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Water requirements of chamomile and origanum plants under North Sinai conditions

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ABSTRACT

This work is an attempt to clarify the effect of organic-inorganic fertilizers and water management of sandy soils on improving water use efficiency of some aromatic and medicinal plants (*Camomile* and *Origanum*) under daily drip irrigation, with emitters adjusted to 4 l/hour under desert conditions at the El-Sheikh Zuwayid region, North Sinai, Egypt. The study was conducted in split-plot design with three replicates. The treatments include three daily irrigation times (¼ hour = 1 liter/plant; ½ hour = 2 liter/plant; ¾ hour = 3 liter/plant) and the use of three types of fertilizers (organic, chemical and mixed organic and chemical). The results were analyzed statistically revealing an increase in *camomile* and *origanum* plants yield of the irrigated daily ½ hour, fertilized by mixed fertilizer. The rate of 1 liter/day (¼ hr/day) seems to cause the accumulation of salts in the root zone, while the 3 liter/day (¾ hr/day) treatment induced the leaching of the fertilizers from the rhizosphere, both reducing crop growth. Also, an increase in water use efficiency and water economy of *camomile* and *origanum* plants by decreasing irrigation time and use of mixed fertilizers. Moreover, a significant decrease in water consumptive use of *camomile* and *origanum* plants, was achieved by decreasing the irrigation time and chemical fertilizer. Depending on the detection of the water consumption for all treatments and economical assessment, the rate of 1 liter/day (¼ hr/day) and organic manures yielded the highest profitable return of *camomile* and *origanum* plants. The empirical averages of the seasonal Kc obtained from the experiment, for the plants, were 0.63 and 0.36 for the *camomile* and *origanum*, respectively.

KEYWORDS

Water requirements;
Irrigation times;
Chemical and organic fertilizers;
Chamomile;
Origanum;
Water use efficiency.

INTRODUCTION

The global problem of water resources shortage is a critical issue demanding the development of sustainable water management programs for the arid and semi-arid regions like Egypt. In such regions, where water availability is a major limitation in crop production, using alternative water resources, and modern irrigation systems, together with proper soil nutrition are a must. Improper timing and scheduling of irrigation water may cause, leaching or accumulation of chemicals in the irrigated zone with hazardous effects on plant roots and yields. Furthermore, low organic matter contents of soils necessitates the addition of organic manures and

composted organic source to improve soil properties and water use efficiency thus increasing yield[3,20].

Medicinal and aromatic plants chosen for study are chamomile and oregano. Chamomile (*Matricaria chamomilla L.*) has been widely used for centuries as a medicinal plant. It may be considered as an economic substitute for field crop since it has adoptability to wide ranges of climate and soil[6,9]. Its phytotherapeutical effect is ascribed to coumarin-related compounds having antimicrobial and anti-inflammatory actions,[8,16] as well as gastrointestinal complaints. Also, oregano herbage (*Origanum vulgare L.*) has an aromatic, warm and slightly good taste due to its contents of essential oil[1,6].

Previous studies by Seidhom and Evon K. Rizk[14] on aromatic and medicinal plants have shown that the highest productivity of the Egyptian Henbane, Echium and Achillea was obtained by the use of chicken manure together with 2 liter/day (½ hr/day).

Kirda[10] and Shaxson and Barber[15] stated that, reductions in yields from disease and pests, losses during harvest and storage, and insufficient fertilizers are much greater than reductions in yields expected from deficit irrigation. Moutonnet[11] stated that, the upper limit for yield is set by soil fertility, climatic conditions and management practices as is in the case of evapotranspiration.

Several other investigators have also recently concluded that water use efficiency and water economy increased with the decreasing amount of irrigation water, decreasing irrigation intervals and by adding organic matter to sandy soils[2,5,14].

This work is an attempt to clarify the effect of fertilizers and water management under the prevailing climatic condition of sandy soils to improve water use parameters of some aromatic and medicinal plants.

MATERIALS AND METHODS

The current work was carried out in the Agricultural Experimental Station of the Desert Research Center at EL–Sheikh Zuwayid City, about 35 km east of El-Arish city, North Sinai Governorate during 2007/2008 season.

Meteorological data of average 12 years (1996-2007) were used to compute potential evapotranspiration (ETo) rates using the Penman – Monteith equation (TABLE 1) as recommended by CROPWAT, software version 5.7[17] to calculate crop coefficient (Kc).

TABLE 1 : Meteorological data of average 12 years (1996-2007) for studied area

Elements	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Max. Temp. °C	16.64	17.25	19.68	22.98	26.12	29.37	32.10	32.95	31.80	28.50	23.59	19.00
Min. Temp. °C	9.57	9.94	11.54	13.59	15.69	17.92	19.85	20.29	19.44	17.24	14.02	11.04
Relative humidity (%)	81.49	80.49	79.84	78.17	82.21	84.94	86.41	85.34	81.65	83.17	77.28	80.74
Wind speed (km/day)	209.46	236.06	222.44	201.54	179.16	148.00	162.48	137.80	154.20	167.56	191.24	186.32
Sunshine hours (n)	6.98	7.69	8.25	9.35	10.34	11.80	11.88	11.30	10.30	9.15	7.70	6.67
Rain (mm) *	42.43	32.46	20.07	8.23	0.46	0.44	0.10	0.08	0.19	13.97	13.23	42.73
ETo (mm/day)	1.75	2.22	2.94	3.90	4.55	5.24	5.59	5.36	4.68	3.47	2.58	1.81

ETo = potential evapotranspiration ***Total rain =174.39 mm/year**

The relevant physical and chemical characteristics of the soils of the studied site were determined according to Richards[13], TABLES (2a & b). The soils is sandy-textured, non-saline non-alkali and, available moisture (7.75 % w/w).

The experimental design was split-plot with three replicates for each treatment. Three different irrigation times (¼ hour = 1 liter/plant), (½ hour = 2 liter/plant) and (¾ hour = 3 liter/plant) were used and three types of fertilizer (organic, chemical and mixed organic and chemical), were applied to the soils.

Seeds of two aromatic and medicinal plants (*camomile* and *origanum*) were sown at a rate of 150 and 250 g/feddan on September, 15th, 2007, and November, 15th, 2007, respectively. Seedlings were translocated from nursery house, and planted in rows on October 16th 2007, and February 16th 2008, respectively. Drip irrigation system having 4 liter / hour GR dripper was

used. The distance between the lateral lines was one meter and drippers were located at ½ meter apart. Consequently, the number of plants per feddan was 8000. Brackish ground water (salinity 2892 ppm) was used for irrigation, TABLE 3. The chemical properties of the organic manures applied to the soil are shown in TABLE 4.

TABLE (2a) : Some soil physical properties

Soil depth (cm)	Particle size distribution (%)				Texture class	Particle density (g/cm^3)	Bulk density (g/cm^3)	Total porosity (%)	Organic matter (%)	Moisture content (%)		Available soil water/layer		Infiltration rate	
	Coarse sand	Fine sand	Silt	Clay						Field capacity	Wilting point	(%)	(mm)	(cm/hr)	Class
0-50	8.11	84.17	3.25	4.47	Sandy	2.50	1.43	42.80	0.23	10.86	3.11	7.75	55.41	16.0	Very rapid

TABLE (2b) : Some soil chemical and physico-chemical properties

Soil depth (cm)	$CaCO_3$ (%)	pH soil paste	ECe (dSm^{-1})	Soluble cations (me/l)				Soluble anions (me/l)				CEC (me/100g soil)	Exchangeable cations (me/100g soil)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Cl^{-}		Ca^{++}	Mg^{++}	Na^{+}	K^{+}
0-50	6.11	7.6	3.12	11.32	5.42	8.65	5.85	0.0	8.75	9.11	13.38	2.54	1.13	0.38	0.7	0.33

TABLE 3 : Chemical analysis of the irrigation water of the north Sinai research station

P^H	E.C (dS/m)	S.A.R	Soluble cations (mq/l)				Soluble anions (mq/l)				Class
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	
7.2	4.52	4.41	11.68	12.13	15.23	6.15	0	13.84	14.74	16.61	C_4 S_2

S.A.R = Sodium adsorption ratio **mq/l = mill equivalent per liter**

TABLE 4 : Some chemical properties of the organic manures applied to the soil

pH	E.C. dS/m	OM %	C %	N %	P %	K %	C/N
7.8	1.9	53.9	31.5	2.2	0.9	1.3	14.1

OM = Organic matter **C = Carbon**
N = Nitrogen **C/N = ratio**

The conventional agricultural practices were used for cultivating *camomile* and *origanum* plants received the recommended doses of mineral fertilization NPK: Calcium superphosphate (15.5 % P_2O_5) at the rate of 300 kg/fed plus 100 kg/fed sulphate chalets was applied during tillage before cultivation. Orgainc manure was added before planting by about 20 m^3/fed. *Camomile* plants received the recommended doses of mineral fertilization NPK: Nitrogen as ammonium sulphate (20.5 % N_2) about 25 kg/fed plus about 6 kg/fed Potassium sulphate (48 % K_2O) was applied and replicatee every 10 days to flowering stage and two replicates after every harvest collection. The fertilization process conducted through irrigation water, i.e. fertigation.

Origanum plants received the recommended doses of mineral fertilization NPK: Nitrogen as ammonium sulphate about 300 kg/fed in two equal doses after 30 and 60 days from planting and 150 kg/fed ammonium sulphate after every harvest collection. Potassium as Potassium sulphate about 50 kg/fed were applied after 60 days from planting and replicate every harvest collection by fertigation. All plants were several harvests and were done, 10–15 days apart, depending on the weather conditions, harvested to April 30th 2008 and September 30th 2008 for *camomile* and *origanum* plants, respectively. Their growing periods in the nursery were 30 and 90 days, whereas in the field they were 197 and 230 days, but their irrigation period was 167 and 185 days and total period were 227 and 320 days for *camomile* and *origanum* plants, respectively.

The amounts of applied irrigation water with no leaching requirements are shown in **TABLE 5** all over the season. The amounts of applied nursery irrigation are calculated as; = ((8 liter/m^2) x (nursery area/8000 plant about 80 m^2) x (reduction factor 0.25) x (nursery irrigation period)) / 1000 = m^3/feddan. All plants were irrigated in nursery by 4.80 and 14.40 m^3/feddan for *camomile* and *origanum* plants, respectively.

Prevent irrigation 3 and 15 days every harvest collection for *camomile* and *origanum* plants, respictevely. To determine the actual water consumption, soil moisture tension was measured by tensiometer, while moisture content was determined by gravimetric method and

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TABLE 5 : Irrigation water applied (m^3/fed/season) for *camomile* and *origanum* plants grown at El-Sheikh Zuwayid region

Plants	Camomile				Origanum			
Daily irrigation	Nursery period (30 days)	Irrigation period (167 days)	Effective rain	Total season (227 days)	Nursery period (90 days)	Irrigation period (185 days)	Effective rain	Total season (320 days)
¼ hour (1 liter/plant)	4.80	1336.00	218.11	1558.91	14.40	1480.00	78.17	1572.57
½ hour (2 liter/plant)	4.80	2672.00	218.11	2894.91	14.40	2960.00	78.17	3052.57
¾ hour (3 liter/plant)	4.80	4008.00	218.11	4230.91	14.40	4440.00	78.17	4532.57

hence the actual evapotranspiration was calculated by the following equation:

$$ETa = (M._2\ \% - M._1\ \%) \times d_b \times D \times 1000$$ [4]

Where: ETa = Actual evapotranspiration, mm.
$M._2$ = Moisture content after irrigation, %.
$M._1$ = Moisture content before irrigation, %.
d_b = Bulk density of soil, g/cm^3
D = Active root depth, cm.

At the end of the experiment, 10 and 3 harvest collections. Fresh and dry weight of harvested flowers and leaves for each plant were measured after drying at room temperature (20–25 °C). After the flowering period, dry weights of stems and roots were harvested and recorded for all plants in each plot for *camomile* and *origanum* plants, respectively.

The water use efficiency was calculated by dividing the dry economical yield / the amount of seasonal evapotranspiration[7]. The water economy was calculated by dividing the crop yield / the amount of water added as kg/m^3[19]. The crop coefficient was calculated by dividing the actual evapotranspiration (ETa) / potential evapotranspiration (ETo)[21]. Data were subjected to the analysis of variance according to Snedecor and Cochran[18]. The investment ratio was calculated as (IR) = Output LE / Input LE, (total costs), Rana *et al*.[12].

RESULTS AND DISCUSSION

Yield of *camomile* and *origanum* plants

Data presented in TABLE 6 show crop dry yield for the 2 cultivated plants and their economical components. The data indicate an increase of the dry yield of *camomile* and *origanum* plants irrigated ½ hour daily and fertilizered by mixed organic and chemical fertilizers. Irrigation with 1 liter/day (¼ hr/day) led to salts accumulation in the root zone, while the 3 liter/day (¾ hr/day) treatment induced the leaching of the fertilizers from the rhizosphere, both reducing crop growth. With regard to irrigation, crops dry yield was in the order of ½ hour, 2 liter/plant/day > ¾ hour, 3 liter/plant/day > ¼ hour, 1 liter/plant/day, with no significance among tratments. These results agree with[11] who showed that any significant decrease in soil water storage has an impact on water availability for a crop and, subsequently, on actual yield. As for the applied fertilizers, the order is mixed organic and chemical > organic > chemical with apparent significance among tratments.

These findings reflect irrigation deficit and insufficient use of fertilizers which necessitate the adoption of flexible planting dates. Also, the upper limit for yield is set by improving soil fertility and management practices to cope with prevailed arid climatic conditions.

These results are in agreement with the findings of Kirda[10], Shaxson and Barber[15], Seidhom and Evon K. Rizk[14], Gonz´alez et al.[6], Kambiz et al.[9] and Ali et al.[1].

Water consumptive use

Data in TABLES (7a & b) show significant decrease in water consumptive use for each of the investigated plants as a result of decreasing irrigation times and chemical fertilization. Obviously, the response to daily irrigation times were in the order of ¾ hour, 3 liter/plant/day > ½ hour, 2 liter/plant/day > ¼ hour, 1 liter/plant/day. Also, fertilization efficiency follows the order, mixed organic and chemical > organic > chemical. Statistical analysis shows highly significant differences among both irrigation times and types of fertilizers.

These findings may be due to decreasing evaporation by short irrigation time which maintains the soil dry much longer thus decreasing evapotranspiration by de-

TABLE 6 : Yield components of camomile and origanum plants

Treatments		Camomile					Origanum				
Daily irrigation times	Fertilizers types	Fresh plant flower weight (g)	Dry plant flower weight (g)	Dry flowers weight, (kg/fed)	Dry weights stems & roots (kg/fed)	Total dry yield (kg/fed)	Fresh plant leaves weight (g)	Dry plant leaves weight (g)	Dry leaves weight, (kg/fed)	Dry weights stems & roots (kg/fed)	Total dry yield (kg/fed)
15 minute (1 liter/plant)	Organic	76.6	68.4	547 b	629.1	1176.1	272.5	227.1	1816.5 ab	2053.2	3870.2
	Chemical	72.7	65.5	524 b	592.1	1116.1	245.7	210.0	1680.0 b	1881.6	3561.6
	Mixed	82.1	72.6	581 a	685.6	1266.6	293.0	236.3	1890.0 a	2154.6	4044.6
Average		77.1	68.8	550.67 a	635.6	1186.3	270.4	224.4	1795.5 a	2029.8	3825.5
30 minute (2 liter/plant)	Organic	89.1	78.9	631 b	738.3	1369.3	302.1	249.6	1997.1 ab	2296.6	4293.6
	Chemical	86.4	77.1	617 b	703.4	1320.4	291.4	244.9	1959.3 b	2233.3	4192.3
	Mixed	92.6	81.3	650 a	773.5	1423.5	323.9	259.1	2072.7 a	2425.4	4498.4
Average		89.4	79.1	632.67 a	738.4	1371.1	305.8	251.2	2009.7 a	2318.4	4328.1
45 minute (3 liter/plant)	Organic	85.5	75.0	600 b	726.0	1326.0	296.9	239.4	1915.2 ab	2259.7	4174.7
	Chemical	82.9	73.4	587 b	698.5	1285.5	277.9	229.7	1837.5 b	2132.1	3970.1
	Mixed	91.0	79.1	633 a	778.6	1411.6	320.7	252.5	2020.2 a	2424.0	4444.0
Average		86.5	75.8	606.67 a	734.4	1341.0	298.5	240.5	1924.3 a	2271.9	4196.3

L.S.D: 0.05 for Irrigation times = 230.1, 747.14 & Fertilizers = 28.21*, 94.16* for *camomile* and *origanum*, respectively.
a, b, letters indicated significant differences between treatments.

TABLE (7a) : Monthly and seasonally water consumptive use (liter/plant/day) of camomile plants

Treatments		Camomile								
Daily irrigation time	Fertilizer types	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Avg. (Liter/plant/day)	season (m^3/fed)
15 minute (1 liter/plant)	Organic	0.424	0.604	0.710	0.787	1.008	1.017	1.023	0.796	1298.7 ab
	Chemical	0.398	0.588	0.649	0.768	1.003	1.010	1.016	0.776	1267.5 b
	Mixed	0.448	0.642	0.745	0.832	1.015	1.022	1.025	0.819	1334.0 a
Average		0.339	0.562	0.645	0.732	0.927	0.935	0.939	0.797	1300.1 b
30 minute (2 liter/plant)	Organic	0.485	0.794	0.933	1.035	1.326	1.337	1.346	1.037	1699.0 ab
	Chemical	0.455	0.773	0.854	1.010	1.319	1.329	1.336	1.011	1658.5 b
	Mixed	0.513	0.844	0.980	1.094	1.334	1.344	1.348	1.065	1744.9 a
Average		0.424	0.703	0.806	0.915	1.159	1.168	1.174	1.038	1700.8 ab
45 minute (3 liter/plant)	Organic	0.587	0.961	1.129	1.253	1.604	1.618	1.628	1.254	2055.8 ab
	Chemical	0.551	0.935	1.033	1.223	1.596	1.608	1.616	1.223	2006.8 b
	Mixed	0.620	1.022	1.185	1.324	1.614	1.626	1.632	1.289	2111.4 a
Average		0.485	0.804	0.922	1.047	1.326	1.337	1.343	1.255	2058.0 a

L.S.D.: 0.05 for Irrigation times = 681.51* & Fertilizers = 81.21*
a, b, letters indicated significant differences between treatments.

creasing the amount of available soil moisture. Also adding organic manure maintains the soil moisture for longer periods, though increasing evaporation, yet increasing the available soil moisture, which makes the rhizosphere a good reservoir for water utilization by plants.

Undoubtedly water consumptive use increased with plant growth enhanced by increasing amounts of irrigation water. TABLES (7a & b) reveal that the consumptive use values were generally low at the beginning of the growing season and gradually increased until the ripening stage then decreased at the harvest stage. The highest increase in consumptive use was associated with the flowering and maturity stages of plants. This is due to the sufficient water available to plants in contrast to the higher evaporation from the wet rather than dry soil surface and the higher transpiration from plants as well as the amount of water needed for plant growth development and build-

ing plant tissues. In brief, ETa decreased with increasing soil moisture deficit. This may be attributed to the fact that soil was kept wet by more irrigation amounts. Nevertheless, higher seasonal consumptive use is mainly rendered to increasing evaporation rates from the soil matrix. These results are in harmony with those of Moutonnet[11], Seidhom and Evon K. Rizk[14], Gonz´alez et al.[6], Kambiz et al.[9] and Ali et al.[1].

TABLE (7b) : Monthly and seasonally water consumptive use (liter/plant/day) of origanum plants

Treatments		Origanum									
Daily irrigation times	Fertilizer types	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Avg. (Liter/plant/day)	season (m^3/fed)
15 minute (1 liter/plant)	Organic	0.373	0.504	0.725	0.953	1.003	1.012	1.018	0.678	0.783	1509.38 ab
	Chemical	0.350	0.491	0.664	0.930	0.998	1.005	1.011	0.620	0.759	1462.98 b
	Mixed	0.394	0.536	0.762	1.007	1.010	1.017	1.021	0.705	0.806	1552.53 a
Average		0.372	0.510	0.717	0.963	1.004	1.012	1.017	0.668	0.783	1508.30 b
30 minute (2 liter/plant)	Organic	0.548	0.672	0.967	1.270	1.374	1.386	1.395	0.929	1.152	2052.66 ab
	Chemical	0.515	0.654	0.885	1.240	1.367	1.377	1.385	0.849	1.115	1989.68 b
	Mixed	0.579	0.714	1.016	1.342	1.383	1.394	1.398	0.966	1.185	2110.93 a
Average		0.547	0.680	0.956	1.284	1.375	1.386	1.393	0.915	1.151	2051.09 ab
45 minute (3 liter/plant)	Organic	0.645	0.791	1.138	1.495	1.618	1.631	1.642	1.093	1.355	2415.72 ab
	Chemical	0.606	0.770	1.042	1.459	1.609	1.621	1.630	0.999	1.312	2341.60 b
	Mixed	0.682	0.841	1.195	1.579	1.628	1.640	1.645	1.137	1.395	2484.29 a
Average		0.644	0.800	1.125	1.511	1.618	1.631	1.639	1.076	1.354	2413.87 a

L.S.D.: 0.05 for Irrigation times = 831.89* & Fertilizers = 97.62*
a, b, letters indicated significant differences between treatments.

Water use efficiency of plants (W.U.E.)

Data in TABLE 8 show an increase in water use efficiency of *camomile* and *origanum* plants by decreasing irrigation time and use of mixed organic-mineral fertilizers. The efficiency of daily irrigation times were in the order, ¼ hour > ½ hour > ¾ hour while being in the order of mixed organic and chemical > organic > chemical for fertilization-manuring scheme.

TABLE 8 : Water use efficiency and water economy (kg/m^3) of camomile and origanum plants

Treatments		Camomile		Origanum	
Daily irrigation time	Fertilizer types	WUE (kg/m^3)	WEco. (kg/m^3)	WUE (kg/m^3)	WEco. (kg/m^3)
15 minute (1 liter/plant)	Organic	0.42 a	0.35 ab	1.20 a	1.16 ab
	Chemical	0.41 a	0.34 b	1.15 a	1.07 b
	Mixed	0.44 a	0.37 a	1.22 a	1.20 a
Average		0.42 a	0.35 a	1.19 a	1.14 a
30 minute (2 liter/plant)	Organic	0.37 a	0.22 ab	0.97 a	0.65 ab
	Chemical	0.37 a	0.21 b	0.98 a	0.64 b
	Mixed	0.37 a	0.22 a	0.98 a	0.68 a
Average		0.37 a	0.22 b	0.98 ab	0.66 b
45 minute (3 liter/plant)	Organic	0.29 a	0.14 ab	0.79 a	0.42 ab
	Chemical	0.29 a	0.14 b	0.78 a	0.41 b
	Mixed	0.30 a	0.15 a	0.81 a	0.45 a
Average		0.29 a	0.14 b	0.80 b	0.42 b

L.S.D: WUE for Irrigation times = 0.14, 0.37* & Fertilizers = 0.02, 0.48 for *camomile* and *origanum*, respectively.
L.S.D: WEco for Irrigation times = 0.09, 0.28 & Fertilizers = 0.012*, 0.038* for *camomile* and *origanum*, respectively.
a, b, letters indicated significant differences between treatments.

These results may be due to the high yields and low water consumption obtained under these conditions suggest an activation of both water and nutrient consumptions by plants, which is reflected on crop yield. Also, irrigation deficit and the insufficient use of fertilizers necessitate the adoption of flexible planting dates.

The upper limit for yield is set by improving soil fertility and proper management practices under the prevailed climatic conditions which as is in the case of evapotranspiration. Any significant decrease in soil water storage has an impact on water availability for a crop and, subsequently, on actual yield and actual evapotranspiration[11]. Similar results were obtained by Allen et *al.*[2], El-Dosouky et *al.*[5], Seidhom and Evon K. Rizk[14], Hsiao et al.[7], Kambiz et al.[9] and Ali et al.[1].

Water economy of plants (W. Eco.)

Results in TABLE 8 show that water economy values of *camomile* and *origanum* follow the same trend of water use efficiency of plants. To suffices, water economy values increased by decreasing irrigation times and use of mixed organic-inorganic fertilizers. The magnitude of daily irrigation times was in the order: ¼ hour, 1 liter/plant > ½ hour, 2 liter/plant > ¾ hour, 3 liter/plant and for fertilizers efficiency the order is: mixed organic and chemical > organic > chemical. Therefore, all tested parameters have shown the best combination between irrigation times and types of fertilization pointed to the highest yield of both plants. These findings may be due to the saving of the stored soil moisture and also to the activation of both water and nutrient consumptions by plants, which gave high yields, thereby high water economy values. Nevertheless, the quality of yield is not assured. Similar results were obtained by Allen et *al.*[2], El-Dosouky et *al.*[5], Seidhom and Evon K. Rizk[14], Kambiz et al.[9] and Ali et al.[1].

Crop coefficient (Kc)

The crop coefficient is useful in meeting the irrigation needs of crops and in the efficient utilization of the scarcely available and costly water in arid areas. It is also used in calculating irrigation programs. Results in TABLE 9 show the empirical averages of the monthly and seasonaly Kc obtained from the best treatment of WUE values of the two experiments, for the *camomile* and *origanum* plants.

Harmony results were obtained by Doorenbos and Pruitt[4], Allen *et al.*[2], Kambiz et al.[9] and Ali et al.[1].

TABLE 9 : Crop coefficient (Kc) of the best WUE values of camomile and origanum plants

Items	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Year
ETo mm/day	3.47	2.58	1.81	1.75	2.22	2.94	3.90	4.55	5.24	5.59	5.36	4.68	3.67
Camomile	0.25	0.47	0.78	0.91	0.87	0.66	0.50						0.63
Origanum					0.34	0.35	0.38	0.42	0.38	0.35	0.36	0.30	0.36

TABLE (10a) : Investment ratio (IR) of camomile plants grown at El-Sheikh Zuwayid region

Items	Plant type	Camomile								
	Soil management	Quarter hour			Half hour			Half & quarter hour		
		Org.	Chem.	Mix.	Org.	Chem.	Mix.	Org.	Chem.	Mix.
List of Inputs	Nurse preparation, LE/fed	60	60	60	60	60	60	60	60	60
	land preparation, LE/fed	60	60	60	60	60	60	60	60	60
	Seeds, LE/fed	200	200	200	200	200	200	200	200	200
	Cultivation, LE/fed	60	60	60	60	60	60	60	60	60
	Irrigation, LE/fed	335	335	335	669	669	669	1003	1003	1003
	Organic Fertilization, LE/fed	750	0	750	750	0	750	750	0	750
	Mineral Fertilization, LE/fed	0	250	250	0	250	250	0	250	250
	Weed Control, LE/fed	60	60	60	60	60	60	60	60	60
	Pest Control, LE/fed	60	60	60	60	60	60	60	60	60
	Labors Costs, LE/fed	60	60	60	60	60	60	60	60	60
	Machines, LE/fed	60	60	60	60	60	60	60	60	60
	Fuel, LE/fed	60	60	60	60	60	60	60	60	60
	Harvesting, LE/fed	60	60	60	60	60	60	60	60	60
	Crop Transportation, LE/fed	40	40	40	40	40	40	40	40	40
	Rent (on season), LE/fed	250	250	250	250	250	250	250	250	250
	Total Inputs, LE/fed	2115	1615	2365	2449	1949	2699	2783	2283	3033
List of Outputs	Yields, kg/fed	547	524	581	631	617	650	600	587	633
	Prices, LE/kg	6.0	3.0	4.5	6.0	3.0	4.5	6.0	3.0	4.5
	Total Prices, LE/fed	3282	1572	2615	3786	1851	2925	3600	1761	2849
	Net Income, LE/fed	1167	-43	249	1337	-98	226	817	-522	-185
Investment Ratio (IR)		1.55	0.97	1.11	1.55	0.95	1.08	1.29	0.77	0.94

Current Research Paper

Economical assessment

The economical evaluation is of a great importance. It depends on the net return from any agricultural practices leading to increasing productivity at economical interest. Align with this approach the values of investment ratio (IR) illustrated in TABLES (10a & b) is a guide that could encourage farmers interested in aromatic and medicinal plants.

TABLE (10b) : Investment ratio (IR) of origanum plants grown at El-Sheikh Zuwayid region

Items	Plant type	Origanum								
	Soil management	Quarter hour			Half hour			Half & quarter hour		
		Org.	Chem.	Mix.	Org.	Chem.	Mix.	Org.	Chem.	Mix.
List of Inputs	Nurse preparation, LE/fed	60	60	60	60	60	60	60	60	60
	land preparation, LE/fed	60	60	60	60	60	60	60	60	60
	Seeds, LE/fed	200	200	200	200	200	200	200	200	200
	Cultivation, LE/fed	60	60	60	60	60	60	60	60	60
	Irrigation, LE/fed	374	374	374	744	744	744	1114	1114	1114
	Organic Fertilization, LE/fed	750	0	750	750	0	750	750	0	750
	Mineral Fertilization, LE/fed	0	250	250	0	250	250	0	250	250
	Weed Control, LE/fed	60	60	60	60	60	60	60	60	60
	Pest Control, LE/fed	60	60	60	60	60	60	60	60	60
	Labors Costs, LE/fed	60	60	60	60	60	60	60	60	60
	Machines, LE/fed	60	60	60	60	60	60	60	60	60
	Fuel, LE/fed	60	60	60	60	60	60	60	60	60
	Harvesting, LE/fed	60	60	60	60	60	60	60	60	60
	Crop Transportation, LE/fed	40	40	40	40	40	40	40	40	40
	Rent (on season), LE/fed	250	250	250	250	250	250	250	250	250
	Total Inputs, LE/fed	2154	1654	2404	2524	2024	2774	2894	2394	3144
List of Outputs	Yields, kg/fed	1817	1680	1890	1997	1959	2073	1915	1838	2020
	Prices, LE/kg	3.0	2.0	2.5	3.0	2.0	2.5	3.0	2.0	2.5
	Total Prices, LE/fed	5450	3360	4725	5991	3919	5182	5746	3675	5051
	Net Income, LE/fed	3296	1706	2321	3468	1895	2408	2852	1281	1907
Investment Ratio (IR)		2.53	2.03	1.97	2.37	1.94	1.87	1.99	1.54	1.61

Notably, the high results of IR values were obtained for applying organic fertilizer for any irrigation time treatments. In addition, referring to the national IR value, which is around 1.20 and 1.50 LE of *camomile* and *origanum*, respectively for the given treatments, could be overcome with all options experimented for *origanum* in this study.

Depending on the detection of the water consumption for all treatments and economical assessment, the rate of 1 liter/day (¼ hr/day) and organic fertilizer yielded the highest profitable gains of *camomile* and *origanum* plants.

The obtained results stand in harmony with those previously reported by Seidhom and Evon K. Rizk[14], Kambiz et al.[9] and Ali et al.[1].

CONCLUSION

The following can be concluded from the aforementioned discussion:

Water use efficiency and water economy of *camomile* and *origanum* plants increased by decreasing irrigation time and use of mixed organic-inorganic fertilizers, but organic fertilizer returns high investment under any water regime along with the 1 liter/plant/day (¼ hr/day) treatment. The empirical averages for seasonal Kc values from the two experiments for the studied plants are 0.63 and 0.36 for the best WUE values of camomile and origanum plants grown at El-Sheikh Zuwayid region, respectively.

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