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Effect of Emulsifying Petroleum Derivatives, Water Deficit Treatment and Emitters Discharge on Dry Weight, Grain yield and Water use Efficiency of Sunflower (*Helianthus annuus* L.)

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Abstract: A field experiment was conducted in Qurnah district, Basrah province on clay soil to study the effect of six treatments of emulsifying petroleum derivatives with irrigation water by using emulsifying agent adding directly to soil surface, gas oil with two ratios of 0.3% (g3) and 0.5% (g5) w/w of soil dry weight, two admixture treatments of fuel oil and gas oil (1:1) with two ratio 0.3%(go3) and 0.5% (go5), fuel oil 0.3% (o3) and control treatment 0% (c) without any addition. The effect of water deficit factor also studied with two levels 0.85 (w1) and 0.65 (w2) of available water by using drip irrigation with two emitters; low discharge 5 Lhr^{-1} (Ld) and high discharge 15Lhr^{-1}(Hd). The results showed that all emulsified derivative conditioners significantly increased dry weight, grain yield and water use efficiency calculated for dry weight WUE (d) and grain WUE (g) of sunflower compared with control treatment, especially at g5 and go5 treatments which recorded the highest values. Soil capability for saving water and available water increased as a result of the addition of emulsified oil derivatives, which contributed to increase the interval time between irrigation periods and reduce the quantity of irrigation water with less value appearing at g5 and go5 under 65% water deficit treatment by using 15 Lhr^{-1} emitter discharge. Increasing emitter discharge from 5 to 15 L hr^{-1}, and increasing irrigation deficit from 0.65 to 0.85 led to increasing all growth parameters, except water use efficiency.

Keywords: Emulsifying petroleum derivative, Emitter discharge, Irrigation deficit, Water use efficiency.

Introduction

The deterioration of soil characteristics and irrigation scarcity are considered the main problems and limitations of agricultural production in arid and semi-arid regions due to the low organic matter content and climatic conditions, as well as failure to choose suitable irrigation system (Bouwer, 1994). Therefore, the use of soil conditioner is considered as one of the methods used to improve physical, chemical and hydrological properties of soil, especially soil structure that increase the ability of soil to store moisture and available water, thus creating suitable conditions for growth and production of crops (Al-Dagestani & Audafa, 1998). The drip irrigation is a suitable method for water scarcity that increases water use efficiency up to 90% due to low loss by evaporation and deep percolation, as well as the possibility of using a different quality of water (Stikic *et al*., 2003).

The movement rate of unsaturated water may be reduced significantly by using soil conditioners derived from petroleum due to the effect of hydrophobization of the soil pores and aggregate surface which led to reduce the sorptivity of water to soil surface, so this impact reduce the water movement in soil under drip irrigation especially at lateral movement, which is limited to the area of wetting front. Therefore, some techniques have been found to enhance this lateral unsaturated movement by using surface irrigation which alternated with drip irrigation or by using high discharge of emitter that increases the efficiency of salt leaching far away from the rhizosphere (Al-Mayahi, 2010; Al-Ibraheemi, 2014).

The deficit irrigation concept is one of the ways, that address water scarcity and increase the efficiency of water uses. It includes processing of scheduling of irrigation through irrigating the root zone with the quantity of water less than evapotranspiration potential must be rationing water use and increase water use efficiency as well as obtain economically acceptable production (English, 1990).

In fact, the water scarcity, poor quality of irrigation water resources and high evaporation potential causes soil salinization and deterioration of the soil characteristics then decline in crops productivity. The present study aimed to investigate the effect of emitter discharge and emulsified petroleum-derivative conditioners on the possibility to use irrigation deficit and their effect on dry and grain yield and water use efficiency of sunflower.

Materials and Methods:

A field experiment was conducted at Qurna district, Basrah province near Al-Gumayj river at 30° 56' 24.8" N and 47 ° 27' 52.0", on clay soil classified as fine silty, smectitic, Calcareous, Hyperthermic Typic Torrifluvents (Al-Atab, 2008). Some physical and chemical properties of soil are presented in table (1). analysis according to the analytical methods described in Black *et al*. (1965) and Page *et al*. (1982).

A field experiment includes three factors, the first was emulsified petroleum-derivative conditioners with six treatments fuel oil with ratio 0.3%(o3); gas oil with two ratios 0.3% (g3) and 0.5% (g5) w/w to dry soil; two admixture treatments of fuel oil and gas oil (1:1) with two ratio 0.3% (go3) and 0.5% (go5) and control treatment 0% (c). The derivatives were emulsified with irrigation water to obtain oil: water (o/w) emulsion by using suitable quantity of emulsifier agent (Anionic surfactant) Alkyl benzene sulfate acid, Sodium lauryl ether sulfate equal to 7 mM (Hermann *et al.,* 2001). The final volume of the mixture of water, oil, and surfactant was added to each experimental site to reach the moisture of field capacity for 0-30 cm depth. The second factor was emitter discharge including two treatments low discharge (Ld) 5Lhr^{-1} and high discharge (Hd) 15 Lhr^{-1}. The third factor, irrigation deficit including two levels 0.65 (w2) and 0.85 (w1) of available water which refer to re-irrigation when soil moisture content decreases to 0.60 of available water to restore soil moisture content up to 0.65 or 0.85 of available water.

The experiment was conducted according to the factorial experiment by using a Randomized Complete Block Design (R.C.B.D) with three replicates (6 derivatives × 2 emitter discharges × 2 irrigation deficit levels). Each experimental unit was represented by field tube (10 m) length that was fixed on it turbo emitter. The distance between emitters was 25 cm. Sunflower seeds were sown in March 2016. All units were fertilized with nitrogen, phosphate, and potassium.

Kohnke's mathematical equation cited by (USAID-Inma, 2012) has also been used to calculate the amount of irrigation water required according to the irrigation deficit level:

Table (1): Some physical and chemical properties of soil.

Properties		Soil depth 0-20	Soil depth 20-40
Sand	$g\ kg^{-1}$ soil	285.60	354.50
Silt	$g\ kg^{-1}$ soil	310. 80	410. 30
Clay	$g\ kg^{-1}$ soil	403.60	235.20
Texture		Clayey	loam
Mean weight diameter	mm	0.428	0.252
Organic matter	$g\ kg^{-1}$	9.20	2.11
E.C.	dSm^{-1}	3.21	2.68
Field capacity	%	30	
Wilting point	%	13	
Available water	%	17	
Dissolved ions mmole L^{-1}	Ca^{++}	6.28	4.83
	Mg^{++}	4.88	3.56
	Na^{+}	16.11	11.25
	K^{+}	0.44	0.23
	CO_3^{-2}	0.00	0.00
	HCO_3^{-1}	3.10	2.50
	SO_4^{-2}	5.69	4.09
	Cl^{-}	22.00	19.40

$$W = A \times \frac{\rho b}{\rho w} \times \left(\frac{pw_{fc}}{100} - \frac{pw_{wp}}{100}\right) \times \text{percent of water deficit} \times D \ldots\ldots\ldots (1)$$

where, W volume of water added to the experimental unit (m^3); A, experimental unit area (m^2); $Pw_{f.c}$, field capacity (w / w); Pw_{wp}, wilting point (w/w); ρ_b, ρ_w density of soil and water ($Mg.\ m^{-3}$) and D, Soil depth (m).

The time required to operate the drip irrigation system for each experimental unit was calculated using the following equation (Hajim & Yasin, 1992):

$$T = \frac{W}{Q \times N} \ldots\ldots\ldots (2)$$

where, T: Irrigation time (hours); W, the volume of water added to the experimental unit; Q emitter discharge ($L\ hr^{-1}$) and N, number of drippers in the sub line.

Result and Discussion

The dry weight of shoot

The results in tables (2 & 3) showed a significant effect of emulsified petroleum conditioners on dry weight of sunflower. Shoot dry weight increased by 45.14, 41.56, 33.18, 28.20 and 23.69 for gas oil with 0.5% (g5), mix gas oil and fuel oil with 0.5% (go5), gas oil with 0.3% (g3), mix gas oil and fuel oil with 0.3% (go3) and fuel oil with 0.3% (o3) respectively, compared with control treatment. The significant variations between conditioners themselves or with control treatment are due to the variation of their ability to make a stable and homogenous emulsion which characterized to form oil droplet less than 2 micrometre that able to penetrate and distribute through soil depths and soil pores overly (Dheyab, 2017). Therefore, it affects water holding capacity and increases the available water due to the decreasing of the hydraulic conductivity of water in the soil and unsaturated conductivity which led to reduce moisture loss by surface evaporation or deep percolation (Shabib, 2016). This its impact must improve soil structure and aggregate stability which contributes to providing suitable conditions for roots growth to absorb water and nutrients which increase the photosynthesis and other physiological processes and then increase the growth (Al-Maleky, 2005).

The results showed a significant effect of the emitter discharge on dry weight. The high discharge (Hd) gave high value compared to the low discharge (Ld) with increase per cent of 5.97 %. This is due to the efficiency of leaching salts away from the root zone and increasing the hydraulic conductivity of water in soil at the high discharge treatment (Camillia *et al*., 2006). Also the high discharge improved soil structure and increased soil moisture,

Table (2): Statistical analysis of the F test for the growth parameters of the sunflower crop.

Dripper discharge		5		15		Average of D*P		Average of P*w		Average of P
Water deficit		0.85	0.65	0.85	0.65	5	15	0.85	0.65	
Petroleum	c	2616.3	2518.6	2880.7	2593.8	2567.4	2737.3	2748.5	2556.2	2652.4
	o3	3170.5	3123.4	3614.7	3214.4	3147.0	3414.6	3392.6	3168.9	3280.8
	g3	3438.1	3354.5	3845.8	3491.6	3396.3	3668.7	3642.0	3423.0	3532.5
	g5	3896.9	3645.5	4137.7	3718.2	3771.2	3928.0	4017.3	3681.8	3849.6
	go3	3372.5	3209.3	3639.5	3380.0	3290.9	3509.8	3506.0	3294.7	3400.3
	go5	3849.8	3557.6	3985.4	3626.6	3703.7	3806.0	3917.6	3592.1	3754.8
$RLSD_{0.05}$		6.29				4.43		4.43		3.12
W*D	0.85	4088.8		4127.2		Average of D.		Average of W.		
	0.65	3121.3		3407.4		3312.7	3510.7	3537.3	3286.1	
$RLSD_{0.05}$		2.56								

which contributed to enhancing growth of root and shoot and thus increase absorption of water and nutrients and increase the activity of photosynthesis and the accumulative of carbohydrates in the grain and thus increase the dry weight (Al-Omran *et al*., 2010; Abd-Ulameer & Ahmad, 2013). So the w1 deficit irrigation treatment gave high value compared to w2 with the increasing per cent of 7.64%. This is due to that the optimum available water is more easily to be absorbed by the plant and led to increase photosynthesis and plant growth, while sever water deficit during grain filling has negatively impact the carbon representation, and reduced dry matter (Kazemeini *et al*., 2009).

Results in the table (3) showed a significant effect of interaction between petroleum conditioners and emitter discharge. It is clear that the variance between Hd and Ld treatments was higher at g3, go3, and o3compared to g5 and go5. This is due to the high ability of the gas conditioner compared to other conditioner that make stable emulsion could penetrate and disturb in soil, leading to increasing the water holding capacity, which causes increasing the efficiency of leaching of the salts away from roots zone, as well as increasing the available water for plant (Shabib, 2016).

Table (3): Effects of experimental treatments and their interactions on a dry weight (kg ha^{-1}). (Abbr. P: petroleum, D: discharge, W: water deficit).

source	df	dry weight	grain weight	WUE	
				Dry	Grain
block	2	15.66	15.66	15.667	15.667
P	5	719067.4**	566.93**	1068.36**	912.28**
D	1	230246.2**	142.40**	515.92**	338.77**
W	1	370776.2**	817.67**	165.22**	49.35**
p*D	5	4401.6**	42.43**	3.59*	5.18**
p*w	5	3815.4**	24.91**	10.73**	13.95**
w*D	1	14418.9**	42.43**	16.93**	62.58**
p*D*w	10	2820.0**	18.45**	1.11 ns	5.05 **

g5 treatment under 15 L hr^{-1} emitter discharge gave the highest value with an average of 3927.96 kg ha^{-1}, while the control treatment at 5 L hr^{-1} emitter discharge gave the lowest value (2567.43 kg ha^{-1}). This is due to the decrease of available water need for physiological processes, growth, and production because of high salinity associated with the lowest water holding capacity in control treatment (Nidewe & Salih, 2012). In addition, there was a significant effect of the interaction between petroleum conditioners with irrigation deficit. It is shown that there is a significant effect of 0.85 (w1) treatment compared to the 0.65 (w2) treatment which varied according to the petroleum conditioners. The lowest difference was in the control treatment, while the highest differences were observed in g5 and go5. This is due to increasing water holding capacity and available water at petroleum conditioners which contributed to increase the growth of roots and increase water and nutrients absorption. That was reflected in the activity of synthesis and its products of carbohydrates and proteins (Fatih *et al*., 2009). This effect increases by increasing the level of irrigation compared to other treatments, The highest value was 4017.32 kg ha^{-1} at g5 treatment with water deficit of 0.85, because this conditioner is more capable to form a stable and homogeneous emulsion that increased the surface area of hydrophobic layer which coated the particle and aggregate then increased the available water for plant (Khan *et al*., 2010). The increasing of salt leaching efficiency by using 0.85 level of deficit is improving soil aggregate and reducing its impact on plant growth. The lowest value was obtained at the control treatment under the level of water deficit of 0.65 with an average of 2556.17 kg ha^{-1} because of the low moisture and high salinity reflected negatively on the availability of nutrients and dry matter. The result also showed that there is no significant differences between g5 treatment at 0.65 deficit and g3, o3 and go3 treatments at 0.85 deficit, which is possible to use that treatment did not cause a negative impact on the productivity of the sunflower instead of using the above-mentioned treatments at the level of water deficit 0.85 of available water.

The results of the table (3) showed that there was a significant effect of the interaction between emitter discharge and irrigation deficit factors. It is clear that the significant effect of high discharge 15 L hr^{-1}, compared to the low discharge 5 L hr^{-1} varied according to the moisture deficit, so the highest differences between discharges were at 0.85, while lowest differences were at 0.65. This is due to increasing of the efficiency of leaching the salts away from root zone at high discharge treatment, in spite of decrease amount of the water added that alleviate the impact of salt on roots growth, thus increased absorption of water and nutrients that reflected on plant growth. The highest value was 3683.98 kg ha^{-1} at Hd under 0.85 treatment, while the lowest value was 3234.98 kg ha^{-1} at Ld under 0.65 deficit treatment, that is due to the low amount of available water and the high salinity of the soil at Ld under 0.65 deficit treatment which increase water stress and lack of absorption of water and nutrients, especially at the stage of grain maturity and filling stage as a critical stages of water shortage in sunflower crop (Kazemeini *et al*., 2009).

The effect of triple interference for experiment factors was significant. Generally, using discharge of 15Lhr^{-1} at some conditioners caused an increase in production in spite of the low level of irrigation at 0.65, as shown at the treatments of g3 and o3 with irrigation deficit of 0.65 and discharge of 15 Lhr^{-1} compared with this treatment at the irrigation deficit of 0.85 and discharge of 5 Lhr^{-1}. It demonstrates the economic potential to use water without adverse effects on the dry weight for the sunflower when using such treatments under drip irrigation system. The highest value was recorded in the treatment of g5 with 0.85 deficit at the discharge of 15 L hr^{-1}, while the lowest value was recorded at the control treatment under the level of moisture of 0.65, and discharge 5 L hr^{-1}.

Grain yield

The results in tables (2 & 4) showed a significant effect of emulsified petroleum conditioners on grain yield of sunflower compared with control treatment with an increase of 78.82, 69.51, 64.49, 53.25 and 41.62% for g5, go5, g3, go3, and o3 respectively. The significant variations among conditioners themselves or with control treatment are due to the variation in their ability to make a stable and homogenous emulsion with which characterized to form oil droplet less than 2 micrometre that is able to penetrate and distribute through soil depths and soil pores overly (Dheyab, 2017). Therefore, it affected water holding capacity and increased the available water, due to the decreasing of the hydraulic conductivity of water in the soil, unsaturated conductivity led to decline moisture loss by surface evaporation or deep percolation (Shabib, 2016). This impact must improve soil structure and aggregate stability which contributes to providing a suitable conditions for roots growth to absorb water and nutrients which increase the photosynthesis and other physiological processes resulted in an increase the growth and production of seeds (Al-Damey & Al-Sammak, 2013; Abd-Ulameer & Ahmed, 2013).

The results showed a significant effect of the emitter discharge on grain yield. The high discharge (Hd) had the highest effect compared to low discharge (Ld) with an increase per cent of 7.92%. This is due to the effect of a high discharge of emitter in increasing the hydraulic conductivity of water in soil and efficiency of leaching salts away from the root zone (Abd-Ulameer & Ahmad, 2013). As well as, improved soil structure and increased soil moisture, which contributed on enhancing the growth of root and shoot and thus increase absorption of water and nutrients then increase the activity of photosynthesis and the collection of carbohydrates in the grain (Camillia *et al*., 2006; Al-Omran *et al*., 2010). The results showed that deficit irrigation treatment of 0.85 had the highest effect compared to 0.65 with an increasing per cent up to 20.01%. This is due to the optimum available water more easily to be absorbed by plant leading to increase photosynthesis and plant growth while severing water deficit during grain filling has negatively impacted on carbon assimilation, and reduced the dry matter and grain yield (Kazemeini *et al*., 2009; Mahmoud & Ahmed, 2016).

The results in tables (3 & 4) showed a significant effect of interaction between petroleum conditioners and emitter discharge. The differences in the grain yield between Hd and Ld treatments was higher at go3 and o3 compared to g3 and g5 due to the differences in the high ability of the gas conditioner compared to other conditioners for making stable emulsion that could penetrate and disturb in soil,

Table (4): Effects of experimental treatments and their interactions on grain yield (kg ha^{-1}).

Dripper discharge		5		15		Average of D*P		Average of P*w		Average of P
Water deficit		0.85	0.65	0.85	0.65	5	15	0.85	0.65	
Petroleum	c	1547.5	1107.5	1809.5	1330.0	1327.5	1569.8	1678.5	1218.8	1448.6
	o3	2353.3	1471.5	2353.5	2028.0	1912.4	2190.8	2353.4	1749.8	2051.6
	g3	2485.6	2238.3	2548.9	2258.8	2362.0	2403.9	2517.3	2248.6	2382.9
	g5	2649.0	2466.6	2676.6	2538.8	2557.8	2607.8	2662.8	2502.8	2582.8
	go3	2480.1	1643.3	2515.0	2241.5	2061.8	2378.3	2497.6	1942.4	2220.0
	go5	2598.1	2240.3	2665.0	2318.5	2419.3	2491.8	2631.6	2279.4	2455.5
$RLSD_{0.05}$		125.36				88.65		61.48		60.11
Deficit	0.85	2352.3		2428.1		Average of D.		Average of W.		
	0.65	1816.3		2119.3		2106.8	2273.7	2390.2	1990.3	
$RLSD_{0.05}$		49.08								

that led to increase the water holding capacity and cause increasing the efficiency of leaching of the salts away from roots zone, as well as increasing the available water for growth and production of plant. The highest value was 2607.75 kg ha^{-1} produced by g5 treatment under 15 L hr^{-1} treatment, while the lowest value was 1327.5 kg $ha^{-1}$for control at 5 L hr^{-1} emitter discharge. This is due to the high salinity associated with the lowest water holding capacity in control treatment as they cause a decrease of available water need for physiological processes, growth and production (Nidewe & Salih, 2012). In addition, there was a significant effect of the interaction between petroleum conditioners with irrigation deficit. The results showed that the significant influence of water deficit 0.85 (w1) compared with the 0.65 (w2) varied according to the uses of petroleum conditioners. The lowest difference was in g5, while the highest differences were observed in (o3) treatment. This is due to the increasing water holding capacity and available water at petroleum conditioners treatment, which contributed to increase the growth of roots and increase water and nutrients absorption, which was reflected in the activity of synthesis and its products of carbohydrates and proteins that move to the sites of grain formation (Fatih *et al*., 2009). This effect was increased by increasing the level of irrigation compared to other treatments. The highest value was 2662.8 kg ha^{-1} at g5 treatment with water deficit of 0.85, because this conditioner is more capable to form a stable and homogeneous emulsion that increased the surface area of hydrophobic layer which coated the particle and aggregate then increased the water available for absorption by the plant, belong to increased activity of photosynthesis processes and its products that combine the carbohydrate content of grains (Al-Damey & Al-Sammak, 2013). The efficiency of leaching salt at 0.85 level was increased because of the improving of the soil aggregate that would reduce the impact of salt on growth and elongation of plant roots and shoots. The lowest value was 1218.75 kg ha^{-1} at the control treatment under the level of water deficit 0.65, because of the high soil salinity and low moisture of this treatment.

The results of the table (4) showed that there was a significant effect of the interaction between emitter discharge and irrigation deficit factors. The significant influence of the high discharge 15 L hr^{-1} treatment compared to the low discharge 5 L hr^{-1} varied according to the moisture deficit, and the highest differences between discharges were obtained at 0.85. This is due to the role of high discharge in increasing the efficiency of leaching the salts away of the root zone, in spite of decrease amount of the water added that alleviate the impact of salt on roots growth, thus increase absorption of water and nutrients that reflected on plant growth and increased grain weight. The Hd at 0.85 treatment recorded the highest value of grain weight of 2446.42 kg ha^{-1}, while the lowest value was 1795.78 kg ha^{-1} at low discharge and water deficit treatment of 0.65. That is due to the low amount of available water and the high salinity of the soil at Ld treatment which increase water stress and lack of absorption of water and nutrients, especially at the stage of grain maturity, which is a critical stage of water shortage in sunflower crop (Kazemeini *et al*., 2009).

The effect of triple interaction for experiment factors was significant. Generally, the use of discharge 15Lhr^{-1} at some conditioners caused an increasing in the production, in spite of the low level of irrigation at 0.65, as shown at the treatments of g5 with irrigation deficit of 0.65 and discharge of 15 Lhr^{-1} compared with the treatment g3, go3 and o3 at the irrigation deficit of 0.85 and discharge 5 Lhr^{-1}. This results demonstrated the economic potential to use water without adverse effect on the net production of cereals for the sunflower when using such treatments under drip irrigation conditions. The highest average was recorded in the treatment of g5 with 0.85 deficit at the discharge of 15 L hr^{-1}, while the lowest value was recorded at control treatment under the level of moisture 0.65 and discharge 5 L hr^{-1} because of the outcome of the effect of the experimental factors affecting the weight values of the grains referred to earlier.

Water use efficiency (WUE)

The results in tables (2, 5 & 7) referred to values of water use efficiency by dry weight WUE (d) and grain weight WUE (g) for all factorial treatments which calculated from the total irrigation water at the growth season (Table 6). A significant effect of the emulsion petroleum conditioners was obtained on the WUE(d) and WUE(g) ,which increased significantly by 92.12, 75.17, 63.51, 52.20 and 41.04 %, and 167.6, 117.9, 100.8, 88.6 and 57.24% for WUE (g) and WUE (d) at treatments of g5, go5, g3, go3, and o3 respectively, compared to the control treatment (c). Gas oil emulsion at treatment 0.5 % (g5) exceeded the achievement of the highest average and significantly followed by treatments of go5 then g3 and go3. The lowest values were at the treatment of o3. This is due to the above mention reasons related to the role of petroleum conditioners to improve soil aggregate and increase soil ability to holding moisture, especially water available to be absorbed by the plant and reduce the added quantities of irrigation water (table 6) (Sweeney *et al*., 2006; Celebi, 2014; Pragna *et al*., 2016).

Tables (5 & 7) showed a significant effect of emitter discharge factor on WUE. The high discharge (Hd) significantly increased WUE (d) and WUE (g) with a per cent of 12.46% and17.43% as compared with the discharge of 5 Lhr^{-1} (Ld), respectively. The increasing discharge will increase the moisture content and efficiency of leaching salts away from root zone distribution then reduce the negative effects on the growth resulting in high absorption of water and nutrients, which reflected positively on the vocabulary of growth in the calculation of water use efficiency (Celebi, 2014). The results in tables (5 & 7) showed a difference in the effects of irrigation deficit on water use efficiency. Treatment of 0.65 significantly increased WUE (d) by 6.87%, while declining the average of WUE (g) by 5.55% compared with treatment 0.85. There were significant differences between 0.85 and 0.65 due to the differences in the quantity of irrigation water added during the growth season (table 6). Deficit water at 0.65 treatment reduced the carbon assimilation and lack of accumulation of dry matter, especially in the grain formation stage, resulting decrease in dry weight and total grain weight (Table 3 & 4), thus reducing the calculated efficiency values based on the weight of dry matter and grain yield (Saeed & El-Nadi, 1998; Mohammad *et al.,* 2015).

There was a significant effect of the interaction between emitter discharge with emulsified petroleum conditioner on WUE values. The significantly increased at high discharge (Hd) compared with low discharge (Ld) was differentiated by the treatment of the emulsified petroleum conditioners. The lowest difference between these emitter discharges in WUE (d) and WUE (g) was observed in control treatment, while the highest variances were observed between them in WUE (d) at g3, go3, and o3, but were at go3 in WUE (g). This is due to the increasing the available water at petroleum conditioners treatment, especially at g5 and go5 treatments, which contributed to increase the growth, as well as reduce the amount of water added (table 6). This impact was enhanced by increasing the discharge from 5 to 15 Lhr^{-1}.

The highest average for WUE (d) and WUE (g) were 5.21 and 3.78 kg ha mm^{-1} at g5 treatment under high discharge 15 Lhr^{-1}, respectively while the lowest average was 2.42 and 1.22 kg ha mm^{-1} at the control treatment and low discharge 5 Lhr^{-1}, respectively. This is due to the effects of high salinity and low amount of available water in control treatment, which caused water stress in plant and decrease dry and grain weight, in addition to the high amounts of water added (table 6).

It was found that there was a significant increase of the 0.65 treatment (w2) compared to the 0.85 treatment (w1) in WUE (d) varied according to the petroleum conditioners treatment. The highest differences between the water deficit treatments were at the o3 treatment, while the lowest difference was at control treatment, this is due to variance between their effects on dry weight and differences of the quantity of irrigation water (table 6). However, in WUE (g), the

Table (5): Effect of experimental factors on water use efficiency for dry weight (kg ha mm^{-1}).

D		5		15		D*P		P*w		Average of P
Water deficit		0.85	0.65	0.85	0.65	5	15	0.85	0.65	
Petroleum	c	2.36	2.48	2.79	2.72	2.42	2.75	2.58	2.60	2.59
	o3	3.06	3.71	3.75	4.09	3.39	3.92	3.41	3.90	3.65
	g3	3.72	4.17	4.43	4.63	3.94	4.53	4.07	4.39	4.23
	g5	4.60	4.88	5.15	5.26	4.74	5.21	4.88	5.07	4.98
	go3	3.48	3.87	4.03	4.38	3.68	4.20	3.76	4.13	3.94
	go5	4.24	4.45	4.64	4.81	4.35	4.73	4.44	4.63	5.54
RLSD0.05		0.215				0.11		0.096		0.064
deficit	0.85	3.58		4.13		Average of D.		Average of W.		
	0.65	3.93		4.31		3.76	4.22	3.86	4.12	
$RLSD_{0.05}$		0.056								

Table (6): Quantity of irrigation water through season growth of sunflower (mm). **(Abbr. P: Petroleum conditioner, D: Emitter discharge, W: Irrigation deficit).**

D		5		15		D*P		P*w		Average of P
Water deficit		0.85	0.65	0.85	0.65	5	15	0.85	0.65	
Petroleum	c	1106.1	1014.6	1031.1	954.6	1060.3	992.8	1068.6	984.6	1026.6
	o3	1034.4	841.5	964.4	786.5	937.9	875.4	999.4	814.0	906.7
	g3	924.4	804.7	868.4	754.7	864.6	811.6	896.4	779.7	838.1
	g5	846.6	746.4	802.6	706.4	796.5	754.5	824.6	726.4	775.5
	go3	967.6	827.3	903.6	772.3	897.5	837.9	935.6	799.8	867.7
	go5	907.9	798.8	857.9	753.8	853.4	805.9	882.9	776.3	829.6
deficit	0.85	964.53		904.70		Average of D.		Average of W.		
	0.65	838.9		788.1		901.7	846.4	934.6	813.5	

Table (7): Effect of experimental factors on water use efficiency for grain yield (kg ha mm^{-1}).

D		5		15		Average of D*P		Average of P*w		Average of P
Water deficit		0.85	0.65	0.85	0.65	5	15	0.85	0.65	
Petroleum	c	1.38	1.07	1.56	1.37	1.225	1.465	1.469	1.221	1.345
	o3	2.15	1.72	2.42	2.16	1.939	2.29	2.287	1.943	2.115
	g3	2.66	2.27	2.91	2.96	2.465	2.937	2.788	2.615	2.701
	g5	3.35	3.48	3.66	3.90	3.418	3.781	3.508	3.692	3.60
	go3	2.54	1.96	2.77	2.87	2.25	2.824	2.658	2.417	2.537
	go5	2.83	2.58	3.07	3.23	2.711	3.152	2.955	2.908	2.932
RLSD0.05		0.147				0.104		0.094		0.064
deficit	0.85	2.49		2.18		Average of D.		Average of W.		
	0.65	2.73		2.75		2.33	2.74	2.61	2.47	
$RLSD_{0.05}$		0.052								

significant effect of deficit treatment of w1 compared with the w2 varied according to the treatment of the petroleum conditioners, so the highest differences between the water deficit treatments were at the o3 treatment, while the lowest variance was at the treatment of go5. It is also noted that g5 treatment behaved differently compared with other conditioners, so it was significantly higher when the water deficit was 0.65 compared to the water deficit 0.85. There was a decreasing in the values for all petroleum conditioner at 0.65 treatment compared with the corresponding treatments at 0.85, except g5 due to the sensitivity of grain filling stage for water shortage as it reduced the grain production which negatively affected the water use efficiency (Ahmed, 2012; Mohammed *et al*., 2015). However, the different behaviour of the treatment g5 is due to its role in increasing the soil ability to save water and provide available water for absorption for both levels of moisture deficit, especially at the critical physiological stage of grain formation and filling, then increasing water use efficiency for both levels, especially 0.65 level which was supplied irrigation water quantity less than 0.85 level (table 6) (Pragna *et al*., 2016).

There are no significant differences in WUE (g) for go5 at both levels of water deficit (table 7). The highest values were 5.07 and 3.69 kg ha mm $^{-1}$ for WUE (d) and WUE (g) at g5 treatment for 0.65 water deficit, respectively. While the lowest value of WUE (d) was 2.58 kg ha mm^{-1} at control treatment of 0.85 deficit. The lowest average of WUE(g) was 1.22 kg ha mm^{-1} at the control treatment for 0.65 water deficit , this can be concluded that the decrease in the amount of water used for these conditioners under the water deficit of 0.65 did not affect the amount produced from the dry matter, which was reflected in the efficiency of water use on the basis of dry weight and grain, thus the possibility of optimal exploitation of water quantity and contribute to providing quantities ranging from 126-268 mm during the growing season without affecting the grain production of the sunflower crop.

The interaction between emitter discharge and water deficit factors in tables (5 & 7) showed a significant effect on water use efficiency. The significant increase of high discharge 15 Lhr $^{-1}$ that compared to the low discharge 5 Lhr $^{-1}$ varied according to the water deficit treatments. The highest significant differences in WUE (d) were obtained at w1 treatment, while the highest differences in WUE (g) were at w2, because of the role of high discharge to reduce the negative impact of salts compared to the discharge of 5 Lhr $^{-1}$, also can contribute to the increase of the available water, which was reflected in the plant growth parameter, including grain weight and thus increase the values of water use efficiency. In general, the highest averages were 4.31 and 2.75 kg ha mm^{-1} for WUE (d) and WUE (g) at Hd treatment below 0.65, respectively, while the lowest averages were 3.58 and 2.18 kg ha mm^{-1} at 5 Lhr^{-1} treatment for WUE (d) at 0.85 and WUE (g) at water deficit of 0.65, respectively.

The results showed a significant effect of the triple interaction between the petroleum derivatives, irrigation deficit and emitter discharge on WUE (g), but there is no significant effect on WUE (d) (tables 5 & 7). In general, superiority effects were recorded of all petroleum conditioners treatments for both deficit treatments at levels of 0.85 and 0.65 of the available water and for the discharges 5 and 15 Lhr^{-1} compared with control treatment. The decreasing in an average of control treatment is due to the high salinity of soil and the deterioration of the physical properties, which negatively affected the plant growth and components of the crop, as well as the increase in the quantities of water added (table 6). The highest average was 3.90 kg ha mm^{-1} at g5 under 0.65 water deficit and discharge 15 Lhr^{-1}. This is due to the role of this conditioner in increasing soil susceptibility to holding moisture and decreasing the amount of irrigation water added (table 6), which enhancing by using 15 Lhr^{-1} emitter discharge, that contributed on increasing salt leaching and reducing its negative impact in increasing the effort exerted by the plant to absorb water and nutrients. The lowest average was at the control treatment under 0.65 deficit at 5 Lhr^{-1} emitter discharge with an average of 1.07 kg ha mm^{-1} because this treatment recorded the lowest values in the production of grain and the highest amount of water added (table 6), resulting in the low efficiency of water use.

Conclusions

The addition of petroleum derivatives, especially gas oil 0.5%, contributes to the increasing of the dry weight of the vegetative part and the weight of the seeds of the sunflower, even at the level of 0.65 of available water when using the discharge 15 litres per hour^{-1}. as well as the role of emulsified conditioners on increasing the soils ability to save moisture and reduce the quantities of water added during the growing season, which led to increase efficiency of water uses, either on the basis of dry weight or grain weight which contributes to the provision of a quantity of irrigation water up to 126-268 mm during the growth season without the negative impact on the productivity of sunflower plant.

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