Impact of Irrigation Levels and Fertigation Frequency on Yield, Water and NPK Use Efficiencies of Safflower under New Valley Conditions

[*]Abdel-Motagally, F.M.F.[1]; M.M.M. Ahmed[2] and A.M.A. Hassan[3]
[1]Agronomy Depart. Fac. of Agric., Assiut Univ., Egypt
[2]Soil, Water and Environment Research Institute, ARC. Giza, Egypt
[3]Central Laboratory for Agric. Climate. ARC, Egypt
[*]**Corresponding author**: Fatmotagally@yahoo.com

Abstract:

Two field experiments were conducted at the Research Farm, Agricultural Research Station, El-Kharga, New Valley Governorate, Egypt, during 2011/2012 and 2012/2013 seasons to study the impact of irrigation levels (I_1=100%, I_2= 80% and I_3= 60% of potential evapotranspiration, ET_p) and fertigation frequency (F_1= 3, F_2= 6, F_3= 12 and F_4= 18 doses) on safflower crop. The experiments were laid out in randomized complete block design in strip-plot arrangement with three replicates. Results showed that the highest mean values of seed yield, oil yield and NPK use efficiency were recorded from drip irrigation at 100% of ET_p with number fertigation splitting to 12 equal doses. The increment percentage of seed yield due to I_1F_3 treatment over fertigation splitting 3 doses under the same irrigation treatment were 62.2% and 61.1%, 42.34% and 41.63% when using I_2F_4 treatment in both seasons, respectively as compared to 100% of ET_p with fertigation splitting 3 equal doses (I_1F_1). The highest mean values of water use efficiency were recorded from drip irrigation at 80% of ET_p with fertigation splitting 18 doses in both seasons. So, it is concluded that treated safflower plants with I_2F_4 to get economical yield and water use efficiency, respectively; therefore it may be saving 20% of irrigation water.

Keywords: Safflower, fertigation, New Valley, NPK, water use efficiency.

Received on: 2/3/2015 **Accepted for publication on:** 21/3/2015

Referees: Prof. Elsaadi A. Ali Prof. Mohsen A. Gameh

Introduction:

Egypt faces severe shortage in vegetable oil production. However, the majority of local edible oil production comes from some crops cultivated in the old soils. Increasing oil production must depend on cultivation of non-conventional oil crops such as safflower in reclaimed or less fertile soils (Osman *et al*., 2008). Egypt desert occupied about 96 % from the total area and the chance of growing of safflower in Nile Valley old soil is very limited because of the high competition with other crops. So, growing safflower in Egypt may become successful if it grown in reclaimed or less fertile soils. These soils are characterized by low water holding capacity, combined with the high infiltration rate make it imperative to follow a strict irrigation scheduling policy and to use an irrigation technique that delivers small amounts of water at relatively short intervals such as drip and sprinkler irrigation systems. Also, safflower is tolerant to drought because it is adaptable to semi-arid and arid conditions; it has significant economic benefits.

In modern agriculture, both fertilization and irrigation are important management factors for controlling yield quantity and quality (Bar-Yosef, 1999). The method of application of fertilizer and irrigation water affects water and fertilizer use efficiency under arid and semi-arid conditions. Application of fertilizers with irrigation water (fertigation) has several advantages over traditional methods. Time and rate of fertilizer applied can be regulated precisely (Gurusamy *et al.,* 2011 and Kumar *et al.,* 2011). Application of water at the time of actual need through drip and irrigation scheduling with right quantity of water to wet the effective root zone soil is the proper irrigation management system to save the precious water. As competition for water resources and the need for water conservation increases, adoption of drip fertigation system is a must in future. The balanced application of NPK fertilizer rates play a great deal in safflower production. Igbadun *et al.* (2006) showed that the crop yield response was very much dependent on the amount of water applied at different crop development stages than the overall seasonal water applied. This approach may save water with little or no negative impact on the final crop yield. In arid and semi-arid environments, both efficient use of available water and a higher yield and quality of safflower are in demand (Lovelli *et al.,* 2007 and Koutroubas *et al.*, 2008). The objective of this work was to investigate the impact of irrigation levels and number of fertigation doses on yield as well as water and NPK use efficiency of safflower under New Valley conditions.

Material and Methods:

Two field experiments were carried out during the two successive winter growth seasons of 2011/2012 and 2012/2013 at the Research Farm, Agricultural Research Station, El-Kharga, New Valley Governorate, Egypt, which is located around the point of 25° 27' 88.48" N latitude and 30° 32' 43.38" E longitudes and at 73 m altitude. This experiment was conducted to study the impact of irrigation levels and number of fertigation doses on yield as well as water and NPK use efficiency of safflower. Monthly meteorological data collected from El-Kharga Weather Station are show in Table (1).

Table 1: Average of monthly meteorological data of El-Kharga Agro-Metrological Station in 2011/12 and 2012/13 seasons

Evaluation meager time	Temperature (°C)			RH%	Wind speed ($m\ s^{-1}$)	Rain fall (mm)	Sun shine (hours)	Solar radiation ($Mjm^{-2}.d^{-1}$)	E pan (mm day^{-1})
	max	min	mean						
2011/2012									
Nov.	26.1	11.6	19.0	43.7	4.20	0	8.5	16.0	6.88
Dec.	22.8	8.1	15.5	49.6	2.84	0	8.4	14.7	6.34
Jan.	20.3	4.9	12.8	49.7	2.08	0	8.8	15.9	5.31
Feb.	24.3	10.2	17.3	37.1	3.24	0	8.6	17.9	10.30
Mar.	26.6	11.2	19.4	33.2	3.40	0	9.9	22.1	11.11
Apr.	35.6	18.2	27.4	24.1	3.51	0	11.6	26.6	17.29
May	38.7	22.9	31.4	22.6	3.59	0	11.3	26.9	19.57
2012/2013									
Nov.	29.9	14.8	22.5	45.5	2.45	0	8.8	16.3	8.63
Dec.	23.5	9.2	16.2	50.7	2.30	0	8.2	14.5	6.18
Jan.	23.8	9.0	16.2	43.3	2.41	0	8.6	15.5	6.46
Feb.	25.9	10.0	18.0	38.1	2.62	0	9.5	18.9	8.13
Mar.	31.5	13.7	22.4	29.7	2.66	0	11.1	23.7	11.43
Apr.	32.9	16.3	24.9	26.5	3.07	0	11.2	26	14.26
May	39.9	23.5	32.2	20.6	3.60	0	11.6	27.4	20.78

The randomized complete block design using strip-plot with three replicates was adopted. Twelve treatments were used which included three irrigation levels (I_1=100%, I_2= 80% and I_3= 60% of potential evapotranspiration, ET_p) and four fertigation splitting (F_1= 3, F_2= 6, F_3= 12 and F_4= 18 doses). The irrigation levels were laid in main plots while the fertilization frequency was arranged in sub plots. Safflower seeds (Giza-1 cultivar) were sown on 15th and 18th November in the first and second seasons, respectively. The physical and chemical properties of soil site and irrigation water are given in Table (2).

After 30 days from sowing the seedlings were thinned one plant per hill. Drip irrigation system was set up of GR polyethylene pipe of 16 mm in diameter with auto emitters every 30 cm apart and 50 cm between the drip lines with flow rate of 4 liter per hour per dripper at pressure of 1.5 bars. Experimental plot area was 36 m^2 (20 m X 1.8 m). There was 1.20 and 1.80 m separation between each treatment and plot, respectively, in order to minimize water movement among different treatments.

Table 2: Some physical and chemical properties of a representative soil samples in the experimental site before sowing (0-30 cm depth) and chemical analysis of water properties at El-Kharga location in 2011/2012 and 2012/2013 seasons.

Soil Characteristic	2011/2012*	2012/2013*	Water properties	2011/2012*	2012/2013*
Sand (%)	90.53	90.65	EC ($dS\ m^{-1}$)	0.46	0.51
Clay (%)	5.35	5.55	pH	6.76	6.65
Silt (%)	4.12	3.80	Soluble cations meq l^{-1}		
Soil texture	Sandy	Sandy	Ca^{+}	0.92	1.19
Organic matter (%)	0.08	0.11	Mg^{++}	1.06	1.26
Field capacity (%)	10.2	9.55	Na^{+}	1.31	1.38
EC (1:1 extract) (dSm^{-1})	0.63	0.67	K^{+}	1.04	1.25
pH (1:1 suspension)	7.68	7.68	Soluble anions meq l^{-1}		
Total nitrogen (%)	0.003	0.003	CO_3^{-2} +HCO_3^{-1}	1.95	2.15
Water saturation % (v/v)	22.5	22.1	Cl^{-1}	1.65	1.63
Field capacity % (v/v)	10.2	9.55	SO_4^{-2}	0.73	1.3
Wilting point % (v/v)	4.9	4.3	SAR	1.32	1.25
Available water	5.3	5.25	Fe (ppm)	1.15	1.43
$CaCO_3$ (%)	3.33	3.63	Mn (ppm)	0.10	0.10
$NaHCO_3$ - P ($mg\ kg^{-1}$)	8.01	8.49			
Exch. K (meq 100 g^{-1}soil)	0.12	0.14			

*Each value represents the mean of three replicates.

The irrigation treatments started at 30 days after emergence. All experimental units received equal amounts of water during germination (112 m^3 $fed.^{-1}$). Nitrogen, phosphorus and potassium fertilizers were added according to the recommended doses of 45 kg N $fed.^{-1}$ as ammonium nitrate (33.5% N), 22.5 kg P_2O_5 $fed.^{-1}$ as phosphoric acid (85% P_2O_5) and 24 kg K $fed.^{-1}$ as potassium sulfate (48% K_2O) were applied through fertigation. The amounts of fertilizers were divided into 3, 6, 12 and 18 equal doses. These doses were given at 21, 15, 7 and 3 day intervals starting at 3rd week after planting. The amounts of NPK fertilizers used per each dose are shown in Table (3).

Table 3: The amounts of NPK fertilizers used per each dose

Fertigation treatments	Ammonium nitrate (Kg $fed.^{-1}$)		Phosphoric acid (Kg $fed.^{-1}$)		Potassium sulphate (Kg $fed.^{-1}$)	
	Dose	Total	Dose	Total	Dose	Total
F_1 (3 doses)	45.0	135	14.0	42	16.7	50
F_2 (6 doses)	22.5	135	7.0	42	8.3	50
F_3 (12 doses)	11.3	135	3.5	42	4.2	50
F_4 (18 doses)	7.5	135	2.3	42	2.8	50

All cultural practices were followed as recommended for safflower crop through the two growing seasons. The amounts of irrigation water applied were measured by flow meter. The daily pan evaporation data was used for scheduling irrigation. Irrigation treatments were given once in three days interval. Times and amounts of applied water at every irrigation treatment are presented in Table (4).

Table 4: The times and amounts of applied water at every irrigation treatment

	No. days	Irrig. interval	No. Irrig.	Network discharge (m^3 h^{-1})	Total applied water (m^3) period^{-1}			Operating time (minutes)		
					100% ET_p	80% ET_p	60% ET_p	100% ET_p	80% ET_{p2}	60% ET_p
2011/12										
At sowing	-	-	1	112	112.00	112.00	112.00	60	60	60
November	13	3	4	112	245.55	245.55	245.55	33	33	33
December	31	3	10	112	518.56	462.21	405.86	28	25	22
January	31	3	10	112	440.14	352.12	264.09	24	19	14
February	29	3	10	112	623.42	498.74	374.05	33	27	20
March	31	3	10	112	804.13	643.30	482.48	43	34	26
April	30	3	10	112	1137.64	910.11	682.58	61	49	37
Total					3881.44	3224.03	2566.61			
2012/13										
At sowing	-	-	1	112	112.00	112.00	112.00	60	60	60
November	10	3	3	112	205.24	205.24	205.24	27	27	27
December	31	3	10	112	518.75	478.83	438.90	28	26	24
January	31	3	10	112	603.17	482.54	361.90	32	26	19
February	28	3	10	112	631.36	505.09	378.82	34	27	20
March	31	3	10	112	904.61	723.69	542.77	48	39	29
April	30	3	10	112	994.56	795.65	596.73	53	43	32
Total					3969.69	3303.04	2636.36			

The pan was located near the experimental field. The following equation (Doorenbos and Pruitt, 1977) was used to calculate the potential evapotranspiration (ET_p):

$$ET_p = E_{pan} \times K_{pan}$$

Where:

E_{pan} = pan evaporation (mm/day)

K_{pan} = pan coefficient

The K_{pan} values were calculated using following equation according Allen *et al.* (1998):

$$K_p = 0.108 - 0.0286\mu_2 + 0.0422 \text{ Ln (fet)} + 0.1434 \text{ Ln } (RH_{mean}) - 0.000631 [\text{Ln (fet)}]^2 \text{ Ln } (RH_{mean})$$

RH_{mean}= average daily relative humidity [%] = $(RH_{max} + RH_{min})/2$

FET= fetch, distance of bare soil upwind of the evaporation pan (m)

u_2= mean wind at 2-m height (m s^{-1})

At harvest, samples of ten guarded plants from each plot were taken randomly in both seasons to measure the following characters: plant height (cm), number of branches, 100-seed weight (g) and seed yield (kg $fed.^{-1}$): was calculated from plot seed yield and convert to seed yield per $fed.^{-1}$. Seed oil percentage**:** It was estimated by soxalet apparatus using petroleum ether (40-60°C) as solvent according to (A.O.A.C. 1995).

- Oil yield (kg $fed.^{-1}$**)**: was calculated as following equation:

$$Oil\ yield\left(kg\ fed.^{-1}\right) = \frac{Oil\% \times seed\ yield\ \left(kg\ fed.^{-1}\right)}{100}$$

Water and fertilizers use efficiencies:

-Water use efficiency (kg seed/m^3)

$$WUE\ \left(kg\ m^{-3}\right) = \frac{\text{Seed yield}\ (kg\ fed.^{-1})}{\text{Consumptive}\ water\ \text{use}\ (m^3\ fed.^{-1})}$$

Fertilizers use efficiency**:** were calculated according to Vijayakumar *et al*. (2010) as follows:

-Nitrogen use efficiency (kg seed/kg N)

$$NUE = \frac{\text{Seed yield}\ (kg\ fed.^{-1})}{\text{N}itrogen\ applied\ (kg\ fed.^{-1})}$$

-Phosphorus use efficiency (kg seed/kg P_2O_5)

$$PUE = \frac{\text{Seed yield}\ (kg\ fed.^{-1})}{Phosphorus\ applied\ (kg\ fed.^{-1})}$$

-Potassium use efficiency (kg seed/kg K_2O)

$$KUE = \frac{\text{Seed yield}\ (kg\ fed.^{-1})}{Potassium\ applied\ (kg\ fed.^{-1})}$$

Actual crop evapotranspiration (ET_c)

Actual crop evapotranspiration under different treatments was measured directly by measuring changes in soil water content using Time Domain Reflectometry (TDR), model Trase System1 6050 X I in 0.15 m depth intervals down to 0.60 m. Actual crop evapotranspiration for any period will be determined according to Israelson and Hansen, 1962 as follows:

$$ET_C = \sum_{i=1}^{n=4} \left(\theta_2 - \theta_1\right)/100$$

Where: ETc= Actual crop evapotranspiration

n= number of layers

θ_1= soil moisture % before irrigation (v/v)

θ_2= soil moisture % 24 h after irrigation (v/v)

Statistical analysis:

The results were statistically analyzed according to Gomez and Gomez (1984), using the computer MSTAT.C statistical analysis package by Freed *et al.* (1989). The least significant differences (L.S.D.) probability level of 5% was manually calculated compare the differences among means.

Results and Discussion:

Effect of irrigation levels

Data presented in Table (5) show that irrigation levels had a significant effect on all studied traits except oil % in both seasons. Moreover, no significant difference was found between I_1 (100% ET_p) and I_2 (80% ET_p) for plant height, number of branches, 100-seed weight (g), seed yield (kg $fed.^{-1}$) and oil yield (kg $fed.^{-1}$) in both seasons. This means that can save 20% irrigation water consequently, decreasing water with draw cost or using the saved quantity to cultivating another area. This might be due to the optimum soil moisture required by safflower plants. Among the three irrigation treatments, irrigation at 100% of ET_p registered the highest values of plant height (117.3 and 117 cm), number of branches (6.48 and 7.45), 100-seed weight (6.81 and 7.17 g), oil yield (425.02 and 464.70 kg $fed.^{-1}$) and seed yield (1392.0 and 1460.1 kg $fed.^{-1}$) in the first and second seasons, respectively. Ghamarnia and Sepehri (2010) reported that maximum seed and oil yields were achieved for treatments 100% ET_p. Also, the results in Table (6) show that irrigation levels had a significant effect on water, N, P and K use efficiency, while it was no significant difference between I_1 and I_2 for these traits. Among the three irrigation treatments, irrigation at 80% of ET_p registered the highest mean values of water use efficiency (0.47 and 0.49 kg m^{-3}), where the highest NUE (30.93 and 32.45 kg seed kg^{-1} N applied), PUE (61.87 and 64.89 kg seed kg^{-1} P applied) and KUE (58.0 and 60.84 kg seed kg^{-1} K applied) were recorded in irrigation at 100% of ET_p (I_1) in the first and second seasons, respectively. Movahhedy-Dehnavy *et al.* (2004) found that there was a decrease in seed yield, total biomass, number of capitula per plant and plant height each growing season by withholding irrigation at various growth stages at all treatment combinations, especially when water deficit stress was imposed at the flowering stage. The results were similar to the findings with Lovelli *et al.* (2007), Esendala *et al.* (2008), Istanbulluoglu *et al.* (2009), Eslam *et al.* (2010), Eslam (2011) and Orange and Ebadi (2012).

Effect of fertigation frequency splitting

Fertigation frequency splitting had a significant effect on all studied traits (Table 5). The third fertigation frequency splitting F_3 (12 equal doses) was superior over the other fertigation frequency splitting in most studied traits. As well as, the differences between F_3 (12 equal doses) and F_4 (18 equal doses) were insignificant. So, it can use F_3 fertigation frequency splitting to achieve economical yield without significant decreases. Application of F_3 fertigation frequency splitting recoded the highest values of 100-seed weight, seed yield, oil% and oil yield. The highest yield might be due to the application of optimum fertilizer time that required by the crop.

On the other hand, data in Table 6 show that fertigation frequency splitting had a significant effect on water, N, P and K use efficiency. The highest water use efficiency (0.49 and 0.51 kg m^{-3}**)**, Nitrogen use efficiency (28.76 and 30.20 kg seed kg^{-1} N applied), Phosphours use efficiency (57.51 and 60.39 kg seed kg^{-1} P applied) and Potassium use efficiency (53.92 and 56.62 kg seed kg^{-1} K applied) were recorded in F_3 in first and second seasons, respectively. Also, the results show that there is no significant difference between F_3 and F_4 in this respect. Das and Ghosh (1993) reported that fertilizer nitrogen doses significantly affected the yield and yield components up to the 60 kg N ha^{-1} dose as an optimum dose. Nimje (1991) found that the water use efficiency was increased by nitrogen application. Murat and Yildirim (2004) found that the different nitrogen fertilizer doses had a significant effect on both seed and oil yields of safflower in both years, but not on the oil%. Ahmed *et al.* (1985) found that various doses of nitrogen (60 kg $fed.^{-1}$) had a significant positive effects on the plant height, the number of branches, the flowering percentage, the seed yield, the 1000 seed number and protein content in seeds of safflower. This combination indicating that the balanced of primary nutrients has more advantages than their imbalanced application, this balance caused to the vigor of vegetative growth of safflower plants and increases synthetic materials in different parts of plant and consequently yield and its components. These results matched those obtained by El-Nakhlawy (1991), Patil and Patil (1998) and Ali and Osman (2004).

Effect of interaction between irrigation levels and fertigation frequency splitting

Results in Table (5) show that irrigation level and frequency splitting fertilizer significantly influenced all studied traits except oil% in both seasons. The maximum mean values of plant height (141.0 and 138.0 cm), number of branches plant^{-1} (7.6 and 8.6) were observed in drip irrigation at 100% of ET_p (I_1) with fertigation splitting into 12 equal doses (F_3) in the first and second seasons, respectively. Whereas the shortest plant (58.0 and 43.0 cm) and the minimum number of branches plant^{-1} (3.8 and 4.3) were recorded in drip irrigation at 60% of ET_p with fertigation splitting into 6 equal doses (F_2) in the first and second seasons, respectively. The improved growth characters in 100% of ET_p and 12 equal doses (I_1F_3) might be due to optimum availability of nutrients through better fertilizer distribution in the root zone of the plants which was enhanced by the presence of adequate moisture in the soil. Also, data in Table 6 revel that the influence of irrigation and fertigation frequency splitting reflected on the yield parameters of safflower in both seasons. The maximum mean values of the studied characters were recorded from drip irrigation at 100% of ET_p with fertigation splitting into 12 equal doses (I_1F_3) treatment. The increment percentages of seed yield due to I_1F_3 treatment over I_1F_1 treatment were 62.2 and 61.1%; while, it were 42.34% and 41.63% when using I_2F_4 treatment in both seasons, respectively. The results could be attributed to positive effect of irrigation and fertigation frequency splitting through application of water and fertilization in the suitable time to plant required. The lowest values of mentioned yield parameters were observed in drip irrigation at 60% of ET_p with fertigation splitting 3 equal doses which was inferior to all the other combinations.

The reason for the lowest values of studied parameters may be due to lesser uptake of nutrients by plants under low soil moisture (drip irrigation at 60% ET_p) even though the applied fertilizer was high. The influences of irrigation and fertigation splitting on safflower water use efficiency (WUE) were shown in Table (6). The highest WUE of 0.63 and 0.65 kg m^{-3} were recorded in drip irrigation at 80% of ET_p with fertigation splitting 18 equal doses (I_2F_4). This result may be related to the reduction in the water consumptive use with F_4 (18 equal doses) compared to other treatments.

Vijayakumar *et al.* (2010) mentioned that the highest WUE was observed in I_2F_3 (Drip irrigation at 75% of pan evaporation (PE) with fertigation at 75% of recommended N and K) whereas the least WUE was recorded in I_1F_1 (Drip irrigation at 100% of (PE) with fertigation at 125% of recommended N and K) on the same crop. These findings are in conformity with those obtained by Manal El-Tantawy *et al.* (2007) on maize and Abdel-Mawgoud *et al.*

(2009) on sunflower. Data illustrated in Table (6) focus that irrigation and fertigation splitting had a significant effect on N, P and K use efficiency in the two growing seasons. Increased nitrogen use efficiency (NUE), phosphorus (PUE) and potassium use efficiency (KUE) with the decreased level of fertilizer doses were observed. The highest NUE (40.20 and 42.04 kg seed kg^{-1} N applied), PUE (80.40 and 84.40 kg seed kg^{-1} P applied) and KUE (75.38 and 78.82 kg seed kg^{-1} K applied) were recorded in I_1F_3 in the first and second seasons, respectively. As the fertilizer doses increased, the Phosphorus use efficiency (FUE) increased when there was less yield difference. Similar findings were observed by Singhandhupe *et al.* (2003), Hongal and Nooli (2007) and Badr and Abou El-Yaized (2007). Safflower has fairly good resistance to soil salinity and drought stress conditions and can be cultivated in dry and semi arid areas (Ali and Mahmoud, 2012).

Conclusion:

Higher mean values of seed yield, oil yield and NPK use efficiency were recorded by using from drip irrigation at 100% of ET_p with splitting fertilizer into 12 equal doses with non-significantly differences as compared to 80% of ET_p. The highest water use efficiency was recorded in drip irrigation at 80% of ET_p with splitting fertilizer into 18 equal doses. So, it is concluded that treated safflower plants with I_2F_4 to get highest yield and water use efficiency, respectively; therefore this may be saving 20% irrigation water.

References:

A.O.A.C. 1995. Association of Official Analytical Chemists. Official Methods of Analysis, 16th ed. AOAC International, Washington, D. C., USA.

Abdel-Mawgoud, A.S.A., M.A. Gameh, S.H. Abd-Elaziz and M.M. El-Sayed. 2009. Sunflower water relations at various irrigation regimes with modern irrigation systems under climatic conditions of Assiut governorate, Upper Egypt. Thirteen International Water Technology Conference, IWTC 13, 2009, Hurghada, Egypt.

Ahmed, Z., S. Meddekkar, and S. Mohammed. 1985. Response of safflower to nitrogen and phosphorus. Indian Agron., 30: 128-130.

Ali, E.A. and A.M. Mahmoud. 2012. Effect of combination between organic and mineral fertilization on productivity of some safflower genotypes. World J. Agric. Sci., 8 (2): 134-140.

Ali, E.A. and E.B.A. Osman. 2004. Effect of hill spacing fertigation using drip irrigation system in sandy calcareous soil on the productivity of some safflower genotypes. The 2nd Syrian-Egyptian Conf., El-Baath Univ., Syria.

Allen, G.R., L.S. Pereira, D. Raes and M. Smith. 1998. Crop evapotranspiration, guidelines for competing crop water requirements. FAO. Irrigation and drainages paper 56. Rome, Italy.

Badr, M.A. and A.A. Abou El-Yazied. 2007. Effect of fertigation frequency from subsurface drip irrigation on tomato yield grown on sandy soil. Australian Journal of Basic and Applied Sciences 1 (3): 279-285.

Bar-Yosef, B. 1999. Advances in fertigation. Adv. Agron., 65, 1-70.

Carrow, R.N., D.V. Waddington and P.E. Rieke. 2001. Turfgrass soil fertility and chemical problems. Assessment and management. Ann Arbor Press, *Chelsea, MI.*

Das, N.R. and N. Ghosh. 1993. Effect of Number of Tillage and N-levels on yields of Rainfed Safflower after Transplanted Wet Rice. Proceedings 3rd International Safflower Conference. 14-18 June. Beijing, China, pp: 403-409.

Doorenbos, J. and W.O. Pruitt. 1977. Crop water requirements. Irrigation and drainage paper, No. 24, FAO, Rome.

El-Nakhlawy, F.S. 1991. Response of safflower to different levels of nitrogen, phosphorus and potassium. Acta Agronomica Hungarica, 40 (1-2): 87-92.

Manal El-Tantawy, M., S.A. Ouda and F.A. Khalil. 2007. Irrigation scheduling for maize grown under middle Egypt conditions. Research Journal of Agriculture and Biological Sciences, 3(5): 456-462.

Esendala, E., A. Istanbulluoglu, B. Arslan and C. Paşa. 2008. Effect of water stress on growth components of winter safflower (*Carthamus tinctorius* L.). Proceedings of the 7th International Safflower Conference, Wagga, New South Wales, Australia.

Eslam, B.P. 2011. Evaluation of physiological indices for improving water deficit tolerance in spring safflower. J. Agr. Sci. Tech. 13: 327-338.

Eslam, B.P., H. Monirifar, and M.T. Ghassem. 2010. Evaluation of late season drought effects on seed and oil yields in spring safflower genotypes. Turk J Agric For Research Article, 34, 373-380.

Freed, R.P., S.P. Eisensmith, S. Goelz, D. Reicozky, W.W. Smail, and P. Woberg. 1989. MSTAT. A Softwar Program for Design, Management and Analysis of Agronomic Research Experiments. Dep. Crop and Soil Sci, Michigan Stat University, USA.

Ghamarnia, H. and S. Sepehri. 2010. Different irrigation regimes affect water use, yield and other yield components of safflower (*Carthamus tinctorius* L.) crop in a semi-arid region of Iran. J. Food, Agriculture & Environment, 8 (2): 590-593.

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures For Agriculture Research. A Willy-Inter Science publication, John Wily and Sons, Inc. NewYork, USA.

Gurusamy, A., P.P. Mahendran, S.V. Krishnasamy and A.D. Kumar. 2011. Study on the influence of irrigation regimes and fertilization levels on sugarcane under subsurface drip fertigation system. 8th International Micro Irrigation Congress. 21 October 2011, Tehran, Iran, pp: 191-199.

Hongal, M.M. and S.S. Nooli. 2007. Nutrient movement in fertigation through drip-a review. Journal of Agricultural Review 28(4): 301-304.

Igbadun, H.E., H.F. Mahoo, A.K.P.R. Tarimo and B.A. Salim. 2006. Crop water productivity of an irrigated maize crop in Mkoji sub-catchment of the Great Ruaha River Basin, Tanzania. Agric. Water Manage. 85, 141–150.

Israelson, O.W. and V.E. Hansen. 1962. Flow of water into and through soils. Irrigation principles and practices. 3rd Edition, John Wiley and Sons, Inc., New York, N.Y., U.S.A.

Istanbulluoglu, A., E. Gocmen, E. Gezer and F. Konukcu. 2009. Effect of water stress at different development stages on yield and water productivity of winter and summer safflower (*Carthamus tinctorius* L.). Agricultural Water Management 96: 1429-1434.

Koutroubas, S.D., D.K. Papakosta and A. Doitsinis. 2008. Nitrogen utilization efficiency of safflower hybrids and open-pollinated varieties under Mediterranean conditions. Field Crops Res. 107, 56–61.

Kumar, V., A. Gurusamy, P.P. Mahendran and S. Mahendran. 2011. Optimization of water and nutrient requirement for maximization in hybrid rice under drip fertigation system. 8th International Micro Irrigation Congress. 21 October 2011, Tehran, Iran, pp 256-263.

Lovelli, S., M. Perniola, A. Ferrara and T.D. Tommaso. 2007. Yield response factor to water (ky) and water use efficiency of (*Carthamus tinctorius* L.) and (*Solanum melongena* L.) Agricultural Water Management 92: 73-80.

Movahhedy-Dehnavy, M., S.A.M. Modarres-Sanavy and A. Mokhtassi-Bidgoli. 2004. Effect of drip and surface irrigation on yield and water production efficiency of brinjal in saline vertisols. Indian Journal of Agricultural Sciences 74, 583-587.

Murat, T. and B. Yildirim. 2004. Effects of different Forms and Doses of Nitrogen Fertilizers on Safflower (*Chartamus tictorius* L.). Pakistan J. of Biol. Scie. 7(8): 1385-1389.

Nimje, P.M. 1991. Influence of irrigation and nitrogen on water use, yield and oil content of safflower. Indian Agron., 36; 165-168.

Orange, M.J. and A. Ebadi. 2012. Responses of phenological and physiological stages of spring safflower to complementary irrigation. African Journal of Biotechnology 11 (10): 2465-2471.

Osman, E.B.A., M.K.M. El-Samanody and G.H.B. Abd El-Aziz. 2008. Effect of Nitrogen fertilizer and plant density on yield and oil content of some safflower genotypes. The 2nd Field Crops Conference, Giza, Egypt 14-16 Oct. 2008.

Patil, B.B. and J.D. Patil. 1998. Effect of fertilization levels and needs-based plant protection on the yield of rainfed safflower (*Carthamus tinctorius* L.). Sesame and safflower newsletter, pp: 119-123.

Singhandhupe, R.B., G.G.S.N. Rao, N.G. Patil and P.S. Brahman. 2003. Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop. European Journal of Agronomy 19, 327-340.

Vijayakumar, G., D. Tamilmani and P.K. Selvaraj. 2010. Irrigation and fertigation scheduling under drip irrigation in Brinjal (*Solanum melongena* L.) crop. J. Bio-resource Management 1 (2): 72-76.

Assiut J. Agric. Sci., (46) No. (3) 2015 (1-15) *ISSN: 1110-0486*
Website: http://www.aun.edu.eg/faculty_agriculture/arabic *E-mail: ajas@aun.edu.eg*

تأثير الرى وعدد جرعات الأسمدة المضافة مع ماء الري على محصول القرطم و كفاءة استخدام الماء والنيتروجين والفوسفور والبوتاسيوم تحت ظروف الوادى الجديد

فتحى محمد فتحى عبدالمتجلى[١] ومحمد محمود محمد أحمد[٢] وأيمن محمد أحمد حسن[٣]
[١] قسم المحاصيل - كلية الزراعة-جامعة أسيوط- مصر.
[٢] معهد بحوث الأراضى والمياه والبيئة- مركز البحوث الزراعية-جيزه-مصر.
[٣] المعمل المركزى للمناخ الزراعى- مركز البحوث الزراعية- مصر.

الملخص:

أجريت تجربتين حقليتين بمزرعة محطة البحوث الزراعيه بالخارجه - الوادى الجديد خلال موسمى الزراعة ٢٠١٢/٢٠١١ و ٢٠١٣/٢٠١٢ لدراسة تأثير الري وعدد جرعات التسميد مع ماء الرى على محصول القرطم وكذلك كفاءة استخدام الماء و كفاءة استخدام النيتروجين والفوسفور والبوتاسيوم تحت ظروف الوادى الجديد حيث أستخدمت القطاعات الكامله العشوائيه بتصميم الشرائح المنشقة فى ثلاث مكررات. أستعمل فى هذه التجربه ثلاث مستويات للرى (١٠٠ و ٨٠ و ٦٠% من بخر الوعاء) مع تقسيم أسمدة NPK الموصي بها إلى جرعات متساوية وهى ٣ و ٦ و ١٢ و ١٨ وإضافتها من خلال مياه الري تحت ظروف الري بالتنقيط.

أوضحت النتائج أن أعلى قيم لصفة أرتفاع النباتات وعدد الفروع ووزن ١٠٠ بذرة ومحصول البذور ومحصول الزيت وكفاءة استخدام الأسمدة كانت راجعة إلى معاملة الري عند ١٠٠٪ من بخر الوعاء وتقسيم الأسمدة إلي ١٢ جرعة تحت نظام الري بالتنقيط. حيث أدت هذه المعاملة إلى زيادة محصول البذور بمقدار ٦٢,٢٪ و٦١,١٪. بينما أدت معاملة الري عند ٨٠٪ من بخر الوعاء وتقسيم الأسمدة إلى ١٨ جرعة إلى زيادة قدرها ٤٢,٣٤٪ و٤١,٦٣٪ بالمقارنة بمعاملة الري عند ١٠٠٪ من بخر الوعاء وتقسيم الأسمدة ٣ جرعات لكلا الموسمين على التوالي.

سجلت أعلى قيمة لكفاءة استخدام مياه الري في معاملة الري عند استخدام٨٠٪ من بخر الوعاء والتسميد بعدد ١٨ جرعة ولهذا فانه باستخدام هذه المعاملة يمكن الحصول على محصول عالى من القرطم مع أعلي كفاءة لاستخدام مياه الرى وبالتالي توفير ٢٠٪ من مياه الرى.