Combination Impacts of Irrigation Regimes and N&K-Humate Rates on Sunflower Productivity and Water Use Efficiency in Sandy Soil.

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TWO field experiments were carried out under sprinkler irrigation system at the agricultural research station (ARC), Ismailia Governorate, Egypt in two successive summer seasons (2009 and 2010) to study the combination effects of irrigation regimes and N&K-humate rates on some soil properties, yield quantity, yield components, oil yield, crop water requirements as well as nitrogen use efficiency (NUE) and water use efficiency (WUE) of sunflower crop in sandy soil. A split- plot design with four replications was used. Two irrigation regimes (25% from the available soil moisture depletion (ASMD) and 50% ASMD) and four levels of N&K-humate combined (F_0: control treatment, F_1: 15 kg N + 2.0 kg k-humate /fed, F_2: 30 kg N + 4.0 kg k-humate /fed, F_3: 45 kg N + 6.0 kg k-humate /fed). The results indicated that the application rates of N&K-humate fertilizers and irrigation scheduling treatments significantly affected soil hydrophysics properties, yield and yield components. Therefore, an increase in total porosity (TP), field capacity (FC) and wilting point (WP), meanwhile, small decreased in soil bulk density and hydraulic conductivity were obtained. The average values of actual evapotranspiration (ETa) were 383.6, 362.6, 352.3 and 330.2 mm, for 25% ASMD irrigation treatments, respectively. Meanwhile those were 321.6, 310.2, 301.4 and 295.9 mm for 50% ASMD irrigation treatments, respectively. Also the chosen treatments were affected on seed yield and yield components. The highest averages of plant height, head diameter, head weight, seed weight/head and 100 seed weight, seeds yield/fed and seed oil/fed, in the two seasons were obtained from the highest application level of N&K-humate fertilizers and under the irrigation regime of 25% ASMD. The highest value of WUE was obtained under the highest level of N&K-humate (F_3) and at 25% ASMD irrigation treatment. On the other hand, the highest value of NUE was obtained under the lowest level of N&K-humate (F_1) and at 25% ASMD irrigation treatment.

Keywords: Sunflower yield, N&K-humate, Irrigation scheduling, Water requirements and water use efficiency.

Sunflower (*Helianthus annuus* L.) crop is considered to be one of the most promising oil crops that can meet the oil needs because it is characterized with

high unsaturated fatty acids and vitamin E content. Sunflower is the fourth oil crop grown worldwide *(Fagundes et al.,* 2007*)*. In Egypt, there is a big shortage in edible vegetable oil for many years due to fluctuations in the production of oil seeds. The cultivated area of sunflower in Egypt is limited in Nile Valley and the delta due to the competition with the other important summer crops. In Egypt, the sunflower is adapted to different types of soils and climatic conditions. This wide adaptability led to the fact that sunflower can be grown in less productive soils, particularly, in the newly reclaimed soil in the desert area, which represented about 96 % of total Egypt area. Moreover, due to the sunflower ability to tolerate short periods of water deficient the potentiality of sunflower to be an important crop in semi-arid environments under limited irrigation. Sunflower is categorized as a low to medium drought sensitive crop (Tolga and Lokman, 2003 and Turhan & Baser, 2004).

As reported by Karam (1978) the increase in the irrigation regimes reduced plant height, head diameter, seed yield, seed index, seed oil content. In contrast, Anwar *et al.* (1995) stated that all the yield components were affected by the number of irrigations, as the number of irrigations increased; plant height, head diameter, 1000-seed weight and stalk yield were increased. Flagella *et al.* (2002) and Ashoub *et al.* (2003) reported that increasing irrigation regimes lead to decrease plant height, head diameter and 100 seed weight. Incontrast, Ghazy and Abu Ghazala (1999) found that seed and oil yields, seed oil content (%) and WUE increase in proportion to the increase in the amount of irrigation water given to sunflower. Ashoub *et al.* (2003) and El-Hafez *et al.* (2002) reported that increase in seed yield of sunflower depended on hybrids and irrigations regimes. Kazi *et al.* (2002) found that oil content of sunflower seeds was increased by increasing irrigation water, while Erdemoglu *et al.* (2003) they observed that oil content did not change significantly by increasing irrigation water. Şandor Maria *et al.* (2011) indicated that irrigation water use efficiency (IWUE) was calculated as report between yield grain obtained using the irrigation and the irrigation rate. The value of the IWUE was 5.03 kg yield grain/mm.

Erdem *et al.* (2005a) showed that irrigations were started when crop water stress index values reached 0.2, 0.4, 0.6, 0.8 and 1.0 (non-irrigated). They found that the total irrigation water amounts of T 0.2, T 0.4, T 0.6 and T 0.8 treatments were 679, 584, 470 and 227 mm, respectively.

N fertilizer application can guarantee the high yield of crop; it is a general method to improve the yield of crop. Significant responses of seed oil yield to increased levels of N, P and K fertilizers have been observed by several investigators (Abu Ghazala *et al.,* 2001 and Zhang *et al.,* 2010). However, Kene et al. (1992) found that seed oil percentage was not affected by N or P levels while El-Kalla *et al.* (1998) found that it decreased with increased N level.

Large nitrogen supply increases the amount of seed oil per plant and depresses seed oil concentration (Steer *et al.,* 1984). The latter effect results from the dilution of oil in heavier seed produced under high nitrogen. Therefore, smaller N

concentration does not offset the advantage that large N supply has on seed number and seed weight so that crop oil yield remains positively related to large N supply.

To date, numerous researches have demonstrated conclusively that humic acids (HS) showed significant impacts on the soil structure and plant growth (Fong *et al.,* 2007). HA in proper concentrations can enhance plant and root growth (Bacilio *et al.,* 2003). Several HS have been identified (Islam *et al.,* 2005). In regard to the potential of the HA, continuous development has led to availability of various commercial humic acid based products and they are widely marketed. The HA products are usually available in the form of inexpensive soluble salts, referred to as potassium humate (Fong *et al.,* 2007). Potassium humate causes an increase in crop quality and tolerance of plant to drought, saline, cold, diseases and pests stresses (Gadimov *et al.,* 2007).

The present research was aimed to investigate the productivity of sunflower as affected by N&K-humate application rates and irrigation regimes under sprinkler irrigation system on newly reclaimed sandy soils of Ismailia Governorate, Egypt.

Material and Methods

Two field experiments were conducted during two successive seasons of 2009 and 2010 at the Agricultural research station (ARC), Ismailia Governorate, (30.35 N; 30.26 E; 20 m, ASL), Egypt to study the combination effects of irrigation regimes and N&k-humate rates on sunflower (*Helianthus annuus* L.) yield, its component, oil yield and water use efficiency grown in sandy soil. The experiment was laid out in split plot design with four replicates. Two irrigation regimes were tested when the sunflower plants consume 25% (I_1) and 50% (I_2) from the available soil moisture depletion (ASMD). The irrigation treatments under sprinkler irrigation system were assigned to the main plots. Four levels of N&k-humate (F_0: control, F_1:15 kg N+ 2.0 kg k-humate /fed, F_2:30 kg N+ 4.0 kg k-humate /fed, F_3:45 kg N + 6.0 kg k-humate /fed) were assigned to the subplots. Sowing of sunflower seeds was carried out in hills 20 cm a part and in rows 60 cm wide (35,000 plants/fed) Irrigation water application was controlled through daily measurements of the soil moisture content in the subsequent soil depths, where it was determined using gravimetric method in order to detect when the soil moisture contents reach to irrigation treatment 25% ASMD (I_1) and 50% ASMD (I_2).

In order to determine actual evapotranspiration (ETa), soil moisture contents before and after irrigation was determined using the collected undisturbed soil samples by core Auger from different depths. The values of soil moisture content were determined by a gravimetric methods (*Klute* 1986).Also values of water use efficiency WUE was determined by dividing seed yield (Kg/fed) on actual evapotranspiration ETa (m^3/fed) according to *Giriappa* (1983).

Phosphorous as superphosphate form (15.5% P_2O_5) was applied to the soil two weeks before planting. Potassium in the form of potassium sulphate (50% K_2O) was applied in two equal doses every two weeks intervals after planting. Nitrogen as ammonium sulphate form (20.5% N) was mixed with k-humate and added in four doses every two weeks intervals starting from plant emergence. Irrigation regimes were starting after planting directly using gravimetric method. The potassium humate component used in this study was as follows: [humic acid (80%), potassium (K_2O) (10-12%) and micronutrients such as zinc, iron, manganese, cupper in chelated form and its concentration was 100 ppm], were sprayed with the recommended doses after 55 and 75 days from planting.

At harvesting samples of 10 guarded plants from each sub-plot were taken randomly in four replications. The recorded data after harvesting include plant length (cm), head diameter (cm), shoot dry matter (g/plant), root dry matter (g/plant), biomass dry matter (g/plant), shoot: root ratio, 100 seed weight, seed yield (kg/fad), oil yield (kg/fad), seed oil content (%) and Nitrogen use efficiency (NUE) (kg seed/kg N).

To determine Oil Percentage (%): Dried mature of seeds were ground into very fine powder and determined oil % using Soxhelt apparatus and diethyl ether according to *A.O.A.C.* (1995).

Nitrogen use efficiency (NUE) was calculated using the formula suggested by Moll *et al.* (1982) by dividing seed yield (Gw) by nitrogen (N) applied to the soil plus mineral nitrogen in the soil before sowing (Ns) {NUE = Gw / N + Ns} **.**

Undisturbed and disturbed surface (0-20 cm) and subsurface (20-40 cm) soil samples were collected before sowing to determine some physical and chemical characteristics of the investigated soil, according to the methods described by *Page et al.* (1982) and *Klute* (1986). Table 1 showed some soil physical and chemical characteristics of the experimental site.

Results and Discussion

Combination impacts of irrigation regimes and N&K-humate rates on
  1. Hydrophysical properties of the studied sandy soil
   The changes in the studied hydrophysical properties of the tested sandy soil under different application rates of N&K- humate after the two growing seasons are presented in Table 2. These data indicate that a negative and positive impacts are noticed on the soil moisture constants with increasing the application rate of N&K-humate, *i.e.,* the values of soil bulk density and hydraulic conductivity are decreased, but these decreases are not significant for bulk density and significant for hydraulic conductivity, whereas the total porosity, retained moisture at field capacity, values of wilting point and available water percentage are significantly increased with increasing the application rates of N&K-humate. The reducing soil bulk density values may be related to the increasing the percentage of storage

pores in the studied soil which can be regarded as an index of improving pore size distribution.

TABLE 1. Some physical and chemical properties of the tested soils.

Character	Value
Particle size distribution	
Clay %	1.6
Silt %	3.7
sand %	94.7
Textural class	Sandy soil
Ca Co$_3$ %	0.75
Organic matter %	0.75
Chemical analysis	
PH (1 : 2.5 suspension)	7.76
EC$_e$ (ds/m, soil paste extract)	2.50
Soluble cations (soil paste meq/L):	
Ca^{+2}	8.4
Mg^{+2}	5.7
Na$^+$	9.4
K$^+$	1.5
Soluble anions (soil paste meq/L):	
HCO$_3^-$ + CO$_3^{-2}$	13.5
Cl$^-$	7.6
SO$_4^{-2}$	3.9
Total N %	0.02
KCl-extractable N (ppm)	31.04

TABLE 2. Effect of different application rates of N&K- humate on some soil hydrophysical properties.

Treatments	Soil moisture constants (% volume)				Bulk density gm/cm^3	Hydraulic conductivity cm/hr
	TP	F.C	W.P	AW		
F$_o$	34.3 a	9.1 a	2.2 a	6.9 a	1.68 a	10.4 a
F$_1$	35.5 b	9.8 b	2.5 b	7.3 b	1.63 a	9.2 b
F$_2$	37.6 c	10.1 c	2.6 c	7.5 b	1.61 a	8.6 c
F$_3$	39.3 d	10.5 d	2.7 d	7.8 c	1.58 a	7.9 d
LSD$_{0.05}$	0.26	0.16	0.18	0.24	0.18	0.18

TP = Total porosity % , FC = field capacity % , WP = wilting point % , AW= available water % .

The pronounced decrease in the values of hydraulic conductivity of the studied sandy soil may be due to decrease of macro pores, and the dominance of meso and micro pores on the expose of the other pore sizes. These results are in agreement with those of *Mona et al.* (2011). Concerning the changes in the values of field capacity, wilting point and available water content at different applied rates of N&k-humate, data show that the treated soils with N&K humate possess relatively high values of over mentioned constants as compared to control. The increasing percentages of available water for treatments F_1, F_2 and F_3 compared to control (F_o) are recorded to be 5.7%, 8.9 % and 13.2%, respectively. These increase may be due to the fact that organic substances (humate) contain pronounced high active organic groups that encourage the water molecules to be chelated. Thus, the N&k-humate is considered as an organic conditioner that improves the previous soil hydrophysical properties through its ability to absorb water and swelling leading to pronounced effect of changing pore size distribution.

2. Actual evapotranspiration (ETa) of sunflower crop

Table 3 shows the mean values of actual evapotranspiration (ET_a) of sunflower crop during the two growing seasons, as a function of irrigation scheduling treatments. The mean values of ET_a are 357.2 and 307.3 mm, for 25% and 50% ASMD treatment respectively. Results in Table 3 show the values of seasonal consumptive use (actual evapotranspiration) (ET_a) of sunflower crop, as a function of irrigation scheduling treatments. The ET_a values are 383.6, 362.6, 352.3 and 330.2 mm, for 25% ASMD treatment respectively. Meanwhile, those are 321.6, 310.2, 301.4 and 295.9 mm for 50% ASMD irrigation treatment, respectively. This reveal that irrigation at 25% ASMD has the highest values of seasonal ET_a whereas, the lowest ET_a values, are resulted from irrigation at 50% ASMD regime. These results may be attributed to that irrigation at 25% ASMD (frequent irrigation) increased the amount of available soil moisture in the root zone of sunflower plants ,which led to visible increase in the transpiration process from sunflower shoots and to the increase of evaporation from the soil surface. On the other hand, the results indicate also that the increasing of application rate of N&K - humus resulted in an observed decrease in the actual evapotranspiration of sunflower crop. Therefore, the highest value of ET_a is recorded for the control treatments (F_o) fallowed by F_1 and F_2 then F_3 which recorded the lowest value. This may be due to the increasing water holding capacity of the sandy soil as a result for adding humus organic materials to the soil.

On the other hand, data listed in Table 3 also indicate that the monthly ETa are started with low values during June, thereafter, increased during July and reached its maximum values during August then it declined again during September (harvesting month) . Such findings may be attributed to most of water losses during June are caused by evaporation from the soil (germination and seedling stages) as the roots of sunflower are still very small. Thereafter, as the plant cover increase (vegetative growth) the monthly ETa increased reaching its peak at flowering and seed filling stages, as the roots and shoots reaching to the maximum growth. The values of ETa re-decreased during September (maturity stage) as a result of the drying of lower leaves and to the low transpiration rate.

TABLE 3. The average values of monthly actual evapotranspiration (ETa) of sunflower crop under different application rates of N&K humate.

N&K humate treatment	ETa mm/month for the irrigation regime at 25% ASMD				
	May	June	July	August	Total
F_0	50.2	129.6	174.8	29.1	383.6
F_1	47.4	122.5	165.2	27.5	362.6
F_2	46.1	119.1	160.5	26.7	352.3
F_3	44.3	114.5	147.0	24.4	330.2
Mean					357.2
N&K humate treatment	ETa mm/month for the irrigation regime at 50% ASMD				
	May	June	July	August	Total
F_0	24.0	109.5	165.5	22.6	321.6
F_1	22.7	103.5	161.8	22.1	310.2
F_2	22.1	100.5	157.3	21.5	301.4
F_3	21.2	96.7	156.6	21.4	295.9
Mean					307.3

3. Plant growth

Generally, plant growth is significantly differing according to different treatments due to the application rates of (N&k-humate). The results in Table 4 reveal that the averages of plant length (PL), head diameter (HD), seed weight (SW), 100-seed weight (100-SW), shoot dry matter (SDM), root dry matter (RDM), and biomass dry matter (BDM) per plant are significantly increased as the N&k-humate rates increased.

The highest application rate of N&k-humate (F_3) give the highest average values of sunflower growth parameters. Comparing to the control treatment (F_0), the percent of increments for the highest rate (F_3) are 34.87 %, 54.59 %, 53.64 %, 54.52 %, 65.15 %, 30.74% and 47.03 % for the following growth parameters PL, HD, SW, 100-SW, SDM, RDM and BDM per plant, respectively. The increment percent of shoot/root ratio are increased by 25.26 %, 26.84 % and 29.47 % for F_1, F2 and F_3 treatments, respectively compared to control. The increase in these parameters with the increasing of N&k-humate rates may be due to the role of nitrogen in activating the growth and yield components and to the role of k-humate in enhancing fertility and physiochemical soil properties. Similar results were obtained by Mojiri and Arzani (2003), Killi (2004) and Osman & Awed (2010).

Irrespective of fertilizer treatments, plant growth parameters are significantly differing due to irrigation regime treatments. Table 4 shows that the averages of plant length (PL), head diameter (HD), seed weight (SW), 100-seed weight (100-SW), shoot dry matter (SDM), root dry matter (RDM) and biomass dry matter (BDM) per plant are decreased as irrigation regimes increased from 25% ASMD (I_1) to 50% ASMD (I_2).

TABLE 4. Effect of irrigation regimes and N&k-humate rates on the average values of growth parameters, yield, yield components and nitrogen use efficiency of sunflower.

Treatments	PL (cm)	HD (cm)	SDM (gm/plant)	RDM (gm/plant)	BDM (gm/plant)	S:R Ratio	SW (gm/plant)	100-SW (gm)	SY (kg/fad.)	OC%	OY (kg/fad.)	NUE (kg seed/kg N)
F_0	87.48d	13.94d	24.02d	12.36d	56.16d	1.90b	19.78d	3.54d	688.00d	39.75a	275.15c	22.17a
F_1	96.92c	17.35c	32.61c	13.71c	70.73c	2.38a	24.42c	4.40c	856.35c	37.59b	323.16b	18.60b
F_2	108.66b	18.93b	35.13b	14.66b	76.49b	2.41a	26.70b	4.81b	934.35b	36.01c	336.69b	15.31c
F_3	117.98a	21.55a	39.67a	16.16a	82.57a	2.46a	30.39a	5.47a	1063.56a	34.80d	370.49a	13.99d
$LSD_{0.05}$	9.00	0.91	1.34	0.85	5.63	0.13	1.28	0.23	45.05	0.69	18.85	0.99
I_1	108.86a	20.00a	37.69a	15.99a	81.93a	2.35a	28.26a	5.08a	986.79a	37.79a	370.76a	19.85a
I_2	96.67b	15.90b	28.03b	12.45b	61.05b	2.22b	22.39b	4.03b	784.36b	36.29b	281.99b	15.18b
$LSD_{0.05}$	6.37	1.36	2.33	1.63	11.07	0.125	2.08	0.35	67.14	0.19	26.87	1.36
I_1F_0	91.4e	17.01d	31.50d	14.23c	69.95cd	2.22b	24.2d	4.3d	839.2 d	40.74a	342.09d	27.00a
I_1F_1	100.5d	19.34c	36.25c	15.38bc	78.90b	2.36ab	27.27c	4.91c	954.55 c	38.85b	370.80b	20.74b
I_1F_2	116.7b	20.70b	38.96b	16.29b	84.43b	2.39ab	29.19b	5.26b	1021.6b	36.22cd	370.10b	16.74c
I_1F_3	126.8a	22.93a	44.05a	18.05a	94.43a	2.45a	32.34a	5.82 a	1131.7a	35.35 d	400.05a	14.88d
I_2F_0	83.33f	10.88f	16.54f	10.49e	42.37e	1.58c	15.34 f	2.76f	536.80f	38.77 b	208.21f	17.30 c
I_2F_1	93.33e	15.36e	28.96e	12.03d	62.57d	2.48a	21.57 e	3.90e	758.14e	36.34 c	275.52e	16.47 c
I_2F_2	100.63d	17.17d	31.31d	13.03d	68.54cd	2.42a	24.20d	4.36 d	847.09 d	35.81cd	303.28d	13.88e
I_2F_3	109.15c	20.17bc	35.29c	14.27c	70.72c	2.48a	28.44bc	5.12bc	995.39bc	34.26 e	340.94c	13.09 e
$LSD_{0.05}$	5.34	1.29	1.89	1.20	7.97	0.178	1.81	0.33	63.70	0.97	26.66	1.40

PL=plant length, HD=head diameter, SDM=shoot dry matter, RDM=root dry matter, BDM=Biomass dry matter, S:R= shoot root ratio, SW=seed weight, 100-SW= 100 seed weight, SY=seed yield, OC%= oil content, OY=oil yield, NUE=nitrogen use efficiency.

The percentages of decrements are 11.2 %, 20.5 %, 20.8 %, 20.7 %, 25.7 %, 22.1% and 25.5 % for PL, HD, SW, 100-SW, SDM, RDM and BDM per plant, respectively. As well as, shoot / root ratio, are decreased as irrigation regime increase from 25% ASMD to 50% ASMD (I_2). This may be refer to the effect of water deficit, which in turn reduced plant growth and all yield components (Abdou *et al.,*2011).

Data presented in Table 4 show that plant length (PL), head diameter (HD), seed weight (SW), 100-seed weight (100-SW), shoot dry matter (SDM), root dry matter (RDM), and biomass dry matter (BDM) per plant are significantly affected by the interaction between irrigation regimes and NK- humate fertilizations rates.

In general, plant growth is markedly affected by N&k-humate application but the magnitude of response varied widely within irrigation regimes. The lowest values of PL (93.33 cm), HD (15.36 cm), SW (21.57 g) 100-SW (3.90 g), SDM (28.96 g), RDM (12.03 g) and BDM (62.57 g) per plant are obtained from 50% ASMD with the lowest rates of N&k-humate rate (F_1), *i.e.,* under I_2F_1 treatment, while, the highest values of PL (126.8 cm), HD (22.93 cm), SW (32.34 g), 100-SW (5.82 g), SDM (44.05 g), RDM (18.05 g) and BDM (94.43 g) per plant are obtained from 25% ASMD (I_1) with the highest rate of N&k-humate (F_3), *i.e.,* I_1F_3 treatment. Vivek *et al.* (1994) obtained similar results quoting that mean yield of sunflower increased with increasing levels of irrigation and nitrogen fertilizer. Khaliq and Cheema (2005) reported that plant growth and total dry matter production varied with irrigation and nitrogen application rates. *Viveck et al. (1994)* also reported that substantial yield increase through N fertilization and the magnitude of the response was dependent on the moisture supply.

4. Yield, oil content and nitrogen use efficiency

It is evident from Table 4 that N&K humate treatments have significant impact on the seed yield (SY), oil yield (OY), oil content (OC) and nitrogen use efficiency (NUE). The positive response are observed on seed and oil yield while, oil content and nitrogen use efficiency recorded the negative response. Seed and oil yield recorded increments by (24.50 %, 35.81% and 54.59 %) and (17.45 %, 22.37% and 34.65 %) for F_1, F_2 and F_3, respectively compared to control treatment. On the other hand, oil content and nitrogen use efficiency recorded decrements by (3.48 %, 8.01% and 14.22 %) and (9.44 %, 32.95% and 58.47 %) for F_1, F_2 and F_3 respectively compared to control treatment. Such results may be due to the adverse effect of nitrogen on oil content, is offset by an increase in protein content. Protein formation competes more strongly for photosynthesis, as a result, less of the latter are available for fat synthesis and nitrogen depressed the seed oil content. Large nitrogen supply increases the amount of seed oil per plant and depresses seed oil concentration *(Steer et al.,* 1984*).* This may be attributed to the dilution of oil in heavier seed produced under high nitrogen. Therefore, smaller N concentration does not offset the advantage that large N supply has on seed number and seed weight so that crop oil yield remains positively related to large N supply. These results are agreement with those of *Khaliq* (2004) *and Nasem el al.* (2012) they reported that with increasing N rates, there were an increments in the total dry matter (TDM), grain yield and yield components, while the oil content was negatively affected.

Data recorded in Table 4 show the averages of seed yield, oil yield, oil content and nitrogen use efficiency which significantly differ due to impact of irrigation regime treatments, whereas irrigation at 25% ASMD always gives the highest averages, in contrast, the lowest ones are detected from irrigation at 50% ASMD. It is obvious that increasing irrigation regimes from 25% to 50% ASMD significantly decreased seed yield, oil yield, oil content and nitrogen use efficiency by 20.5 %, 23.9 %, 4.0 % and 23.5 %, respectively. These results may refered to the effect of water deficit, resulted from irrigation at (50% ASMD). The results are agreement with the finding of El-*Hafez et al.* (2002) *and Ashoub et al*. (2003).

It is evident from Table 4 that the interaction affects of N&k-humate and irrigation regimes have a highly significant effect on seed yield (SY), oil yield (OY), oil content (OC) and nitrogen use efficiency (NUE). In contrast, oil content and nitrogen use efficiency recorded the negative response for all N&k-humate rates at both 25% and 50% ASMD regimes.

As regard to the interaction of the irrigation regimes and N&k-humate fertilization rates, the (F3 I1) treatment produced high seed and oil yield compared to (F3 I2) treatment. This may be related to low water availability under (F3 I2) treatment. On the other side, the response of sunflower plants for nitrogen fertilizer mainly related to irrigation regimes, where plant growth, yield and yield components are decreased due to increase of irrigation regimes from 25% to 50% ASMD which decreased amount of available water availability for plants. These results were agreement with Unger (1990) which reported that fertilizer requirements for sunflower rise with increased irrigation because of the high yields obtained.

5.*Water use efficiency of seeds and oil yield*

Data listed in Table 5 indicate that irrigation at 25% ASMD lead to high values of WUE ,that are 0.52, 0.63 ,0.69 and 0.82 kg seeds/ m^3 water for the treatments Fo,F_1,F_2 and F_3, respectively. Meanwhile, the WUE values of 50% ASMD reached 0.40, 0.58, 0.67 and 0.80 kg seeds/ m^3 for the same treatments, respectively. These results indicate that irrigation at 25% ASMD in sandy soil increase the availability of water to consume by sunflower plants, consequently this was reflected on the seed yield. In contrast, sunflower plants that irrigated at 50% ASMD are suffer from water deficit so, these plants consume more of energy to absorb water, which reflected negatively on the seed yield of the cultivated crop. These results are agreement with *Ghazy and Abu Ghazala* (1999).

Data also, indicate that increasing application rate of N&K-Humate resulted in an increase of WUE of sunflower crops. This may be attributed to the increase of the seed yield and the decrease in the values of actual evapotranspiration resulted from improving water holding capacity of the sandy soil.

Data listed in Table 5 indicate that the WUE values of oil yield take the same trend of WUE of seed yield, as the irrigation at 25% ASMD give high values compared with 50% ASMD for N&k-humate treatments. The data indicate that increasing of application rate of N&K-humate resulted in an increase in oil WUE of sunflower crop. This may due to the visible increase in the oil yield and the decrease of actual evapotranspiration resulted from improving physical and chemical properties of sandy soil.

TABLE 5. The average values of seed and oil water use efficiencies of sunflower crop.

N& K-humate treatments	25% ASMD					50% ASMD				
	Seed yield Kg/fed	Oil yield Kg/fed	ETa m^3	Seed WUE kg/m^3	Oil WUE kg/m^3	Yield Kg/fed	Oil yield Kg/fed	ETa m^3	Seed WUE kg/m^3	Oil WUE kg/m^3
F_o	839.2	342.1	1611.1	0.52	0.21	536.8	208.2	1350.9	0.40	0.15
F_1	954.6	370.8	1522.9	0.63	0.24	758.1	275.5	1302.6	0.58	0.21
F_2	1021.7	370.1	1479.8	0.69	0.25	847.1	303.3	1265.9	0.67	0.24
F_3	1131.7	400.1	1386.7	0.82	0.29	995.4	340.9	1242.8	0.80	0.27
Mean	986.8	370.8	1500.1	0.66	0.25	784.4	282.0	1290.5	0.61	0.22
$LSD_{0.05}$			74.4	0.028	0.0113			21.6	0.026	0.0112

Results in Table 5 indicate that there are positive significant effects for N&K humate rates on seed and oil yields of sunflower, where the yields of seed and oil as well as seed and oil WUE increase as N&K humate rates increased. Meanwhile ETa values decrease with increasing N&K humate rates. This may be due to increase of water holding capacity and encouraging soil aggregation occur due to the presence of humates.

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**التأثيرات المتبادلة للرى ومعدلات النيتروجين وهيومات البوتاسيوم
على انتاجية محصول دوار الشمس وكفاءة استخدام المياه فى
الاراضى الرملية**

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*معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية و**قسم
الأراضي – كلية الزراعة – جامعة القاهرة – الجيزة – مصر .

أجريت تجربتان حقليتان في المزرعة البحثية التابعة لمحطة بحوث الاسماعيلية
(مركز البحوث الزراعية) خلال الموسم الصيفى لعامى ٢٠٠٩ و٢٠١٠ لدراسة
التأثير المتبادل لنظام الرى ومعدلات مختلفة من مخلوط النيتروجين وهيومات
البوتاسيوم على بعض خواص التربة ومحصول دوار الشمس (صنف جيزة ١٠٢)
ومكوناته والاحتياجات المائية وكذلك كفاءة استخدام الماء والنيتروجين في الاراضي
الرملية تحت نظام الرى بالرش . استخدم تصميم القطع المنشقة بعدد ٤ مكررات لكل
معاملة حيث وضعت معاملات الرى في القطع الرئيسية وهى (الرى عند استنزاف
٢٥% و ٥٠% من الماء الميسر) كما وضعت معدلات اضافة النيتروجين وهيومات
البوتاسيوم في القطع التحت رئيسية وهى (الكنترول F_0 و ١٥ كجم نيتروجين + ٢
كجم هيومات بوتاسيوم/فدان F_1 و٣٠ كجم نيتروجين + ٤ كجم هيومات
بوتاسيوم/فدان F_2 و ٤٥ كجم نتروجين + ٦ كجم هيومات بوتاسيوم/فدان F_3).

وأوضحت النتائج أن معاملات الرى ومعدلات اضافة النيتروجين وهيومات
البوتاسيوم لها تأثير معنوى على كل من الخواص الهيدروفيزيائية للتربة
والاحتياجات المائية وكذلك المحصول ومكوناته فى كلا الموسمين. حيث انهما
سببت زيادة في قيم كل من المسامية الكلية والسعة الحقلية ونقطة الذبول الدائم بينما
نقصت قيم كل من الكثافة الظاهرية ومعامل التوصيل الهيدروليكى المشبع . وقد كان
متوسط الاحتياجات المائية الفعلية ٣٨٣,٦ و٣٦٢,٦ و٣٥٢,٣ و٣٣٠,٢ مم / موسم
تحت معاملة الرى ٢٥% استنزاف من الماء الميسر. بينما كانت ٣٢١,٦ و ٣١٠,٢
و٣٠١,٢و٢٩٥,٩ مم / موسم تحت معاملة الرى ٥٠ استنزاف من الماء الميسر
لمعدلات الاضافة F_0 و F_1 و F_2 و F_3 على التوالى .وكذلك أظهرت النتائج أن
أعلى قيمة من حيث ارتفاع النبات وقطر وزن القرص ومحصول البذور/القرص
ووزن ١٠٠ بذرة ومحصول البذور ومحصول الزيت/ فدان تم الحصول عليها من
أعلى معدل اضافة للنيتروجين وهيومات البوتاسيوم تحت معاملة الرى ٢٥%
استنزاف من الماء الميسر .

وجد أن كفاءة استخدام المياة والنيتروجين تأثرت معنويا بمعاملات الرى
والتسميد وكانت أعلى النتائج المتحصل عليها لكفاءة استخدام المياة هي لأعلى معدل
اضافة للنيتروجين وهيومات البوتاسيوم F_3 تحت معاملة الرى ٢٥% استنزاف من
الماء الميسر . وعلى الجانب الاخر، كانت أعلى كفاءة استخدام للنتروجين تحت
معاملة الاضافة F1 وتحت معاملة الرى ٢٥% استنزاف من الماء الميسر .