J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 5 (12): 1691 -1716 , 2014

EFFECT OF IRRIGATION INTERVALS AND DIFFERENT PLANT DENSITIES ON FABA BEAN YIELD, SOME WATER RELATIONS AND SOME SOIL PROPERTIES UNDER DRIP IRRIGATION SYSTEM IN NORTH MIDDLE NILE DELTA REGION.

Moursi,E.A. ; M.M.I. Nassr and Mona A.M-EL-Mansoury
Soils, Water and Environment Research Institute. Agric. Res. Center, Giza, Egypt.

ABSTRACT

Two field experiments were conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The site is located at 31^0 07ˉ N Latitude and 30^0 57ˉ E longitude with an elevation of about 6 meters above mean sea level. This location represents the conditions of the North Middle Nile Delta region during the two successive winter growing seasons 2012/2013 and 2013/2014 to investigate the effect of irrigation intervals and plant densities on faba bean yield, some yield attributes and some water relations under drip irrigation system. Faba bean (*Vicia faba* L.) seeds, variety Sakha 2, were planted on 10^{th} and 15^{th} November and harvested on 28^{th} April and 2^{nd} May in the first and second growing seasons, respectively. A split plot design with four replicates was used. The main plots were randomly assigned by (irrigation intervals, I) which were I_1 (irrigation every 6 days), I_2 (irrigation every 9 days), I_3 (irrigation every12 days), I_4 (irrigation every15 days), I_5 (irrigation every18days). The sub- main treatments were also randomly assigned by (plant densities, D) which were, D_1 (planting one plant on one lateral from each side adjusted with opening the emitter), D_2 (planting two plants on one lateral from one side adjusted with the emitter), D_3 (planting four plants on one lateral on the two sides of the emitter), two plants from each side and D_4 (planting four plants on one lateral on the two sides of the emitter, two plants from each side). In addition, two plants were planted in the middle of the two adjacent emitters with one plant in each side.

The obtained results can be summarized as follows:-

Data clearly illustrated that, the values of seasonal water applied, water stored in the effective root zone and water consumptive use were affected by irrigation intervals, where the highest overall mean values for the abovementioned three studied parameters were recorded under irrigation interval (I_1) and the values are 1475.52, 1205.20 and 1059.44 m^3/fed. On the other hand, the lowest values for the same abovementioned studied parameters were recorded under irrigation interval, I_5 and the values are 990.64, 905.16 and 850.44 m^3/fed. for seasonal water applied, water stored in the effective root zone and water consumptive use, respectively. Generally, the values of the three abovementioned studied parameters can be descended in order (I_1) > (I_2) > (I_3) > (I_4) > (I_5).

Concerning water application efficiency (WAE%) the mean values were slightly affected by irrigation intervals. The highest mean values were recorded under irrigation interval (I_4) and the values are 94.92 and 94.47 %. The lowest mean values were recorded under irrigation interval (I_1) and the values are 81.57 and 81.79% in the first and second growing seasons, respectively.

Regarding, water productivity (WP) and productivity of irrigation water (PIW), the highest overall mean values were recorded under irrigation interval (I_5) and the values are 1.38 and 1.19 kg/ m^3. Meanwhile, the lowest overall mean values were recorded under irrigation interval (I_1) and the values are 1.29 and 0.92 kg/ m^3 for (WP) and (PIW), respectively. Concerning water consumptive use efficiency (Ecu), the highest overall mean value was recorded under irrigation interval (I_4) and the value is 86.18%, but the lowest one was recorded under irrigation interval (I_1) 71.80%. Concerning the amount and percentage of water saving can be descended in order $I_5 > I_4 > I_3 > I_2 > I_1$ in the two growing seasons.

Concerning the effect of irrigation intervals on faba bean seed yield, the highest mean values were achieved under irrigation interval, I_1 and the values are 1357.19 and 1364.05 kg/fed., but the lowest mean values were recorded under irrigation interval I_5 and the values are 1175.64 and 1170.16 kg/fed. in the first and second growing seasons, respectively. Generally, the mean values of faba bean seed yield can be descended in order $I_1> I_2 > I_3> I_4> I_5$. Regarding, the effect of plant densities on faba bean seed yield, the highest mean values were recorded under D_1 in the two growing seasons. The same trend was observed for straw yield, where the highest mean values were recorded under irrigation interval (I_1) and the mean values are 2.79 and 2.80 ton/fed. On the other hand, the lowest mean values were recorded under irrigation interval (I_5) and the mean values are 1.61 and 1.58 ton/fed. in the first and second growing seasons, respectively. Concerning the effect of plant densities on straw yield, the highest mean values were recorded under D_1 in the two growing seasons.

Data also declared that some yield components such as plant height, number of branches / plant, number of pods /plant and weight of 100 seeds were affected by irrigation intervals where the highest mean values were recorded under irrigation interval I_1. Generally, the mean values of the abovementioned studied parameters can be descended in order $I_1 > I_2 > I_3 > I_4 > I_5$. Regarding, the effect of plant densities, the highest mean values were recorded under D_1 comparing with other plant densities D_2, D_3, and D_4 in the two growing seasons.

Concerning, the effect of irrigation intervals and plant densities on soil pH, soil salinity, soluble cations, anions, calculated SAR and ESP. The mean values of soil pH were increased under surface irrigation method comparing with using drip irrigation system. While the lowest mean value was recorded under irrigation interval (I_1). Data also showed that, the highest mean value was recorded under plant density D_4 under all irrigation intervals. Regarding, the soil salinity, the highest mean value was recorded under I_5 and the value is 1.409 ds/ m, but the lowest mean value was recorded under I_1 and the value is 1.075 ds/ m. The highest mean value for soil salinity was recorded under D_4 for all irrigation intervals. Regarding, soluble cations, anions, calculated SAR and ESP, the highest mean value was recorded under irrigation interval (I_1) but the lowest value was recorded under (I_5). The effect of plant densities on the abovementioned studied parameters (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, HCO^{-}, CO_3^{--}, Cl^{-}, SO_4^{--}, SAR and ESP) was not clear, however, some parameters increased under D_1 but the others increased under D_4.

Keywords:-drip irrigation, irrigation intervals, plant densities, faba bean yield, water relations, some soil characteristics**.**

INTRODUCTION

Faba bean (vicia faba L.) is the most important legume crop in Egypt, due to its high nutritive value for human being food, also it plays an integral part in animal feeding and its role break crop in cereal rotation system. The cultivated area was about 216,000 feddans in the last five seasons with an average seed yield of 9.0 ardab/fed. In Northern part of Egypt the planted area represents about 85% of the total planted faba bean area (El-Galaly,Ola *et al.,* (2008) and El-Saady *et al*.,2011). About 20 to 30% of the bean production areas in the Middle East Delta were affected by soil salinity **(**Boyelo-Jimenes *et al.,*2002) and (Atwa *et al.,*2009). Faba bean also grows well in the Mediterranean sea region. It is rich in protein and carbohydrates. The protein content was estimated at 5.5% and 5.9% for green and dry straw, respectively. Faba bean grains contain a high content of protein which may be reached 28%, also, its content from carbohydrates is high and it is 58%. When faba bean carefully managed it can yield more than 6 tons/ha. of seed, Eid *et al.,(*2005). Additionally, it helps to increase the fertility of soil in crop rotations through biological nitrogen fixation because it supplies the soil after harvesting with about 20-30 N unit/fed.

Irrigation water is gradually becoming scarce not only in arid and semi-arid regions but also in the regions where rainfall is abundant. Egypt is a country of water scarcity due to general low precipitation, high evaporation and the temporal and spatial distribution of rainfall. Therefore, water saving and conservation is a vital and essential demand to face the water gap problem and support agricultural activities, which account for 85% of the total water consumed in semi-arid region. Irrigation is one of the most important inputs in agricultural practices and particularly in all crops cultivation to increase crop productivity. Crop water management and its yield in different environments are very important concern in irrigation planning for irrigation policy makers and maximizing yield.

The present capita share of water is less than 1000 m^3/year for different purposes or which so-called water poverty limit (El-Quosy, 1998). In addition to that, the water demand is continuously increasing due to population growth, increased economic activities and the escalating standards of living. Egypt is currently approaching the status where the water demand can't be met by the national water supply. The River Nile is the main source for fresh water which supplies Egypt with about 95% from its water needs. Also, there are other water resources for irrigation water but their contribution values are limited. So, effective management at the irrigation sector is the principal way towards the rationalization policy for the country. El-Maghraby (1984) reported that drought is an important factor limiting yield and most faba bean crops in arid climates which give a substantial and often economic response to well time irrigation. He also found that increasing the duration between planting irrigation and the first post planting irrigation from 3 to 8 weeks caused a clear decreasing in plant height, 100 seed weight, seed yield, straw yield and biological yield.

Trickle or drip irrigation has been considered one of the most important obligatory irrigation systems, which keeps and manages water in arid land and dry areas. In addition to, it allows a large degree of water saving enabling accurate application of irrigation amounts according to crop water requirements. Under optimum water management, trickle irrigation system will reduce the water losses caused by evaporation and deep percolation (Sepaskhah and Kamgar- Haghighi 1997). Goldberg and Shmueli(1970) and Eid *et al.(*2005) Stated that by using a good trickle irrigation yield increased by 30 % or more over furrow or sprinkler irrigation.

Under limitation of water resources, high water consumed in agricultural sector and decreasing irrigation efficiency which is about 60%

under traditional irrigation system. So, using pressurized irrigation system such as trickle irrigation which has a high efficiency. Therefore, decreasing irrigation losses and hence, using these techniques in irrigation becomes a must to save water by decreasing losses to make maximization for each unit of irrigation water and this reflects on yield. Also, increasing plant populations is a good practice to increase yield to maximize the benefit from each land unit.

For the abovementioned facts about the importance of faba bean and limitation of water resources, therefore, effective irrigation management at on the farm level becomes a must. Nowadays, Egypt is in a need for rationalization of irrigation water to make water saving particularly in agricultural sector which consumes about 85% from water budget (48 milliard cubic meter).

The main targets for this present investigation were to:

1-Identify the suitable irrigation interval for faba bean irrigation in the studied area,

2-Investigate the effect of irrigation intervals and plant densities under trickle irrigation on faba bean yield, some yield attributes and water relations.

MATERIALS and METHODS

Two field experiments were conducted at Sakha Agricultural Research Station, kafr El–Sheikh Governorate. The site is located at 31^{o}-07' N latitude, 30^{o}-57' E longitude with an elevation of about 6 metres above mean sea level. This location is representative the conditions in the North Middle Nile Delta region during the two successive winter growing seasons 2012/2013 and 2013/2014 to investigate the effect of irrigation intervals under trickle irrigation system and plant densities on yield, some yield attributes of faba bean (vicia faba) variety (Sakha 2) and some water relations. Some physical and chemical characteristics of the studied site were shown in Tables (1and 2), respectively.

Table (1): The mean values of some physical characteristics of the studied site before cultivation

Soil Depth, cm.	Particle Size Distribution			Texture classes	F.C %	P.W.P %	AW %	Bd Mg/m³
	Sand%	Silt %	Clay %					
0 – 15	16.0	18.0	66.0	Clay	46.0	25.00	21.00	1.16
15 – 30	19.0	13.0	68.0	Clay	38.0	20.65	17.35	1.19
30 – 45	16.5	16.0	67.5	Clay	37.0	20.11	16.89	1.20
45 – 60	17.5	15.5	67.0	Clay	37.5	20.38	17.12	1.30
Mean	17.25	15.63	67.13	Clay	39.63	21.54	18.09	1.21

Where:-
F.C % = Soil field capacity,
P.W.P % = Permanent wilting point,
AW % = Available water and
Bd Mg/m³ = Soil bulk density.

Table (2) : The mean values of some chemical characteristics of the studied site before cultivation of faba bean.

Soil depth, Cm	Ec, dS/m	PH (1: 2.5) soil water suspension	ESP	SAR	Soluble ions, meq/l							
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO^{-}	Cl^{-}	SO_4^{--}
0-15	1.50	8.11	1.07	1.59	6.40	4.60	3.72	0.91	0.00	4.80	4.86	5.97
15-30	1.57	8.03	2.00	2.24	6.21	3.69	4.98	0.82	0.00	4.91	4.95	5.86
30-45	1.64	8.01	2.44	2.55	6.38	3.58	5.68	0.77	0.00	5.18	5.29	5.93
45-60	1.71	7.90	2.69	2.73	6.34	3.88	6.17	0.74	0.00	5.25	5.57	6.75
Mean	1.61	8.01	2.05	2.27	6.33	3.94	5.14	0.81	0.00	5.04	5.17	6.13

Where:

SAR = Sodium adsorption ratio. The values of SAR were calculated by using the following formula.

$$SAR = \frac{Na}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

Where: Na^{+}, Ca^{++} and Mg^{++} means soluble sodium, calcium and magnesium (meq/l), respectively.

ESP = Exchangeable sodium percentage. The values of ESP were calculated by using the following equation.

$$ESP = \frac{100(-0.0126+0.01475\ SAR)}{1+(-0.0126+0.01475SAR)}$$

Some physical and chemical characteristics of the studied site:-

The studied physical characteristics of the site such as mechanical analysis was determined according to the international pipette method. Soil bulk density, soil field capacity and permanent wilting point were determined according to (Klute, 1986). Available soil moisture was calculated as the difference between soil field capacity and permanent wilting point. The studied chemical characteristics such as soil reaction (pH) values were determined in 1:2.5 soil water suspension (Jackson, 1973). Total soluble salts were measured by electrical conductivity (EC) apparatus in the saturated soil paste extract (Jackson, 1973). Soluble cations and anions (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Co_3^{--}, HCO^{-}, Cl^{-} and SO_4^{--} as (Meq/l) were also determined in soil paste extract (Jackson, 1973). But SO_4^{--} was calculated by difference between soluble cations and anions.

The drip irrigation system consists of a pumped unit which contains a pump, control unit, groups of pipes which differ in its diameter and distribution lines. The control unit of the system contains a venture injector (25.4 mm), fertilizer tank, disk filters, control valves and a water flow meter. Distribution lines consists of polyethylene (PE) pipes manifolds (display and discharge) laterals of 16 mm in diameter and 40 m in length had in- line emitters spaced 0.5 m apart, each delivering 4 lh^{-1}at a pressure of 1 bar. Drip irrigation lines were spaced 0.8 m apart equally spaced between every other row of faba bean. Water was applied from a pressurized hydrant and filtered through gravel and refiltered through disk filters. The texture of the experimental field soil is heavy clay. Water table level is about 150 cm from soil surface.

Table (3): Mean of some meteorological data for kafr El –Sheikh area during the two growing seasons.

a- 2012/2013 season.

Month	T (C^0)			RH (%)			W_s m/sec at 2 m height	Pan Evap. mm/ day.	Rain Mm
	Max.	Min.	Mean	Max.	Min.	Mean			
Nov.	25.32	15.47	20.40	89.53	61.80	75.67	0.66	1.87	28.20
Dec.	21.35	10.52	15.94	84.77	60.83	72.80	0.73	2.25	13.02
Jan.	19.22	7.62	13.42	91.06	65.35	78.21	0.52	1.99	78.74
Feb.	20.68	8.88	14.78	89.89	64.04	76.97	0.73	2.89	-------
Mar.	24.56	12.45	18.51	79.48	50.84	65.16	1.03	4.46	-------
April.	26.04	15.87	20.96	74.20	43.90	59.05	1.11	5.30	8.40
May	31.43	21.85	26.64	75.03	45.78	60.41	1.20	6.35	------

b-2013/2014 season.

Month	T (C^0)			RH (%)			W_s m /sec at 2 m height	Pan Evap. mm/ day.	Rain Mm
	Max.	Min.	Mean	Max.	Min.	Mean			
Nov.	25.39	15.14	20.27	87.00	64.43	75.72	0.80	2.28	-------
Dec.	19.64	8.51	14.06	92.07	67.61	79.84	0.61	4.15	81.9
Jan.	20.34	7.55	13.95	93.69	70.55	80.55	0.54	1.60	20.7
Feb.	20.64	8.19	14.42	91.90	67.15	79.53	0.79	2.52	16.5
Mar.	22.94	11.71	17.33	86.10	56.80	71.45	0.96	3.14	26.2
April.	27.50	15.53	21.52	81.80	49.80	65.8	1.07	4.91	20.2
May	30.47	19.57	25.02	77.20	48.60	62.90	1.14	5.87	-----

Source: Meteorological Station at Sakha Agricultural Research Station 31°-07N latitude, 30°-57E longitude with an elevation of about 6 meters a above mean sea level.

The treatments were arranged in a spilt plot design with four replicates as follows:-

The main treatments (irrigation intervals, I):

I_1 = irrigation every 6 days,
I_2 = irrigation every 9 days,
I_3 = irrigation every 12 days,
I_4 = irrigation every 15 days and
I_5 = irrigation every 18 days.

The sub main treatments (plant densities, D):

D_1 = planting one plant on one lateral from each side adjusted with the emitter,

D_2 = planting two plants on one lateral from one side adjusted with the emitter,

D_3 = planting four plants on one lateral on the two sides from the emitter, two plants each side and

D_4 = planting four plants on one lateral on the two sides of the emitter, two plants from each side. In addition, two plants were planted in the middle of the two adjacent emitters one plant in each side.

Faba bean as a winter crop was planted on 10th and 15th November and harvested on 28th April and 2nd May in first and second seasons, respectively. The recommended seed rate is 40 kg/fed. of faba bean (Vicia faba) variety Sakha 2. All agronomic practices and fertilization were performed as recommended for the crop and the studied area except the studied treatments.

*** Data collection:-**

1- Irrigation water applied (IW, m^3/fed)

The amount of water applied at each irrigation was measured by using flow meter.

2- Water stored in the effective root zone (m^3/ fed.):

Seasonal stored water (SW) in the effective root zone was calculated by using the following equation:-

$$WS = \sum_{i=1}^{i=N} \{[(\theta 2 - \theta 1) * Dbi * di * 4200]/100\}$$

Where:

WS = Seasonal stored water in the effective root zone (m^3/ fed.),

Θ_2 = Soil moisture % after irrigation in the i th layer,

Θ_1= Soil moisture % before irrigation in the i th layer,

(i.e. directly, before and after the same irrigation.)

Dbi = Soil bulk density (Mg/m^3) for the given depth,

D_i = Soil layer depth (20 cm) and

i = number of soil layers (1-3).

3-Water consumptive use (m^3/ fed.):

The amount of water consumed in each irrigation was obtained from the difference between soil moisture content after and before the following irrigation. Water consumptive use by growing plants was calculated based on soil moisture depletion (SMD) according to Hansen *et al.,* (1979).

$$Cu = SMD = \sum_{i=1}^{i=N} \frac{\theta_2 - \theta_1}{100} * Dbi * Di * 4200$$

Where:

CU = Water consumptive use in the effective root zone (60 cm),

Θ_2 = Gravimetric soil moisture percentage after irrigation,

Θ_1= Gravimetric soil moisture percentage before the next irrigation,

Dbi = soil bulk density (Mg/m^3) for depth,

D_i = soil layer depth (20 cm) and

i = number of soil layers (1-3).

4-Irrigation water efficiencies:

Irrigation application efficiency (WAE %):

Values of irrigation application efficiency (WAE) for each treatment were obtained by dividing the total stored water in the effective root zone on the irrigation applied water (Downy, 1970).

WAE = (WS / Wa) * 100

Where:

WAE = Water application efficiency (%),

WS = Water stored in the effective root zone and

Wa = applied water to the field plot.

Water consumptive use efficiency (Ecu):

Value of water consumptive use efficiency (Ecu) was calculated according to Bos (1980).

$$Ecu = (ETc / Wa) * 100$$

Where:

Ecu = Water consumptive use efficiency (%),

ETc = Total evapotranspiration ~ consumptive use and

Wa = Water applied to the field.

Water productivity (WP, kg/m^3)

Water productivity is generally defined as crop yield per cubic meter of water consumption. Water productivity is defined as crop production per unit amount of water used **(Molden, 1997).** Concept of water productivity in agricultural production systems is focused on producing more food with the same water resources or producing the same amount of food with less water resources. It was calculated according to (**Ali *et al.,* 2007**).

$$Wp = \frac{Y}{ET}$$

Where:

WP = water productivity (kg seed /m^3),

Y = Seed yield (kg/fed.) and

ET = Total water consumption, m^3/ fed.

productivity of irrigation water (PIW, kg seeds/m^3)

Productivity of irrigation water (PIW) as calculated according to **(Ali *et al.,* 2007)**

PIW = y / Wa

Where:

PIW = productivity of irrigation water (kg /m^3),

y = Seed yield kg/fed and

Wa = Applied water to the field m^3.

Yield and yield components:

- Seed yield (kg/ fed.),
- Straw yield (ton/ fed.),
- Plant height (cm),
- Number of branches/plant,
- Number of pods/plant and
- Weight of 100 seeds (g).

Statistical analysis:

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by Gomez and Gomez (1984). Means of the treatments were compared by the least significant difference (LSD) at 5 % level of significance which developed by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Effect of irrigation intervals on:

1-Amount of seasonal water applied (Wa), water stored in the effective root zone (Ws) and water consumptive use (Cu) (m^3/fed.).

Amount of seasonal water applied for faba bean as a winter crop consists of the two main components; irrigation water applied or irrigation water delivered to the field (IW) and rainfall (R), Doorenbos and Pruitt (1975). The seasonal amounts of rainfall are 128.36 and 165.50 mm during the two growing seasons of 2012/2013 and 2013/2014, respectively which are shown in Table (3).

Presented data in Tables (4&5) clearly illustrated that the overall mean values for the abovementioned studied parameters were affected by irrigation intervals. The highest overall mean values for the three studied parameters were recorded under the shortest irrigation intervals (I_1), 6 days between watering through the two growing seasons in comparison with the other irrigation intervals 9, 12, 15 and 18 days (I_2, I_3, I_4 and I_5) which exposed to water stress. The highest overall mean values are 1475.52, 1205.20 and 1059.44 m^3/fed. for seasonal water applied, water stored in the effective root zone and water consumptive use, respectively. Meanwhile, the lowest overall mean values for the abovementioned studied parameters were recorded under the longest irrigation interval (I_5) 18 days between watering in the two growing seasons and the overall mean values are 990.64, 905.16 and 850.44 m^3/fed. for seasonal water applied, water stored in the effective root zone and water consumptive use, respectively. Generally, the overall mean values for the three studied parameters can be descended in order $I_1 > I_2 > I_3 > I_4 > I_5$, in the two growing seasons.

Table (4): Effect of irrigation intervals on seasonal amount of water applied and water stored in the effective root zone (m^3/fed.) for faba bean crop in the two growing seasons.

Irrigation treatments, (I)	1st growing season		2nd growing season		The overall mean values during two growing seasons	
	Wa, (m^3/ fed.)	Ws, (m^3/ fed.)	Wa, (m^3/ fed.)	Ws, (m^3/ fed.)	Wa, (m^3/ fed.)	Ws, (m^3/ fed.)
I_1	1469.28	1198.50	1481.76	1211.90	1475.52	1205.20
I_2	1380.42	1163.20	1398.24	1176.50	1389.33	1169.85
I_3	1064.04	990.80	1100.22	1020.70	1082.13	1005.75
I_4	1011.98	960.60	1048.48	990.47	1030.23	975.54
I_5	990.60	900.14	990.68	910.18	990.64	905.16

Where:
Wa = Seasonal amount of water applied (m^3/fed.) and
Ws = Water stored in the effective root zone, (m^3/fed.).
Note:

$$Wa = (IW + R)$$

Where:
Wa = Seasonal amount of water applied (m^3/fed.),
IW = Irrigation water delivered to the field and R = Seasonal amount of rainfall.

Increasing the overall mean values for the abovementioned studied parameters under irrigation treatment (I_1) in comparison with other irrigation treatments might be attributed to increasing number of irrigations under the conditions of this treatment because of decreasing intervals between waterings, so, increasing amount of water applied, consequently, amount of water stored in the effective root zone and water consumptive use. These results are in a great harmony with those obtained by El-Gibali *et al.,(*1968); Miseha et al.,(1971), Towadros *et al.,(*1993a), Omer *et al.,* (2008), Moursi *et al.,* (2010), El-Saady et al. (2011), Nahed, M. Rashed and E. A. Moursi (2012), Moursi *et al.,* (2013) and Aiad *et al.,* (2014).

Table (5): Effect of irrigation intervals on seasonal water consumptive use (m^3/fed.) and water application efficiency (%) for faba bean crop in the two growing seasons.

Irrigation treatments, (I)	1st growing season		2nd growing season		The overall mean values during two growing seasons	
	Cu, (m^3/ fed.)	WAE, (%)	Cu, (m^3/ fed.)	WAE, (%)	Cu, (m^3/ fed.)	WAE, (%)
I_1	1052.70	81.57	1066.17	81.79	1059.44	81.68
I_2	1015.50	84.26	1020.28	84.14	1017.89	84.20
I_3	925.20	93.12	910.10	92.77	917.65	92.95
I_4	880.14	94.92	895.23	94.47	887.69	94.70
I_5	860.12	90.87	840.75	91.87	850.44	91.37

Where:
Cu = Seasonal water consumptive use (m^3/fed.) and
WAE = Water application efficiency (%).

2-Amount and percentage of water saving:

The amount of seasonal water applied for faba bean crop under traditional irrigation method (surface irrigation, which practises by local farmers in the studied area) were ranged from 1596 to 1586 m^3/fed. in the first and second growing seasons, respectively (El-saady *et al.,*2011). As shown in Table (4) the amount of water applied under different irrigation treatments were clearly differ under trickle irrigation system comparing with traditional irrigation method. Data in Table (6) indicated that, the shortest irrigation interval (I_1) saved irrigation water by about 126.72 m^3/fed. (7.94%) and 104.24 m^3/fed. (6.57%) compared to traditional irrigation in the first and second growing seasons, respectively. This amount and percentage of water saving were occurred by using trickle irrigation technique instead of using traditional irrigation one. This may be attributed to increasing efficiency of trickle irrigation system in comparison with traditional method. So, decreasing water losses, which may be reached the minimum level under this technique and hence makes saving for irrigation water as shown in Table (6).Also, data in the same Table clearly showed that under the different irrigation treatments under trickle irrigation technique cause saving for irrigation water, where, under irrigation treatment (I_5), the overall mean values for water saving is 484.88 m^3/fed. (32.86%) comparing with the shortest irrigation interval (I_1).

Also, there are difference in water saving between all irrigation treatments as shown in Table (6). The amount and percentage of water saving can be descended in order I_5> I_4 > I_3 >I_2 >I_1 in the two growing seasons. The differences between these treatments in water saving may be due to increasing irrigation interval and hence, decreasing irrigation number under the conditions of irrigation treatment (I_5) in comparison with other irrigation treatments I_1, I_2, I_3 and I_4 in the two growing seasons.

Table (6): Effect of irrigation intervals on amount and percentage of water saving for faba bean crop in the two growing seasons.

Irrigation treatments, (I)	1st growing season		2nd growing season		The overall mean values during two growing seasons	
	Water saving		Water saving		Water saving	
	(m^3/ fed.)	%	(m^3/ fed.)	%	(m^3/ fed.)	%
I_1	126.72	7.94	104.24	6.57	115.48	7.26
I_2	88.86	6.05	83.52	5.64	86.19	5.85
I_3	405.24	27.59	381.54	25.75	393.39	26.67
I_4	457.30	31.12	433.28	29.24	445.29	30.18
I_5	478.68	32.58	491.08	33.14	484.88	32.86

Note:

The amounts of seasonal water applied for faba bean crop under traditional irrigation method (surface irrigation) were ranged from 1596 to 1586 m^3/ fed. in the first and second growing seasons, respectively (El-Saady *et al.,* 2011).

3-Water application efficiency (WAE, %) and water consumptive use efficiency (Ecu,%):

Tabulated data in Tables (5&7) clearly illustrated that, the overall mean values for WAE and Ecu were affected by irrigation treatments. The highest overall mean values for the two studied efficiencies were recorded under irrigation treatment I_4 (irrigation every 15 days between irrigations) and the values are 94.70 and 86.18% for water application and consumptive use efficiencies, respectively. Meanwhile, the lowest overall mean values were recorded under the shortest irrigation interval I_1 (irrigation every 6 days between irrigations) and the values are 81.68 and 71.80% for water application and consumptive use efficiencies, respectively. Increasing the overall mean values for the two studied efficiencies under water stress conditions comparing with non- stressed ones may be due to decreasing amount of seasonal water applied. These results are in a great harmony with those reported by Kassab and Ibrahim (2007), Moursi *et al.,* (2010), El-Saady *et al.,(*2011), Moursi *et al.,* (2013) and Aiad *et al.,* (2014).

4-Water productivity (Wp, kg/ m^3) and productivity of irrigation water (PIW, kg/ m^3):

Presented data in Table (7) declared that, the overall mean values for water productivity and productivity of irrigation water were clearly affected by irrigation treatments. The highest overall mean values for the abovementioned studied parameters were recorded under irrigation treatment

I_5 (irrigation every 18 days between waterings) and the values are 1.38 and 1.19 kg/ m^3 for (Wp) and (PIW), respectively. Meanwhile, the lowest overall mean values for (Wp) and (PIW) were recorded under irrigation treatment I_1 (irrigation every 6 days between waterings) and the values are 1.29 and 0.92 kg/ m^3 for (Wp) and (PIW), respectively. Increasing the mean values of (Wp) and (PIW) under irrigation treatment (I_5) in comparison with other irrigation treatments I_1, I_2, I_3 and I_4 may be due to decreasing amount of seasonal water applied and water consumptive use. These results are in the same line with those obtained by Kassab and Ibrahim (2007), Moursi *et al.,* (2010), El-Saady et al.,(2011), Moursi *et al.,* (2013) and Aiad *et al.,* (2014).

Table (7): Effect of irrigation intervals on water consumptive use efficiency (%), water productivity (kg/ m^3) and productivity of irrigation water (kg/ m^3) for faba bean crop in the two growing seasons.

Irrigation treatments, (I)	1st growing season			2nd growing season			The overall mean values during two growing seasons		
	Ecu, (%)	Wp, (kg/m^3)	PIW, (kg/m^3)	Ecu, (%)	Wp, (kg/m^3)	PIW, (kg/m^3)	Ecu, (%)	Wp, (kg/m^3)	PIW (kg/m^3)
I_1	71.65	1.29	0.92	71.95	1.28	0.92	71.80	1.29	0.92
I_2	73.56	1.32	0.97	72.97	1.26	0.92	73.27	1.29	0.95
I_3	86.95	1.36	1.18	83.63	1.38	1.14	84.17	1.37	1.16
I_4	86.97	1.34	1.17	85.38	1.33	1.13	86.18	1.34	1.15
I_5	86.83	1.37	1.19	84.87	1.39	1.18	85.85	1.38	1.19

Where:
Ecu = Water consumptive use efficiency (%),
Wp = Water productivity (kg/ m^3),
PIW = Productivity of irrigation water (kg/ m^3).

2- Effect of irrigation intervals and plant densities on yield and some yield components of faba bean:

Seed yield (kg/m^3):

Presented data in Table (8) clearly showed that, the mean values of faba bean seed yield were affected by irrigation intervals under the same plant densities in the two growing seasons. Concerning, the effect of irrigation intervals, the highest mean values were produced under irrigation interval (I_1) and the mean values are 1357.19 and 1364.05 (kg/ fed.) in the first and second growing seasons, respectively. Meanwhile, the lowest mean values were recorded under irrigation interval (I_5), and the mean values are 1175.64 and 1170.16 (kg/fed.) in the first and second growing seasons, respectively. Generally, the mean values of faba bean seed yield can be descended in order $I_1 > I_2 > I_3 > I_4 > I_5$ and the mean values in the first growing season are 1357.19, 1345.53, 1259.48, 1179.73 and 1175.64 (kg/ fed.) While, the corresponding mean values in the second growing season are 1364.05, 1287.33, 1256.22, 1188.47 and 1170.16 (kg / fed.) under irrigation intervals I_1 , I_2 , I_3 , I_4 and I_5 , respectively.

Table (8) Effect of irrigation intervals and plant densities on faba bean seed yield (kg/ fed.) in the two growing seasons.

Irrigation treatments, (I, days)	Plant densities, (D)	1st growing season Seed yield (kg/ fed.)	2nd growing season Seed yield (kg/ fed.)
I_1	D_1	1460.77	1477.83
	D_2	1421.53	1421.57
	D_3	1450.50	1460.77
	D_4	1095.97	1096.03
Mean		1357.19	1364.05
I_2	D_1	1527.20	1585.20
	D_2	1365.30	1290.30
	D_3	1374.87	/1353.40
	D_4	1114.73	920.43
Mean		1345.53	1287.33
I_3	D_1	1453.33	1457.33
	D_2	1278.37	1210.20
	D_3	1324.40	1261.33
	D_4	981.80	1096.00
Mean		1259.48	1256.22
I_4	D_1	1377.60	1305.67
	D_2	1096.50	1155.67
	D_3	1329.50	1215.30
	D_4	915.80	1077.23
Mean		1179.73	1188.47
I_5	D_1	1327.80	1469.30
	D_2	1136.80	1123.30
	D_3	1176.10	1210.20
	D_4	1061.87	877.83
Mean		1175.64	1170.16

1st growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	28.89	43.77
2- I means at each D	26.80	36.03

2nd growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	91.42	123.10
2- I means at each D	90.10	123.36

Increasing the mean values of faba bean seed yield under irrigation interval (I_1) in the two growing seasons comparing with other irrigation treatments I_2 , I_3 , I_4 and I_5 may be due to these treatments always expose to water stress by elongation irrigation intervals comparing with (I_1), Which led to increasing the amount of irrigation water applied and increase soil nutrients availability. Therefore, increasing the amount of nutrients uptake, consequently, forming strong plants with a good vegetative cover, also, plants becoming healthy and more resistance to diseases, pests, insects and herbs. So, this reflects on increasing yield. These results are in a great harmony with those obtained by Meriaux (1972); Metwally (1973); El- Maghraby (1980); Krogman *et al.,* (1980); Ainer *et al.,* (1994) and El- Waraky and Wahba (1998) who found that the number and time of irrigation treatments exhibited significant effects on seed yield of faba bean. Also, Roshdy (1975) reported that seed yield increased with increasing the number of irrigations. Also, these findings are in a great harmony with those reported by Omer et al. (2008), Younis *et al.* (2009), Moursi *et al.* (2010), Nahed, M. Rashed and Moursi (2012), Moursi *et al.* (2013) and Aiad *et al*. (2014).

Concerning the effect of plant densities on faba bean seed yield, the results in the same table showed that, the highest mean values for faba bean seed yield were recorded under treatment D_1(planting on one lateral with one plant from each side adjusted with the emitter) under all irrigation intervals comparing with other treatments of plant densities D_2 , D_3 and D_4 in the two growing seasons. Increasing the mean values of faba bean seed yield under D_1 might be attributed to decreasing number of plants under the conditions of this treatment. So, decreasing the rate of competition between plants on their nutritional requirements and light, consequently plants grow well and become healthy. Consequently, improvement yield in comparison with other plant densities which plants do their best to take their needs and hence form weak plants with low seed yield. These findings are in good agreement with those obtained by Moursi *et al.* (2010).

Straw yield (ton/fed.):

Data in Table (9) illustrated that, the mean values of faba bean straw yield were clearly affected by both irrigation intervals and plant densities in the two growing seasons. Concerning the effect of irrigation intervals, the highest mean values were recorded under irrigation interval (I_1) comparing with other irrigation treatments I_2, I_3, I_4 and I_5 which exposed to water stress through the growing season. The highest mean values for faba bean straw yield are 2.79 and 2.80 ton/ fed. under irrigation interval I_1 in the first and second growing seasons, respectively. On the other hand, the lowest mean values were recorded under irrigation interval I_5 in the two growing seasons and the mean values are 1.61 and 1.58 ton/fed. in the first and second growing seasons, respectively. Generally, the mean values of faba bean straw yield can be descended in order $I_1 > I_2 > I_3 > I_4 > I_5$ in the two growing seasons and the mean values are 2.79, 2.71, 2.48, 1.98, 1.61 and 2.80, 2.49, 2.36, 1.94 and 1.58 ton/fed. in the first and second growing seasons, under I_1 , I_2 , I_3 , I_4 and I_5, respectively. Increasing the mean values of straw yield under irrigation interval (I_1) comparing with other irrigation treatments (I_2 , I_3 , I_4 and I_5) which suffered from water stress through the growing season might be attributed to increasing the amount of water applied and hence forming strong plants with thick vegetative cover as a result of increasing number of branches and leaves/ plant. So, increasing the mean values of straw yield. These findings are in a great harmony with those obtained by Roshdy (1975), Ainer *et al.* (1994), El-Waraky and Wahba (1998), Omer *et al*. (2008), Moursi *et al*. (2010), Nahed, M. Rashed and Moursi (2012) and Aiad *et al*. (2014). Regarding, the effect of plant densities on faba bean straw yield, data in the same table illustrated that the mean values of straw yield were clearly affected by plant densities in the two growing seasons. The highest mean values for faba bean straw yield were recorded under treatment of D_1 (planting on one lateral with one plant from each side adjusted with the emitter) comparing with other treatments of plant densities D_2, D_3, and D_4 in the two growing seasons. Data in the same Table clearly showed under the same irrigation treatments, the highest mean values are 3.28 and 3.34 ton/ fed. in the first and second growing seasons, respectively. On the contrary, under the same irrigation treatments the lowest mean values for straw yield were recorded under D_4 treatment and the mean values are 1.23 and 1.13 ton/fed. in the first and second growing seasons, respectively. The interactions between studied treatments (irrigation intervals, I and plant densities, D), the highest mean values were achieved from I_5D_4 in the two growing seasons.

Table (9) Effect of irrigation intervals and plant densities on faba bean straw yield (ton/ fed.) in the two growing seasons.

Irrigation treatments, (I, days)	Plant densities, (D)	1st growing season	2nd growing season
		Straw yield (ton/ fed.)	Straw yield (ton/ fed.)
I_1	D_1	3.28	3.34
	D_2	2.77	2.86
	D_3	3.03	2.97
	D_4	2.07	2.03
Mean		2.79	2.80
I_2	D_1	3.10	3.26
	D_2	2.20	2.13
	D_3	2.93	2.80
	D_4	2.60	1.67
Mean		2.71	2.47
I_3	D_1	3.13	3.00
	D_2	2.27	2.29
	D_3	2.60	2.53
	D_4	1.93	1.62
Mean		2.48	2.36
I_4	D_1	2.41	2.46
	D_2	1.77	1.80
	D_3	2.25	2.14
	D_4	1.49	1.35
Mean		1.98	1.94
I_5	D_1	1.97	2.31
	D_2	1.50	1.18
	D_3	1.73	1.70
	D_4	1.23	1.13
Mean		1.61	1.58

1st growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	0.115	0.154
2- I means at each D	0.122	0.169

2nd growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	0.029	0.039
2- I means at each D	0.032	0.045

Increasing the mean values of faba bean straw yield under D_1 comparing with D_2, D_3 and D_4 may be attributed to lowest number of plants. So, plants find a good chance to take their nutritional requirements and hence, forming strong plants with thick vegetative cover as a result of decreasing rate of competition between plants nutrients. Using this technique in cultivation is preferable because it decreases the amount of seeds which uses in cultivation. Therefore, decreasing the cultivation expenses: These results are in a great harmony with those obtained by Moursi, et al. (2010).

Yield components (plant height, cm., number of branches/ plant, number of pods/ plant.

Data in Tables (10, 11, 12 and 13) clearly declared that the mean values of the abovementioned studied parameters were affected by both the two studied parameters (irrigation interval, I and plant densities, D). Concerning the effect of irrigation intervals, the highest mean values for the studied parameters were recorded under the shortest irrigation interval I_1 (irrigation every 6 days) under the same plant densities comparing with other irrigation treatments I_2 , I_3 , I_4 and I_5 which suffered from water deficit through the growing season. Generally, the mean values of the studied parameters can be descended in order $I_1 > I_2 > I_3 > I_4 > I_5$ in the two growing seasons.

Increasing the mean values of the abovementioned studied parameters under the shortest irrigation interval (I_1) comparing with other irrigation treatments I_2, I_3, I_4 and I_5 might be due to that the irrigation treatment I_1 received the highest amount of water applied which increase the solubility and availability of nutrients and hence, increase the uptake of these nutrients by plants and yield components. On the contrary, the lowest mean values for the abovementioned studied parameters were recorded under irrigation interval I_5 in the two growing seasons. These results are in a great harmony with those obtained by Krogman *et al*. (1980), Moursi *et al.* (2010) and Nahed, M. Rashed and Moursi (2012).

Regarding, the effect of plant densities on the abovementioned studied parameters, the highest mean values were recorded under D_1 comparing with other treatments of plant densities D_2, D_3, and D_4 in the two growing seasons. Increasing the mean values of the studied parameters under D_1 might be due to decreasing number of plant densities and hence, decreasing competition rate between plants on their nutritional needs. Therefore, forming good and healthy plants with good qualities. For the effect of the interactions between irrigation intervals, I and plant densities, D. The interaction between I_1 and D_1 achieved the highest yield components while the lowest values were recorded from combination between I_5 and D_4 in the two growing seasons. These results were obtained by Moursi *et al.* (2010).

Table (10):Effect of irrigation intervals and plant densities on faba bean plant height in the two growing seasons.

Irrigation treatments, (I, days)	Plant densities, (D)	1st growing season	2nd growing season
		Plant height, cm	Plant height, cm
I_1	D_1	140.1	145.4
	D_2	132.8	134.3
	D_3	136.1	141.1
	D_4	131.8	130.1
Mean		135.2	137.7
I_2	D_1	141.5	138.0
	D_2	130.4	132.6
	D_3	136.7	134.2
	D_4	130.0	132.2
Mean		134.7	134.3
I_3	D_1	132.3	131.0
	D_2	128.7	130.3
	D_3	130.1	130.3
	D_4	128.3	125.8
Mean		129.9	129.3
I_4	D_1	133.4	131.6
	D_2	127.2	128.3
	D_3	131.1	129.6
	D_4	125.3	127.8
Mean		129.3	129.3
I_5	D_1	129.7	132.3
	D_2	127.8	126.0
	D_3	128.6	130.3
	D_4	125.6	123.3
Mean		127.9	128.0

1st growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	0.58	0.88
2- D means	0.81	1.09

2nd growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	4.02	6.10
2- I means at each D	4.82	6.49

Table (11): Effect of irrigation intervals and plant densities on faba bean number of branches/ plant in the two growing seasons.

Irrigation treatments, (I, days)	Plant densities, (D)	1st growing season number of branches/ plant	2nd growing season number of branches/ plant
I_1	D_1	7.80	7.73
	D_2	5.00	5.33
	D_3	7.10	7.23
	D_4	4.33	4.33
Mean		6.06	6.16
I_2	D_1	8.70	8.27
	D_2	4.90	4.97
	D_3	5.87	5.90
	D_4	4.43	4.53
Mean		5.98	5.92
I_3	D_1	6.57	6.47
	D_2	4.23	4.07
	D_3	6.23	6.23
	D_4	2.87	3.67
Mean		4.98	5.11
I_4	D_1	5.90	5.60
	D_2	3.90	4.17
	D_3	5.67	5.60
	D_4	3.80	3.80
Mean		4.82	4.79
I_5	D_1	6.10	6.10
	D_2	3.80	3.97
	D_3	5.43	5.27
	D_4	2.10	2.70
Mean		4.36	4.51

1st growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	2.20	2.96
2- I means at each D	0.98	1.32

2nd growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	1.93	2.60
2- I means at each D	2.04	2.82

Effect of irrigation intervals and plant densities on soil pH, EC, soluble cations and anions, calculated SAR and ESP.

Soil pH

Data in Table (14) clearly illustrated that the values of soil pH were affected by irrigation intervals and plant densities. Comparing data before planting and after harvesting, the values were less before planting in comparison with after harvesting of faba bean. Data in the same table also showed that the values of soil pH were slightly higher under surface irrigation method (traditional irrigation, as practice by local farmers in the studied region) in comparison with using drip irrigation system. Increasing the values of soil pH under surface irrigation method comparing with other irrigation intervals (drip irrigation treatments) might be due to increasing amount of water applied. Data in the same table indicated that, the values of soil pH were affected by plant densities where, the highest values were recorded under D_4 under all irrigation treatments. Generally, the values of soil pH can be descended in order D_4 >

Table (12):Effect of irrigation intervals and plant densities on faba bean number of pods/ plant in the two growing seasons.

Irrigation treatments, (I, days)	Plant densities, (D)	1st growing season number of pods/ plant	2nd growing season number of pods/ plant
I_1	D_1	28.67	28.90
	D_2	27.80	27.80
	D_3	28.57	28.57
	D_4	21.43	21.43
Mean		26.62	26.68
I_2	D_1	29.87	31.00
	D_2	26.70	25.20
	D_3	26.90	26.47
	D_4	21.80	18.00
Mean		26.32	25.17
I_3	D_1	30.20	28.50
	D_2	21.43	23.67
	D_3	26.00	24.67
	D_4	17.90	21.43
Mean		23.88	24.57
I_4	D_1	25.90	25.53
	D_2	32.33	22.60
	D_3	25.00	23.77
	D_4	19.20	21.07
Mean		25.61	23.24
I_5	D_1	25.97	28.73
	D_2	22.23	21.97
	D_3	23.00	23.67
	D_4	20.73	17.17
Mean		22.98	22.89

1st growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	10.16	14.29
2- I means at each D	4.74	6.39

2nd growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	1.79	2.41
2- I means at each D	1.77	2.42

$D_3 > D_2 > D_1$ under all irrigation treatments. Decreasing the values of soil pH under drip irrigation comparing with control treatment (traditional irrigation) may be attributed to decomposition of organic materials and production of organic acids, mineralization and nitrification of the added organic nitrogen and or increased partial pressure of Co_2 of the soil atmosphere due to increasing microbiological activity. Data in the same table illustrated that the lowest values for soil pH were recorded under the shortest irrigation interval I_1 (irrigation every 6 days between irrigations), this decreasing in the values of soil pH leads to increasing the availability of macro and micronutrients. Therefore, increasing uptake rate of these nutrients which reflects on increasing yield and yield attributes as clearly shown in Tables (8 through 13).

Table (13): Effect of irrigation intervals and plant densities on faba bean 100 seeds weight (g) in the two growing seasons.

Irrigation treatments, (I, days)	Plant densities, (D)	1st growing season	2nd growing season
		100 seeds weight (g)	100 seeds weight (g)
I_1	D_1	108.33	108.93
	D_2	100.33	100.33
	D_3	97.33	100.53
	D_4	75.67	60.70
Mean		95.42	92.62
I_2	D_1	103.33	102.67
	D_2	99.20	96.33
	D_3	69.33	70.57
	D_4	52.67	55.30
Mean		81.13	81.22
I_3	D_1	100.67	99.63
	D_2	88.67	80.27
	D_3	58.67	58.67
	D_4	44.00	46.40
Mean		73.00	71.24
I_4	D_1	89.33	88.73
	D_2	71.33	73.47
	D_3	49.33	49.57
	D_4	48.00	48.97
Mean		64.50	65.19
I_5	D_1	94.00	91.10
	D_2	70.67	52.47
	D_3	36.47	38.30
	D_4	29.33	30.43
Mean		57.62	53.08

1st growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	45.66	61.49
2-I means at each D	40.42	27.50

2nd growing season

Comparison	LSD (5)	LSD (1)
2- D means at each I	3.72	5.01
2- I means at each D	3.64	4.98

As clearly declared in Table (14), the values of soil pH were decreased under drip irrigation intervals comparing with traditional irrigation which received a large amount of irrigation water. Increasing yield and yield attributes of faba bean under drip irrigation treatments due to increasing the availability of macro and micronutrients. So, this present study recommends that under limitation of water resources in Egypt, using drip irrigation technique is preferable under these conditions, because it has high efficiency. Consequently, reaching the losses with the minimum level. In case of salt accumulation near the soil surface under drip irrigation system, the study recommends that giving a one surface irrigation every season to decrease the hazards of salt accumulation. These results are in a great agreement with those obtained by **Darwesh (2006).**

Table (14): Effect of irrigation intervals and plant densities on pH, EC, soluble cations and anions, calculated SAR and ESP.

Irrigation treatments I, days	Plant densities D	pH	Ec, dSm^{-1}	SAR	ESP	Soluble cations, meq/L				Soluble anions, meq/ L			
						Ca^{++}	Mg^{++}	Na+	K^{+}	Co_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Control	**Surface irrigation**	8.47	1.188	5.25	6.13	1.78	2.30	7.50	0.17	0.00	6.09	1.87	3.92
I_1	D_1	7.93	1.046	3.64	3.99	2.01	2.87	5.68	0.32	0.00	6.21	0.54	3.71
	D_2	7.96	1.079	4.09	4.60	1.52	2.85	6.05	0.30	0.00	6.18	0.96	3.65
	D_3	7.99	1.085	4.16	4.69	1.48	2.81	6.09	0.28	0.00	6.16	1.07	3.62
	D_4	8.01	1.090	4.18	4.72	1.51	2.80	6.14	0.27	0.00	6.11	1.22	3.57
Mean			**1.075**	**4.02**	**4.50**	**1.63**	**2.83**	**5.99**	**0.29**	**0.00**	**6.17**	**0.95**	**3.64**
I_2	D_1	8.03	1.093	5.18	6.04	1.20	2.61	7.15	0.26	0.00	6.09	1.33	3.51
	D_2	8.06	1.126	5.33	6.23	1.14	2.53	7.22	0.24	0.00	6.05	1.73	3.48
	D_3	8.07	1.155	5.16	6.01	1.49	2.48	7.27	0.22	0.00	6.01	2.10	3.44
	D_4	8.10	1.169	5.12	5.96	1.62	2.45	7.30	0.21	0.00	5.98	2.30	3.41
Mean			**1.136**	**5.20**	**6.06**	**1.36**	**2.52**	**7.24**	**0.23**	**0.00**	**6.03**	**1.87**	**3.46**
I_3	D_1	8.11	1.172	5.49	6.44	1.45	2.42	7.63	0.20	0.00	5.92	2.40	3.40
	D_2	8.14	1.193	5.72	6.73	1.39	2.38	7.86	0.19	0.00	5.86	2.69	3.38
	D_3	8.15	1.208	6.02	7.12	1.32	2.34	8.15	0.18	0.00	5.83	2.89	3.36
	D_4	8.17	1.251	6.52	7.75	1.27	2.31	8.73	0.16	0.00	5.79	3.39	3.33
Mean			**1.206**	**5.94**	**7.01**	**1.36**	**2.36**	**8.09**	**0.18**	**0.00**	**5.85**	**2.84**	**3.37**
I_4	D_1	8.18	1.265	6.73	8.01	1.21	2.30	8.90	0.15	0.00	5.78	3.47	3.47
	D_2	8.19	1.299	7.02	8.37	1.17	2.26	9.19	0.15	0.00	5.73	3.49	3.77
	D_3	8.21	1.331	7.32	8.74	1.11	2.24	9.47	0.13	0.00	5.70	3.62	3.99
	D_4	8.29	1.364	7.68	9.18	1.10	2.22	9.89	0.12	0.00	5.66	3.52	4.46
Mean			**1.315**	**7.19**	**8.58**	**1.15**	**2.26**	**9.36**	**0.14**	**0.00**	**5.72**	**3.53**	**3.92**
I_5	D_1	8.30	1.381	7.54	9.01	1.09	2.39	9.95	0.12	0.00	5.62	4.46	4.73
	D_2	8.34	1.397	7.85	9.39	1.06	2.32	10.21	0.10	0.00	5.59	3.44	4.94
	D_3	8.36	1.418	8.07	9.66	1.05	2.30	10.44	0.08	0.00	5.57	3.48	5.13
	D_4	8.39	1.439	8.19	9.80	1.03	2.31	10.58	0.07	0.00	5.51	3.48	5.40
Mean			**1.409**	**7.91**	**9.47**	**1.06**	**2.33**	**10.30**	**0.09**	**0.00**	**5.57**	**3.47**	**5.05**
The overall Mean values			**1.228**	**6.05**	**7.12**	**1.31**	**2.46**	**8.20**	**0.19**	**0.00**	**5.87**	**2.53**	**3.89**

Soil Salinity (Electrical Conductivity, dS/ m.)

Presented data in Table (14) showed that, the mean values of soil salinity were affected by both irrigation intervals and plant densities. Concerning, the effect of irrigation intervals, data illustrated that the mean values of salinity were increased by increasing irrigation intervals, where the highest mean values were recorded under the longest irrigation interval I_5 (irrigation every 18 days) and the mean value is 1.409 ds/m. Meanwhile, the lowest mean value was recoded under the shortest irrigation interval I_1 (irrigation every 6 days) and the mean value is 1.075 ds/ m. Generally, the mean values of soil salinity can be descended in order $I_5 > I_4 > I_3 > I_2 > I_1$ and the mean values are 1.409, 1.315, 1.206, 1.136 and 1.075 ds/ m, respectively. Data in the same table declared that the decreasing of irrigation interval, the mean values of soil salinity decreased. Increasing the mean values of soil salinity under elongation irrigation interval has a bad effect on yield as well as yield attributes, because of increasing osmotic pressure and hence, increasing water holding capacity of the soil. So, uptake of nutritional requirements by the plants need a great effort, this affects negatively on the productivity of faba bean. Therefore, under the limitation of water resources and obligation to use localized irrigation system, to avoid the salt accumulation, decreasing irrigation interval to make dilution, leaching and removing salts from the effective root zone or giving a one surface irrigation every season to decrease the hazards of salts accumulation. Presented data in the same table indicated that the overall mean values under all drip irrigation treatments were higher in comparison with surface irrigation (traditional irrigation) and the overall mean values are 1.228 and 1.188 ds/ m under drip irrigation treatments and surface irrigation method, respectively. Decreasing the values of soil salinity under surface irrigation in comparison with drip irrigation technique may be attributed to increasing amount of applied water and hence, decreasing salt accumulation in the effective root zone because of leaching salts far from this zone. These results are in a great harmony with those reported by Mungal *et al.* (2001), Metwally (2001), El-Henawy (2006) and Jiaxia Sun *et al.* (2012).

Regarding, the effect of plant densities, the mean values of soil salinity were affected by plant densities. Under all irrigation intervals the highest mean values were recorded under D_4 (the highest plant densities). This leads to decreasing yield and yield attributes under the conditions of this treatment comparing with other plant densities, D_1, D_2 and D_3. The lowest mean values of soil salinity were recorded under D_1 which gave the highest yield because, under these conditions the competition rate between plants decreased. So, it gaves healthy and good plants with a good yield. Therefore, the present study recommends that under obligation of using drip irrigation system in heavy clay soil, decreasing irrigation intervals and also plant densities.

Soluble cations, anions, calculated SAR and ESP

Presented data in Table (14) clearly declared that the mean values of soluble cations (Ca^{++}, Mg^{++}, Na^{+}, K^{+}) and soluble anions (HCO_3^-, Cl^- and So_4^{--}) meq/ L, sodium adsorption ratio (SAR) and Exchangeable sodium percentage (ESP) were affected by irrigation intervals and plant densities. Concerning, the effect of irrigation intervals, the mean values of Ca^{++}, Mg^{++}, K^{+}, HCO_3^- and So_4^{--} were decreased by increasing irrigation intervals, where the highest mean values were recorded under irrigation treatment I_1 (irrigation every 6 days) in comparison with other irrigation treatments. On the other hand, the mean values of (Na^{+}, Cl^- , SAR and ESP) were increased by increasing irrigation intervals, where, the highest mean values were recorded under irrigation treatment (I_5). Meanwhile, the lowest values were recorded under irrigation treatment (I_1) these results are in a great harmony with those obtained by Darwesh (2006) and Jiaxia Sun e*t al.* (2012). Regarding, the effect of plant densities, there is no clear relation for this factor on soluble cations, anions, SAR and ESP where some parameters increasing under D_1 but the others, increasing under D_4.

REFERENCES

Aiad, M.A.; E. A. Moursi; R. A. El-Dissoky and M.M.Amer (2014). Response of maize crop to irrigation under different rates and dose of nitrogen fertilization in the North Nile Delta region. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol 5 (1): 97-113.

Ainer, N.G.; Miseha,W.I. and Abdel. Maksoud, H. H. (1994). Water management for faba bean in the Delta. Zagazig J. Agric. Res. 20(6):2045-2053.

Ali, M.H., M.R. Hoque: A.A. Hassan and A.khair (2007). Effects of deficit irrigation on yield, water productivity and economic returns of wheat. Agricultural water management, 92 (3): 151-161.

Atwa; A.A.E.,H.S. Hamoud, R.A.I.Abo.Mostafa and Manal A. Aziz (2009). Tolerance of some faba bean varieties to soil salinity levels. J. Agric. Res. Kafr El-Sheikh Univ., 35(2).

Bos, M.G. (1980). Irrigation efficiencies at crop production level. ICID. Bulletin 29, 2: 189-260 New Delhi.

Boyelo. Jimenes J.S., DG Debouck and JP, Lynch (2002). Salinity tolerance of phaseolus species during early vegetative growth, crop science 42: 2184-2192.

Darwesh,R.Kh. (2006). Maximizing water use efficiency by some vegetable crops under drip irrigation system. Msc. Thesis. Agric. Sci. (soils) Fac. of Agric. Mansoura,Univ.

Doorenbos,J. and W.O.Pruitt (1975). Crop water requirements. Irrigation and Drainage paper, No. 24, FAO. Rome.

Downy, L.A. (1970). " Water use by Maize at three plant densities " paper , 33, FAO, Rome.

Eid, S. M.; M. M. Kassab and M.A.M. Ibrahim (2005). Drip irrigation and maize production in clayey soil J. Agric. Sci. Mansoura Univ.; 30 (5): 2937-2944.

El-Galaly, Ola A. M.; R. A. I., Abou- Mostafa; A. M. Nagwa and M. A. Mahmoud (2008). Response of two faba bean (vicia faba L.,) promising lines and Sakha 3 cultivar to different sowing dates and densities J. Agric. Res., Kafr El-Sheikh Univ., 34 :647-661.

El-Gibali, A. Ashenouda, H. N.; Badawy, A. Y. and Mansour, S. F. (1968). Irrigation requirements, frequency and effect on yield and quality of horse bean grains in Middle Egypt., Agric.Res. Rev., Cairo, 46(1):91-98.

El-Henaway, A. S. (2006). Effect of drip irrigation and soil mulching on some soil properties, yield and quality of Navel orange trees at North Delta. Ph.D. Thesis Agric., Soil Sci. Fac. Of Agric. Kafr El-Sheikh Univ.

El-Maghraby, S.S.M.(1980). Effect of water regime, nitrogen and phosphatic fertilizers on growth and yield of broad bean (vicia faba L.) M.Sc. Thesis, Fac. Agric. Moshtohor, Zagazig Univ., Egypt.

El-Maghraby, S.S.M.(1984). Effect of some agricultural practices on yield and quality characters of faba bean plant (Vicia Faba L.) ph. D. Thesis, Fac. of Agric. Moshtohor, Zagazig Univ. Egypt.

El-Quosy, D. (1998). The challenge for water in the twenty first century. The Egyptian experience. Arab-water 98. Ministry of Water Resources and Irrigation (MWRI) April 26 - 28, 1998, Cairo, Egypt.

El-Saady, A. S. M.; Gh. Sh. El-Atawy and R. H. Atia (2011). Effect of furrow spacing and phosphorus fertilization treatments on faba bean yield, nutrients content and some water relationships. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 2 (5): 597-610.

El-Waraky, M. K. and Wahba, M.F.(1998). Influence of irrigation frequency before and after canal closure on the productivity of faba bean. Food Legume Crops Program, Field Crops Research Institute, Agriculture Res. Center, Egypt.

Goldberg, D. and M. Shmueli (1970). Drip irrigation, a method used under arid and desert conditions of high water and soil salinity. Am. Soc. Agric. Eng. Trans. 13 (1): 38-41.

Gomez, K.A. and A.A. Gomez (1984). Statistical procedures for Agricultural Research, second (Ed.) Willey and Sons Inc. New Yourk.

Hansen, V.W.; D.W. Israelsen and D.E. Stringharm (1979). Irrigation principle and practices, 4 th ed Johns Willey &Sons; New York.

Jackson, M.l (1973). Soil Chemical Analysis. prentice Hall of India private, LTD New Delhi.

Jiaxia sun, Yaohu Kang, Shuqin Wan, Wei Hu, Shfang Jiang, Tibin Zhang (2012). Soil salinity management with drip irrigation and its effects on soil hydraulic properties in North China coastal saline soils. Agric. Water management 115 (2012)10-19.

Kassab, M. M. and M.A.M.Ibrahim (2007). Cut off wheat (triticum sp.). Irrgation as an effective technique for improving water management. Alexandria science Exchange Journal Vol. 28 No. 4 October – December.

Klute, A.C (1986). Water retention: laboratory Methods. In: A. koute (ed), Methods of Soil Analysis, part12nd(ed.) Agron. Monogr.9, ASA, Madison, W1 U.S.A, pp. 635 – 660.

Krogman, K.K.; R.C. Mckenzie and E.H. Hobbs (1980). Response of faba bean yield, protein production, and water use to irrigation. Can. J. Plant Sci. 60:91-96.

Meriaux, S. (1972). The influence of drought on the growth, yield and composition of the faba bean. Ann. Agron. 23(5): 533-546. (C.F. Field Crop Abst., 26: Abstr. No. 3701. Michael, A. M. (1978). Irrigation Theory and Practice Vikas Publishing House PVT. LTD.

Metwally,M.A. (1973). Study on the effect of irrigation and fertilization on yield, and technological properties in faba bean (vicia faba L.) M.Sc. Thesis, Fac. Agric. Al Azhar Univ., Egypt.

Metwally, M.F. (2001). Fertigation management in sandy soil. M.Sc. Thesis, Ag. Eng., Fac. of Agric. Mansoura Univ.

Miseha, W. I.; M. A. Hassanien; H. W. Tawadros and S.F. Abd El-Rassol (1971). Effect of irrigation regime and nitrogen fertilizer on the yield and yield components of faba bean. Fert. Conf., Fac. Agric., Ain Shams Univ., Cairo.

Molden, D. (1997). Accounting for water use and productivity. SWIM paper 1. International Irrigation Management Institute, Colombo, Srilanka.

Moursi, E. A.; M.M.Kassab; M. K. M. El-Samanody and M.A.M. Ibrahim (2010). Determining the optimum irrigation intervals and plant densities for sunflower under drip irrigation system J. Soil Sci. And Agric. Engineering, Mansoura Univ., Vol. 1 (5): 487-500.

Moursi, E.A.; Manal A. Aziz; M. A. Aiad and R. Kh. Darwesh (2013). Effect of water stress, Biofertilizers and nitrogen application rates on cowpea yield and some water relations in the North Middle Nile Delta region. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 4 (11): 1289-1311.

Mungal, M.S.; P.R. Bharambe and M.S. Pendke (2001). Moisture and salt distribution under drip irrigation for banana. Bioved. 12(1-2): 1-10.

Nahed, M. Rashed and E.A. Moursi (2012). Influence of Cultivation Method and irrigation Regime on growth, oil yield and yield and some water relations of sage (Salvia officinalis,L.) in heavy clay soils. Alexandria Science Exchange Journal.Vol. 33, No.2 April – June.

Omer, E. H. ; M. A. Abd El-Aziz; M.M. Ragab and M.M. Saied (2008). Response of chickpea and maize crops plants grown in a clayey soil to subsurface drip irrigation, bio - solids and mineral NPK fertilizers. J. Agric. Sci. Mansoura Univ., 33(6): 4651-4665.

Roshdy,M.A. (1975). Some chemical changes in vicia faba plant during maturity stages under different levels of fertilization and irrigation. M.Sc. Thesis, Fac.Agric.,Ain Shamas Univ., Egypt.

Sepaskhah, A.R. and Kamgar – Haghighi, A.A., (1997). Water use and yields of sugar beet grown under every – other furrow irrigation with different irrigation intervals. Agric. Water Manage. 34, 71-79.

Towadros, H. W.; G. M. Gad El-Rab and W. I. Miseha (1993a). Effect of irrigation frequency and wetting depth on faba bean production. J. Agric. Sci. Mansoura Univ. 18(12):3752-3764.

Waller, R.A. and D.B. Duncan (1969). Symmetric multiple comparison problem. Amer. Stat. Assoc. Jour. December, 1485 – 1503.

Younis, S.I.; E.A. Moursi, F.R.Moussa and I.A. Shalaby (2009). Effect of irrigation intervals on the yield and quality of Roselle plants (Hibiscus SABDA riffal. Under drip irrigation in heavy clay soil. J. Biol – Chem. Environ. Sci.; 4 (1), 589-605.

تـأثير فتـرات الـرى والكثافـات النباتيـه علـى محصـول الفـول البلـدى وبعض العلاقـات المائية وخصائص التربة تحت نظام الرى بالتنقيط فى منطقة شمال وسط دلتـا النيـل .

السيد أبو الفتوح مرسى ، مجدى محمد ابراهيم نصر و ومنى عبد الحليم المنصورى
معهد بحوث الاراضى والمياه والبيئة...... مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربتان حقليتان فى المزرعة البحثيه بمحطة البحوث الزراعية بسخا – محافظة كفر الشيخ خلال موسمى النمو الشتوى2013/2012 و 2014/2013 بهدف دراسة تأثير فترات الرى والكثافات النباتيه على محصول الفول البلدى ومكوناته ، و بعض العلاقات المائيه تحت نظام الرى بالتنقيط--- الصنف المنزرع سخا 2 تم زراعته فى 10، 15 نوفمبر فى الموسم الاول والثانى على الترتيب وتم الحصاد فى 28 ابرايل ، 2 مايو فى الموسم الاول والثانى على الترتيب. تم استخدام نظام القطع المنشقه مره واحدة فى 4 مكررات حيث وزعت المعاملات الرئيسيه عشوائيا بفترات الرى و التى كانت I_1 =رى كل 6أيام ، I_2 = رى كل 9أيام ، I_3 = رى كل 12 يوم ، I_4 = رى كل 15 يوم ، I_5 = رى كل 18 يوم ......والمعاملات تحت الرئيسية الكثافات النباتيه (D) و كانت D_1 = زراعة نباتين عند النقاط نبات من كل جهة ،D_2 = زراعة نباتين عند النقاط من جهة واحدة ، D_3 = زراعة 4 نباتات عند النقاط نباتين من كل جهة ، D_4 = زراعة4 نباتات عند النقاط نباتين من كل جهة ونباتين فى منتصف المسافة بين النقاطات نبات من كل جهة.

اهم النتائج يمكن تلخيصها فيما يلى:

- ❖ أعلى القيم بالنسبه للماء الموسمى المضاف ، الماء المخزن فى منطقه الجذور و كذلك الاستهلاك المائى سجلت أعلى القيم للمقاييس سالفه الذكر تحت فترة الرى (I_1) حيث كانت القيم 1475.52 ، 1205.20 ، 1059.44 م^3 /فدان.... على العكس من ذلك سجلت أقل القيم تحت فترة الرى (I_5) و القيم 990.64 ، 905.16 ، 850.44 م^3 / فدان على الترتيب. بصفه عامة قيم المقاييس سالفه الذكر يمكن ترتيبها تنازليا :
  $I_5 < I_4 < I_3 < I_2 < I_1$.
- ❖ بالنسبه لقيم كفاءة الرى التطبيقيه سجلت أعلاها تحت فترة الرى (I_4) حيث كانت القيم 94.92 ، 94.47 وكما سجلت أقل القيم تحت المعاملة (I_1) 81.57 ، 81.79 % فى الموسم الاول والثانى على الترتيب .
- ❖ بالنسبة لانتاجيه وحدة المياة المستهلكة و كذلك وحدة المياة المضافة سجلت أعلى القيم تحت فترة الرى (I_5) و القيم 1.38 ، 1.19 كجم/ م^3 بينما سجلت أقل القيم تحت معاملة الرى (I_1) والقيم 1.29 ، 0.92 كجم/ م^3 بالنسبة لانتاجيه وحدة المياة المستهلكه والمضافة على الترتيب. وبالنسبة لكفاءة الاستهلاك المائى سجلت أعلى القيم تحت فترة الرى (I_4) والقيمة 86.18 % و لكن الأقل سجلت تحت فترة الرى (I_1) والقيمة 71.80 % . بالنسبة لكمية المياه المضافة والنسبة المئوية للماء المتوفر يمكن ترتيبها تنازليا كما يلى
  $I_5 < I_4 < I_3 < I_2 < I_1$. فى كلا موسمى الدراسة.
- ❖ بالنسبة لمحصول البذورسجلت أعلى القيم مع فترة الرى (I_1 = رى كل 6 أيام) حيث كانت القيم 1357.19 و 1364.05 كجم / فدان كما سجلت أقل القيم مع فترة الرى (I_5 = رى كل 18 يوم) والقيم هى 1175.64 و 1170.16 كجم /فدان فى الموسم الأول والثانى على الترتيب. بصفه عامه القيم يمكن ترتيبها تنازليا هكذا
  $I_5 < I_4 < I_3 < I_2 < I_1$. بالنسبه لتأثير الكثافات أعلى القيم سجلت تحت معاملة D_1 .
- ❖ بالنسبه لمحصول العرش سجلت أعلى القيم تحت معاملة الرى I_1 و القيم 2.79 و 2.80 طن / فدان الأقل سجلت تحت معاملة الرى I_5 و القيم 1.61 و 1.58 طن / فدان فى الموسم الأول والثانى على الترتيب و لكن بالنسبه لتأثير الكثافات سجلت أعلى القيم تحت المعاملة D_1 و الأقل تحت المعاملة D_4 .
- ❖ بالنسبه لتأثير فترات الرى على بعض مكونات المحصول مثل (طول النبات ، عدد الفروع / نبات ، عدد القرون /نبات و وزن 100 بذرة حيث سجلت أعلى القيم للصفات سالفة الذكر تحت معاملة الرى I_1 (رى كل 6 أيام) و الأقل سجلت تحت معاملة الرى I_5 (رى كل 18 يوم). بصفه عامة القيم يمكن ترتيبها تنازليا هكذا $I_5 < I_4 < I_3 < I_2 < I_1$. بالنسبه لتأثير الكثافات أعلى القيم سجلت تحت المعاملة D_1 مقارنة ب D_2 ، D_3 و D_4 فى الموسمين.
- ❖ زيادة قيم ال pH تحت الرى السطحى مقارنة باستعمال الرى بالتنقيط . سجلت أقل القيم تحت فترة الرى (I_1) .... و لكن بالنسبه لتأثير الكثافات النباتيه أعلى القيم سجلت تحت المعاملة D_4 .
- ❖ بالنسبة لملوحة التربه سجلت أعلى القيم تحت فترة الرى I_5 و القيمة 1.409 ds/ m و لكن أقل القيم سجلت تحت فترة الرى I_1 و القيمة 1.075 ds/ m – بالنسبة لتأثير الكثافات النبلتيه أعلى القيم سجلت تحت المعاملة D_4 لكل فترات الرى .
- ❖ بالنسبة للكاتيونات والانيونات الذائبه وكذلك قيم SAR، ESP سجلت أعلى القيم مع فترة الرى I_1 و الاقل سجلت تحت فترة الرى I_5 و لكن بالنسبة لتأثير الكثافات النباتيه ليس هناك اتجاه واضح حيث زادت بعض المقاييس تحت D_1 و الاخرى تحت D_4 .