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EFFECT OF IRRIGATION INTERVAL AND PHOSPHORUS FERTILIZATION RATE ON FABA BEAN (*Vicia faba l.*) YIELD, YIELD COMPONENTS AND SOME CROP-WATER RELATIONSHIPS

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ABSTRACT

A field experiment was conducted during 2012/13 and 2013/14 winter seasons at Sids Agric. Res. Station, Beni-Swief Governorate, Egypt. These trials aiming at investigating the effect of irrigation intervals, i.e. 14, 21 and 28 days and phosphorus fertilization rates of 7.5, 15 and 30 kg P_2O_5 fed^{-1} and interaction on seed yield components, seed and straw yields and some crop-water relations of faba bean crop (Giza–843 hybrid). The adopted treatments were assessed in a split-plot design with four replicates. The most important results could be summarized as follows:-

- ***** Seed & straw yield and yield components e.g. plant height, pods N^{o} $plant^{-1}$, seeds N^{o} pod^{-1} and 100-seed weight were significantly influenced due to the adopted irrigation and P- rate treatments and interaction as well in 2012/13 and 2013/14. Higher values of seed yield and the abovementioned yield components resulted from irrigating at 21 days interval, whereas plant height and straw yield were positively responded with 14 days interval. The 30 kg P_2O_5 fed^{-1} rate resulted in higher values of seed & straw yields and yield components e.g. pods N^{o} $plant^{-1}$, seeds N^{o} pod^{-1} and 100-seed weight and plant height as well. Interaction of irrigating at 21days interval and 30 kg P_2O_5 fed^{-1} rate exhibited higher values of the abovementioned variables, except plant height where the highest values were noticed with irrigating at 14 days interval as interacted with 30 kg P_2O_5 fed^{-1} rate.
- ***** The highest Water consumptive use (Cu) values were attained due to irrigating at 14 days interval, whereas Water Productivity and Water Use Efficiency were the highest as irrigation was practiced at 21 days interval. The highest figures of Cu, WP and WUE were achieved with supplying P fertilizer at the highest rate (30 kg P_2O_5 fed^{-1}). Irrigating at 14 days interval as interacted with 30 kg P_2O_5 fed^{-1} rate exerted the highest Cu values, whereas interaction of irrigation at 21 days interval and 30 kg P_2O_5 fed^{-1}rate exhibited the highest WP and WUE values.
- ***** Under the conditions of the present experiment and to conserve the limited irrigation water resources, as an important national issue, it is advisable to irrigate faba bean crop at 21 days interval and supplying P-fertilizer at 30 kg P_2O_5 fed^{-1} rate in order to obtain reasonable values of seed yield, water productivity and water saving as well.

Keywords: Faba bean, seeds yield, yield components, irrigation intervals, phosphorus fertilization rates, crop - water relations.

INTRODUCTION

The agricultural sector consumes almost 80-90 % of the total water allocated to Egypt, and the increased population is normally resulted in steady decrease in per capita share of water. Therefore, optimizing the crop water use became an important national issue. Efficient irrigation methods could mitigate the problem of insufficient water resources. Taylor (1965), stated that innovated irrigation practices such as wide irrigation interval, higher soil moisture depletion, skipping irrigation at growth stages which

insensitive for soil moisture deficit etc, could contribute for reducing the crop irrigation requirements and consequently conserve the limited water resources.

Grain legumes are major crops cultivated in the Northern of River Nile Governorates of Egypt (Attia, 2013). It is an important source of protein for humans and animals (Kamal *et al.* 2012). The faba bean cultivated area is about 59,908 fed in old- cultivated and 40.628 fed in the newly reclimated lands producing 526688 and 381137 ardab, respectively, Economic affairs sector, 2013. One feddan equals 0.42 ha and one ardab equals 155 kgs. The crop is exhibiting wide adaptability in world agriculture, and it is regarded as a drought-sensitive crop where the major factor restricting faba bean cultivation is the high year-to-year yield variability which is usually attributed to drought stress (Gordner, *et al.* 1985). El- Maghraby (1980) and Krogman *et al.* (1980) found that increasing the amount of irrigation water significantly increased 100- seed weight of faba bean. In addition, Shawky *et al.* (2004) reported that the reduction in 100-seed weight of faba bean with increasing soil moisture stress may be attributed to the decrease in water availability to plant, which leads to visible reduction in cell division and cell elongation. Balasio *et al.* (2006) found that irrigating at 14 and 28 days intervals, respectively, during vegetative and reproductive stages gave the highest grain yield for faba bean. The authors added that with irrigation at 28 days interval, the crop received 6 irrigation events with total applied water reached to 4464 m^3 ha^{-1}, compared to 8 irrigation events with total of 7429 m^3 ha^{-1} under 14 days irrigation interval. El- Dakroury (2008) found that increasing irrigation level from 60 to 100% ETo significantly increased plant height, number of branches, leaves and pods $plant^{-1}$. In this sense, Yang *et al.* (2005) and El-Atawy (2007) mentioned that the efficiency of water use had decreased as the soil moisture was maintained high by the frequent irrigation..

One of the major problems that economically limited successful agricultural production worldwide is poor soil fertility, which is a particular problem for small land holders in developing countries, where much grain-legume production occurs, Baset and Shamsuddin (2010). Phosphorus (P) is an important limiting nutrient after nitrogen majority of soil for crop production, especially legume plants. Phosphorus plays an important role in biological nitrogen fixation in legumes. Symbiotic nitrogen fixation has a high P demand because the process consumes large amounts of energy (Schulze *et al.* 2006).Without proper P fertilization, Rhizobium and nitrogen fixation is depressed. Moreover, Turk and Tawaha (2002) in north of Jordan, found that the assessed phosphorus levels e.g. 0, 17.5, 35.0 and 52.5 kg P ha^{-1} significantly affected faba bean seed yield which amounted to 798.6, 916.6, 1038.9 and 1190.0 kg ha^{-1}, respectively.

The objective of this work was to study the effect of irrigation intervals and phosphorus fertilization on faba bean growth, yield components, seed and straw yields, and some crop water relations to determine the most proper interaction resulting in higher water productivity figures.

MATERIALS AND METHODS

Experiment setup:

The present research trials were conducted during 2012/13 and 2013/14 winter seasons at the Experiment Farm of Sids Agricultural Research Station, Beni Swief Governorate (Middle Egypt, Lat. 29º 04' N, Long. 31º 06' E and 30.40 m above the mean sea level). Some physiochemical properties and soil-moisture constants of the experimental site, determined according to Page *et al.* (1982) and Klute (1986) , are listed in Tables 1 and 2. The trial aimed to investigate the effect of different both irrigation intervals and Phosphorus fertilization rates on faba bean (Giza–843 hybrid) growth, seed yield, yield components and straw yield as well as some crop-water relationships.

Table 1: Soil particle size distribution and some chemical properties of the experimental site in 2012/13 and 2013/14 seasons.

Season	Particle size distribution*			Textural class	Chemical properties**					
	Clay	Silt	Sand		O.M. (%)	EC dSm^{-1} (1:5)	Available (ppm)			pH (1:2.5)
	%						N	P	K	
2012/13	51.30	32.40	16.30	Clay loam	1.95	0.26	37.00	9.11	207.5	7.79
2013/14	50.26	32.41	17.33	Clay loam	2.20	0.31	32.00	8.73	202.30	7.95

*** According to Klute (1986)** ****according to Page (1982)**

Table 2: Some soil water constants and bulk density of the experimental site.

Season	Soil layer depth (cm)	Field capacity (%, w/w)*	Wilting point (%, w/w)*	Available water (%, w/w)*	Bulk density (gc m^{-3})*
2012/13	00 – 15	44.56	22.17	22.39	1.170
	15 – 30	37.09	17.66	19.43	1.299
	30 – 45	35.55	16.92	18.63	1.357
	45 – 60	33.19	15.80	17.39	1.379
Mean		37.59	18.13	19.46	1.301
2013/14	00 – 15	47.59	22.66	24.93	1.139
	15 – 30	39.38	18.75	20.63	1.325
	30 – 45	34.10	16.24	17.86	1.449
	45 – 60	32.78	15.61	17.17	1.550
Mean		38.46	18.31	20.14	1.366

***Determined as described by Klute (1986)**

The treatments were laid out in a split-plot experimental design with four replicates. Irrigation intervals were allocated at the main plots, while the assessed phosphorus fertilizer rates occupied the sub-plots as follows:

1- Main plots (Irrigation Intervals, I):

1_1 = Irrigation at14 days interval
1_2 = Irrigation at 21days interval
1_3 = Irrigation at 28 days interval

It is worthy to mention that the irrigation treatments were started after the life irrigation.

2- Sub plots (Phosphorus fertilization rates, P):

P_1 = 7.5 kg P_2O_5 fed^{-1}

P_2 = 15 kg P_2O_5 fed^{-1}

P_3 = 30 kg P_2O_5 fed^{-1}

The sub - plot size was 5.6 m width x 7.5 m length (1/100 fed.). The seeds of faba bean were planted on the two sides of the ridge (60 cm width) in hills, 20 cm apart, on October 27, 2012 and November 1, 2013, in 1st and 2nd seasons, respectively. N and K fertilizers were applied as recommended for faba bean production in the area. The assessed phosphoric fertilizer rates were broadcasted and incorporated into the soil surface during seedbed preparation. The plants were harvested on 11th and 18th April in the 1st and 2nd seasons, respectively. All the recommended cultural practices for faba bean production were applied and adapted to surface irrigation conditions.

The quantity of applied irrigation water was measured using flow-meter attached to the irrigation pump.

The following characters were measured:

1-Plant height (cm). 2- Pods N^{o} $plant^{-1}$. 3- Seeds N^{o} pod^{-1}.

4- 100- seed weight (g). 5-Seed yield (kg fed^{-1}). and 6- Straw yield (kg fed^{-1}).

The data collected for the above variables were subjected to statistical analysis using analysis of variance (ANOVA) technique (Snedecor and Cochran, 1980). The means were compared using Least Significant Difference (LSD) at 5% probability level according to Waller and Duncan (1969).

Crop - water relationships:

1- Water consumptive use (CU)

For determining the crop water consumptive use (CU), soil samples were taken before and 48 hours after each irrigation, as well as at harvest time in 15 cm increment to 60 cm depth of the soil profile. The crop water consumptive use between two successive irrigations was calculated according to the equation given by Israelsen and Hansen (1962) as follows:

$$Cu = \frac{D.Bd.[Q2 - Q1]}{100}$$

Where:

Cu = Consumptive use (cm).

D = Effective root zone depth (cm).

Bd = Bulk density of soil layer (g cm^{-3}).

Q2 = Soil moisture content (%, wt/wt) 48 hrs after irrigation.

Q1 = Soil moisture content (%, wt/wt) just before the next irrigation.

2. Water Productivity (WP):

Water productivity is an efficiency term calculated as a ratio of product output over water input. The output could be biological goods such as crop grain, fodder….etc. So, water productivity, in the present study, is expressed as kilogram of faba bean seed obtained per the unit of applied irrigation water. The water productivity values (kilograms of faba bean seeds/m^3 applied water) were calculated as follows:

WP (kg m^{-3}) = seed yield (kg ha^{-1}) / applied water (m^3 ha^{-1}), FAO (2003).

3. Water use efficiency (WUE)

Water use efficiency was calculated according to Jensen (1983) as follows:

$$WUE = \frac{Y}{CU}$$

Where:

WUE = kg seeds m^{-3} water consumed.

Y= Seed yield (kg fed^{-1}).

CU= Seasonal water consumptive use (m^3 fed^{-1}).

RESULTS AND DISCUSSION

Plant height, pods N^{o} plant^{-1}, seeds N^{o} pod^{-1} and 100-seed weight

Results in Table 3 show that plant height, pods N^{o} plant^{-1}, seeds N^{o} pod^{-1} and 100-seed weight of faba bean were significantly affected due to the adopted irrigation intervals, P- fertilization rates and interactions, and such findings were true in 2012/13 and 2013/14. The highest plant height values (122.75 and 114.00cm) were recorded with irrigation at 14 days interval. The relative increases, with irrigation at 14 days interval, reached to 7.05 and 21.33% and 5.39 and 24.70% more than those with irrigation at 21 and 28 days intervals, respectively. The present results could be attributed to sufficient soil moisture prevailing throughout growing season, under 14 days irrigation interval, encouraging luxury water and nutrients uptake which reflected on vigorous plant growth. The attained results are in accordance with El- Dakroury (2008) who found that increasing irrigation rate from 60 to 100% of the ETo significantly increased plant height. Furthermore, Tayel and Sabreen (2011) and Hegab et al. (2014) with drip-irrigated faba bean reported that irrigating at 100% of Etc regime exhibited the highest figures of plant height.

Data also reveal that plant height was significantly responded to increasing phosphorus fertilization rate, where 30 kg P_2O_5 fed^{-1} resulted in the highest figures reached to (13.21 and 6.59%) and (17.52 and 6.30%) higher than those under 7.5 and 15 kg P_2O_5 fed^{-1} rates in 2012/13 and 2013/14, respectively. The present results are in harmony with those obtained by Turk and Tawaha (2002). In this sense, Ogoke *et al.* (2003) reported that P plays a vital role in physiological and development process in plant life and may be accelerated the growth process that increased the plant performance.

Regarding the interaction, the highest plant height value was noticed under 14 days irrigation interval as interacted with 30 kg P_2O_5 fed^{-1} rate in 2012/13 and 2013/14.

Concerning pods N^{o} plant^{-1} and seeds N^{o} pod^{-1} traits, data in Table 3 reveal that both yield components exhibited differed trend to that of plant height. The highest Pods N^{o} plant^{-1} values (20.72 and 20.00) were resulted from irrigation at 21 days interval in 2012/13 and 2013/14. The value tended to be lower by (7.70 and 21.45%) and (12.80 and 26.74%) in 2012/13 and 2013/14 under irrigation at 14 and 28 days intervals, respectively,

comparable with irrigation at 21 days interval. As for seeds N^{o} pod^{-1} trait, irrigation at 21 days interval still exhibited the highest figures (3.62 and 3.61) in 2012/13 and 2013/14. The values tended to reduction with irrigating at 14 and 28 days intervals to be (12.77 and 18.59%) and (11.08 and 20.74%) in 2012/13 and 2013/14, respectively, comparable with irrigation at 21 days interval. Such findings indicate that neither 14 nor 28 days intervals provide the proper soil moisture which may be higher to induce leaching down of nutrients or lower to induce water stress and both are restricting ideal crop performance.

Table 3: Plant height, pods N^{o} plant^{-1} and seeds N^{o} pod^{-1} and 100-seed weight as affected by irrigation intervals, P-fertilizer rates and interaction in 2012/13 and 2013/14 seasons.

Irrigation Interval (I)	P-Fertilizer rate *	Plant height (cm)		Pods N^{o} plant^{-1}		seeds N^{o} pod^{-1}		100-seed weight (g)	
		2012/13	2013/14	2012/13	2013/14	2012/13	2013/14	2012/13	2013/14
14 days	P_1	116.75	107.25	15.43	15.43	2.75	2.80	53.30	56.15
	P_2	121.25	115.25	19.80	17.85	3.28	3.30	59.78	64.68
	P_3	130.25	119.50	22.48	19.93	3.60	3.65	66.30	68.61
Mean		122.75	114.00	19.24	17.73	3.21	3.25	59.79	63.15
21 days	P_1	107.00	101.25	17.85	17.43	3.05	3.13	47.28	48.93
	P_2	113.25	108.50	20.35	20.30	3.68	3.68	57.03	56.71
	P_3	123.75	114.75	23.95	22.28	4.13	4.03	64.95	63.33
Mean		114.67	108.17	20.72	20.00	3.62	3.61	56.42	56.32
28 days	P_1	94.25	78.25	15.30	13.45	2.65	2.60	43.97	47.41
	P_2	103.25	93.25	16.40	16.75	3.02	2.96	52.60	51.48
	P_3	106.00	102.75	19.48	17.75	3.47	3.41	59.53	58.47
Mean		101.17	91.42	17.06	15.98	3.05	2.99	52.03	52.45
Fertilizer Mean	P_1	106.00	95.58	16.19	15.44	2.82	2.84	48.18	95.58
	P_2	112.58	105.67	18.85	18.30	3.33	3.31	56.47	105.67
	P_3	120.00	112.33	21.97	19.99	3.73	3.70	63.59	112.33
LSD at 5%	(I)	7.76	6.52	0.73	2.93	0.11	0.13	1.99	6.52
	(P)	2.90	3.31	1.41	1.81	0.18	0.20	3.15	3.31
	I x F	5.03	5.59	2.45	3.14	0.31	0.35	5.46	5.59

***P_1, P_2 and P_3 are referred to 7.5, 15 and 30 kg P_2O_5 fed^{-1} rates, respectively**

The highest P–rate, 30 kg P_2O_5 fed^{-1}, still resulting in the highest values of pods N^{o} plant^{-1} which were higher than those with 7.5 and 15 kg P_2O_5 fed^{-1} rates by (35.70 and 16.55%) and(29.47 and 9.23%) in 2012/13 and 2013/14, respectively. The seeds N^{o} pod^{-1} exhibited similar trend, where the highest values (3.73 and 3.70) were recorded with 30 kg P_2O_5 fed^{-1} rate, which were decreased under 7.5 and 15 kg P_2O_5 fed^{-1} rates to be (32.27 and 12.01%) and (30.28 and 11.78%) in 2012/13 and 2013/14, respectively, lower than those with 30 kg P_2O_5 fed^{-1} rate. The present results are in parallel with Turk and Tawaha (2002).

In connection, Tayel and Sabreen (2011) stated that P has important effects on photosynthesis, nitrogen fixation, root development, flowering, seed formation, fruiting and improvement of crop quality. In addition, response of pods N^{o} plant^{-1} and seeds N^{o} pod^{-1} to increased P-rate could be

explained on the basis that P is an essential major nutrient especially for legumes which is required for nodules formation.

Regarding the interaction effect, the data reveal that both number of pods plant^{-1} and seeds pod^{-1} were significantly affected by the interaction between irrigation and phosphorus treatments. The highest number of pods plant^{-1} and seeds pod^{-1} were recorded for the plants irrigated every 21 days and fertilized with 30 kg P_2O_5 fed^{-1}, while the plants supplied with 7.5 kg P_2O_5 fed^{-1} under irrigating at 28 days interval resulted in the lowest ones.

Data indicate that the highest 100-seed weight values (59.79 and 63.15g) in 2012/13 and 2013/14, respectively, were attained as irrigation was practice at 14 days interval. The values seemed to reduce by (5.97 and 14.91%) and (12.13 and 20.40%) with 21 and 28 days irrigation intervals, respectively, in 2012/13 and 2013/14 lower than that with14 days interval.

The results indicate that 100-seed weight trait was responded positively to higher soil moisture content resulted from frequent irrigation e.g. irrigating at 14 days interval.

Such findings are in parallel with Tayel and Sabreen (2011) who stated that the highest 100-seed weight, for drip-irrigated faba bean, was obtained due to irrigation along the growing season at 100% of ETc.

Increasing P- rate was accompanied with increases in100-seed weight, where 30 kg P_2O_5 fed^{-1} rate exhibited the highest values (63.59 and 112.33g) in 2012/13 and 2013/14, respectively. The reductions in100-seed weight due to 7.5 and 15 kg P_2O_5 fed^{-1} rates the values were (31.98 and 12.61%) and (17.52 and 6.30%) in 2012/13 and 2013/14, respectively, comparable with 30 kg P_2O_5 fed^{-1} rate. The attained findings are coincided with those of Turk and Tawaha (2002) and Tayel and Sabreen (2011) who found that 100-seed weight, for faba bean, was gradually increased with increasing P- rate.

Data of interactions indicate that the highest 100-seed weight values (66.30 and 68.61g) were recorded due to irrigating at 18 days interval as interacted with 30 kg P_2O_5 fed^{-1} rate. On the contrary, the lowest ones (43.97 and 47.41g) were observed with irrigating at 28 days interval and with7.5 kg P_2O_5 fed^{-1} rate, and such findings were true in 2012/13 and 2013/14.

Seed yield and straw yield

Data in Table 4 reveal that seed and straw yields for faba bean were significantly influenced due to the adopted irrigation intervals, P- fertilizer rates and interaction in 2012/13 and 2013/14. The highest seed yield figures (1764 and 1689.7 kg fed^{-1}) in 2012/13 and 2013/14, respectively, were recorded as irrigation was practice at 21 days interval. Irrigation at 14 and 28 days intervals, comparable with 21 days interval, resulted in seed yield values reached to (5.60 and 15.15%) and (11.23 and 21.88%) in 2012/13 and 2013/14,respectively, lower than that with 21 days interval. Such findings prove that favorite soil moisture, for appropriate crop performance, was attained under 21 days interval, whereas under 14 and 28 days intervals, the soil moisture may be higher to induce nutrient leaching down or lower to induce water stress and both situations are restricting for crop growth which resulting in seed yield reductions. Similar results and justification were previously recorded with pods N^{o} plant^{-1} and seeds N^{o} pod^{-1} yield attributes. Krogman et al. (1980), El- Gindy et al. (2003), Tayel and Sabreen (2011) and

Hegab et al. (2014) reported that increasing soil moisture supply, irrespective to irrigation regime and irrigation method, increased faba bean seed yield. Such different may be attributed to differed experimental circumstances and prevailing soil and weather conditions.

Table 4: Seed yield and straw yield as affected by irrigation intervals, P-fertilizer rates and interaction in 2012/13 and 2013/14 seasons.

Irrigation Interval (I)	P-Fertilizer rate *	Seed yield (kg fed^{-1})		Straw yield (kg fed^{-1})	
		2012/13	2013/14	2012/13	2013/14
14 days	P_1	1574	1358	1885	1721
	P_2	1655	1462	2038	2094
	P_3	1767	1680	2141	2226
Mean		1665.3	1500.0	2021.33	2013.67
21 days	P_1	1654	1559	1755	1636
	P_2	1772	1676	1994	1828
	P_3	1866	1834	2062	2106
Mean		1764.00	1689.7	1937.00	1856.67
28 days	P_1	1360	1238	1495	1387
	P_2	1430	1290	1664	1566
	P_3	1619	1432	1791	1845
Mean		1496.8	1320.0	1650.00	1599.33
P-fertilizer rates Mean	P_1	1529	1385	1712	1581
	P_2	1619	1476	1899	1829
	P_3	1751	1649	1998	2059
LSD , 5%	(I)	88.8	140.7	189.0	70.9
	(P)	88.3	145.4	121.0	44.3
	I X P	153.0	182.5	209.5	76.7

***P_1, P_2 and P_3 are referred to 7.5, 15 and 30 kg P_2O_5 fed^{-1} rates, respectively.**

As for faba bean seed yield as affected by the adopted P-rates, data in Table 4 illustrate that the highest figures (1751 and 1649 kg fed^{-1}) in 2012/13 and 2013/14were recorded under 30 kg P_2O_5 fed^{-1} rate, respectively. Decreasing P- rate resulting in reduced seed yield values reached to (12.68 and 7.54%) and (16.01 and 10.48%) under 7.5 and 15 kg P_2O_5 fed^{-1} rates in 2012/13 and 2013/14, respectively, lower than with kg P_2O_5 fed^{-1} rate. The results are coincided with Turk and Tawah (2002) who reported that faba seed yield was positively responded with increasing P-rate.

Concerning interaction effect, data show that the highest seed yield was obtained for plants irrigated at 21 days interval and received P- fertilizer as 30 kg P_2O_5 fed^{-1}. On the other hand, the plants irrigated at 28 days interval and supplied P- fertilizer at 7.5 kg P_2O_5 fed^{-1}produced the lowest seed yield.

As for straw yield, data in Table 4 illustrate that the highest straw yield values (2021.33 and 2013.67 kg fed^{-1} in 2012/13 and 2013/14, respectively) were recorded as irrigation was practice at 14 days interval. Irrigation at 21 and 28 days intervals resulted in lower values amounted to (4.17 and 18.37%) and (7.80 and20.58%) in 2012/13 and 2013/14, respectively, less

than those with 14 days interval. Such findings could be attributed to luxurious soil moisture, due to irrigating at 14 days interval, allowing higher water and nutrients uptake which resulted in vigorous plants. In connection, Hegab et al. (2014) reported that irrigating at 0.60 ETc of led to decline vegetative growth traits for faba bean, comparable with 0.80 and 1.00 Etc.

As for straw yield as affected by the adopted P- rates, data reveal that the highest figures (1998 and 2059 kg fed^{-1}) in 2012/13 and 2013/14were recorded under 30 kg P_2O_5 fed^{-1} rate, respectively. Reducing P-rate resulting in lower seed yield values reached to (14.31 and 4.95%) and (23.22 and 11.17%%) due to 7.5 and 15 kg P_2O_5 fed^{-1} rates in 2012/13 and 2013/14, respectively, lower than with30 kg P_2O_5 fed^{-1} rate. These results are coincided with Turk and Tawah (2002) and Tayel and Sabreen (2011) who reported that primary branches No $plant^{-1}$ of faba bean were gradually increased as P-rate increased.

Concerning interaction effect, data show that the highest straw yield e.g. 2226 kg ha^{-1} was obtained due to irrigating at 14 days interval and applying P-fertilizer as 30 kg P_2O_5 fed^{-1}. On the contrary, the plants irrigated at 28 days interval and supplied P-fertilizer at 7.5 kg P_2O_5 fed^{-1} produced the lowest straw yield amounted to 1387 kg ha^{-1}.

Crop-water relationships:

Applied irrigation water

Regardless the adopted P-rates, irrigating at 14 days interval recorded the highest figures of seasonal applied water, which amounted to 1991 and 1923 m^3 fed^{-1} 2012/13 and 2013/14, respectively. Under 21 and 28 days intervals the values tended to reduction and comprised (17.13 and 26.67%) and (17.21 and 25.17%), respectively, 2012/13 and 2013/14 lower than those with at 14 days interval. The attained results are in parallel with those reported by Balasio *et al.* (2006) who reported that irrigating faba bean at 28 days interval, the total applied water reached to 4464 m^3 ha^{-1} comparable with 7429 m^3 ha^{-1} as irrigation was practiced at 14 days irrigation interval.

Table 5: Seasonal applied irrigation water (m^3 fed^{-1}) under the adopted irrigation intervals in 2012/13 and 2013 /14 seasons.

Irrigation interval	P-Fertilizer rate	Applied irrigation water (m^3 fed^{-1})	
		2012/13	2013/14
14 days	7.5 kg P_2O_5 fed^{-1}	1991	1923
	15 kg P_2O_5 fed^{-1}		
	30 kg P_2O_5 fed^{-1}		
21 days	7.5 kg P_2O_5 fed^{-1}	1650	1592
	15 kg P_2O_5 fed^{-1}		
	30 kg P_2O_5 fed^{-1}		
28 days	7.5 kg P_2O_5 fed^{-1}	1460	1439
	15 kg P_2O_5 fed^{-1}		
	30 kg P_2O_5 fed^{-1}		

Water consumptive use (Cu)

Data in Table 6 reveal that the highest Cu values (34.01 and 33.14 cm) resulted from irrigating at 14 days interval in 2012/13 and 2013/14,

respectively. As irrigation interval was extended, Cu values tended to reduction, where Cu values were reduced by (5.35 and 10.85%) and (5.46 and 13.16%) in 2012/13 and 2013/14, respectively, under 21 and 28 days irrigation intervals comparing to that under irrigating at 14 days interval. Zabawi and Dennet (2010) found that total water use responded positively with plant available water level. Hegab et al. (2014) with drip-irrigated faba bean, reported that seasonal irrigation water under 1.00Etc regime were higher by about 25 and 66%, respectively, than those with 0.8 and 0.6 Etc ones.

Increasing P-rate resulted in higher Cu values, where 30 kg P_2O_5 fed^{-1} rate exhibited higher values comprised (7.09 and 2.82%) and (8.60 and 3.49%) in 2012/13 and 2013/14, respectively, higher than those with 7.5 and 15 kg P_2O_5 fed^{-1} rates. On justification, higher Cu values under 30 kg P_2O_5 fed^{-1} rate is expected to match higher values of seed and straw yields besides the assessed yield components under such P-rate. In this respect, Dang (1999) stated that P plays an important role in increasing not only total soil water use but also water extraction from deep soil layer.

Interaction data illustrate that the highest Cu figures (34.76 and 33.14 cm) were recorded due to irrigating at 14 days interval and 30 kg P_2O_5 fed^{-1} rate interaction, respectively, in 2012/13 and 2013/14.

Table 6: Water consumptive use, water productivity and water use efficiency as affected by irrigation intervals, P-rates and interaction in 2012/13 and 2013/14 seasons.

Irrigation interval	P-Fertilizer rate *	WCU (cm)		WP (kg m^{-3})		WUE (kg m^{-3})	
		2012/13	2013/14	2012/13	2013/14	2012/13	2013/14
14 days	P_1	33.05	31.95	0.79	0.71	1.13	1.02
	P_2	34.22	33.58	0.83	0.76	1.15	1.04
	P_3	34.76	34.25	0.89	0.87	1.21	1.17
Mean		34.01	33.14	0.84	0.78	1.16	1.08
21 days	P_1	30.73	29.65	1.00	0.98	1.28	1.25
	P_2	32.23	31.32	1.07	1.05	1.31	1.27
	P_3	33.61	33.03	1.13	1.15	1.32	1.32
Mean		32.19	31.33	1.07	1.06	1.30	1.28
28 days	P_1	29.25	27.74	0.93	0.86	1.11	1.06
	P_2	30.45	28.85	0.98	0.90	1.12	1.06
	P_3	31.27	29.74	1.11	0.99	1.23	1.15
Mean		30.32	28.78	1.01	0.92	1.15	1.09
P-fertilizer rates Mean	P_1	31.01	29.78	0.91	0.85	1.17	1.11
	P_2	32.30	31.25	0.96	0.90	1.19	1.12
	P_3	33.21	32.34	1.04	1.00	1.25	1.21

***P_1, P2 and P3 are referred to 7.5, 15 and 30 kg P_2O_5 fed^{-1} rates, respectively.**

Water productivity (WP)

Data in Table 6 illustrate that the highest WP values e.g. 1.07 and 1.06 kg m^{-3} were recorded as irrigation was practiced at 21 days interval, respectively, in 2012/13 and 2013/14. Such higher WP values are mainly attributable to higher seed yield under irrigating at 21days interval,

comparable with irrigating at 14 and 28 days intervals. In this sense, Hegab et al. (2014) observed similar trend, where higher WUE, for drip- irrigated faba bean, resulted from irrigation at 0.60 Etc regime and tended to reduction with irrigating at 0.8 and 1.00 ones.

Increasing P- rate induced a gradual increase in WP, where the values were increased by (14.29 and 8.33%) and (17.65 and 11.11%) with 30 kg P_2O_5 fed^{-1} rate in 2012/13 and 2013/14, respectively, comparing with 7.5 and 15 kg P_2O_5 fed^{-1} rates. Such increases are due to higher seed yield resulted from supplying the highest P-rate. Othman and EL-Sharkawy (2006) found that WUtE for faba bean was higher by 6.5% with 23.3 kg P_2O_5 fad^{-1} rate than that with 15.53 kg P_2O_5 fad^{-1} rate.

The highest WP figures e.g.1.13 and 1.15 kg m^{-3} were attained due to irrigating at 21 days interval as interacted with the highest P-rate and such findings were true in 2012/13 and 2013/14, respectively.

Water use efficiency (WUE):

The results in Table 6 reveal that irrigating faba bean crop at 21 days interval improved the water use efficiency and such findings were true in 2012/13 and 2013/14. Water use efficiency were increased under 21 days interval by (12.10 and 13.04%) and (18.52 and 17.43%) in 2012/13 and 2013/14, respectively, comparable with irrigating at 14 and 28 days intervals. Higher WUE with 21 days interval, comparing with that under 14 days interval is mainly attributable to both higher seed yield and less water consumed under the former. In spite of water consumed under 28 days interval was lower than that with 21 days interval, WUE was improved under the later which is attributable to higher seed yield. It has been frequently reported that lack of water availability can reduce the amount and efficiency of water use (Ehdaie 1995; Massacci et al. 1996; Maman et al. 2003). In connection, Zabawi and Dennet (2010) reported higher WUE with the lower plant available water level and tended to reduce as plant available water level increased. On the contrary, Hegab et al. (2014) observed a differed trend, where higher WUE, for drip-irrigated faba bean, resulted from irrigation at 0.60 Etc regime and tended to reduction with irrigating at 0.8 and 1.00 ones. The amount of water use and water use efficiency vary with climatic, soil conditions and the ability of the crops to extract water stored in the soil (Ehdaie et al. 1991; Ebdon et al. 1998).

Increasing P-rate resulted in gradual WUE increases, where the values due to supplying 30 P_2O_5 fed^{-1} rate were higher by (6.84 and 5.04%) and (9.01 and 8.04%) in 2012/13 and 2013/14, respectively, comparable with 7.5 and 15 kg P_2O_5 fed^{-1} rates. Such findings indicating that with increasing P-rate, the increase in seed yield was proportionally higher than the increase in water consumptive use.

Interaction data clear out that the highest WUE (1.32 and 1.32 kg m^{-3}) were attained due to irrigating at 21 days interval and 30 kg P_2O_5 fed^{-1} rate interaction, respectively, in 2012/13 and 2013/14.

CONCLUSION

Under the conditions of the present experiment and to conserve the limited irrigation water resources, as an important national issue, it is

advisable to irrigate faba bean crop at 21 days interval and supplying P-fertilizer at 30 kg P_2O_5 fed^{-1} rate in order to obtain reasonable values of water productivity and water saving as well.

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تأثير فترات الرى والتسميد الفوسفاتى على المحصول ومكوناته وبعض العلاقات المائية للفول البلدى.

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أقيمت تجربتان حقليتان خلال موسمى ٢٠١٢/٢٠١٣ ، ٢٠١٣/٢٠١٤ بمحطة البحوث الزراعية بسدس – بنى سويف بهدف دراسة تأثير فترات الري (١٤،٢١، ٢٨ يوم) والتسميد الفوسفاتي (٧,٥ ، ١٥ ، ٣٠ كجم فو٢ا٥/ فدان) على محصول الفول البلدي ومكوناته وبعض العلاقات المائية واستخدم في ذلك تصميم القطع المنشقة مره واحدة في أربعة مكررات وكانت أهم النتائج المتحصل عليها كما يلي:

معاملات الري ومستويات التسميد الفوسفاتى تحت الدراسة وكذا التفاعل أثروا معنويا علي محصولي البذور والقش وكذا مكونات محصول البذرة مثل ،عدد القرون بالنبات ، عدد البذور بالقرن ، وزن ال١٠٠ بذرة وارتفاع النبات.

أعلي القيم للمحصول ومكوناته سجلت مع الري كل ٢١ يوم بينما أعلي محصول للقش وارتفاع النبات سجلا مع الري كل ١٤ يوم. أعلي القيم للصفات المذكورة أعلاه كانت مع المعدل الأعلى من التسميد الفوسفاتي (٣٠ كجم فو٢ا٥/ فدان). تفاعل الري كل ٢١ يوم و ٣٠ كجم فو٢ا٥/ فدان أدي إلي أعلي القيم للصفات السابقة فيما عدا ارتفاع النبات والذي أعطي قيم عالية نتيجة تفاعل الري كل١٤ يوم والتسميد ب ٣٠ كجم فو٢ا٥/ فدان.

قيم الاستهلاك المائي للفول البلدي كانت الأعلى مع الري كل ١٤ يوم بينما كلا من إنتاجية المياه وكفاءة استخدام المياه كانتا الأعلى بالري كل ٢١ يوم . مع المعدل الأعلى من التسميد الفوسفاتي (٣٠ كجم فو٢ا٥/ فدان) سجلت أعلي القيم الاستهلاك المائي وإنتاجيه المياه وكفاءة استخدام المياه. تفاعل الري كل ١٤ يوم والتسميد الفوسفاتي (٣٠ كجم فو٢ا٥/ فدان) أدي الي قيم مرتفعة من الاستهلاك المائي ، بينما تفاعل الري كل ٢١ يوم والتسميد الفوسفاتي (٣٠ كجم فو٢ا٥/ فدان) أدي الي قيم عالية من انتاجية مياه الري وكفاءة استخدام المياه.

من نتائج التجربة يمكن الحصول علي قيم مرتفعة من محصول بذور الفول البلدي ومن إنتاجية مياه الري مع المحافظة علي مصادر المياه ، بري الفول البلدي كل ٢١ بوم مع إضافة السماد الفوسفاتي بمعدل ٣٠ كجم فو٢ا٥/ فدان.