# RATIONALIZATION OF IRRIGATION WATER USE FOR FABA BEAN (*vicia faba* L.).

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## ABSTRACT

The present investigation was conducted at Fayoum Agric. Res. Station (Tamiea), Fayoum Governorate, Egypt during 2009/2010 and 2010/2011 seasons to study the combined effect of ridge width (60, 80 and 100 cm) and available soil moisture depletion (35, 55 and 75% ASMD) on seeds yield, yield components and some water relations of faba bean crop (Giza - 843 hybrid). A split plot design with four replications was used in both seasons. The main obtained results were as follows:

Plant height (110.6, 102.7cm), pod number/plant (20.9, 19.10), seed weight/plant (50.2, 48.9 gm), 100- seed weight (64.5, 62.3 gm) and highest seed yield/fed (1611.51 and 1402.2 kg/fed in 2009/2010 and 2010/2011 seasons, respectively), resulted from planting on ridges of 60 cm width and irrigation at 35% ASMD, surpassed significantly those obtained from the other treatments, in the two successive seasons. However, the highest number of branches/ plant were detected from planting on ridges of 80 cm width and irrigating at 35% ASMD, in the two seasons.

Seasonal consumptive use ($ET_C$) averaged 33.15 and 33.00 cm in 2009/2010 and 2010/2011, respectively. Planting on ridges of 60 cm width and irrigation at 35% ASMD gave the highest $ET_C$ values, i.e., 37.95 and 36.66 cm in the two successive seasons. The lowest $ET_C$ values, i.e., 28.62 and 30.14 cm were detected from planting on the widest beds and 75% ASMD treatment in both seasons, respectively.

Daily $ET_C$ rates were low during Oct., Nov. and Dec. then increased during Jan. reached its maximum values during Feb. and declined again till harvesting. The crop coefficient ($K_C$) values were 0.49, 0.62, 0.73, 0.81, 0.90 and 0.59 for Oct., Nov., Dec., Jan., Feb. and March, respectively. (average of the two seasons)

The highest water use efficiency values i.e., 1.011 and 0.911 kg seeds/$m^3$ water consumed were obtained from planting on ridges of 60 cm width and irrigation at 35% ASMD treatment in 2009/2010 and 2010/2011 seasons, respectively.

Results indicate that planting on wide ridges of 100 cm width safe about 11.45% of the water consumed and produced an acceptable economic seed yield

**Key words:** faba bean, yield, yield components, ridge width, irrigation regimes, water relations.

## INTRODUCTION

Faba bean considered the most important winter legume crop in Egypt. The high protein content of its seeds (28%) gave this crop the greet importance in human consumption, as well a sheep source of protein. Also, the role of this crop in improving soil characteristics after harvesting, because it increased soil fertility as nitrogen fixation in soils by root nodules, leaving about 20-25 units of N/fed, which will be beneficial for the next cultivated crop.

Concerning, the effect of ridge width many investigators have been reported a tendency for increase in yield and some yield components such as no. of branches/plant, no. of pods, seeds weight/plant and 100-seed weight by increasing the row spacing. **Mohamed (1980), Sary *et al.* (1989), El-Douby *et al.* (1996 & 2000) and Talal Thalji (2006).** The effect of ridge width on some water relations was studied by **Tawadros and Abd-Aziz (1992), Salib *et al.* (1998), Chiroma *et al.*(2006)** and **El-Saady(2011)** and they pointed out that the seasonal ET of cotton, sunflower, sorghum and faba bean were affected significantly by reducing ridge width. However, there was inversely proportional, where water use efficiency was increased by decreasing the ridge width as well.

Regarding, the effect of irrigation regimes, **Ibrahim (1986), Ageeb *et al.* (1989), Tawadros *et al.* (1993a &b),** and **Mashari and Naeem(2008)** showed that the yield and its components of faba bean were affected by irrigation deficit,when available soil water depletion increased from 15% ASMD to 30% or 45% ASMD. **Tawadros *et al.* (1993b)** found that the $K_C$ for faba bean were 0.62, 0.78 and 0.56 respectively for the stages in the same order. **Tawadros (1993b), Ainer *et al.* (1994)** and **Khalil (1995)** reported that water use efficiency increased by increasing soil moisture stress.

## MATERIALS AND METHODS

Two field experiments were carried out at the farm of Fayoum Agric. Res. Station (Tamiea), Fayoum Governorate, Egypt during 2009/2010 and 2010/2011 seasons to study the effect of ridge width and irrigation regimes on faba bean yield, yield components and some crop water relations. To achieve this target, three ridge width treatments, i.e. $R_1$: ridges of 60 cm width, $R_2$: ridges of 80 cm width and $R_3$: ridges of 100 cm width (beds), were integrated with three irrigation regime treatments, i.e. irrigation at $I_1$: 35%, $I_2$: 55% and $I_3$: 75% available soil moisture depletion (ASMD), in a spilt-plot design with four replications. Faba bean seeds (hybrid Giza 843) at the rate of 30 kg/fed were sown on Oct. 27$^{th}$ and 25$^{th}$ in 2009/2010 and 2010/2011 seasons, respectively, in hills of 25 cm apart. Rhizobium inculcation mixed with fine sand and sprayed on the covered hills after planting seeds and immediately before irrigation. The most population densities/fed of different ridge treatment were kept constant by varying the number of plants/hill at thinning. Calcium super phosphate (15.5% $P_2O_5$) at the rate of 200 kg/fed and potassium sulphate (48%$K_2O$) at the rate of 100 kg/fed were applied during field preparation. Simulative dose of N was added as ammonium nitrate 33.5% N at the rate of 68.5 kg/fed at the 1$^{st}$ irrigation. Each plot was isolated from the others by allays 1.5 m between plots to avoid the lateral movement of water. Harvesting was done on March 25$^{th}$ in both seasons. The soil physical and chemical properties of experimental plots, were determined according to **Klute (1986)** and **page *et al.* (1982)** and are presented in Table (1). The averages of climatic factor for Fyoum Governorate during winter season are recorded in Table (2).The soil moisture values were gravimetrically determined on oven dry basis, as the technique of Water Requirements and Field Irrigation Dept., A.R.C., Egypt for soil layers, each of 15.0 cm from soil surface and down to 60.0 cm depth, and the soil moisture constants, estimated for the experimental field are shown in Table(3).At harvesting time the following data were recorded for each sub- plots.

**I. yield and yield components:**

1- Plant height (cm).
2- Number of branches/plant.
3- Number of pods/plant
4- Seed weight/plant (gm).
5- 100- seed weight (gm).
6- Seed yield (kg/fed.)

All the collected data were subjected to the statistical analysis according to the procedures outlined by **Snedecor and Cochrum (1980)** and the means were compared by L.S.D. test at 5.0% level.

**II. Crop water relations:**

For determining the crop water consumptive use ($ET_C$), soil samples were taken from each sub-plot, just before and after 48 hours from each irrigation, as well as at harvesting time and the $ET_C$ between each two successive irrigations was calculated according to the following equation

Cu ($ET_C$) = $\{(Q_2 - Q_1) / 100\} \times Bd \times D$ **(Israelsen and Hansen, 1962).**

Where: Cu = crop water consumptive use (cm).gg by the number of days.

**3. Reference evapotranspiration ($ET_0$)**

Estimated as a monthly rate (mm/day), using the monthly averages of climatic factors of Fayoum Governorate and the procedures of the **FAO-Penman Monteith** equation **(Allen *et al.* 1998)**

**4. Crop Coefficient ($K_C$).**

The crop coefficient was calculated as follows:

$$K_C = ET_C / ET_0$$

Where: $ET_C$ = Actual crop evapotranspiration (mm/day)

$ET_0$ = Reference evapotranspiration (mm/day).

**5. Water use efficiency (WUE).**

The water use efficiency as kg grains/ $m^3$ water consumed was calculated for different treatments as the method described by **Vites (1965):**

$$WUE = \text{Grain yield (kg/fed)} / \text{Seasonal } ET_C \text{ } (m^3/\text{fed.})$$

**Table (1): Physical and chemical analysis of the experimental field during 2009/2010 and 2010/2011**

| Physical properties | | | | | |
|---|---|---|---|---|---|
| sand % | Silt% | Clay% | Texture classe | Organic matter% | $CaCo_3$% |
| 38.00 | 21.2 | 40.8 | Clay loam | 1.68 | 5.18 |

| Chemical analysis | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soluble cations meq/1L | | | | Soluble anions meq/1L | | | | EC dS/m | pH 1:2.5 Extract | CEC Meq/ 100 gm soil | Exchangeable Cations Meq/100 gm soil | | | |
| $Ca^{++}$ | $Mg^{+}$ | $Na^{+}$ | $K^{+}$ | $Cl^{-}$ | $HCO_3^{-}$ | $CO_3^{--}$ | $SO_4^{--}$ | | | | $Ca^{++}$ | $Mg^{++}$ | $K^{+}$ | Na+ |
| 8.18 | 7.69 | 24.67 | 0.33 | 20.73 | 3.06 | _ | 17.08 | 4.00 | 8.12 | 31.83 | 16.29 | 10.29 | 1.2 | 4.05 |

**Table (2): The monthly averages of climatic factors for Fayoum Governorate during 2009/2010 and 2010/2011 seasons.**

| Months | seasons | Temperature C° | | | Relative Humidity % | Wind Speed m/sec. | Class A pan evaporation mm/day |
|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Mean | | | |
| **October** | 2009 | 26.6 | 13.1 | 19.85 | 52 | 1.49 | 2.9 |
| | 2010 | 25 | 11.7 | 18.35 | 52 | 1.48 | 2.5 |
| **November** | 2009 | 22.2 | 9.1 | 15.65 | 54 | 1.03 | 1.6 |
| | 2010 | 22.4 | 8.9 | 15.65 | 53 | 1.05 | 1.9 |
| **December** | 2009 | 20.7 | 6.7 | 13.70 | 53 | 1.2 | 1.7 |
| | 2010 | 21.9 | 7.6 | 14.80 | 53 | 1.18 | 1.8 |
| **January** | 2010 | 22.3 | 6.4 | 14.35 | 48 | 1.65 | 2.5 |
| | 2011 | 24.4 | 8.2 | 16.30 | 49 | 1.65 | 2.8 |
| **February** | 2010 | 23.2 | 7.9 | 15.55 | 49 | 2.11 | 4.4 |
| | 2011 | 27.5 | 11.4 | 19.50 | 50 | 2.13 | 4.3 |
| **March** | 2010 | 30.8 | 12.5 | 21.65 | 46 | 2.42 | 5.1 |
| | 2011 | 31.8 | 14.3 | 23.00 | 46 | 2.43 | 5.9 |

**Table (3): The average values of soil moisture constants for the experimental field during 2009 and 2010 seasons (average of the two seasons).**

| Soil depth (cm) | Field capacity (%) | Wilting point (%) | Bulk density (g/cm$^3$) | Available moisture (%) |
|---|---|---|---|---|
| **0-15** | **42.56** | **21.16** | **1.41** | **21.4** |
| **15-30** | **40.76** | **19.84** | **1.43** | **20.92** |
| **30-45** | **38.32** | **18.65** | **1.31** | **19.67** |
| **45-60** | **33.59** | **17.34** | **1.39** | **16.25** |

## RESULTS AND DISCUTION

### I- Yield and yield components.

The analysis of variance proved that seed yield of faba bean and its components were significantly affected due to ridge width and soil moisture levels, as well as the interaction between them in both seasons of this study.

Results presented in Tables (4 and 5) show that seed yield and its components were significantly increased by planting faba bean on ridges of 60 cm except number of branches/plant which its high records were detected from planting on ridges of 80cm ( i.e. 3.63 and 3.40 ). These results are true in both seasons. The maximum plant height (96.87 cm), number of pods/plant (17.37), seed weight/plant (39.8 gm), 100-seed weight (59.97 gm) and seed yield (1389.39 kg/fed), were obtained from planting on ridges of 60 cm in 2009/2010 season. The corresponding values of maximum seed yield and its components in 2010/2011 season were 92.43 cm, 15.8, 38.53 gm, 56.73 gm and 1258.03 kg/fed, in the order respectively. These results can be attributed to inadequate welting of the lower part of the bed (wide ridges) for some days after irrigation and this in turn reduced dry matter accumulation in the productive organs. It is clear that planting on wide ridges caused pronounced reduction in faba bean yield and its components than those obtained from planting on ridges of 60 cm. These results are in accordance with those by **Mohamed(1980), Sary *et al.* (1989), , El-Douby *et al.* (1996& 2000) and Talal Thalji (2006).**

**Table (4): Effect of ridge width and irrigation regimes on faba bean yield and yield components in 2009/2010 season.**

| Treatments | | Plant Height (cm) | Number of branches /plant | Number of pods/ plant | Seed Weight/ plant (gm) | 100-seed Weight (gm) | Seed yield /fed (kg/fed) |
|---|---|---|---|---|---|---|---|
| Row Width (cm) | Irrig. Regimes | | | | | | |
| **$R_1$ 60 (cm)** | $I_1$ : 35% | 110.6 | 4.0 | 20.9 | 50.2 | 64.5 | 1611.51 |
| | $I_2$: 55% | 96.8 | 3.2 | 17.4 | 40.8 | 60.6 | 1355.40 |
| | $I_3$: 75% | 83.2 | 2.6 | 13.8 | 28.4 | 54.8 | 1201.25 |
| | **Mean** | **96.87** | **3.27** | **17.37** | **39.8** | **59.97** | **1389.39** |
| **$R_2$ 80 (cm)** | $I_1$ : 35% | 103.4 | 4.2 | 18.4 | 45.3 | 63.1 | 1413.61 |
| | $I_2$: 55% | 91.2 | 3.7 | 16.1 | 36.9 | 58.2 | 1239.75 |
| | $I_3$: 75% | 79.9 | 3.0 | 13.7 | 27.1 | 56.6 | 1084.47 |
| | **Mean** | **91.5** | **3.63** | **16.07** | **36.43** | **59.3** | **1245.94** |
| **$R_3$ 100 (cm)** | $I_1$ : 35% | 96.5 | 4.0 | 17.9 | 44.6 | 62.8 | 1300.94 |
| | $I_2$: 55% | 84.6 | 3.5 | 15.2 | 33.4 | 58.0 | 1153.10 |
| | $I_3$: 75% | 75.7 | 2.9 | 12.3 | 26.9 | 55.2 | 1018.46 |
| | **Mean** | **85.6** | **3.47** | **15.13** | **34.97** | **58.67** | **1157.50** |
| **Irrig. Mean** | $I_1$ : 35% | **103.50** | **4.07** | **19.07** | **46.70** | **63.47** | **1442.02** |
| | $I_2$: 55% | **90.87** | **3.47** | **16.23** | **37.03** | **58.93** | **1249.42** |
| | $I_3$: 75% | **79.60** | **2.83** | **13.27** | **27.47** | **55.53** | **1101.39** |
| **L.S.D: at 0.05** | | | | | | | |
| **R** | | **0.53** | **0.16** | **0.18** | **1.86** | **0.32** | **15.80** |
| **I** | | **0.56** | **0.26** | **0.31** | **1.2** | **0.28** | **13.58** |
| **R × I** | | **0.98** | **N.S** | **0.53** | **2.08** | **0.49** | **23.52** |

Regarding the effect of soil moisture levels, data recorded in Tables (4 and 5) indicate that under the wet watering regime (35% ASMD), seed yield of faba bean and its components increased significantly than the other two moisture levels. In 2009/2010 season, irrigating faba bean at 75% ASMD (dry level) reduced plant height, number of branches/plant, number of pods/plant, seed weight/ plant, 100-seed weight and seed yield, significantly, by 23.09%, 30.47%, 30.41%, 41.18%, 12.51% and 23.62%, whereas, in 2010/2011 season the corresponding values of reductions were 21.85%, 32.8%, 35.96%, 44.20%, 15.12% and 14.68%, respectively. It can be concluded that as soil moisture depletion (stress) increase than 35% ASMD, seed yield and its components reduced significantly. These results can be attributed to the bad effects of water stress on leaf area, physiological processes, vegetative and reproductive growth, and dry matter accumulation and translocation when compared with non stressed plants. These results are in the same line of those reported by

**Ibrahim (1986), Ageeb *et al.* (1989), Tawadros *et al.* (1993 a & b),** and **Mushari and Naeem (2008)**

The interaction effect between ridge width and soil moisture levels in 2009/2010 and 2010/2011 seasons, on faba bean yield and its components were significant except number of branches/plant, Tables (4 and 5). It was found that planting on ridges of 60 cm under the wet moisture level (35% ASMD) gave the higher means of seed yield and its components in 2009/2010 and 2010/2011 seasons. Whereas, planting on ridges of 100 cm (beds) and irrigation at 75% ASMD, produced the lower seed yield and yield components in both seasons.

**Table (5): Effect of ridge width and irrigation regimes on faba bean yield and yield components in 2010/2011season.**

| Treatments | | Plant Height (cm) | Number of branches /plant | Number of pods/ plant | Seed Weight/ plant (gm) | 100-seed Weight (gm) | Seed yield /fed (kg/fed) |
|---|---|---|---|---|---|---|---|
| Row Width (cm) | Irrig. Regimes | | | | | | |
| **$R_1$ 60 (cm)** | $I_1$ : 35% | 102.7 | 3.7 | 19.1 | 48.9 | 62.3 | 1402.2 |
| | $I_2$: 55% | 94.1 | 3.1 | 16.7 | 39.1 | 57.2 | 1295.6 |
| | $I_3$: 75% | 80.5 | 2.4 | 11.6 | 27.6 | 50.7 | 1076.3 |
| | **Mean** | **92.43** | **3.07** | **15.8** | **38.53** | **56.73** | **1258.03** |
| **$R_2$ 80 (cm)** | $I_1$ : 35% | 97.6 | 4.0 | 16.9 | 41.6 | 59.9 | 1286.5 |
| | $I_2$: 55% | 85.9 | 3.5 | 15.3 | 32.4 | 54.2 | 1193.2 |
| | $I_3$: 75% | 76.2 | 2.8 | 11.1 | 23.5 | 51.8 | 1027.8 |
| | **Mean** | **86.57** | **3.4** | **14.43** | **32.5** | **55.3** | **1169.17** |
| **$R_3$ 100 (cm)** | $I_1$ : 35% | 93.1 | 3.9 | 15.4 | 40.3 | 57.8 | 1183.2 |
| | $I_2$: 55% | 80.7 | 3.3 | 14.6 | 30.7 | 52.9 | 1109.1 |
| | $I_3$: 75% | 72.6 | 2.6 | 10.2 | 21.9 | 50.3 | 991.9 |
| | **Mean** | **82.13** | **3.27** | **13.4** | **30.97** | **53.67** | **1094.73** |
| **Irrig. mean** | $I_1$ : 35% | **97.8** | **3.87** | **17.13** | **43.60** | **60.00** | **1290.63** |
| | $I_2$: 55% | **86.9** | **3.30** | **15.53** | **34.07** | **54.77** | **1199.30** |
| | $I_3$: 75% | **76.43** | **2.60** | **10.97** | **24.33** | **50.93** | **1101.13** |
| **L.S.D: at 0.05** | | | | | | | |
| **R** | | **0.60** | **0.41** | **0.61** | **1.60** | **1.13** | **15.63** |
| **I** | | **0.64** | **0.18** | **0.38** | **0.64** | **0.52** | **19.89** |
| **R × I** | | **1.09** | **N.S** | **0.66** | **1.12** | **0.90** | **34.46** |

## II- Water relations.

### 1- Seasonal consumptive use ($ET_C$).

As shown in Table (6), the mean values of seasonal water use by faba bean under different ridges width and soil moisture regimes were 33.15 and 33.00 cm in 2009/2010 and 2010/2011 seasons, respectively. Results indicated that planting on ridges of 60 cm gave the higher values of water consumptive use (35.55 and 34.89 cm) in the two successive seasons, respectively. Planting on ridges of 80 cm or 100 cm (beds) reduced seasonal water use to 32.85 and 31.04 cm, respectively, in 2009/2010 season and to 32.79 and 31.33 cm, respectively, in 2010/2011 season. The most probable explanation for these results is that: the bottoms numbers between wide ridges (beds) will be less than those between normal ridges (60 cm width) and this in turn reduced water runoff, evaporation and inadequate wetting area under beds, which may also reduced plant transpiration. These results are in the same trend with those reported by **Tawadros and Abd-Aziz (1992), Salib *et al.*(1998), Chiroma *et al.*(2006)** and **El-Saady (2011)**.

Regarding the effect of soil moisture levels on seasonal consumptive use, results presented in Table (6) show that the maximum values of seasonal consumptive use (35.64 and 34.47 cm) were resulted from irrigation at 35% ASMD, in 2009/2010 and 2010/2011 seasons, respectively. As soil moisture depletion increased to 55% (medium level) or 75% (dry level) seasonal consumptive use reduced to 33.17 and 31.17 cm in 2009/2010 season, respectively, while in 2010/2011 season it reduced to 33.05 and 31.49 cm, respectively. These results revealed that faba bean plants consumed more water when soil moisture was maintained high. The magnitude of ET, was in ascending orderd wet > medium > dry soil moisture level. These results can be due to that at 35% ASMD there was luxuriant use of water which ultimately resulted in increasing transpiration and more losses by evaporation than 55% and 75% ASMD treatments. The present results are in harmony with those obtained by **Tawadros (1993b), Ainer *et al.* (1994)** and **Khalil (1995)**.

**Table (6): Effect of ridge width and available soil moisture depletion and their interaction on seasonal consumptive use of faba bean crop ($ET_C$) in cm.**

| Ridge width | 2009/2010 | | | | 2010/2011 | | | Mean |
|---|---|---|---|---|---|---|---|---|
| | 35% | 55% | 75% | Mean | 35% | 55% | 75% | |
| **$R_1$** | 37.95 | 35.58 | 33.13 | **35.55** | 36.66 | 35.07 | 32.95 | **34.89** |
| **$R_1$** | 35.27 | 33.13 | 30.16 | **32.85** | 34.16 | 32.83 | 31.37 | **32.79** |
| **$R_1$** | 33.71 | 30.80 | 28.62 | **31.04** | 32.60 | 31.24 | 30.14 | **31.33** |
| **Mean** | **35.64** | **33.17** | **31.17** | **33.15** | **34.47** | **33.05** | **31.49** | **33.00** |

## 2- Daily $ET_C$ rate (mm/day).

The data recorded in Table (7) generally, indicate that the daily $ET_C$ rates as a mean of different treatments, tested (over all means) started with high values during October (2.65 and 2.98 mm/day) in the two successive seasons, then decreased to be (1.64 and 1.97 mm/ day) in November and (1.45 and 1.63 mm/day) in December, respectively, after that it increased during January (2.21 and 2.12 mm/day), and reached its maximum values in February (3.08 and 2.89 mm/day), then declined again during March (2.78 and 2.56 mm/day) as maturity and harvesting. These results were found to be true in the two seasons.

The results of Table (7) show that planting on wide ridges of 80 cm or 100 cm width led to decrease in daily $ET_C$ rates throughout the growing season months from November to March in both seasons, than the values of $ET_C$ rates resulted from planting on ridges of 60 cm width.

The presented data in Table (7) reveal that irrigating faba bean at 35% ASMD (frequent irrigations) gave the highest daily $ET_C$ rates during all the growing season months in the two seasons. However, irrigation at 75% ASMD gave the lowest values of daily $ET_C$ rates from November until March in both seasons. It is obvious that increasing ASMD in the root zone of faba bean during the growing season decreased the daily $ET_C$ rate.

**Table (7): Effect of ridge width and available soil moisture depletion and their interaction on daily water consumption use (mm/day) in 2009/2010 and 2010/2011 seasons.**

| Treatment | | 2009/2010 | | | | | | 2010/2011 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** |
| **$R_1$** | **35%** | 2.70 | 2.12 | 1.69 | 2.07 | 3.47 | 3.28 | 3.06 | 2.45 | 1.75 | 1.93 | 3.15 | 302 |
| | **55%** | 2.70 | 1.97 | 1.57 | 1.96 | 3.23 | 3.09 | 3.06 | 2.31 | 1.67 | 1.86 | 3.05 | 2.84 |
| | **75%** | 2.70 | 1.76 | 1.47 | 1.82 | 3.03 | 2.90 | 3.06 | 2.14 | 1.56 | 1.73 | 2.86 | 2.71 |
| **Mean** | | **2.7** | **1.95** | **1.58** | **1.95** | **3.24** | **309** | **3.06** | **2.30** | **1.66** | **1.84** | **3.02** | **2.86** |
| **$R_2$** | **35%** | 2.65 | 1.94 | 1.59 | 1.96 | 3.23 | 2.99 | 2.99 | 2.28 | 1.63 | 1.82 | 2.99 | 2.71 |
| | **55%** | 2.65 | 1.79 | 1.47 | 1.84 | 3.03 | 2.85 | 2.99 | 2.14 | 1.56 | 1.77 | 2.86 | 2.62 |
| | **75%** | 2.65 | 1.56 | 1.31 | 1.63 | 2.86 | 2.61 | 2.99 | 2.07 | 1.50 | 1.73 | 2.76 | 2.35 |
| **Mean** | | **2.65** | **1.76** | **1.46** | **1.81** | **3.04** | **2.82** | **2.99** | **2.16** | **1.56** | **1.77** | **2.87** | **2.56** |
| **$R_3$** | **35%** | 2.59 | 1.85 | 1.51 | 1.89 | 3.13 | 2.80 | 2.93 | 2.14 | 1.56 | 1.75 | 2.89 | 2.53 |
| | **55%** | 2.59 | 1.65 | 1.37 | 1.70 | 2.86 | 2.61 | 2.93 | 2.07 | 1.48 | 1.71 | 2.79 | 2.35 |
| | **75%** | 2.59 | 1.53 | 1.29 | 1.59 | 2.65 | 2.38 | 2.93 | 1.97 | 1.43 | 1.64 | 2.73 | 2.21 |
| **Mean** | | **2.59** | **1.68** | **1.39** | **1.73** | **2.88** | **2.60** | **2.93** | **2.06** | **1.49** | **1.70** | **2.80** | **2.36** |
| **Mean of irrigation 35%** | | 2.65 | 1.94 | 1.58 | 1.95 | 3.24 | 2.97 | 2.98 | 2.26 | 1.63 | 1.81 | 2.98 | 2.70 |
| **55%** | | 2.65 | 1.77 | 1.45 | 1.83 | 3.00 | 2.80 | 2.98 | 2.15 | 1.55 | 1.76 | 2.87 | 2.56 |
| **75%** | | 2.65 | 1.36 | 1.33 | 2.85 | 3.01 | 2.60 | 2.98 | 1.50 | 1.70 | 2.78 | 2.81 | 2.42 |
| **Over mean** | | **2.65** | **1.64** | **1.45** | **2.21** | **3.08** | **2.78** | **2.98** | **1.97** | **1.63** | **2.12** | **2.89** | **2.56** |

**3- Reference evapotranspiration rate ($ET_0$).**

The reference ET or $ET_0$ daily (mm/day) during faba bean growing season duration from October to March in both seasons were estimated using the FAO Penman-Monteith equation and the meteorological data of Fayoum area and recorded in Table (8). The obtained results showed that the daily $ET_0$ rate values were high during Oct., then decreased during Nov. and Dec. months. Thereafter, the daily $ET_0$ values started to increase from Jan. and up to March. These results are mainly attributed to the changes in climatic factors from month to the other.

**4- Crop coefficient ($K_C$).**

Results of Table (8) reveal that the $K_C$ values for faba bean, as affected by different treatments (over all mean) were low in the initial growth period (Oct. and Nov.), then increased during (Dec. and Jan.), as the crop cover increased (vegetative growth period). The $K_C$ values reached its maximum values during Feb., as the maximum growth and pod formation stage. Thereafter, the $K_C$ values redecreased again when plants reached its maturity till harvesting. These results may referred to the large diffusive resistance of bare soil at the initial growth period, which decreased with increasing plant growth or crop cover percentage until the peak of growth and pod formation. However, at maturity stage the plant transpiration decreased, as the drying of most green leaves of the plants.

Data recorded in Table (8) indicate that increasing ridge width from 60

**Table (8): Reference evapotranspiration, $ET_0$ (mm/day) and $K_C$ for faba bean crop during 2009/2010 and 2010/2011 seasons as affected by ridge width and available soil moisture depletion.**

| Treatments | | 2009/2010 | | | | | | 2010/2011 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ridge width | ASMD | **Oct.** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Oct.** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** |
| Reference $ET_0$ mm/day | | **5.52** | **2.90** | **2.04** | **2.30** | **3.44** | **4.75** | **6.11** | **3.45** | **2.14** | **2.19** | **3.21** | **4.51** |
| **$R_1$** | 35% | 0.49 | 0.72 | 0.83 | 0.90 | 1.01 | 0.69 | 0.50 | 0.71 | 0.82 | 0.88 | 0.98 | 0.67 |
| | 55% | 0.49 | 0.67 | 0.77 | 0.85 | 0.94 | 0.65 | 0.50 | 0.67 | 0.78 | 0.85 | 0.95 | 063 |
| | 75% | 0.49 | 0.60 | 0.72 | 0.79 | 0.88 | 0.61 | 0.50 | 0.62 | 0.73 | 0.79 | 0.89 | 0.60 |
| | **Mean** | **0.49** | **0.66** | **0.77** | **0.85** | **0.94** | **0.65** | **0.50** | **0.67** | **0.78** | **0.84** | **0.94** | **0.63** |
| **$R_2$** | 35% | 0.48 | 0.66 | 0.78 | 0.85 | 0.94 | 0.63 | 0.49 | 0.66 | 0.76 | 0.83 | 0.93 | 0.60 |
| | 55% | 0.48 | 0.61 | 0.72 | 0.80 | 0.88 | 0.60 | 0.49 | 0.62 | 0.73 | 0.81 | 0.89 | 0.58 |
| | 75% | 0.48 | 0.53 | 0.64 | 0.71 | 0.83 | 0.55 | 0.49 | 0.60 | 0.70 | 0.77 | 0.86 | 0.52 |
| | **Mean** | **0.48** | **0.60** | **0.71** | **0.79** | **0.88** | **0.59** | **0.49** | **0.63** | **0.73** | **0.80** | **0.89** | **0.57** |
| **$R_3$** | 35% | 0.47 | 0.63 | 0.74 | 0.82 | 0.91 | 0.59 | 0.48 | 0.62 | 0.73 | 0.80 | 0.90 | 0.56 |
| | 55% | 0.47 | 0.56 | 0.67 | 0.74 | 0.83 | 0.55 | 0.48 | 0.60 | 0.69 | 0.78 | 0.87 | 0.52 |
| | 75% | 0.47 | 0.52 | 0.63 | 0.69 | 0.77 | 0.50 | 0.48 | 0.57 | 0.67 | 0.75 | 0.85 | 0.49 |
| | **Mean** | **0.47** | **0.57** | **0.68** | **0.75** | **0.84** | **0.55** | **0.48** | **0.60** | **0.70** | **0.78** | **0.87** | **0.52** |
| **Mean of irrigation** | | | | | | | | | | | | | |
| | 35% | 0.48 | 0.67 | 0.78 | 0.86 | 0.95 | 0.64 | 0.49 | 0.66 | 0.77 | 0.84 | 0.94 | 0.61 |
| | 55% | 0.48 | 0.61 | 0.72 | 0.80 | 0.88 | 0.60 | 0.49 | 0.63 | 0.73 | 0.81 | 0.90 | 0.58 |
| | 75% | 0.48 | 0.55 | 0.66 | 0.73 | 0.83 | 0.55 | 0.49 | 0.60 | 0.70 | 0.77 | 0.87 | 0.54 |
| **Over all mean** | | **0.48** | **0.61** | **0.72** | **0.80** | **0.89** | **0.60** | **0.49** | **0.63** | **0.74** | **0.81** | **0.90** | **0.57** |

cm to 80 cm or 100 cm decreased the $K_C$ values during the months of the growing season duration in both seasons. These results were found to be true, since the daily $ET_C$ values of $R_2$ or $R_3$ treatments were lower than those of $R_1$ treatment and the $ET_0$ rate is constant during each month of season. On the other hand, increasing the ASMD to 55% or 75% caused reduction in the $K_C$ values in all the months of the two growing seasons. Irrigation at 35% ASMD gave the highest $K_C$ values during all months of the growing season duration, whereas, the lowest ones were recorded from irrigation at 75% ASMD in both seasons. For the high faba bean yield the $K_C$ values were: 0.48, 0.55, 0.65, 0.72, 0.81 and 0.50 for Oct., Nov., Dec., Jan., Feb. and March, respectively (mean of the two seasons). These results are in the same order with those found by **Tawadros (1993b), Ainer *et al.* (1994)** and **Khalil (1995)**.

**5- Water use efficiency (WUE).**

Results in Table (9) show that WUE values, as affected by ridge width and irrigation regime treatments were: 0.904 and 0.845 kg seeds/ $m^3$ water consumed in 2009/2010 and 2010/2011 seasons, respectively. Planting on ridges of 60 cm gave the highest WUE values in the two successive seasons i.e. 0.927 and 0.856 kg seeds / $m^3$ water consumed, whereas planting on ridges of 100 cm reduced the WUE by 4.42% in 2009/2010 season and by 2.92% in 2010/2011 season, compared with $R_1$ treatment These results may be referred to that in 2009/2010 season, planting on ridges (100 cm) decreased seed yield by 16.69%, however, $ET_C$ decreased by 12.69% only. In 2010/2011 season seed yield decreased by 12.98% and $ET_C$ decreased by 10.17%. These results are in the same trend of those reported by **Mohamed(1980), Sary *et al.* (1989), Tawadros and Abd-Aziz (1992), El-Douby *et al.* (1996, 2000) Salib *et al.*(1998), Chiroma *et al.*(2006) Talal Thalji(2006)**, and **El-Saady(2011)**.

Data listed in Table (9) indicate that irrigating faba bean at 35% ASMD gave the highest WUE values, i.e. 0.961 and 0.891 kg seeds/ $m^3$ water consumed in 2009/2010 and 2010/ 2011 seasons, respectively. Irrigation at 55% ASMD reduced WUE by 6.76 and 3.14% in 2009/2010 and 2010/2011 seasons, respectively, compared with irrigation at 35% ASMD. The lowest values of WUE were detected from irrigation faba bean at 75% ASMD i.e. 0.855 and 0.845 kg seeds/$m^3$ water consumed, in the two successive seasons, respectively. It could be noticed that WUE decreased as ASMD increased over 35%. Such finding is in harmony with the results found by **Tawadros (1993b), Ainer *et al.* (1994)** and **Khalil (1995)**.

**Table (9): Effect of ridge width and available soil moisture depletion and their interaction on water use efficiency of faba bean in 2009/2010 and 2010/2011 seasons.**

| Treatments | 2009/2010 | | | | 2010/2011 | | | |
|---|---|---|---|---|---|---|---|---|
| Ridge width | ASMD | | | | ASMD | | | |
| | **35%** | **55%** | **75%** | **Mean** | **35%** | **55%** | **75%** | **Mean** |
| **$R_1$ 60 (cm)** | 1.011 | 0.907 | 0.863 | **0.927** | 0.911 | 0.880 | 0.778 | **0.856** |
| **$R_1$ 80(cm)** | 0.954 | 0.891 | 0.856 | **0.900** | 0.897 | 0.865 | 0.780 | **0.847** |
| **$R_1$ 100 (cm)** | 0.919 | 0.891 | 0.847 | **0.886** | 0.864 | 0.844 | 0.784 | **0.831** |
| **Mean** | **0.961** | **0.896** | **0.855** | **0.904** | **0.891** | **0.863** | **0.781** | **0.845** |

## CONCLUSION:

The obtained results indicated that when the water is scarcer, it is preferable to plant the faba bean crop on wide ridges in order to reduce the water runoff and evaporation from ridge bottoms. In our research the yield was reduced by 14.84%, whereas the water consumption reduced by 11.45%. These results revealed that we can save about (169.37 $m^3$/fed) and get an economic yield from faba bean.

## REFERENCES

**Ageeb, O.A.A.; Salih, F.A. and Ali, M.A. (1989).** The effect of sowing date, watering interval and intercropping with sourghum and maize on the yield of faba bean. FABIS-Newsletter, 24: 8-10.

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

**Allen, R.G.; Pereio, L.S.; Raes, D.S. and Smith, M.D. (1998).** Crop evapotranspiration. Guidelines for computing crop water requirements. Irrigation and Drainage, PP No.56.FAO, Rome, Italy.

**Chiroma, A.M.; Folorunso, O.A. and Alhassan, A.B. (2006).** Soil water conservation, growth, yield and water use efficiency of sorghum as affected by land configuration and wood-shavings mulch in Semi- arid Northeast Nigeria. Exp. Agric., 42(2): 199-216.

**El-Douby, K.A.; El-Habbak, K.E.; Seif El-Nasr, F.M. and Basal, S.A. (1996).** Effect of tillage system and plant density under different phosphoric fertilization of faba bean (*vicia faba* L.) Ann. Agric. Sci. Moshtohor, vol. 34(3): 907-918.

**El-Douby, K.A.; Toaima, S.E. and Atalla, R.A. (2000).** Effect of ridge width and plant distribution patterns on faba bean yield and some of its components. Ann.. Sci. Moshtohor, vol. 38(2): 711-722.

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

**Ibrahim, H.S. (1986).** Effect of differential irrigation on the growth and yield of faba bean in the Selain basin of Sudan (*vicia faba*). FABIS-Newsletter (ICARDA). Faba bean information Service (Dec.1986). No. 16: 22-25.

**Israaelesn, O.W. and Hansen, V.E. (1962).** Irrigation Principles and Practices. The 3rd ed. John, Wiley and Sons Inc., New York.

**Khalil, F.A.F. (1995).** Scheduling irrigation of faba bean using the evaporation pan method.M.Sc. theseis, Fac. Agric., Zagazig Univ., Egypt.

**Klute, A. (1986).** Methods of Soil Analysis. Part-1: Physical and Mineralogical Methods (2nd ed.) American Society of Agronomy, Madison, Wisconsin. U.S.A.

**Mashari A. Al-Naeem (2008).** Effect of irrigation scheduling on growth parameters and water use efficiency of barely and faba bean crops in Al-Ahsa, Saudi Arabia. American Journal of plant physiology 3(3): 111-120.

**Mohamed, A.K. (1980).** Sowing date, plant population and distribution experiment Shendi Res. Station. Ann. Report 1980 Sudan.

**Page, A.L.; Miller, R.H. and Keeney, D.R. (eds.) (1982).** Methods of Soil Analysis. Part-2: Chemical and Microbiological Properties. (2nd ed.) American Society of Agronomy, Madison, Wisconsin. USA.

**Salib, A.Y.; Yousef, K.M.R. and El-Marsafawy, S.M. (1998).** Sunflower yield and water use efficiency in relation to nitrogen fertilizer rates and irrigation method. Fayoum, J. Res. and Dev. (11): 155-169.

**Sary, G.A.; El- Sayed, K.I.; El-Deepah, H.R.A. and Shams El-Din. G.M. (1989).** Effect of planting methods, plant densities and weed control on faba bean and associated weeds. 11 – faba bean yield and yield components. Ann. Agric. Sci. Moshtohor, vol. 32(3): 1131-1146.

**Snedecor, G.W. and Cockran, W.G. (1980).** Statistical Methods. (7th ed.) Iowa State Univ.Iowa,U.S.A.

**Talal Thalji (2006).** Impact of row spacing on faba bean. growth under Mediterranean rainfed conditions. J. Agronomy 5(3): 527-532.

**Tawadros, H. W. and Abd El-Aziz, M. E. (1992).** Rationalization of irrigation water in the Nile Valley and Delta and its economic effect. Water Resources in Egypt and Growth in the twenty-first century. 10th conf. Egypt 2000, Giza, Egypt, Dec., **1992.**

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

**Tawadros, H. W.; Miseha, W. I.; Wahba, M. F. and Nageib, B. H. (1993b).** Effect of withholding irrigation at different stages of plant growth on faba bean. Egypt J. Appl. Sci. 8(8): 123-141.

**Vites, F.G. (1965).** Increasing water use efficiency by soil management in plant environment and efficient water use. J. American Soc. Agron., 26: 537-546.

## ترشيد استخدام مياة الري في محصول الفول البلدي

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**معهد بحوث الاراضي والمياة البيئة – مركز البحوث الزراعية – جيزة – مصر**

أقيمت تجربتان حقليتان بمحطة بحوث الفيوم (طامية) محافظة الفيوم - مصر خلال موسمي الزراعة ٢٠١٠/٢٠٠٩ ، ٢٠١١/٢٠١٠ لدراسة تأثير عرض الخط (٦٠ ، ٨٠، ١٠٠ سم) والري عند فقد نسب معينة من الماء الميسر بالتربة (٣٥ ، ٥٥، ٧٥% ) علي محصول الفول البلدي ومكوناته وبعض العلاقات المائية . وفيما يلي اهم النتائج المتحصل عليها:

أوضحت الدراسة تفوق معاملة الزراعة علي عرض خط ٦٠ سم والري عند المستوي الرطوبي فقد ٣٥% من رطوبة التربة الميسرة في زيادة محصول الفول البلدي ومكوناته (إرتفاع النبات، عدد القرون بالنبات، وزن بذور النبات، وزن المائة بذرة) ومحصول الفدان (١٦١١,٥١، ١٤٠٢,٢ كجم / فدان ) في كلا الموسمين علي الترتيب بالمقارنة بجميع المعاملات الاخري تحت الدراسة، بينما تم الحصول علي اعلي متوسط لعدد الافرع بالنبات من الزراعة علي عرض خط ٨٠ سم والري عند فقد ٣٥% من رطوبة التربة الميسرة، في موسمي ٢٠١٠/٢٠٠٩ ، ٢٠١١/٢٠١٠ علي الترتيب.

كان متوسط الاستهلاك المائي الموسمي كتفاعل لكل المعاملات تحت هذه الدراسة هو٣٣.١٥ ، ٣٣.٠٠ سم في موسمي الزراعة ٢٠١٠/٢٠٠٩ ، ٢٠١١/٢٠١٠ علي الترتيب، وقد أعطت الزراعة علي عرض خط ٦٠ سم والري عند فقد ٣٥% من ماء التربة الميسر أعليمتوسط للاستهلاك المائي وهي ٣٧,٩٥ ، ٣٦,٦٦ سم في موسمي ٢٠١٠/٢٠٠٩ ، ٢٠١١/٢٠١٠ علي الترتيب. وكانت اقل متوسطات للاستهلاك المائي الموسمي هي ٢٨.٦٢ ، ٣٠.١٤ سم وذلك عند الزراعة علي عرض خط ١٠٠ سم والري عند استنزاف ٧٥% من الرطوبة الارضيه الميسرة في الموسمين المتعاقبين علي التوالي.

بدأ معدل الاستهلاك المائي اليومي بقيم منخفضة خلال اكتوبر ونوفمبر وديسمبر ثم ازداد خلال يناير ليصل الي اقصي قيمة له خلال فبراير ثم عاود الانخفاض مرة اخري حتي الحصاد في الموسمين ، وكانت قيم ثابت المحصول ٠,٤٨، ٠,٥٥، ٠,٦٥، ٠,٧٢، ٠,٨١ و ٠,٥٠ خلال اكتوبر، نوفمبر، ديسمبر، يناير، فبراير ، مارس علي الترتيب( كمتوسط عام للموسمين).

بلغت أعلي كفاءة في استخدام ماء الري (١,٠١١ ، ٠,٩١١ كجم بذور/م٣ ماء ) في موسمي ٢٠١٠/٢٠٠٩ ، ٢٠١١/٢٠١٠ علي الترتيب عند الزراعة علي عرض خط ٦٠ سم والري عند فقد ٣٥% من ماء التربة الميسر.

وتشير النتائج المتحصل عليها الي ان الزراعة علي مصاطب عرض ١٠٠ سم تؤدي الي خفض الاستهلاك المائي بنسبة ١١,٤٥% أو ١٦٩,٣٧ م٣/ف وكان النقص في المحصول في نطاق مقبول اقتصاديا مقابل التوفير في كية المياه.