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Comparative study on some Faba bean cultivars under water limitation conditions and different sowing dates

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ABSTRACT

In order to investigate the effects of different irrigation regimes on growth and yield of some Faba bean cultivars under different sowing dates; two field experiments were carried out in a private farm in Tamia District, Fayoum Governorate. Egypt during the two successive winter seasons of 2015 /2016 and 2016/2017. The treatments of the each experiment composed of four faba bean cultivars (Sakha-1, Giza-3, Nubaria-1 and Misr-1) and four sowing dates (1stOct, 15th Oct, 1st Nov and 15th Nov) as well as three irrigation treatments (100%, 80% and 60% irrigation water requirements IR). Plant growth parameters i.e. plant height, leaf area index (LAI), crop growth rate (CGR), seed yield and biological yield as well as seeds crude protein% and water use efficiency (WUE) were determined. The obtained results showed that the 100% of IR produced the highest seed yield and biological yield as well as CGR and LAI while, the 60 % of IR produced the highest values of water use efficiency. Moreover, the highest yield was obtained at 1st Nov sowing date in all the tested cultivars for the two seasons. Furthermore, the results showed that Misr-1 cultivar occupied the first rank and produced the highest values for CGR, LAI, seed yield and biological yield. Finally, the highest value of protein contents in the faba bean seeds was obtained by the lowest irrigation level for the two seasons. From the obtained results, it can be concluded that sowing Misr-1 cultivar at 1st Nov under IR (60%) produced the highest value for WUE, although it significantly reduced seed yield compared with other irrigation treatment. Our recommendation is to cultivate Misr-1 cultivar at 1st Nov under (80%) IR, since it produce quit reasonably yield and save nearly 300 m^3 irrigation water especially under the circumstances of climate of Tamia District, Fayoum Governorate region.

***Keywords*:** Faba Bean cultivars, Irrigation requirement (IR), sowing dates, Water Use Efficiency (WUE).

Introduction

Faba bean (*Vicia faba* L.) is one of essential winter legume crops in Egypt due to its high nutritive value and high protein contents i.e., 25-40% (Matthews and Marcellos, 2003). Moreover, it is a good source of nutritive minerals, such as phosphorus, potassium, calcium, sulphur and iron. Due to its high nutritive value of protein and minerals, it is consider a cheap source in the diet of low-income people. Its seed produced a cheap source of protein and food of high nutritive value especially in the diet of low-income people. Its protein is a good alternative compared with expensive meat and fish protein (Chavan *et al*., 1989).

Over the next few decades, the world's farmers will face the challenging task of increasing food production to keep up with growing population, growing per-capita consumption and the use of agricultural products as bibfuls. Climate change, and the associated increases in climatic variability, will compound this challenge, especially in developing countries (Parry *et al*., 2004).

One strategy that farmers can use to maintain or increase crop yields in the face of a changing climate is to adjust planting dates (Lauer *et al*., 1999). Sowing dates proved to be an important management technique for improving seed yields. We examined how bean production can be improved by altering planting date in Egypt's semiarid region, thus improving bean adaptation to climate change.

Numerous studies have suggested that climate variability and climate change have adverse impacts on global food production and food security. So we have to avoid this negative impact of

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climate changes by changing sowing dates and choose the exact cultivar adapted to hard conditions (Toshichika and Navin 2015). As adjusting sowing dates proved to be an important management technique for improving plant yields and improving faba bean adaptation to climate change. Moreover, sowing dates is an important factor affects the timing and duration of vegetative and reproductive stages and consequently yield, its components and seed quality of faba bean (Turk and Tawaha, 2002). Sowing date is a standout amongst the most imperative agronomic variables identified with crop growth and yield. It affects greatly the time and duration of vegetative and reproductive growth.

Since, environmental factors such as temperature and light differ with varying sowing dates. Whereas, early date of sowing (late October and early November) resulted significant increase in vegetative growth and production more pods per plant, consequently increased yield and quality of faba bean seeds (Abido and Seadh, 2014). Furthermore, sowing date also controls crop phenological stages and total biomass production and influences the efficiency of biomass conversion into performance (Hossam, 2016). It is well known also that bean cultivars differ in their response to environmental changes. In this concern, Mohamed and El-Abbas (2005) working on three faba bean cultivars concluded that Sakha-1 cultivar surpassed Giza 3 and Giza 2 cultivars in seed weight /plant, 100-seed weight and seed yield (ardab*/fed**.). Salama and Awad (2005) reported that Sakha 1 cultivar had the tallest plants compared with eight faba bean genotypes i.e. Sakha 1, Sakha 2, Nubaria 1, Giza 461, Giza 714, Giza 716, Giza blanka and Giza 3. Giza 714 cultivar was the best cultivar for seed yield and its components (number of branches/ plant, number of pods/ plant and seed yield /plant. The aim of this experiment is to test some faba bean cultivars under water limitation conditions and different sowing dates.

Materials and Methods

Two field experiments were carried out at a private farm in Tamia, Fayoum Governorate Egypt, during two successive winter seasons of 2015/2016 and 2016/2017. The main objectives of this work was to study the effect of sowing date and rate of water irrigation as well as their interactions on the performance of some faba bean cultivars. The treatments of the experiment composed of four faba bean cultivars (Sakha-1, Giza-3, Nubaria-1 and Misr-1) and four sowing dates (1^{st}Oct, 15th Oct, 1st Nov and 15th Nov for the two seasons) as well as three irrigation regime treatments (100%, 80% and 60% of irrigation water requirements IR).

Each experiment was laid out in split-split plot design with three replications. Four sowing dates were distributed in the main plots while the irrigation treatments were performed in the sub plots. The sub-sub plots were devoted to the faba bean cultivars (Sakha-1, Giza-3, Nubaria-1 and Misr-1).

Bean cultivars were obtained from Food Legumes Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. All bean seeds used in the experiments for the two seasons were inoculated with the specific Rhizobium strain before swing.

Faba bean seeds were sown at rate of 20 kg seeds /fed. for all treatments. Calcium superphosphate (15.5 % P_2O_5) was applied during soil preparation at the rate of 100 kg/fed. Nitrogen in the form of ammonium nitrate (33% N) at the rate of 15 kg N/fed. was added as starter dose before the first irrigation. Potassium sulphate (48 % K_2O) at the rate of 50 kg/fed. was applied to soil after 35 days from sowing. All the other recommended agricultural practices for faba bean production were applied at the proper time as recommended for this District by the Ministry of Agriculture. Plot size was 10.5 m (3 m length x 3.5 m width) 1/400 fed. Under each sowing date three irrigation treatments were applied. Each irrigation treatment had valve and flow-meter to control water application, bean cultivars were randomly distributed within each irrigation treatment. Drip irrigation was used during all experimental period. A distance of 2 m was left between each two irrigation treatments as a border among the treatments. Soil samples of experimental site were randomly collected before sowing to determine some physical and chemical properties of the soil for the two seasons according to Klute (1986) and Chapman and pratt (1961) as shown in Table (1).

*Ardab= 150 kg faba bean seeds
**Fed= 4200m^2

Table 1: Some physical and chemical properties of the soil used (average two seasons 2015/2016 and 2016/2017).

Properties	Value
Physical Properties	
Sand%	71.02
Silt%	16.31
Clay%	12.67
Soil texture	Sandy clay loam
Chemical properties	
Total N%	17
Available Phosphorus (mg/Kg)	10.8
Organic matter %	0.19
pH	8.07
E.C. (ds/m)	1.2
Soluble anions (meq/L)	
HCO^{3-}	11.84
Cl^{-}	21.8
SO^{4-}	20.1
Soluble Cations (meq/L)	
Ca^{2+}	23.15
Mg^{2+}	18.92
Na^{+}	34.8
K^{+}	13.97

The meteorological data of air temperature, relative humidity, rainfall precipitation, wind speed and soil temperature, were obtained from Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Giza, Egypt, during the growing seasons of 2015/2016 and 2016-2017.

Total irrigation water (m^3/fed./season) was calculated from the meteorological data of the Central Laboratory for Agricultural Climate (CLAC) depending on Penman method (Penman, 1984).

The seasonal irrigation water applied of 100% IR in the experimental location was found to be 1741, 1705, 1652 and 1584 m^3 /fed. in both seasons for the four planting dates 1st Oct, 15th Oct, 1st Nov and 15th Nov, respectively (Table, 2) (CLAC). Irrigation was carried out using drip irrigation system where water was added every 7 days by applying the specified IR.

Table 2: Average seasonal irrigation quantities under different water levels 2015/2016 and 2016/2017.

Sowing dates (A)	Irrigation treatment (B)	m^3/fed.
1st October	100% IR	1741
	80% IR	1393
	60% IR	1045
	Mean	1393
15th October	100% IR	1705
	80% IR	1364
	60% IR	1023
	Mean	1364
1st November	100% IR	1652
	80% IR	1322
	60% IR	991
	Mean	1322
15th November	100% IR	1584
	80% IR	1267
	60% IR	950
	Mean	1267

Table (3) show the measured climatic factors during the experimental period. Samples of ten plants of each experimental plot were taken after 40 and 70 days from sowing to determine some growth parameters, i.e. plant height (cm), leaf area index, crop growth rate (CGR) (g / cm^2 / day): Dry weight of plants (g) in each sub-plot was recorded at 40 and 70 days after sowing and then crop growth rate was calculated by using the formula:

Crop growth rate (g / cm^2 / day) CGR =T2 -T1/ W2 - W1, Where W1 = Dry weight (40 DAS), W2 = Dry weight (70 DAS), T1 and T2 are the time interval in days. Leaf Area Index was also calculated as (leaf area per plant / ground area per plant, cm^2 / cm^2). At harvesting time, seed yield (Kg/fed.) and biological yield (ton/fed.) were determined for each plot. The water use efficiency (WUE) was calculated according to FAO (1982) as follows: The ratio of crop yield (Y) to the total amount of irrigation water use in the field for the growth season (IR) is WUE (kg/m^3) = Y (kg)/IR (m^3). Since, (Y) is the crop yield (kg) and IR (m^3) is the total amount of irrigation water use in the field for the growth season. Total nitrogen was estimated for faba bean seeds by Kjeldahl method, crude protein calculated by multiplying seeds total N%x6.25, according to Chapman and Pratt (1961).

Table 3: Average monthly climatic data of the Fayom location during the two studied seasons 2015/1016 and 2016/2017.

Month Season	Solar radiation (W/m^2)	Precipitation (mm)	Wind speed (m/sec)		Air temp (°C)			Relative Humidity (%)
			Aver	Max	Aver	Min	Max	
Oct.	45.18	1.68	2.19	5.29	20.67	10.77	30.57	60.14
Nov.	48.57	2.36	2.09	5.09	16.86	9.97	23.74	63.83
Dec.	52.26	1.7	2.59	6.18	17.29	9.82	24.77	66.63
Jan.	66.63	2.79	2.19	5.98	17.35	7.68	27.03	57.95
Feb.	95.35	2.21	2.29	5.69	18.73	8.68	28.78	57.45
Mar.	109.71	1.12	2.69	7.88	21	11.07	30.92	54.26
Apr.	123.35	0	2.98	8.79	22.2	12.15	32.25	49.23

Data were statistically analyzed according to Snedecor and Cochran (1990). The combined analysis was conducted for the data of the two growing seasons. The least significance differences (L.S.D) at 5% level significance was used to compare the treatments means (Steel and Torrie, 1980).

Results and Discussion

I. Plant height (cm) of some Faba bean cultivars as affected by sowing dates, irrigation treatment

Data in Table (4) showed the individual effect of sowing dates (A), irrigation requirements (B) and cultivars (C) as well as the interactions of Ax B, Ax C, B x C and Ax B x C. However, plant height significantly affected by sowing dates and irrigation requirements for all the studied bean cultivars. It is clear that sowing bean seeds on Oct.15th gave the tallest plants, while, the respective shortest plants were obtained by sowing on Nov. 15th. The increase in plant height of faba bean might be due to the role of photoperiod that prevailed during growth period of early planting on Oct. 15th, which may result in an increase in both number and length of plant internodes. Similar results were reported by Grenz *et al*., (2005), Hossam (2016) and Ekram *el al*., (2017). they mentioned that delaying sowing of field bean over mid- November resulted in progressively reduction in plant height and seed yield. The reduction in plant height of faba bean plants might be due to the role of photoperiod and light intensive. Concerning the effect of water treatments, irrigation treatment 100% IR produced the highest values as compared with the other treatments (Table 4). However, 80% IR produced reasonable plant height from that of 100% IR. On the other hand, 60 % significantly produced the shortest plant. These results are confirmed with those obtained by Ekram *el al*., (2017). With respect to the performance of different cultivars, the same table, showed significant differences among the four tested cultivars of field bean. From the obtained results, it could be concluded that Sakha -1 and Nubaria- 1 cultivars significantly recorded the highest values for plant height. These

variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Salama and Awad (2005) and Hossam (2016). Regarding the effect of interactions, all the interaction effect (Ax B & A x C& BXC &Ax B x C) were significant. From data listed in the same Table, the highest value of plant height was obtained by sowing faba bean Nubaria - 1cultivar at 15th Oct. under 100% IR. followed by the same cultivar sown in the same date and under 80% IR.

Applying water deficit stress caused reduction in the plant height. This reduction in the plant height due to water deficit stress is probably related to decline in photosynthetic products as a result of soil moisture decrease, which eventually causes the plant to not reach its genetic. The response of plants to stresses depends on species and genotypes, the length and severity of water deficit, and age and development stage (Barnabás *et al*., 2008) and Hegabe *et al.,* (2014). Faba bean cultivation particularly in arid and semi-arid regions is unsuitable because this crop is not sufficiently drought and heat tolerant as it is susceptible to moisture and high temperature stresses (Loss and Siddique, 1997).

Table 4: Plant height (cm) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions (combined over two seasons 2015/2016 and 2016/2017)

Sowing dates (A)	Irrigation level (B)	Cultivars (C)				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	63.2	59.8	65.3	62.2	62.6
	80% IR	61.2	57.3	62.3	61.3	60.5
	60% IR	52.5	49.8	51.6	53.3	51.8
	Mean	59.0	55.6	59.7	58.9	58.3
15th October	100% IR	65.2	60.1	67.4	63.9	64.2
	80% IR	62.3	58.7	65.1	62.3	62.1
	60% IR	55.3	51.2	56.2	54.8	54.4
	Mean	60.9	56.7	62.9	60.3	60.2
1st November	100% IR	62.3	61.3	63.5	60.3	61.9
	80% IR	59.4	59.3	61.8	58.3	59.7
	60% IR	52.3	54.4	53.7	52.6	53.3
	Mean	58.0	58.3	59.7	57.1	58.3
15th November	100% IR	59.6	58.8	60.2	58.6	59.3
	80% IR	57.3	56.5	58.7	57.3	57.5
	60% IR	51.4	48.7	52.3	51.2	50.9
	Mean	56.1	54.7	57.1	55.7	55.9

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	62.6	60.0	64.1	61.3	62.0
80% IR	60.1	58.0	62.0	59.8	59.9
60% IR	52.9	51.0	53.4	53.0	52.6
Mean	58.5	56.3	59.8	58.0	
LSD 5% :(A) : 1.23 & (B): 1.25 & (C): 1.02 & (Ax B):2.01 &(Ax C): 2.25 & (B x C): 2.17 & (A x B x C): 3.54					

II. Crop Growth Rate CGR (g/day/m^2) of some Faba bean cultivars as affected by sowing dates, irrigation treatments and their interactions

Data in Table (5) showed the individual effect of sowing dates (A), irrigation requirements (B) and cultivars (C) as well as the interactions of Ax B, Ax C, B x C and Ax B x C on Crop Growth Rate (CGR) (g/cm^2/day) However, CGR significantly affected by sowing dates and irrigation requirements for all the studied faba bean cultivars. It is clear that sowing bean on Nov.1st gave the

highest values of CGR, while the least values were obtained by sowing on Oct. 1st. Hegab *et al.,* (2014) and Hossam (2016). Concerning the effect of water treatments, irrigation with 100% IR produced the highest values as compared with the other treatments (Table5). It appears that the maintenance of adequate levels of water throughout the vegetative growth of faba bean is essential for high yields. In this study, water shortage exerted a large adverse influence CGR of all faba bean cultivars. These results confirmed by findings of Ahmed *et al*., (2008) and Ekram *et al*., (2017). With respect to the performance of different cultivars, data presented in the same table, show significant differences among the four tested cultivars of field bean for all the studied characters. From obtained results of this study, it could be concluded that Misr-1 and Nubaria-1 cultivars significantly surpassed other studied cultivars and recorded the highest values for CGR. These variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Abou El-Yazied (2011) and Hossam (2016) working on faba bean.

Regarding the effect of interactions, all the interaction effect (Ax B &Ax C& BXC &Ax B x C) were significant. The obtained data in the same table show that the highest value of CGR amounting to 4.19 g/ cm^2/ day was obtained as a result of sowing faba bean plants Misr-1 sown on 1st November under 100% IR. Smilar results are recorded by Ekram *et al*., (2017).

Table 5: Crop Growth Rate (CGR) (g/day/m^2) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions (combined over two seasons 2015/2016 and 2016/2017)

Sowing dates (A)	Irrigation level (B)	Cultivars (C)				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	2.71	2.52	3.01	3.04	2.82
	80% IR	2.40	2.25	2.56	2.85	2.52
	60% IR	1.96	1.79	1.84	2.47	2.02
	Mean	2.36	2.18	2.47	2.79	2.45
15th October	100% IR	3.08	2.79	3.30	3.37	3.14
	80% IR	2.65	2.42	2.84	3.12	2.76
	60% IR	2.11	1.96	2.11	2.77	2.23
	Mean	2.61	2.39	2.75	3.09	2.71
1st November	100%IR	3.63	3.27	3.97	4.19	3.76
	80% IR	3.16	2.97	3.38	3.67	3.30
	60% IR	2.59	2.36	2.43	2.99	2.59
	Mean	3.12	2.87	3.26	3.62	3.22
15th November	100% IR	3.18	2.89	3.46	3.50	3.26
	80% IR	2.67	2.59	2.95	3.28	2.87
	60% IR	2.11	2.05	2.18	2.63	2.24
	Mean	2.65	2.51	2.86	3.14	2.79

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	3.15	2.87	3.43	3.53	3.24
80% IR	2.72	2.56	2.93	3.23	2.86
60% IR	6.66	2.04	2.14	2.71	2.27
Mean	2.69	2.49	2.84	3.16	
LSD 5% :(A) : 0.12 & (B): 0.14 & (C): 0.12 & (AxB):0.18 &(AxC): 0.17 & (BxC): 0.19 & (AxBxC): 0.23					

III. Leaf Area Index (LAI) (leaf area / ground area, m^2 / m^2) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions

Data in Table (6) showed the individual effect of sowing dates (A), irrigation requirements (B) and cultivars (C) as well as the interactions of Ax B, Ax C, B x C and Ax B x C. However, (LAI) Leaf Area Index significantly affected by sowing dates and irrigation requirements for all the studied faba bean cultivars. It is clear that sowing bean plant on Nov.1st gave the highest values of LAI, while

the least values were obtained by sowing on Oct. 1st. Concerning the effect of water treatments, irrigation with 100% IR produced the highest values as compared with the other treatments (Table 6).In this research, water shortage exerted a large adverse influence LAI of all the tested faba bean cultivars. With respect to the performance of different cultivars, data presented in the table, show significant differences among the four tested cultivars of field bean. From obtained results of this study, it could be concluded that Misr- 1 and Nubaria- 1 cultivars significantly surpassed other studied cultivars and recorded the highest values for LAI. These variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Salama and Awad (2005) and Hossam (2016).

Regarding the effect of interactions, all the interaction effect (Ax B& Ax C& BXC &Ax B x C) were significant. The highest value of LAI amounting to 5.85 leaf areaper plant / ground areaper plant, cm^2 / cm^2 was obtained by as a result of sowing faba bean plants (Misr- 1 sown on 1st November under 100% IR. Similar results were reported by Erdem *et al.* (2006) working on bean (*Phaseolus vulgaris*) stated that adequate moisture availability for the soil leads to increase various physiological processes better nutrients uptake, highest rate of photosynthesis which might reflected on more numbers and area of leaves and higher yields. Thus, the higher LAI in improved genotypes, which could lead to greater photosynthesis, is a desirable physiological trait that has the potential to enhance crop productivity; particularly under water stress conditions where often soil moisture is a limiting factor.

Table 6: Leaf aria index LAI (leaf area / ground area, m^2 / m^2) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions (combined over two seasons 2015/2016 and 2016/2017)

Sowing dates(A)	Irrigation level (B)	Cultivars (C)				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	3.81	3.08	3.90	4.20	3.75
	80% IR	3.55	2.73	3.71	3.98	3.49
	60% IR	3.02	2.46	3.34	3.64	3.11
	Mean	3.46	2.75	3.65	3.94	3.45
15th October	100% IR	4.57	3.69	4.68	5.04	4.50
	80% IR	4.26	3.27	4.45	4.78	4.19
	60% IR	3.62	2.95	4.01	4.37	3.74
	Mean	4.15	3.30	4.38	4.73	4.14
1st November	100% IR	5.10	4.27	5.23	5.84	5.11
	80% IR	4.81	3.95	4.94	5.42	4.78
	60% IR	4.38	3.49	4.50	5.10	4.37
	Mean	4.76	3.90	4.89	5.46	4.75
15th November	100% IR	3.72	2.84	4.23	4.56	3.84
	80% IR	3.47	2.76	3.54	3.87	3.41
	60% IR	3.18	2.53	3.35	3.45	3.13
	Mean	3.46	2.71	3.71	3.96	3.46

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	4.30	3.47	4.51	4.91	4.30
80% IR	4.02	3.18	4.16	4.51	3.97
60% IR	3.55	2.86	3.80	4.14	3.59
Mean	3.96	3.17	4.16	4.52	
LSD 5% :(A) : 0.23 & (B): 0.24 & (C): 0.22 & (Ax B):0.35 &(Ax C): 0.32 & (B x C): 0.36& (A x B x C):0.42					

IV. Seed yield (kg/fed.) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions

Data in Table (7) showed the individual effect of sowing dates (A), irrigation requirements (B) and cultivars (C) as well as their interactions of Ax B, Ax C, B x C and Ax B x C. However, seed yield (kg/fed.) significantly affected by sowing dates and irrigation requirements for all the studied bean

cultivars. It is clear that sowing bean on Nov.1st gave the highest values of seed yield (kg/fed.), while the least values were obtained by sowing on Oct. 1st. Similar results obtained by Hegab *et al.,* (2014) Concerning the effect of water treatments, irrigation with 100% IR produced the highest values followed by 80 % IR as compared with the other treatments (Table7). It appears that the maintenance of adequate levels of water throughout the vegetative growth of faba bean is essential for high yields. As shown in this research, water shortage exerted a large adverse influence on seeds yield (kg/fed.) of all faba bean cultivars. With respect to the performance of different cultivars, data presented in the same table, show significant differences among the four tested cultivars of faba bean. From the obtained results of this study, it could be concluded that Misr-1 and Nubaria-1 cultivars significantly surpassed other studied cultivars and recorded the highest values for Seed yield (kg/fed.) These results confirmed by the finding obtained by Hossam (2016). These variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Salama and Awad (2005) and Hossam (2016). Regarding the effect of interactions, the data show the interaction effect of (Ax B& Ax C& BXC &Ax Bx C) was significant. The highest value of seed yield (614.38 kg/fed.) was obtained as a result of sowing faba bean plants (Misr -1 sown on 1st November under 100% IR. The increases in faba bean growth, seed yield and its components characters due to sowing on November might be attributed to the seasonal environmental conditions during this period such as temperature, day length and light intensity which allow rapid germination, establishment, vegetative growth, development and ripening consequently increasing by dry matter accumulation, and yield components as well as seeds yield per unit area. These results are in agreement with those reported by El-Metwally *et al*., (2013) and Hegab *et al*., (2014).

Table 7: Seed yield (kg/fed.) of some Faba bean cultivars as affected by sowing dates and irrigation treatment and their interactions (combined over two seasons 2015/2016 and 2016/2017)

Sowing dates(A)	Irrigation level (B)	Cultivars (C)				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	399.15	375.87	423.03	443.65	410.43
	80% IR	364.23	334.43	384.24	418.54	375.36
	60% IR	305.23	286.45	317.48	374.24	320.85
	Mean	356.20	332.25	374.92	412.14	368.88
15th October	100% IR	468.89	436.75	488.57	515.32	477.38
	80% IR	423.44	383.96	446.64	483.43	434.36
	60% IR	351.00	332.47	374.52	436.98	373.74
	Mean	414.44	384.39	436.58	478.57	428.50
1st November	100% IR	534.51	508.46	563.55	614.38	555.22
	80% IR	488.08	466.36	510.07	557.21	505.43
	60% IR	427.01	395.82	424.66	495.72	435.80
	Mean	483.20	456.88	499.42	555.77	498.82
15th November	100% IR	422.83	417.99	471.13	493.66	451.40
	80% IR	376.28	357.55	397.38	438.02	392.31
	60% IR	323.81	308.37	338.71	372.40	335.82
	Mean	374.31	361.30	402.41	434.69	393.18

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	456.34	434.77	486.57	516.75	473.61
80% IR	413.01	385.57	434.58	474.30	426.87
60% IR	351.76	330.78	363.84	419.83	366.55
Mean	407.04	383.71	428.33	470.30	
LSD 5% :(A) : 0.23 & (B): 0.24 & (C): 0.22 & (Ax B):0.35 &(Ax C): 0.32 & (B x C): 0.36& (Ax B x C):0.42					

V. Biological yield (ton/fed.) of some Faba bean cultivars as affected by sowing dates, irrigation treatments and their interactions

It is clear from Table (8) that the coefficients of sowing dates(A), irrigation requirements (B) and cultivars (C) whether alone or interacting between them Ax B, Ax C, B x C and Ax B x C., have been given significance. However, biological yield (ton/fed.) significantly affected by sowing dates and irrigation requirements for all the studied faba bean cultivars. It is clear that sowing faba bean on first of November gave the highest values of biological yield (ton/fed.), while the least values were obtained by sowing on first of October. Concerning the effect of water treatments, irrigation with 100% IR produced the highest values as compared with the other treatments (Table 8). In the same content, Hegab *et al*,. (2014) reported that using 100% (IR) increased faba bean biological and seed yields significantly. With respect to the performance of different cultivars, data presented in the same Table, show significant differences among the four tested cultivars of field bean for all the studied characters. From obtained results of this study, it could be concluded that Misr-1 and Nubaria-1 cultivars significantly surpassed other studied cultivars and recorded the highest values for biological yield (ton/fed.). These variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Salama and Awad (2005) and Hossam (2016). Regarding the effect of interactions, all the interaction effect (Ax B& A x C& BXC &Ax B x C) was significant. From data listed in the same Table, the highest value of biological yield (kg/fed.) amounting to 2.07 (ton/fed.) was obtained as a result of sowing faba bean plants (Misr -1sown on 1st November under 100% IR. Similar results were reported by El- Metwally *et al*., (2013) and Ekram *et al*., (2017) working on faba bean yield.

Table 8: Biological yield (ton/fed.) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions(combined over two seasons 2015/2016 and 2016/2017).

Sowing dates (A)	Irrigation level (B)	Cultivars (C)				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	1.65	1.56	1.69	1.72	1.66
	80% IR	1.56	1.44	1.61	1.66	1.57
	60% IR	1.34	1.27	1.40	1.49	1.37
	Mean	1.52	1.42	1.57	1.62	1.53
15th October	100% I R	1.84	1.73	1.90	1.93	1.85
	80% IR	1.74	1.60	1.82	1.85	1.75
	60% IR	1.51	1.42	1.60	1.67	1.55
	Mean	1.70	1.58	1.77	1.82	1.72
1st November	100% IR	1.93	1.90	1.97	2.07	1.97
	80% IR	1.83	1.79	1.88	1.95	1.86
	60% IR	1.64	1.60	1.68	1.81	1.68
	Mean	1.80	1.76	1.85	1.94	1.84
15th November	100% IR	1.58	1.62	1.71	1.76	1.67
	80% IR	1.50	1.44	1.53	1.59	1.51
	60% IR	1.36	1.28	1.41	1.42	1.37
	Mean	1.48	1.45	1.55	1.59	1.51

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	1.75	1.70	1.82	1.87	1.78
80% IR	1.66	1.57	1.71	1.76	1.67
60% IR	1.46	1.39	1.52	1.59	1.49
Mean	1.62	1.55	1.68	1.74	
LSD 5% :(A) : 0.06 & (B): 0.06& (C): 0.05 & (Ax B):0.12 &(Ax C): 0.14 & (B x C): NS& (Ax B x C):0.18					

VI. Seeds Crude protein % of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions

The individual effect of sowing dates (A), irrigation requirements (B) and cultivars (C) as well as the interactions of Ax B, Ax C, B x C and Ax B x C. are presented in Table (9). However, seeds CP% significantly affected by sowing dates and irrigation requirements for all the studied bean cultivars. It is clear that sowing bean on Nov.1st gave the highest values of seeds CP%, while the least values were obtained by sowing on 1st October. Concerning the effect of water treatments, irrigation with 60% IR produced the highest values followed by 80% IR as compared with the other treatments (Table 9).With respect to the performance of different cultivars, data presented in the same Table, show significant differences among the four tested cultivars of faba bean. It is worthy to note from the same table that CP increased gradually with dcreasing IR. From the obtained results of this study, it could be concluded that Misr-1 and Nubaria-1 cultivars significantly surpassed other studied cultivars and recorded the highest values for seeds CP%. These variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Salama and Awad (2005) and Hossam (2016).

Regarding the effect of interactions, data show that all the interaction effect (Ax B& Ax C & BXC &Ax B x C) was significant. From data listed in the same Table, the highest value of CP% amounting to 22.93% was obtained as a result of sowing faba bean plants (Misr -1sown on 1st November under 60% IR. Concerning the effect of irrigation levels, data showed that increasing irrigation level led to a gradual decrease in protein percentage. Interpretation of these findings could be due to that protein considered a good indicator for plant tolerance to water drought as in adequate water supply caused hydrolysis and catabolism in protein. In this concern, Hegab *et al*., (2014) stated that the 100% irrigation treatments gave the highest grain yield and released free amino acids and ammonia as well as proline (Fayed, 1972).

Table 9: Seeds crude protein % of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions (combined over two seasons 2015/2016 and 2016/2017)

Sowing dates (A)	Irrigation level (B)	Cultivars (C)				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	20.22	20.06	20.33	20.83	20.36
	80% IR	20.74	20.48	20.91	21.22	20.84
	60% IR	21.05	20.84	21.25	21.44	21.14
	Mean	20.67	20.46	20.83	21.16	20.78
15th October	100% IR	20.62	20.46	20.83	21.38	20.82
	80% IR	21.26	20.91	21.46	21.78	21.35
	60% IR	21.66	21.38	21.83	22.06	21.73
	Mean	21.18	20.92	21.37	21.74	21.30
1st November	100% IR	21.29	21.02	21.27	21.89	21.37
	80% IR	21.83	21.63	22.02	22.43	21.98
	60% IR	22.23	22.00	22.49	22.93	22.41
	Mean	21.78	21.55	21.92	22.42	21.92
15th November	100% IR	20.38	20.25	20.52	20.81	20.49
	80% IR	20.84	20.68	21.03	21.39	20.99
	60% IR	21.25	21.21	21.68	21.87	21.50
	Mean	20.83	20.71	21.07	21.36	20.99

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	20.63	20.45	20.74	21.23	20.76
80% IR	21.17	20.93	21.36	21.70	21.29
60% IR	21.55	21.36	21.81	22.08	21.70
Mean	21.11	20.91	21.30	21.67	
LSD 5% :(A) : 0.23 & (B): 0.24 & (C): 0.22 & (Ax B):0.35 &(Ax C): 0.32 & (B x C): 0.36& (Ax B x C):0.42					

VII. Water use efficiency WUE (g/m^3) of some Faba bean cultivars as affected by sowing dates, irrigation treatment and their interactions

Results of Table (10) showed the individual effect of sowing dates (A), irrigation requirements (B) and cultivars (C) as well as the interaction of Ax B, Ax C, B x C and A x B x C. However, WUE water use efficiency (g/m^3) significantly affected by sowing dates and irrigation requirements for all the studied bean cultivars. It is clear that sowing bean on Nov.1st gave the highest values of WUE (g/m^3), while the least values were obtained by sowing on Oct. 1st. Concerning the effect of water treatments, irrigation with 60% IR produced the highest values as compared with the other treatments (Table 10).

Similar results were obtained by Hegab *et al*., (2014). They stated that increasing irrigation water more than 60% significantly decrease in values of water use efficiency.

In our research, water shortage positively influenced WUE (g/m^3) of all faba bean cultivars With respect to the performance of different cultivars, data presented in Table (10), show significant differences among the four tested cultivars of field bean for all the studied characters. From obtained results of this study, it could be concluded that Misr-1 and Nubaria-1 cultivars significantly surpassed other studied cultivars and recorded the highest values for WUE (g/m^3). These variations among cultivars may be attributed to the genetic constitution of genotype and the response of genotype to environmental conditions. Similar variations, among genotypes, were reported by Salama and Awad (2005).Regarding the effect of interactions. Effect of (Ax B &Ax C& BXC &Ax B x C) was significant. The highest value of WUE (g/m^3) 484.57 (g/m^3) was obtained as a result of sowing faba bean plants (Misr -1sown on 1st November under 60% IR. Similar results were reported by loss and Siddique (1997) and Ekram *et al*., (2017).

Table 10: Water use efficiency WUE (g/m^3) of some Faba bean cultivars as affected by sowing dates and irrigation treatments and their interactions (combined over two seasons 2015/2016 and 2016/2017)

Sowing dates (A)	Irrigation level (B)	Cultivars C				Mean
		Sakha-1	Giza-3	Nubaria-1	Misr-1	
1st October	100% IR	229.26	215.89	242.98	254.83	235.74
	80% IR	261.47	240.08	275.84	300.46	269.46
	60% IR	292.09	274.11	303.81	358.12	307.03
	Mean	260.94	243.36	274.21	304.47	270.74
15th October	100% IR	275.01	256.16	286.55	302.24	279.99
	80% IR	310.44	281.49	327.45	354.42	318.45
	60% IR	343.11	324.99	366.10	427.16	365.34
	Mean	309.52	287.55	326.70	361.27	321.26
1st November	100% IR	313.49	298.22	330.53	360.34	325.64
	80% IR	357.83	341.90	373.95	408.51	370.55
	60% IR	417.41	386.92	415.11	484.57	426.00
	Mean	362.91	342.35	373.20	417.81	374.07
15th November	100% IR	247.99	245.16	276.32	289.54	264.75
	80% IR	275.86	262.13	291.33	321.13	287.61
	60% IR	316.53	301.44	331.10	364.03	328.27
	Mean	280.13	269.58	299.58	324.90	293.55

Irrigation treatment x Cultivars

Irrigation x Cultivars	Sakha-1	Giza-3	Nubaria-1	Misr-1	Mean
100% IR	266.44	253.86	284.10	301.74	276.53
80% IR	301.40	281.40	317.14	346.13	311.52
60% IR	342.28	321.87	354.03	408.47	356.66
Mean	303.38	285.71	318.42	352.11	
LSD 5% :(A) : 16.3& (B): 15.94 & (C): 17.8 & (Ax B):25.8 &(Ax C): 24.8 & (B x C): 23.3 (Ax B x C):35.8					

Conclusion

Since, increasing water productivity is a major goal in modern agriculture and accomplishes to maintain food security and agriculture sustainability. From the obtained results, it can be concluded that sowing Misr-1 cultivar at 1st Nov under IR (60%) produced the highest value for WUE, although it significantly reduced seed yield compared with other irrigation treatment. Our recommendation is to cultivate Misr-1 cultivar at 1st Nov under (80%) IR, since it produce quit reasonably yield and save nearly 300 m^3 irrigation water especially under the circumstances of climate of Tamia District, Fayoum Governorate region.

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