide % (AE%), Pyrazole(4,5-b)imidazole, 1-formyl-3-ethyl-6-beta.-d-ribofuranosyl % (PIFEBR%), Formamide, N-methyl-N-4- {1-(pyrrolidinyl)-2-butynyl} % (FNMB%), 2-Buten-1-one, 1- [2,6,6-trimethyl-1-cyclohexen-1-yl] % (BOTC%), 10- Heptadecen -8- ynoic acid, methyl ester, (E)- % (HYME%), 1,2-Ethanediol, diacetate % (ED%) and oil %.

The rate of OAME %, DEE %, AE %, PIFEBR %, FNMB %, BOTC %, HYME %, ED % and oil produced the highest value under full irrigation I_4 which were 0.763%; 55.916%; 10.575%; 8.700%; 3.053%; 6.131%; 2.340%; 5.645%; 31.483%; 1217.538 kg h^{-1}, 0.751%; 48.223%; 4.413%; 8.243%; 1.725%; 5.252%; 1.996%; 5.682% and 28.616%, at both locations, respectively while the lowest values of all characters recorded under I_2 were 0.499%; 22.401%; 7.562%; 5.557%; 0.997%; 3.491%; 0.995%; 4.247%; 25.720%, and 0.451%; 23.103%; 3.339%; 4.816%; 0.626%; 3.084%; 0.990%; 4.018%; 22.626, at both locations, respectively.

This study detected that available water increased the % of sunflower seed main phytochemicals and oil % increased as well as the primary water-deficit-sensitive parameters during the flowering and reproduction development stages. Furthermore, various adjustments have been made to lower the frequency of oxidative stress by utilizing antioxidants (Salih *et al*., 2021). Previous research suggested that increased irrigation rate levels increased seed oil content (Ashrafi & Razmjoo, 2010; Mahmood *et al*., 2019). Water deficits is allowed during seed production, but throughout the flowering stage it should be avoided (Rajper *et al*., 2021). However, crops that are water-stressed during the blossoming stage can have effect on oil content (Ali *et al*., 2013). Lower irrigation levels drastically decrease the sunflower oil content (Sezen *et al*., 2011). As water availability increases, the % of oleic acid increases (Anastasi *et al*., 2010). Sunflower's reproductive formation and the blooming stages were the most sensitive to dryness concerning the oil content (Kaya & Kolsarici, 2011). Drought resulted in a considerable reduction of 8-14% of oleic acid in a conventional hybrid (Flagella *et al*., 2002).

Table 4: Effect of irrigation treatments on main phytochemical components % and oil % at both locations (Ranya and Qaladza)

Irrigation treatments	OAME	DEE	AE	PIFEBR	FNMB	BOTC	HYME	ED	Oil %
Ranya location									
I_1	0.669^b	37.602^b	9.422^b	6.906^b	2.495^b	4.975^b	1.369^b	5.574^a	28.153^c
I_2	0.499^d	22.401^d	7.562^c	5.557^c	0.997^c	3.491^c	0.995^b	4.247^c	25.720^d
I_3	0.618^c	25.323^c	9.189^b	6.088^c	2.271^b	4.970^b	1.292^b	5.229^b	29.463^b
I_4	0.763^a	55.916^a	10.575^a	8.700^a	3.053^a	6.131^a	2.340^a	5.645^a	31.483^a
Qaladza location									
I_1	0.649^b	34.208^b	4.055^b	6.834^b	1.532^a	4.090^b	1.292^b	5.509^a	24.780^b
I_2	0.451^d	23.103^c	3.339^c	4.816^d	0.626^b	3.084^c	0.990^c	4.018^c	22.626^c
I_3	0.566^c	25.396^c	3.921^b	5.880^c	1.504^a	3.971^b	1.267^b	4.535^b	25.886^b
I_4	0.751^a	48.223^a	4.413^a	8.243^a	1.725^a	5.252^a	1.996^a	5.682^a	28.616^a

3.2 (SA) effect on main phytochemical components % and oil % at both locations (Rana and Qaladza):

Table 5 shows that the SA effect had significant differences for all characters except the HYME, which were of no significant differences at the first location. However, at the 2nd location, it was responded significant differences for DEE %, AE %, PIFEBR %, HYME %, ED % and oil%, but there was no significant difference for OAME %, FNMB % and BOTC %.

The rate of 8,11-Octadecadiynoic acid, methyl ester % (OAME%), 2,4-Decadienal, (E,E)- % (DEE%), Ascaridole epoxide % (AE%), Pyrazole (4,5-b) imidazole, 1-formyl-3-ethyl-6-.beta.-d-ribofuranosyl % (PIFEBR%), Formamide, N-methyl-N-4- {1-(pyrrolidinyl)-2-butynyl} % (FNMB%), 2-Buten-1-one, 1- [2,6,6-trimethyl-1-cyclohexen-1-yl] % (BOTC%), 10-Heptadecen -8-ynoic acid, methyl ester, (E)- % (HYME%), 1,2-Ethanediol, diacetate % (ED%) and oil% produced the highest value under (SA) applied S1 were 0.6594%; 36.072%; 9.5707%; 7.113%; 2.4778%; 5.4187%; 1.5744%; 5.4774%; 29.4827%, and 0.6166%; 34.2615%; 4.3299%; 6.618%; 1.4364%; 4.1627%; 1.4943%; 5.2883%; 25.9766%, at both locations, respectively. The lowest values of all characters recorded under S0 were 0.6153%; 34.5492%; 8.8036%; 6.5128%; 1.9304%; 4.365%; 1.4237%; 4.87%; 27.9273%, and 0.5924%; 31.203%; 3.5341%; 6.2681%; 1.2571%; 4.0363%; 1.2787%; 4.5839%; 24.9771%, at both locations, respectively. SA spraying boosted the activity of enzymes when compared to a control (Bapir &Hamad, 2023). Antioxidants' capacity to lessen the negative effects and their defense against oxidative stress (Salih *et al*., 2023). Therefore, the sequential application of some phytochemical compounds improves the growth and yield of crops (Dogara *et al*., 2022). SA preserves superoxide dismutase activity for O_2 removal, it guards against oxidative damage (Rao *et al*., 1997). H_2O_2 inhibited SA and free benzoic acid accumulation in tobacco leaves. H_2O_2 initiates the manufacture of (SA) (Leon *et al*., 1995).

Table 5: Effect of (SA) treatments on main phytochemical components % and oil % at both locations

(SA) treatments	OAME	DEE	AE	PIFEBR	FNMB	BOTC	HYME	ED	Oil %
Ranya location									
S0	0.6153^b	34.5492^b	8.8036^b	6.5128^b	1.9304^b	4.365^b	1.4237^a	4.87^b	27.9273^b
S1	0.6594^a	36.072^a	9.5707^a	7.113^a	2.4778^a	5.4187^a	1.5744^a	5.4774^a	29.4827^a

Qaladza location									
S0	0.5924^{a}	31.203^{b}	3.5341^{b}	6.2681^{b}	1.2571^{a}	4.0363^{a}	1.2787^{b}	4.5839^{b}	24.9771^{b}
S1	0.6166^{a}	34.2615^{a}	4.3299^{a}	6.618^{a}	1.4364^{a}	4.1627^{a}	1.4943^{a}	5.2883^{a}	25.9766^{a}

3.3 Interactive effect of (SA) and irrigation treatments on main phytochemical components % and oil % at both locations:

Table 6 sho ws the interaction between irrigation treatments and (SA), it shows the height significant differences for all characters ((8,11-Octadecadiynoic acid, methyl ester % (OAME%), 2,4-Decadienal, (E,E)- % (DEE%), Ascaridole epoxide % (AE%), Pyrazole (4,5-b) imidazole, 1-formyl-3-ethyl-6-.beta.-d-ribofuranosyl % (PIFEBR%), Formamide, N-methyl-N-4- {1-(pyrrolidinyl)-2-butynyl} % (FNMB%), 2-Buten-1-one, 1- [2,6,6-trimethyl-1-cyclohexen-1-yl] % (BOTC%), 10-Heptadecen -8-ynoic acid, methyl ester, (E) % (HYME%), 1,2-Ethanediol, diacetate % (ED%) and oil %)), at both locations.

The rate of OAME %, DEE %, AE %, PIFEBR %, FNMB %, BOTC %, HYME %, ED % and oil% produced the highest value under interaction of full irrigation (non-skipping irrigation) and (SA) applied I_4S_1 were 0.765%; 57.379%; 11.074%; 9.337%; 3.375%; 6.150%; 2.362%; 6.051%; 32.530%, and 0.764%; 52.686%; 4.968%; 8.493%; 1.771%; 5.409%; 2.028%; 6.092%; 29.049% at both locations, respectively. While, at the first location, the lowest values of characters OAME %, DEE %, AE %, PIFEBR %, FNMB %, BOTC % and oil% recorded under I_2S_0 were 0.461%, 21.504%, 6.912%, 5.092%, 0.840%, 3.089% and 25.446% respectively. The minimum of HYME % and ED % were 0.974% and 4.237% recorded under I_2S_1 respectively. But, at the second location, the lowest values of all characters recorded under I_2S_0 were 0.442%, 22.727%, 2.925%, 4.669%, 0.316%, 2.986%, 0.954%, 3.974% and 22.19%, respectively.

These results showed that none SA and water deficit treatments are the most susceptible during the flowering and reproduction development stages. In addition, it was confirmed that application of SA enhanced the % of seed main phytochemicals, oil %, and oil production per unit of available water; additionally, the application of (SA) alleviated drug stress in sunflower plants. Using (SA) in sunflower irrigation schemes became a must-do to conserve water and reduce crop losses brought on by drought stress (El–Bially *et al*., 2022). Deficit irrigation and (SA) have an impact on oil content at every stage of growth and development (Ashrafi & Razmjoo, 2010). SA inhibits catalase and peroxidase enzymes and osmotic-regulators (proline, glycine, and betaine) in some plants and mitigates the stress effects (cold, drought, salinity, heavy metals, and heat) (Pancheva *et al*., 1996).

Table 6: Interactive effect of (SA) and irrigation treatments on main phytochemical components % and oil % at both locations

Irrigation and (SA) treatments		OAME	DEE	AE	PIFEBR	FNMB	BOTC	HYME	ED	Oil %
Ranya location										
I_1	**S_0**	0.650b^{c}	37.253^{c}	9.275^{cd}	6.779^{cd}	2.120^{cd}	4.082^{bc}	1.11^{3c}	5.181^{c}	27.652^{c}
	S_1	0.689^{ab}	37.952^{c}	9.570^{c}	7.034^{c}	2.871^{b}	5.868^{a}	1.626^{b}	5.967^{a}	28.654^{c}
I_2	**S_0**	0.461^{e}	21.504^{e}	6.912^{f}	5.092^{e}	0.840^{e}	3.089^{c}	1.016^{c}	4.256^{e}	25.446^{d}
	S_1	0.537^{d}	23.298^{de}	8.213^{e}	6.022^{d}	1.154^{e}	3.894^{bc}	0.974^{c}	4.237^{e}	25.995^{d}
I_3	**S_0**	0.590^{cd}	24.988^{d}	8.953^{d}	6.117^{d}	2.032^{d}	4.178^{b}	1.248^{bc}	4.804^{d}	28.175^{c}
	S_1	0.647^{bc}	25.659^{d}	9.426^{c}	6.059^{d}	2.511^{bc}	5.763^{a}	1.336^{bc}	5.655^{b}	30.752^{b}
I_4	**S_0**	0.760^{a}	54.452^{b}	10.075^{b}	8.063^{b}	2.730^{b}	6.112^{a}	2.317^{a}	5.239^{c}	30.436^{b}
	S_1	0.765^{a}	57.379^{a}	11.074^{a}	9.337^{a}	3.375^{a}	6.150^{a}	2.362^{a}	6.051^{a}	32.530^{a}
Qaladza location										
I_1	**S_0**	0.634^{bc}	33.418^{c}	3.699^{c}	6.698^{b}	1.521^{ab}	4.122^{b}	1.060^{c}	5.030^{c}	24.533^{c}
	S_1	0.664^{b}	34.997^{c}	4.412^{b}	6.969^{b}	1.542^{ab}	4.059^{b}	1.524^{b}	5.989^{a}	25.027^{c}
I_2	**S_0**	0.442^{e}	22.727^{d}	2.925^{d}	4.669^{d}	0.316^{c}	2.986^{c}	0.954^{c}	3.974^{d}	22.19^{d}
	S_1	0.460^{e}	23.478^{d}	3.752^{c}	4.962^{d}	0.936^{bc}	3.183^{c}	1.026^{c}	4.062^{d}	23.061^{d}
I_3	**S_0**	0.555^{d}	24.906^{d}	3.654^{c}	5.712^{c}	1.511^{ab}	3.942^{b}	1.135^{c}	4.060^{d}	25.003^{c}
	S_1	0.577^{cd}	25.885^{d}	4.188^{b}	6.048^{c}	1.497^{ab}	4.000^{b}	1.399^{b}	5.010^{c}	26.769^{b}
I_4	**S_0**	0.738^{a}	43.760^{b}	3.859^{c}	7.993^{a}	1.679^{a}	5.095^{a}	1.965^{a}	5.272^{b}	28.183^{a}
	S_1	0.764^{a}	52.686^{a}	4.968^{a}	8.493^{a}	1.771^{a}	5.409^{a}	2.028^{a}	6.092^{a}	29.049^{a}

3.4 Effect of study locations on main phytochemical components % and oil %:

Figure 2 shows the location effect on oil, and it is components. AE%, FNMB% and oil% responded significant differences to location effect, but it didn't show any significant differences for OAME%, DEE%, PIFEBR%, BOTC%, HYME% and ED%.

It was confirmed that all the 1st location characters showed the highest values, they were predominated by 2.64, 3.78, 40.05, 2.79, 24.14, 8.81, 3.89, 2.35, 5.95 and 8.84 % respectively, compared to the 2nd location. These results support the suitability of the 1st location for sunflower oil and its components compared to the 2nd location.

Sunflower as a variable influenced by a variety of factors including soil quality, soil moisture, and soil organic matter, and at the 1st location, they are higher than the 2nd location.

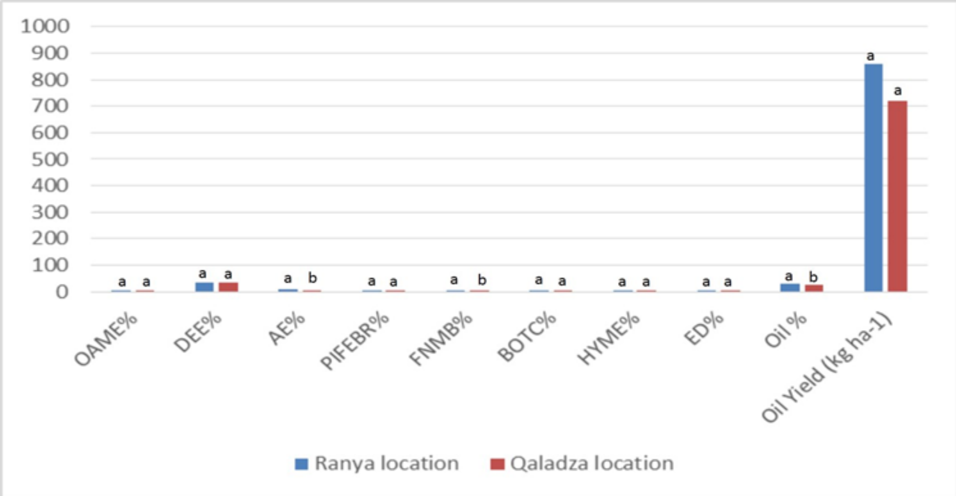

Figure 2: Effect of study locations on main phytochemical components % and oil %

CONCLUSION

At specific growth stage, sunflower is one of the candidates for deficit irrigation throughout the growing season. The ultimate objective of optimal irrigation management systems in deficient areas is to maximize both quantity and quality.

The findings of this experiment indicated that the maximum values reached by (SA) applied with full irrigation. If irrigation is more restricted, it is advisable to refrain from reducing irrigation water throughout the flowering stage. However, when a low concentration of (SA) is employed to sunflower, it has a significant effect on oil % and the seed's main phytochemical compounds %.

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