INFLUENCE OF SOWING DATES AND IRRIGATION SCHEDULING ON SOME WATER RELATIONS, SNAP BEAN (*PHASEOLUS VULGARIS* L.) PRODUCTIVITY AND APHID, PISUM APHID (*ACYRTHOSIPHON PISUM* HARRIS) POPULATIONS

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ABSTRACT

Snap bean (*Phaseolus vulgaris* L.) is one of the most important exporting vegetable crops in Egypt. The experiment was done for two Nili seasons 2014 and 2015 in split plot design. Main plots were assigned to sowing dates and the sub plots were irrigation scheduling treatments. This study aims to investigate the effect of three sowing dates (1st, 16th of August and 1st of September); irrigation scheduling regime by using cumulative pan evaporation C.P.E. from Class A Pan evaporation (1.0, 0.8 and 0.6 C.P.E.) on the population fluctuations of pisum aphid, *Acyrthosiphon pisum* Harris and growth parameters of snap bean. Results showed that the combination of third sowing date and irrigation at 0.8 C.P.E. (about 18-21 days irrigation interval) gave a low density of *A. pisum* comparing by the first and second sowing dates; highest averages of fresh pod yield (10196 and 10482 kg ⁄ha in 2014 and 2015, respectively) as well as it achieved the greatest net farm income (28653 L.E. ha^{-1}) for the third date comparing by anther two dates.

Key wards: snap bean – *Phaseolus vulgaris* - sowing date – irrigation scheduling– water consumption – water use efficiency- pisum aphid- *Acyrthosiphon pisum* - population fluctuations

INTRODUCTION

Egypt is one of the important exporters of snap bean (*Phaseolus vulgaris* L.) to Dutch markets with 25% followed by Spain 24% and Kenya by 20%. The cultivated snap bean area in Egypt is expanded in the last decade to be 21300 hectare (2.4%) of the total snap bean cultivated area all over the world with productivity of 215000 tons (3.5%) of total world production (FAO STAT, 2016). Suitable sowing date as a cultural practice and adequate amount of irrigation water are two main factors affecting directly the growth and productivity of snap bean Regarding sowing date, many investigators revealed that tendency of increasing in growth parameter, yield and yield components as snap bean (*Phaseolus vulgaris* L.) was planted in suitable sowing date with appropriate varieties and optimum plant spacing (Porch and Jhan, 2001; Amanullah *et al.*, 2002; Darby and Lauer, 2002; Bhardwaj *et al.*, 2004; De Bruin *et al.*, 2010; Babaeian *et al.*, 2012; Abdou, *et al.*, 2013; Getachew *et al.*, 2015). Climate (as temperature, humidity and wind) and non- climate (pests, weeds, diseases and birds) factors and play an important role to determine the suitable sowing date (Mazaheri and Hosseini, 2005; Mojaddam and Nouri, 2014). Additionally, water consumption affected by sowing date according the high or low temperature during growth stages and it is effecte on water relations as crop coefficient and efficiency of water use in snap bean , Abdou *et al.*, 2013 in faba bean). Optimum sowing date affected in snap bean by decreasing aphids' population due to low temperature (Abate and Ampofo, 1996; Abate *et al.*, 2000; Sucke *et al.*, 2009; Abdou *et al.*, 2013).

The concept of irrigation scheduling means saving the moisture in the soil within an acceptable range for plants, generally between the field capacity and the wilting point to avoid the problems resulted from either over- irrigate or under. irrigation scheduling involves deciding; when irrigate, how much water and how to apply and based on monitoring soil moisture, climate observation or plant appearance. Concerning climate-based systems, measurement of evaporation rates from an automated class A evaporation pan can accurately estimate ET_0 and used as an irrigation scheduling tool (Phene *et al.*, 1992 and Phene, 1995). Concerning the scheduling irrigation, decrement in plant size due to decreasing in prolongation of cells and cell division moreover increment in leaf thickness and in general reduction in yield and yield components as available soil water depletion% increased (Abdel -Mawgoud *et al*., 2005; Mozumder *et al.*, 2005; Sezen *et al.*, 2005; Ibrahim *et al.*, 2010; Abdou *et al.*, 2013; Marzouk *et al.*, 2016). For high efficiency of water use in snap bean the adding water in irrigation have to not more than 75% of soil moisture capacity (Doorenbos *et al.*, 1979; Alderfasi and Alghamdi, 2010; Ashry *et al*., 2012; Abdou *et al*., 2013). Aphid population significantly varied according to the infected stage, increased at the vegetative stage, followed by maturity stage (Birch, 1985). Increasing of aphids infection due to increment of wet conditions around snap bean plants (Hasan *et al.*, 2009; Abdou *et al.*, 2013).

The present work aims to investigate the suitable sowing date and the best irrigation scheduling regimes and their effect on reducing density of aphids, to obtain a maximum income of snap bean without using any insecticides to keep human healthy& clean environment.

MATERIALS AND METHODS

Current trial was carried out at El-Mokrani village, Youssef Al - Siddiq District, El-Fayoum Governorate, where snap bean seeds (*Phaseolus vulgaris* Branco cv) were planted in hills 25 cm apart at the rate of 52.5 kg ha^{-1} which inoculate with rhizobium as recommended in two successive Nili seasons (2014 and 2015) to study the effect of sowing date and irrigation scheduling and their combination on aphid (*A. pisum*) population and consequently on snap bean productivity. The experiment area was cultivated with branco cv. and implemented with three replicates per each sowing date in split plot design. Main plots were assigned to sowing dates as (1^{st}, 16^{th} of August and 1^{st} of September) and the sub plots were occupied by irrigation scheduling treatments based on of 1.0, 0.8 and 0.6 (three replicates per each pan) pan coefficients for cumulative

Pan Evaporation (C.P.E.) records. Each sub plots was 21 m^2 (3.5x 6 m) with containing 7 ridges 50 cm in width and 6 m length. To minimize the effect of water lateral movement on next adjacent plot; each plot was isolated from the others by allays of 1.5 m width. Aphid identification was done according to the key of the Aphids family (Hemiptera: Aphididae) **Habib and El- Kady (1961).** To study the population density of *A. pisum*, samples were taken weekly after two weeks of planting, samples were monitored and counted during the two years. Three plants were taken randomly from each replicate and they fixed throughout the season (12 plant ⁄ sowing date). Aphids count was done as described by Hafez (1964). The ministry of agriculture recommendations about fertilization process were taken into considers without using insecticides. Soil and water analysis laboratory at Fayoum Faculty of Agriculture was used for determining the required soil where the used soil was clayey with 22.91% and, 19.36% silt, and 58.13% clay, with organic matter content of 1.44 % and with CaCO3 content at 3.18%, pH is 8.11 and Ec is 0.57dSm^{-1},. For determining the irrigation time, pan evaporation records was multiplied by the different adopted coefficient, and irrigation was practiced as the two sides of the following formula were the same later.

Pan evaporation record (mm) x assessed coefficient = Available soil moisture (mm) in the root zone

The applied irrigation events, were 7, 6 ; 6 with 1.0 C.P.E. regime & 6, 5 ; 5 with 0.8 C.P.E. regime and 5, 4 ; 4 with 0.6 C.P.E. regime under the 1^{st}, 2^{nd} and the 3^{rd} sowing dates, respectively.

A- Crop - water relationships:

1- Crop water evapotranspiration (crop water consumptive use) (ET_C):

In the present trial, crop evapotranspiration (ET_C) was determined gravimetrically via soil samples taken from each sub-plot, just before and after 48 hours of irrigation, as well as at harvesting time. Some of soil water constants are shown in Table 2. The crop evapotranspiration between each the two successive irrigations was calculated according to Israelson and Hansen, (1962) as follows:-

$$Cu\ (ET_C) = \{(Q_2-Q_1) / 100\} \times Bd \times D$$

Where

Cu = Crop water evapotranspiration (cm).

Q_2= Soil moisture percentage (wt/wt) 48 hours after irrigation.

Q_1= Soil moisture percentage (wt/wt) just before irrigation.

Bd = Soil bulk density (g cm^{-3}).

D = Soil layer depth (cm).

2-Daily ET_C rate (mm/day):

Daily ET_C = ET_C between each two successive irrigations / the number of days.

3- Reference evapotranspiration (ET_0):

ET_0 was estimated as (mm day^{-1}), using the monthly averages of weather factors for Fayoum Governorate (Table 1) and the procedures of the FAO-Penman Monteith equation (*Allen et al.*, 1998).

4- Crop Coefficient (K_C):

K_C was calculated by Israelsen and Hansen (1962) equation as follows:

$$K_C = ET_C / ET_0$$

Where:

ET_C = Actual crop evapotranspiration

ET_0 = Reference evapotranspiration.

5- Water productivity (WP):

In agricultural production systems, crop water productivity (WP) accounts for crop production per unit amount of water used (**Molden, 1997**).. We used the following definitions of crop WP (**Dehghanisanij *et al.*, 2008,** where, WP is based on the irrigation water (I) plus effective rainfall (Re) **(Doorenbos and Pruitt, 1977**) is the marketable part of the total aboveground biomass production (i.e. grain yield for wheat and maize) .

WP, kg m^3 = {fresh pods yield (kg ha^{-1}) ⁄ Seasonal crop consumptive use (ET_C) "Cu"(m^3 ha^{-1}).

Table 1: The monthly averages of weather factors for Fayoum Governorate in 2014 and 2015 seasons.

Month	Year	Temperature C°			Relative Humidity %	Wind speed m sec^{-1}	Class A pan evaporation mm day^{-1}
		Max	Min	Mean			
August	2014	37.8	24.1	30.9	36.3	2.1	5.89
	2015	41.5	25.7	33.6	44.6	2.2	6.55
September	2014	38.5	24.2	31.4	37.0	1.8	5.90
	2015	38.5	24.4	31.4	45.7	2.3	6.23
October	2014	35.5	22.8	29.1	41.0	2.2	4.60
	2015	34.8	21.5	28.1	47.7	2.0	3.79
November	2014	27.7	15.7	21.7	41.0	1.9	2.20
	2015	29.4	17.2	23.3	51.2	2.1	2.02
December	2014	21.6	9.9	15.7	43.0	1.8	1.50
	2015	26.1	12.6	19.4	51.0	1.9	1.50

(Source: Itsa metrological station, Fayoum Governorate)

Table 2: Average values of some soil moisture constants and bulk density for the experimental field in 2014 and 2015 seasons (two season's average).

Soil depth (cm)	Field capacity (%,w/w)	Wilting point (%,w/w)	Available soil moisture (%,w/w)	Bulk density (gcm^{-3})	Available soil moisture (mm)
00-15	46.80	26.02	20.78	1.13	35.22
15-30	40.38	24.11	16.27	1.18	28.80
30-45	37.56	22.48	15.08	1.22	27.60
45-60	34.22	20.81	13.41	1.35	27.16

6- Growth and yield components parameters

Number of leaves $plant^{-1}$ at 60, 75 and 90 DAS, leaf area/ $plant^{-1}$ at 60, 75 and 90 DAS, pod number $plant^{-1}$, pod weight (g) $plant^{-1}$, fresh pod yield (kg) ha^{-1} and weekly numbers of pisum aphids(*A. pisum)* $plant^{-1}$ were recorded. Furthermore, the cost of production, total income (in local markets or export markets) and net income for farmer were estimated.

7- Statistical analysis

Data were subjected to statistical analysis and the means were compared using least significant different at 5% level of significance according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

A- Crop water relations:

1- Crop water evapotranspiration (ET_C):

Data in (Table, 3) indicate that the 3rd sowing date gave the lowest values of snap bean ET_C (32.21 and 32.67cm) in the two successive seasons, respectively. The 1st and 2nd sowing dates seem to increase ET_C in the two seasons by 19.53% and 7.98% respectively in 2014, , and by 19.65% and 7.99%, respectively in 2015, in comparison with the 3rd date.

Concerning the effect of scheduling, irrigation snap bean at 1.0 C.P.E. regime, data in Table (3) indicate that the highest averages of ET_C in 2014 and 2015 seasons (38.96 and 39.42 cm) in 2014 and 2015, respectively. Irrigation at 0.8 C.P.E. decreased the ET_C by 10.88 % and 10.56% in the two successive seasons as compared with irrigation at 1.0 C.P.E. This could be attributed to luxury of the available soil moisture in the root zone of snap bean plants, under irrigating at 1.0 C.P.E., resulted in highest ET_C values which are resulted from both higher transpiration rate from plants canopy and evaporative demands from soil surface. Concerning the interaction between the 1st sowing date and irrigation at 1.0 C.P.E. data revealed that the highest values of ET_C were (42.17 and 42.86 cm) in the two successive seasons, respectively. Otherwise, the lowest averages of ET_C (29.04 and 29.65 cm) in 2014 and 2015 seasons, respectively, were obtained from the interaction between the 3rd sowing date and irrigation at 0.6 C.P.E.

Table 3: Effect of sowing date and irrigation scheduling regime and their interaction on seasonal consumptive use of snap bean crop (ET_C, cm). in 2014 and 2015 seasons.

Sowing date	2014			Mean	2015			Mean
	C.P.E.				C.P.E.			
	1.0	0.8	0.6		1.0	0.8	0.6	
August 1st	42.17	38.17	35.16	**38.50**	47.86	38.73	35.68	**39.09**
August 16th	38.82	34.27	31.26	**34.78**	39.20	34.90	31.75	**35.28**
September 1st	35.88	31.71	29.04	**32.21**	38.19	32.16	29.65	**32.67**
Mean	**38.96**	**34.72**	**31.82**	**35.16**	**39.42**	**35.26**	**32.36**	**35.68**

2-Daily ET_C rate (mm/day):

The results presented in (Table, 4) show that the daily ET_C rates as influenced by different treatments in both seasons were started with low values during August then increased during September to reach its maximum values on October. Thereafter, it decreased during November and December (plant harvesting). These results are referred to that at the initial growth stage, most of the water loss is due to evaporation from the bare soil (germination and seedling stages). The highest values of ET_C during the different months of the two growing seasons were resulted from the 1st sowing date however; the 3rd sowing date gave the lowest values of daily ET_C rates in the two growing season months. These results in general agreement with the finding by, Mozumder *et al.*, 2005; Sezen *et al.*, 2005; Ibrahim *et al.*, 2010; Abdou *et al.*, 2013; Marzouk *et al.*, 2016).

3-Reference evapotranspiration (ET_0):

Reference evapotranspiration rate in mm day^{-1} during the months of growing seasons estimated using the FAO Penman- Monteith method and the meteorological data of Fayoum Governorate are recorded in

According to (Table, 5) the ET_0 rate values were started with somewhat high during August, then decreased during subsequent months. Reference ET values depend mainly on the evaporative power of the air at each area, i.e. temperature, radiation, relative humidity and wind speed, (Allen *et al.*, 1998).

4-Crop coefficient (K_C):

Results in (Tables 4 and 5) indicate that in both seasons, K_C values were low at the initial growth stage (August), and then increased in September to reach the maximum values during October (maximum plant growth, flowering and seed setting periods). K_C values decreased again during November and December as plants reaching pods filling and harvesting. These results are due to high diffusive resistance of bare soil which tended to decrease as the plants become dry and transpiration decreased to lower rates, (Abdou *et al.*, 2013)

data in (Table, 5) show that delaying sowing date from the 1st to the 3rd date decreased the K_C values during the months of the two growing seasons; early sowing date gave the highest K_C values during the growing months in both seasons. On the other hand, decreasing irrigation intervals from 0.6 to 0.8 or 1.0

C.P.E. increased the K_C values in all months of the two growing seasons. The highest values of Kc were detected from interaction between 1st sowing date and irrigation at 1.0 C.P.E. These results are in agreement with (Doorenbos *et al.*, 1979; Abdou *et al.*, 2013) in both seasons.

Table (4): Effect of sowing date, irrigation scheduling treatments on daily water consumption used (mm day^{-1}) in 20014 and 2015 seasons.

treatments		2014					2015				
Sowing date	scheduling irrigation	August	September	October	November	December	August	September	October	November	December
S_1 1/8	I_1 (C.P.E.)	3.43	4.49	5.41	2.18	-	3.56	4.83	5.03	2.07	-
	I_2 (C.P.E.)	3.43	3.74	4.89	1.99	-	3.56	4.13	4.51	2.02	-
	I_3 (C.P.E.)	3.43	3.40	4.42	1.68	-	3.56	3.64	4.09	1.71	-
Mean		**3.43**	**3.88**	**4.91**	**1.95**	**-**	**3.56**	**4.20**	**4.54**	**1.93**	**-**
S_2 16/8	I_1 (C.P.E.)	3.28	4.08	5.30	2.10	-	3.40	4.48	4.98	2.13	-
	I_2 (C.P.E.)	3.28	3.67	4.68	1.90	-	3.40	4.13	4.42	1.96	-
	I_3 (C.P.E.)	3.28	3.40	4.16	1.54	-	3.40	3.64	3.90	1.60	-
Mean		**3.28**	**3.72**	**4.71**	**1.85**	**-**	**3.40**	**4.08**	**4.43**	**1.90**	**-**
S_3 1/9	I_1 (C.P.E.)	-	3.47	4.63	3.11	1.78	-	3.71	4.42	3.36	1.98
	I_2 (C.P.E.)	-	3.47	3.85	2.91	1.60	-	3.71	3.67	3.08	1.66
	I_3 (C.P.E.)	-	3.47	3.38	2.52	1.44	-	3.71	3.24	2.63	1.48
Mean		**-**	**3.47**	**3.95**	**2.85**	**1.61**	**-**	**3.71**	**3.78**	**3.02**	**1.71**
Mean Of irrigation	I_1 (C.P.E.)	3.36	4.01	5.11	2.46	1.78	3.48	4.34	4.81	2.52	1.98
	I_2 (C.P.E.)	3.36	3.63	4.47	2.27	1.60	3.48	3.99	4.20	2.35	1.66
	I_3 (C.P.E.)	3.36	3.42	3.99	1.91	1.44	3.48	3.66	3.74	1.98	1.48

Table (5): Reference evapotranspiration, ET0 (mm day^{-1}) and K_C for snap bean crop during 2014 and 2015 seasons as affected by sowing date and irrigation scheduling treatments and their interaction.

treatments		2014						2015					
ET_0 mm day^{-1}		7.8	6.8	5.2	2.8	2.0		7.9	7.0	4.7	2.8	2.0	
Sowing date	scheduling irrigation	August	September	October	November	December	Average	August	September	October	November	December	Average
S_1 1/8	I_1 (C.P.E.)	0.44	0.66	1.04	0.78	-	0.73	0.45	0.69	1.07	0.74	-	0.74
	I_2 (C.P.E.)	0.44	0.55	0.94	0.71	-	0.66	0.45	0.59	0.96	0.72	-	0.68
	I_3 (C.P.E.)	0.44	0.50	0.85	0.60	-	0.60	0.45	0.52	0.96	0.72	-	0.66
Mean		**0.44**	**0.57**	**0.94**	**0.70**	**-**	**0.66**	**0.45**	**0.60**	**1.00**	**0.73**	**-**	**0.69**
S_2 16/8	I_1 (C.P.E.)	0.42	0.60	1.02	0.75	-	0.70	0.43	0.64	1.06	0.76	-	0.72
	I_2 (C.P.E.)	0.42	0.54	0.90	0.68	-	0.64	0.43	0.59	0.94	0.70	-	0.67
	I_3 (C.P.E.)	0.42	0.50	0.80	0.55	-	0.57	0.43	0.52	0.83	0.57	-	0.59
Mean		**0.42**	**0.55**	**0.91**	**0.66**	**-**	**0.63**	**0.43**	**0.58**	**0.44**	**0.68**	**-**	**0.66**
S_3 1/9	I_1 (C.P.E.)	-	0.51	0.89	1.11	0.89	0.85	-	0.53	0.94	1.2	0.94	0.90
	I_2 (C.P.E.)	-	0.51	0.74	1.04	0.80	0.77	-	0.53	0.78	1.1	0.83	0.81
	I_3 (C.P.E.)	-	0.51	0.65	0.90	0.72	0.70	-	0.53	0.69	0.94	0.74	0.73
Mean		**-**	**0.51**	**0.76**	**1.02**	**0.80**	**0.77**	**-**	**0.53**	**0.80**	**1.08**	**0.84**	**0.81**
Mean Of irrigation	I_1 (C.P.E.)	0.43	0.59	0.98	0.88	0.89	0.76	0.44	0.62	1.02	0.90	0.94	0.79
	I_2 (C.P.E.)	0.43	0.53	0.86	0.81	0.80	0.69	0.44	0.57	0.89	0.84	0.83	0.72
	I_3 (C.P.E.)	0.43	0.50	0.77	0.68	0.72	0.62	0.44	0.52	0.83	0.74	0.74	0.66

5- Water productivity:

Results in (Table 6) show that the average weight of fresh pods as affected by the average values of WP which affected by the sowing date and irrigation scheduling treatments were 2.28 and 2.30 kg / fresh pods/ m ^{3} water consumed in 2014 and 2015 seasons, respectively. The highest water productivity, for the 3rd sowing date (2.93 and 2.94 kg/ fresh pods /m^{-3} water consumed) were obtained in 2014 and 2015, respectively, whereas, the lowest ones (1.53 and 1.54 kg fresh pods /m^{-3} water) were obtained from the 1st owing date. These results are in the same trend with those obtained by (Karas, *et al.*, 1999 in snap bean and Abdou, *et al.*, 2013 in faba bean).

Regarding irrigation scheduling regimes, the highest WUE values (2.54 and 2.56 kg /fresh pods /m^{-3} water consumed) were detected from irrigating snap bean plants at0.8 C.P.E in the two seasons, respectively,.. On the contrary, irrigation at 1.0 C.P.E. gave the lowest WUE values (2.05 and 2.07 kg seeds /m^{-3} water consumed) in the two successive seasons, respectively. These results are in agreement with those reported by (Karas, *et al.*, 1999 in snap bean and Abdou, *et al.*, 2013 in faba bean).

Table 6: Effect of sowing date, irrigation scheduling regime and their interaction on water productivity for snap bean (kg fresh pods m^{-3} water consumed) in 2014 and 2015 seasons

Sowing date	2014			Mean	2015			Mean
	C.P.E.				C.P.E.			
	1.0	0.8	0.6		1.0	0.8	0.6	
August 1st	1.33	1.86	1.39	**1.53**	1.35	1.88	1.40	**1.54**
August 16th	2.16	2.60	2.41	**2.39**	2.18	2.62	2.43	**2.41**
September 1st	2.67	3.17	2.94	**2.93**	2.68	3.19	2.95	**2.94**
Mean	**2.05**	**2.54**	**2.25**	**2.28**	**2.07**	**2.56**	**2.16**	**2.30**

6- Growth and yield component parameters:

6-1--Growth parameters:

According to (Table, 7) sowing date significantly affected the studied snap bean growth parameters. In general, the highest averages of number of leaves $plant^{-1}$ and leaf area $plant^{-1}$ at 60, 75 and 90 DAS were detected from planting in the 3rd sowing date in the two seasons. These increments may be related to the suitable climate factors during growth stages especially temperature, (Mazaheri and Hosseini, 2005; Mojaddam and Nouri, 2014).

Data in (Table, 7) indicate that the growth parameters were affected positively by interaction between sowing dates and irrigation scheduling treatments, the highest values in measured parameters were detected from the 3rd sowing date with the irrigation at 1.0 C.P,E., treatment. Whereas, the lowest one was obtained from 1st date and irrigation at 0.6 C.P.E., in the two successive seasons.

Results in (Table 8) indicate that, irrigation at 1.0 C.P.E. gave the highest averages of number of leaves $plant^{-1}$ and leaf area $plant^{-1}$ at 60, 75 and 90 DAS compared with those obtained with irrigation at 0.8 and 0.6 C.P.E. in the two successive seasons. these results may be attributed to the exposed the plants to water stress led to reduced photosynthesis, cell division, stem elongation leaf area and increased the leaf thickness, (Abdel -Mawgoud *et al.*, 2005; Mozumder *et al.*,
2005; Sezen *et al.*, 2005; Ibrahim *et al.*, 2010; Abdou *et al.*, 2013; Marzouk *et al.*, 2016).

6-2- Yield components:

Concerning sowing date, data in (Table 8) show that, the highest averages of the estimated yield were detected from sowing in 3rd sowing date (9478 and 9693 kg ha^{-1}) in the two seasons, respectively. Planting in 1st or 2nd sowing date led to decrease the yield by 38% and 10.42%, respectively.

Concerning the irrigation scheduling treatments, the highest averages of pod number $plant^{-1}$, pod weight $plant^{-1}$ (g) and estimated fresh pod yield ha^{-1} (kg) were obtained from irrigation at 0.8 C.P.E (8851 and 9098 kg ha^{-1}) in the two successive seasons, respectively. Irrigation at 1.0 C.P.E. or 0.6 C.P.E. led to decrease the yield in 2014 by 10.74% and 19.5% and in 2015 by 11.74% and 20.15%, respectively.

For the interaction between sowing date and irrigation scheduling the 3rd sowing date and irrigation at 0.8 C.P.E. gave the highest averages in the yield and its components (10196 and 10482 kg ha^{-1}) in the two successive seasons, respectively . On the other hand, the lowest averages of yield and its components were detected from the 1st sowing date and 0.6 C.P.E.

Table (7). Effect of sowing date, irrigation scheduling regime and interaction on some snap bean growth Parameter in 2014 and 2015 seasons.

Treatments		Number of leaves plant^{-1}						Leaf area plant^{-1} (cm)					
Sowing dates	Irrigation	60 DAS		75 DAS		90 DAS		60 DAS		75 DAS		90 DAS	
		2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
S_1 1/8	I_1: (C.P.E.)	40	43	43	44	35	39	2306	2389	2415	2447	1702	1789
	I_2: (C.P.E.)	36	38	39	41	32	35	2111	2180	1913	1946	1336	1405
	I_3: (C.P.E.)	27	28	32	34	24	27	1710	1792	1828	1886	1194	1222
Mean		**34**	**36**	**38**	**40**	**30**	**34**	**2042**	**2120**	**2052**	**2093**	**5411**	**1472**
S_2 16/8	I_1: (C.P.E.)	45	49	56	59	36	39	2710	2821	3015	3082	2421	2471
	I_2: (C.P.E.)	40	43	49	53	34	36	2695	2728	2888	2925	2235	2256
	I_3: (C.P.E.)	30	32	40	43	32	35	2605	2691	2613	2701	1731	1796
Mean		**38**	**41**	**48**	**52**	**34**	**37**	**2670**	**2747**	**2839**	**2903**	**2129**	**2174**
S_3 1/9	I_1: (C.P.E.)	46	49	70	73	48	51	3460	3516	4614	4658	2909	3078
	I_2: (C.P.E.)	42	45	58	60	41	43	3321	3374	3922	3983	2772	2821
	I_3: (C.P.E.)	32	34	54	57	35	37	2919	3031	3780	3862	2611	2680
Mean		**40**	**43**	**61**	**63**	**41**	**44**	**3233**	**3307**	**4105**	**4168**	**2764**	**2860**
Mean of Irrigation	I_1: (C.P.E.)	44	47	56	59	40	43	2825	2909	3348	3396	2344	2446
	I_2: (C.P.E.)	39	42	49	51	36	38	2709	2761	2908	2951	2114	2161
	I_3: (C.P.E.)	30	31	42	45	30	33	2411	2505	2740	2816	1845	1899
L.S.D at 5%	S	2.61	3.30	5.50	3.32	3.00	2.10	160	120	181	125	132	113
	I	3.00	4.20	3.40	4.41	3.20	2.50	119	120	122	130	115	102
	S X I	2.10	2.21	2.89	2.92	2.95	1.52	105	141	210	148	129	110

Table (8). Effect of sowing date, irrigation scheduling regime and interaction on snap bean fresh pods yield and some yield components, 2014 and 2015 seasons.

Treatments		Pod No. plant^{-1}		Pod weight plant^{-1} (g)		Fresh pod yield ha^{-1} (kg)	
Sowing dates	Irrigation	2014	2015	2014	2015	2014	2015
S_1 1/8	I_1: (C.P.E.)	45	48	182	183	5655	5736
	I_2 (C.P.E.)	47	49	227	227	7128	7288
	I_3: (C.P.E.)	42	42	156	157	4950	5010
Mean		**45**	**45**	**188**	**189**	**5911**	**6011**
S_2 16/8	I_1: (C.P.E.)	55	56	263	263	8461	8644
	I_2: (C.P.E.)	59	60	277	278	9230	9525
	I_3: (C.P.E.)	51	52	244	245	7771	7897
Mean		**55**	**56**	**261**	**262**	**8487**	**8689**
S_3 1/9	I_1: (C.P.E.)	64	65	299	299	9584	9710
	I_2: (C.P.E.)	68	69	335	336	10196	10482
	I_3: (C.P.E.)	61	61	268	269	8654	8887
Mean		**64**	**65**	**301**	**301**	**9478**	**9693**
Mean of Irrigation	I_1: (C.P.E.)	54	56	248	248	7900	8030
	I_2: (C.P.E.)	58	59	280	280	8851	9098
	I_3: (C.P.E.)	51	52	223	224	7125	7265
L.S.D at 5%	S	6.1	5.8	31.0	30.4	371	326
	I	2.7	2.6	22.5	24.1	319	310
	S X I	1.1	1.2	14.0	19.7	169	161

B- Aphid population of *A. pisum* :

Data in (Table 9) indicate that, Aphid population ***A. pisum*** during the two seasons are nearly same. Aphid was found at the third week of planting. The average number of Aphid started with a low number, the number increased gradually throughout the subsequent weeks to reach the main peak at the 7th week then the number decreased gradually during the remaining four weeks. The weekly activity curve of Aphid population was nearly similar for the three sowing dates and the three C.P.E. But aphid population was higher during the 1st sowing date than those of the 2nd or the3rd sowing dates and for 1.0 C.P.E, than for 0.8 C.P.E, or 0. 6 C.P.E

These results may be related to the increasing of wet conditions around snap bean plants led to increase the aphid infection. These results are in agreement with those obtained by (Hasan *et al.,* 2009; Abdou *et al.,* 2013)

Statistical analysis proved that the correlation between the population of *A. pisum* and sowing date in the two successive seasons were (r= 0.607 and 0.810, respectively). Similarly, the correlation of *A. pisum* population and irrigation scheduling showed significantly correlation between them (r= 0.966 and 0.955) in 2014 and 2015, respectively) (Table, 10).

Table (9): Effect of sowing date and irrigation scheduling regime on weekly number of pisum aphid (*Acyrthosiphon pisum*) ⁄ 12 plant of-69+-+-*-8* snap bean during 2014 and 2015 seasons.

Weeks	**S_1: 1/8**							**S_2: 16/8**							**S_3: 1/9**						
	I_1 1.0 (C.P.E.)		**I_2 0.8 (C.P.E.)**		**I_3 0.6 (C.P.E.)**			**I_1 1.0 (C.P.E.)**		**I_2 0.8 (C.P.E.)**		**I_3 0.6 (C.P.E.)**			**I_1 1.0 (C.P.E.)**		**I_2 0.8 (C.P.E.)**		**I_3 0.6 (C.P.E.)**		
	2014	**2015**	**2014**	**2015**	**2014**	**2015**		**2014**	**2015**	**2014**	**2015**	**2014**	**2015**		**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	
1/8	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	
8/8	-	-	-	-	-	-		-	-	-	-	-	-		-	-	-	-	-	-	
15/8	4.3	3.8	1.9	2.1	1.2	1.9		-	-	-	-	-	-		-	-	-	-	-	-	
22/8	8.0	7.7	3.5	4.0	3.9	4.5		-	-	-	-	-	-		-	-	-	-	-	-	
29/8	11.2	12.1	4.7	4.9	4.1	4.9		2.5	3.0	1.0	1.4	0.5	0.7		-	-	-	-	-	-	
5/9	16.3	15.6	7.2	8.7	5.3	6.8		3.4	4.1	1.5	1.9	1.7	2.0		-	-	-	-	-	-	
12/9	19.4	20.5	8.1	9.6	6.2	7.2		4.6	5.5	2.1	2.7	1.8	2.3		1.8	2.3	0.7	0.9	0.4	0.7	
19/9	22.3	25.7	10.0	12.1	8.4	9.1		5.8	7.0	3.2	4.0	2.4	2.9		2.7	3.2	1.2	1.6	0.9	1.5	
26/9	**28.2**	**30.5**	**13.3**	**13.5**	**10.8**	**12.2**		7.8	9.5	3.7	4.5	2.7	3.5		3.4	3.9	1.6	2.1	1.3	2.0	
3/10	24.4	23.7	11.1	10.7	6.4	8.4		8.4	9.9	4.4	5.7	3.6	4.7		4.6	5.5	2.4	2.8	1.7	2.2	
10/10	16.7	15.9	7.8	8.9	3.5	4.2		**11.7**	**14.1**	**6.1**	**7.4**	**4.6**	**5.8**		6.6	8.1	2.9	3.3	2.1	2.8	
17/10	11.3	12.1	7.4	5.1	4.1	3.5		7.1	8.5	5.2	6.4	2.8	3.4		8.2	8.6	3.4	3.9	2.6	3.1	
24/10	7.9	6.8	3.3	3.6	1.6	2.0		5.6	6.8	3.8	4.5	1.4	1.9		**9.8**	**11.2**	**4.7**	**6.3**	**3.5**	**4.6**	
31/10	16.1	15.4	7.0	6.4	2.3	2.5		4.2	4.9	2.5	3.0	1.8	2.2		6.5	7.3	4.0	4.4	2.2	3.2	
7/11	-	-	-	-	-			3.5	4.0	1.9	2.4	0.7	0.9		4.2	3.1	3.1	2.7	1.6	2.4	
14/11	-	-	-	-	-			2.7	3.2	3.2	4.0	1.1	1.6		3.3	2.4	2.2	2.0	1.0	1.7	
21/11	-	-	-	-	-			-	-	-	-	-	-		2.7	2.0	1.6	1.4	0.6	0.5	
28/11	-	-	-	-	-			-	-	-	-	-	-		1.9	1.7	2.4	1.9	0.8	1.0	
5/12	-	-	-	-	-			-	-	-	-	-	-		-	-	-	-	-	-	
Over all	15.0	15.8	7.1	7.5	4.8	5.6	**9.3**	5.6	6.7	3.2	4.0	2.1	2.7	**4.0**	4.6	4.9	2.5	2.8	1.6	2.1	**3.1**

Table 10: Correlation coefficient (r) and linear regression parameters (Y = a + bx) for the relationships of pisum aphid *(Acyrthosiphon pisum)* population and both sowing dates and irrigation scheduling regimes in 2014 and 2015 seasons.

	Linear regression parameters	**2014**	**2015**
Sowing dates	r	0.607**	0.810**
	a	- 1.188	- 1.238
	b	11.108	11.981
irrigation Scheduling regimes	r	0.966***	0.955***
	a	- 2.80	- 2.82
	b	10.77	11.41

B-1-Relationship between Aphid population *A. pisum* and snap bean yield:

The presented data in (Table, 11) illustrate that, in 2014 and 2015 seasons the correlation coefficient between (*A. pisum*) population and snap bean fresh pod *yield* were (r= - 0.590 and -0.607, respectively). Results indicate that the increasing of Aphid population led to significantly decrease in fresh pod yield (R^2) in 2014 by 35% and in 2015 season by 37%. These results may be due to virus transmission which causing symptoms, including growth retardation, stunting, distortion of stems, leaves and abort flowers, drop newly buds and plants may collapse, (Bakhetia *et al.*, 1987; El-Defrawi, 1987 ; El-Defrawi *et al.*, 1994; El-Defrawi *et al.*, 2000; Abdou *et al.*, 2013).

, the highest average of net income were achieved by planting snap bean in the 3rd date and irrigation at 0.8 C.P.E. Conversely, planting snap bean in the 1st date and irrigation at 0.6 C.P.E. gave the lowest average of net income.

Table 11: Correlation coefficient (r) and linear regression parameters (Y = a + bx) for the relationship of snap bean fresh pod yield (kg ha^{-1}) and pisum aphid (*A. pisum*) population in 2014 and 2015 seasons.

	Linear Regression parameters	2014	2015
Aphid population	**r***	- 0.590	- 0.607
	a	20.60	19.774
	b	- 3.654	- 3.818

C- Economic return.

It is clear from data in (Table, 12) that, highest total income (28586L.E. ha^{-1}) were obtained by planting snap bean crop in the 3rd sowing date but planting snap bean in 1st date or 2nd date led to decrease the net income by 56.5% and 23.8%, respectively. Furthermore, the increment of total farm net income was detected from irrigation at 0.8 C.P.E. by average (24865L.E. ha^{-1}) compared with irrigation at 1.0 or 0.6 C.P.E.

Table (12). Economic return (L.E.* ha^{-1}) of snap bean production under sowing dates and irrigation scheduling treatments, combined over two seasons.

Sowing date	**parameters**		**Cumulative Pan Evaporation (C.P.E.)**			**Average of net income (L.E.* ha^{-1})**
			1.0	0.8	0.6	
S_1 1st August	Total income	Local market	6977	8830	6101	
		Export market	17428	22056	15239	**12444**
	Variable Costs		13300	13100	12900	
	Net income		**11105**	**17786**	**8440**	
S_2 16th August	Total income	Local market	6735	7385	6169	
		Export market	27796	30477	25461	**21774**
	Variable Costs		13100	12900	12700	
	Net income		**21431**	**24962**	**18930**	
S_3 1st September	Total income	Local market	3647	3908	3315	
		Export market	38106	40839	34643	**28586**
	Variable Costs		13100	12900	12700	
	Net income		**28653**	**31847**	**25258**	
Average of net income (L.E.* ha^{-1})			20396	24865	17543	

*L.E. (Egyptian pound).

CONCLUSION

Based on the study, it can be concluded that, it is advisable plant snap bean in the 1st of September and irrigate at 0.8 C.P.E. to achieve higher fresh pods yield with high water productivity and low density of Aphid population *A. pisum***.**

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تأثير معاملات مواعيد الزراعه وجدولة الري علي بعض العلاقات المائيه والانتاجيه في الفاصوليا وتعداد المن (من البسله).

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تعد الفاصوليا واحدة من أهم محاصيل الخضر التصديرية في مصر. ويلعب كلا من مواعيد الزراعه ونظام الري دورا حيويا في انتاجية المحصول. وفيما يتعلق بهذا، تم اجراء تجربتين حقليتين في قرية المقراني – مركز يوسف الصديق – محافظة الفيوم – مصر خلال الموسم النيلي في عامين ٢٠١٤ و ٢٠١٥ لدراسة تأثير مواعيد الزراعة (١ أغسطس ، ١٦ أغسطس ، ١ سبتمبر) وجدولة الري باستخدام البخر التراكمي من وعاء البخر القياسي (١,٠ ، ٠,٨ ، ٠,٦ بخر وعاء تراكمي) علي بعض المعاملات المائية وقياسات النمو الخضري ومحصول القرون الاخضر ومكوناته وتعداد حشرة المن وكذلك الدخل المزرعي الصافي. وقد أظهرت النتائج أن الجمع بين موعد الزراعه الثالث (١ سبتمبر) والري عند ٠,٨ من بخر الوعاء التراكمي (تقريبا من ١٨ – ٢١ فترة الري) قد أعطي أعلي متوسطات لكفاءة استهلاك المياه (WUE) وأقل تعداد لحشرات من البسلة بمتوسط ٣.١ فرد مقارنه بالميعادين الأخرين الأول والثاني و كذلك لمحصول القرون الاخضر (١٠١٩٦ ، ١٠٤٨٢ كجم للهكتار في موسمي ٢٠١٤ و ٢٠١٥ علي التوالي) وكذلك حقق أعلي دخل مزرعي صافي (٢٨٦٥٣ جنيه مصري للهكتار)٠