Egypt. J. Chem. **Vo. l63**, No. 12 pp. 5103 - 5116 (2020)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Impact of Drip and Gated Pipe Irrigation Systems, Irrigation Intervals on Yield, Productivity of Irrigation Water and Quality of Two Common Bean (*Phaseolus vulgaris* L) Cultivars in Heavy Clay Soil

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Abstract

Two field experiments were conducted during the two successive winter growing seasons of 2018/2019 and 2019/2020 at Kafer El-Khawazim, Talkha district, Dakahlia Governorate, Egypt to study the effect of irrigation systems (drip and gated pipe) and irrigation intervals (5, 7 and 9 days) on some evaluation criteria were studied to determine the best conditions to increase yield, productivity of irrigation water and quality of beans under heavy clay soil conditions. Data indicated that the highest value for water applied recorded under gated pipe irrigation and interval 9 days. For concerning irrigation application efficiency for drip irrigation were occurred with 5 days interval, while the lowest value was recorded under gated pipe system and irrigation interval 9 days. The highest values for vegetative growth, yield components, seed yield, productivity of irrigation water and quality traits of common beanrecorded under drip system comparing with gated pipe and for irrigation interval, the highest values recorded with 7days, while they decreased slightly at 5 days and then decreased at 9days. The best value for the vegetative growth, yield components, seed yield, productivity of irrigation water and quality traits of common beanwere occurred with recombinant inbred line "RIL 115" compared to common bean (Navv bean). Finally, using drip irrigation system and irrigation interval at 7 days and selection RIL 115 are highly recommended to increase and improve the yield, productivity of irrigation water and quality traits of common bean under clay soils conditions.

"Keywords: Common bean; Drip irrigation; Gated pipe; irrigation intervals; Water productivity; Yield."

1. Introduction

The global water crisis has drawn attention around the world to the urgent need to achieve more efficient use of water resources, particularly in agriculture, to increase crop production and achieve global food security. In arid and semi-arid regions with large population densities and freshwater, there is great pressure on the agricultural sector to reduce the limited consumption of fresh water for irrigation [4, 5, 27]. Water scarcity is one of the serious problems facing crop production in arid Egypt, and it is important to reduce irrigation water consumption by developing innovative technologies [10, 22] In Egypt, the agricultural sector faces a serious challenge to increase food production with less water, which can be achieved by increasing crop productivity of irrigation water [8, 12] . Increasing the productivity of irrigation water of crops is an important goal of increasing demand of the increase in high population growth [2, 13, 19, 33]. Water resources in Egypt suffer from severe water scarcity, which increases with increasing population growth. Increasing competition for scarce water resources is

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Received date: 07 November 2020, Revise Date: 18 November 2020, Accept Date: 25 November 2020
DOI: 10.21608/EJCHEM.2020.49013.3001

competing with new irrigation techniques to increase water productivity, improve crop productivity and quality characteristics [9, 31]. Egypt suffers from water shortages in recent years, and in addition to climate change, there is frequent water shortage. Water resources in Egypt are still limited compared to the increasing demand for water. Therefore, modification of water management in both new and old lands is a major component of agricultural development.

Productivity of irrigation water of crops in Egypt is critical, given the limited water resources, rainfall, and very limited and low rainfall factors [3, 27]. The application of modern irrigation methods and associated technologies are important concepts that must be undertaken in arid regions as in Egypt to provide part of the irrigation water [4, 7, 20]. Irrigated agriculture is the main contributor to agricultural production and faces the challenge of improving irrigation water use efficiency while ensuring food security [30]. Global water consumption for irrigation has seen steady growth over the past 50 years, and today it accounts for 70% of total water consumption [39], in Egypt Agriculture uses about 85% of the total renewable water supply. The biggest challenge facing the agricultural sector is to produce more food with less water, which can be accomplished by increasing crop productivity of irrigation water (CWP) [42]. The shortage of fresh water has increased in high altitude locations around the world. According to projections by the Food and Agriculture Organization and the International Food Policy Research Institute, global demand for water resources will increase in accordance with the usual development scenario by 2030 twice. The improved irrigation systems on the farm are an important part of the development of Egyptian agriculture. The main reason for such a large water demand is the high above ground mass production of leaves with a high transpiration factor. In the studies of [34, 41], as the amount of irrigation increased, the yield characteristics increased significantly. On the other hand, although irrigation usually increases the yield, it often results in a decrease in the chemical composition of the fruit.

The global use of surface and underground drip irrigation systems has increased significantly in recent decades. The main advantage of these systems is the ability to increase crop yields while reducing the use of water and added fertilizers, and hence farming costs. The pattern of soil moisture distribution around the water source depends on (1) the total volume of applied water; (2) transmitter flow rate, source configuration (surface, subsurface, point or line), and initial-boundary conditions; (3) the physical properties of soil and its spatial distribution; (4) plant root activity and (5) irrigation management. [21] also determined that surface and underground drip irrigation systems can increase water use efficiency but only if the system is designed to meet soil and plant conditions. Drip irrigation can achieve high water efficiency, but only when the system is properly designed, with adequate emission spacing, flow rate, and installation depth [35].

Nowadays, the drip irrigation system, which supplies water directly to the plant root zone from the plants, is one of the most economically effective solutions for supplying the plants with water. Moreover, with drip irrigation, the aboveground parts remain dry, so they are less susceptible to bacterial or fungal infections.

The bean (*Phaseolus vulgaris,* L) is one of the most important vegetable crops in the world as a commercial crop for green fields and greenhouses. Fava beans are among the most important leguminous grains cultivated for human consumption, with an area of 23 million hectares. It has grown around the world [14] approx. 12 million metric tons (MMT) are produced annually, of which approximately. 8 MMT from Latin America and Africa [24]. Beans are considered one of the most important non-traditional crops, as well as promising agricultural crops that can contribute to achieving the objectives of the Egyptian agricultural policy in terms of global demand and the possibility of cultivating them throughout the year through three seasons. [32].

The purpose of this study was to evaluate the performance of two irrigation systems gated pipe as modified surface and drip as pressurized irrigation and three intervals for improving common bean yield, productivity of irrigation water and quality in clay heavy soils in Egypt.

2. MATERIAL AND METHODS

Experimental site: The field experiment was conducted during the two successive growing seasons of 2018/19 and 2019/20 at Kafer El-Khawazim, Talkha district, Dakahlia Governorate, Egypt, the experimental area has an arid climate with mild winter and hot dry summer.

Physical and chemical properties of the soil and irrigation water: Irrigation water was supplied by an open irrigation canal. The irrigation water had a pH of 7.6 and an electrical conductivity of 0.48 dS m^{-1}. The main chemical and physical properties of the soil were determined in site and in the laboratory at the beginning of the field trial (table 1). The experimental soil was clay in texture with organic matter of 1.85 %, pH 7.7, total N 0.078 % and available P 14.8 ppm.

Table (1): Some characteristics of the soil of the experiment.

Parameter	Soil depth, cm		
Soil layer (cm)	0–20	20-40	40-60
Texture	Clayey	Clayey	Clayey
Sand (%)	1.55	1.65	1.78
Fine sand (%)	15.30	15.65	16.61
Silt (%)	19.00	18.78	18.55
Clay (%)	64.15	63.92	63.06
Bulk density (t m^{-3})	1.27	1.29	1.35
EC (dS m^{-1})	2.4	2.6	2.5
pH (1:2.5) soil water suspension	7.7	8.2	8.5

Experimental design: The experiment was established with a split- split plot design with three replications. The main plots included three irrigation intervals (5, 7 and 9 days), the sub-main plot was for two irrigation systems (drip and gated pipe) and the sub-sub plot was for two common beans cultivars **(**Recombinant inbred line "RIL 115" which was evaluated and compared to Navv common bean as a local cultivar) which commonly cultivated in the studied area. The normal agricultural practices of growing common bean plants were followed. Each plot area was 42 m^2 (2.1 m width * 20 m length). The 36 plots with total area of the 36 plots was 1512 m^2 (36 plot * 42 m^2) without buffer zone left between each two plots

Irrigation systems: The main components of surface drip irrigation network were as follows: Control head is located at the source of the water supply, it consists of centrifugal pump (80 m^3/h discharge and 50 m lift), media filter 48" diameter (two tanks), back flow prevention device, pressure regulator, control valve, pressure gauges, flow meter, and chemical injection equipment. 110 mm diameter PVC pipes main lines were used to convey the water from the water source to the main control points in the field. 75 mm diameter PVC pipes sub-main lines were used to convey the water from the main line to the manifold line through a control unit consists of screen filter, gate valves and pressure gauges. Drip irrigation: Manifold lines were 32 mm diameter P.E. pipe used to supply laterals (drip lines) with the irrigation water. 16 mm diameter P.E. laterals drip built-in (4.0 L/h / 0.4 m spacing). Laterals spacing were 0.70 m. Gated pipes: The slide gate space was 75 cm, the opening diameter was 32 mm with 4 m^3/h discharge, and this gate fixed on PVC pipe of 160 mm diameter.

Common bean cultivars: Recombinant inbred line "RIL 115" was evaluated and compared to Navv common bean as a control cultivar. The seeds of RIL 115 were provided by Institut National de la Recherche Agronomique, Ecologie Fonctionnelle & Biogeochimie des Sols, Montpellier Cedex, France. The beans seeds were sown on November 15, 2018 for the first season, and on November 20, 2019 in the second season.

Irrigation requirements: Irrigation water requirements of common bean were calculated according to the following equations 1, 2 and 3 that presented in Table (2).

Table (2): Irrigation water requirements equation of common bean for two irrigation systems

	Drip Irrigation (DI)	Gated Pipes (GP)
Equation	$IRg = [(ET_o \times Kc \times Kr) / I_E] + LR$ …….(1)	$IRg = [(ET_o \times Kc) / I_E] + LR$ …..(2)
	Ei = 90%	Ei = 55%

Where: IRg: Gross irrigation requirements, mm/day; ET_O: Reference evapotranspiration, mm/day, Kc: Crop factor of common bean (FAO-56); Kr: Ground cover reduction factor and I_E: Irrigation efficiency, %, LR: Amount of water required for the leaching of salts, mm and Ei: irrigation efficiency

Water application efficiency: Water application efficiency (AE_{IW}) is the actual storage of water in the root zone to the water applied to the field. AE_{IW} was calculated according to [28] using equation 3:

$$AE_{IW} = Ds/Da \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where AE_{IW} is the application efficiency of irrigation water, %, Ds is the depth of stored water in the root zone, cm and Da is the depth of applied water (mm), according to [28] by equation 4.

$$Ds = (\theta1 - \theta2) * d * \rho \ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where:, d is the soil layer depth (mm), θ1 is the average of soil moisture content after irrigation (g/g) in the root zone, θ2 is the average of soil moisture content before irrigation (g/g) in the root zone, ρ = bulk density of soil (g/cm^3).

Soil moisture percentage was determined (on Weight basis) before and after each irrigation as well as at harvesting. Soil samples for moisture determination were taken from successive soil layers each 20 cm depth for a total depth of 60 cm, by auger. The soil samples were weighted after sampling immediately and dried in an electric oven to a constant weight at 105°c. Percentage of soil moisture content at the three soil depths (0-20, 20-40, 40-60) was calculated on an oven-dry basis.

Vegetative growth: After 60 days from planting, five plants from each sub-sub plot were randomly taken for studying the vegetative growth parameters of common bean plant, i.e., number of leaves, plant height, shoot dry weight and leaf area.

Seed yield: At harvesting, biological yield, some of yield components and seed yield of common bean for each plot were harvested and total seeds yield were determined.

Productivity of Irrigation Water: *"*PIW_{Bean} *":* The productivity of irrigation water of common bean was calculated according to [29] as follows by equation 5:

$$PIW_{Bean} = Ey/Ir \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where PIW_{Bean} is productivity of irrigation water of common bean ($kg_{Bean}\ m^{-3}_{water}$), Ey is the economical yield (kg_{Bean} /fed); Ir is the amount of applied irrigation water (m^3_{water}/fed.).

Quality traits: Some of quality traits of common bean such as, fruit length, weight and diameter were determined.

Statistical analysis: The data obtained were subjected to analysis of variance (ANOVA) according to [26], using Co-Stat Software Program Version 6.303 (2004) and LSD at 0.05 level of significance was used for the comparison between means.

3. RESULTS

3.1. Applied irrigation water

Data presented in Figure (1) revealed that the mean values of applied irrigation water for crop, water tended to was less for drip irrigation system compared with gated pipe system. The reduction in applied water amounted to 31.41 and 29.34 % under drip irrigation less than gated pipe irrigation system in the first and second seasons, respectively.

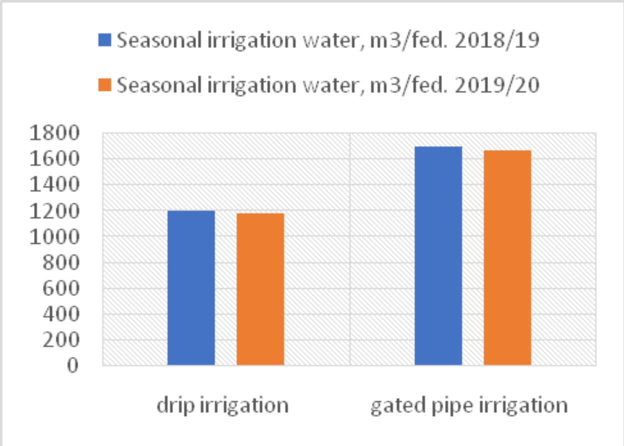

Figure (1) Mean seasonal applied irrigation waterunder two irrigation systems in the two growing seasons

3.2. Water application efficiency

The presented results in Figure (2) came to conform the highest estimation of water application efficiency values was found when using drip irrigation system compared to the gated pipe and this resulted from the minimum loss of irrigation water under drip irrigation where the irrigation source is next to the plant while in the other systems was more water by deep percolation. Water application efficiency values decreased under studied systems by increasing the periods between irrigations. The total amount of added irrigation water tothe soil after 5 days was higher thantotal amount of added other periods but it was divided, which helps to retain the roots. As a result,the total amount of added irrigation water whether after 7 days or 9 days is higher than the ability of the clay soil to retain and deep percolation occur outside the root zone. The highest value for the water application efficiency for drip irrigation occurred with 5 days as the period between irrigations, while the lowest value was for gated pipe irrigation with adding irrigation water every 9 days.

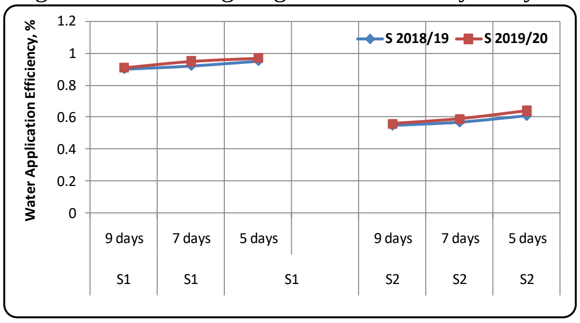

Figure (2): Effect of irrigation system and irrigation interval on the water application efficiency (I.I.: Irrigation interval; d: days; I.S.: Irrigation system; S1: Drip irrigation S2: Gated pipe ; D.W.: Dry weight)

3.3. Vegetative growth

The lowest values for all vegetative traits (number of leaves/plants, plant height, shoot dry weight/plant, leaf area/plant and SPAD value) were observed 9 days irrigation interval, while they increased at 7 days expect leaf area which was the highest when the irrigation period was at 5day interval (Tables 3 and 4). The values for the aforementioned vegetative traits were increased under drip irrigation system compared to gated pipe irrigation. The better values for all above mentioned vegetative traits were occurred with recombinant inbred line "RIL 115" compared to Navv common bean cultivar. The highest values for above mentioned vegetative traits expect leaf area, were at irrigation interval of 7 days plus drip irrigation system for the inbred line RIL 115while the lowest values for all tested treats were at 9 day irrigation interval plus gated pipe for Navv cultivar.

Table (3): Effect of irrigation system and interval on some vegetative growth characteristics of the common bean at 60 day of planting agefor 2018/2019 season and 2019/2020 season

I.I.	I. S	N. of Leaves/ plant V1	V2	Mean	Plant height (cm) V1	V2	Mean	Shoot D.W. (g) V1	V2	Mean
				2018/19 season						
9d	S1	8.2	7.9	8.1	27.1	26.7	26.9	11.7	10.0	10.9
	S2	7.5	7.3	7.4	27.2	25.5	26.4	10.9	9.7	10.3
7d	S1	10.3	9.7	10.0	30.6	29.0	29.8	14.0	12.9	13.5
	S2	9.1	8.5	8.8	28.6	27.1	27.9	12.7	11.7	12.2
5d	S1	9.6	9.2	9.4	28.1	28.0	28.1	13.5	11.7	12.6
	S2	8.1	7.9	8.0	27.5	26.2	26.9	11.1	11.1	11.1
Mean		8.8	8.4		28.2	27.1		12.3	11.2	
Mean for I.S	S1		9.2			28.3			12.3	
	S2		8.1			27.1			11.2	
Mean for I. I.	9 d		7.8			26.7			10.6	
	7 d		9.4			28.9			12.9	
	5 d		8.7			27.5			11.9	
				LSD 5%						
I.S.			0.3			0.3			0.4	
Var.			0.3			0.6			0.2	
I.I.			0.4			1.1			0.4	
I.SXVar.			N.S.			N.S.			N.S.	
I.S X I.I.			N.S			0.6			N.S.	
Var X I.I.			N.S			N.S.			N.S.	
I.S X Var X I.I.			N.S			0.8			N.S.	
				2019/20 season						
9d	S1	11.2	8.7	8.2	8.5	29.0	28.0	28.5	13.2	11.2
	S2	10.2	8.1	8.3	8.2	28.7	27.2	28.0	11.8	10.2
7d	S1	12.9	10.7	9.5	10.1	31.7	30.1	30.9	15.7	12.9
	S2	11.9	9.5	9.5	9.5	30.5	28.2	29.4	13.5	11.9
5d	S1	12.5	9.9	10.5	10.2	31.2	29.3	30.3	13.9	12.5

	S2	12.1	9.2	9.1	9.2	29.0	28.9	29.0	13.1	12.1
Mean		11.8	9.4	9.2		30.0	28.6		13.5	11.8
Mean for I.S	S1		9.6			29.9			13.2	
	S2		9.0			28.8			12.1	
Mean for I. I.	9 d		8.4			28.3			11.6	
	7 d		9.8			30.2			13.5	
	5 d		9.7			29.7			12.9	
LSD 5%										
I.S.			0.3			0.5			0.4	
Var.			N.S.			0.4			0.6	
I.I.			0.9			0.3			0.8	
I.SXVar.			N.S			N.S.			N.S.	
I.S X I.I.			N.s			N.S.			N.S.	
Var X I.I.			N.s			N.S.			N.S.	
I.S X Var X I.I.			0.6			N.S.			N.S.	

I.I.: Irrigation interval; d: days; I.S.: Irrigation system; Var.: Variety V1: Recombinant inbred line "RIL 115" ; V2: Common bean (Navv bean) (control) ; S1: Drip irrigation S2: Gated pipe ; D.W.: Dry weight

Table (4): Effect of irrigation system and interval on the SPAD value of common bean for seasons 2018/2019 and 2019/2020

I.I.	I. S	SPAD value		Mean	Leaf area (cm^2)		Mean
		V1	V2		V1	V2	
Season 2018/19							
9d	S1	41.2	40.2	40.7	750	707	729
	S2	40.3	39.7	40.0	710	649	680
7d	S1	42.9	41.5	42.2	830	789	810
	S2	41.7	41.2	41.5	780	750	765
5d	S1	42.7	41.1	41.9	890	820	855
	S2	41.1	40.7	40.9	830	810	820
Mean		41.7	40.7		798	754	
Mean for I.S	S1		41.6			798	
	S2		40.8			755	
Mean for I. I.	9 d		40.4			705	
	7 d		41.9			788	
	5 d		41.4			838	
LSD 5%							
I.S.			0.3			10	
Var.			0.4			25	
I.I.			0.6			11	
I.SXVar.			0.5			N.S.	
I.S X I.I.			N.S			N.S.	
Var X I.I.			N.S			N.S.	
I.S X Var X I.I.			N.S			25	
Season 2019/20							
9d	S1	41.3	40.8	41.1	811	750	781
	S2	41.0	40.0	40.5	750	730	740
7d	S1	42.9	42.3	42.6	922	860	891
	S2	42.3	41.4	41.9	830	790	810
5d	S1	42.6	41.5	42.1	921	901	911
	S2	42.2	41.5	41.9	870	831	851
Mean		42.1	41.3		851	810	
Mean for IS	S1		41.9			861	
	S2		41.4			800	
Mean for I. I.	9d		40.8			761	
	7d		42.3			851	
	5d		42.0			881	

LSD 5%		
I.S.	0.2	15
Var.	0.3	22
I.I.	0.3	25
I.SXVar.	N.S	N.S.
I.S X I.I.	N.S	N.S.
Var X I.I.	N.S	N.S.
I.S X Var X I.I.	N.S	N.S.

I.I.: Irrigation interval; d: days; I.S.: Irrigation system; Var.: Variety V1: Recombinant inbred line "RIL 115" ; V2: Common bean (Navv bean) (control) ; S1: Drip irrigation S2: Gated pipe ; The SPAD meter measures the difference between the transmittance of a red (650 nm) and an infrared (940 nm) light through the leaf, generating a three-digit SPAD value [40]

3.4. Yield components

The lowest mean values for the studied yield components of common bean (number of pods/plant, number of seeds/pod and 100 seed weight) were at 9 days irrigation interval compared to those recorded with 7 or 5 day intervals (Table 5). The values for all yield components of common bean (number of pods/plant, number of seeds/pod and 100 seed weight) were higher under drip irrigation system compared to those under gated pipe irrigation. The better values for all yield components of common bean (number of pods/plant, number of seeds/pod and 100 seed weight) were occurred with recombinant inbred line "RIL 115" compared to Navv common bean. The highest values for the studied yield components of common bean (number of pods/plant, number of seeds/pod and 100 seed weight) were recorded at 7 days irrigation interval and drip irrigation using RIL 115 inbred whereas the lowest values for all recorded characters were by using 9 days and gated pipe for Navv cultivar.

Table (5): Effect of irrigation system and interval on the yield components of common bean for 2018/2019 and 2019/2020 seasons.

I.I.	I. S	N. of pods/plant		Mean	No of seeds/pod		Mean	100 seed weight (g)		Mean
		V1	V2		V1	V2		V1	V2	
2018/19 season										
9d	S1	28.0	20.3	24.2	8.4	7.8	8.1	51.2	50.0	50.6
	S2	19.3	19.3	19.3	7.9	7.0	7.5	50.1	49.5	49.8
7d	S1	27.0	21.3	24.2	9.9	8.5	9.2	54.5	51.5	53.0
	S2	24.7	17.7	21.2	8.5	7.8	8.2	53.0	51.4	52.5
5d	S1	23.0	25.7	24.4	9.6	8.4	9.0	54.2	52.9	53.6
	S2	20.0	20.7	20.4	8.6	8.2	8.4	52.7	51.0	51.9
Mean		23.7	21.2		8.8	8.0		52.6	51.1	
Mean for I.S	S1		24.3			8.8			52.4	
	S2		20.3			8.0			51.4	
Mean for I. I.	9 d		21.8			7.8			50.2	
	7 d		22.7			8.7			52.8	
	5 d		22.4			8.7			52.8	
LSD 5%										
I.S.			2.5			0.2			0.8	
Var.			2.3			0.2			0.4	
I.I.			N.S			0.4			0.9	
I.SXVar.			3.9			N.S			N.S	
I.S X I.I.			N.S			N.S			N.S	
Var X I.I.			N.S			N.S			0.7	
I.S X Var X I.I.			N.S			N.S			N.S	
2019/20 season										
9d	S1	22	27	24.5	8.7	7.8	8.3	51.9	50.4	51.2
	S2	25	20	22.5	8.2	7.4	7.8	51.4	50.6	51.0
7d	S1	33	32	32.5	10.2	8.7	9.5	54.9	52.0	53.5
	S2	27	39	33.0	9.4	8.1	8.8	53.6	51.0	52.3
5d	S1	22	25	23.5	9.7	8.6	9.2	54.2	51.9	53.1

	S2	21	26	23.5	9.1	8.2	8.7	53.0	51.1	52.1
Mean		25.0	28.2		9.2	8.1		53.2	51.2	
Mean for I.S	S1		26.8			9.0			52.6	
	S2		26.3			8.4			51.8	
Mean for I. I.	9 d		23.5			8.1			51.1	
	7 d		32.8			9.2			52.9	
	5 d		23.5			9.0			52.6	
LSD 5%										
I.S.			2.5			0.4			0.5	
Var.			N.S			0.3			0.6	
I.I.			3.6			0.3			1.9	
I.SXVar.			3.9			N.S			N.S	
I.S X I.I.			N.S			N.S			N.S	
Var X I.I.			N.S			N.S			N.S	
I.S X Var X I.I.			5.6			N.S			N.S	

I.I.: Irrigation interval; d: days; I.S.: Irrigation system; Var.: Variety V1: Recombinant inbred line "RIL 115" ; V2: Common bean (Navv bean) (control) ; S1: Drip irrigation S2: Gated pipe

3.5. Seed yield

The lowest value for the seed yield and biological yield of common bean were with irrigation interval at 9 days, compared to those irrigated after 5 or 7 days in both seasons (Table 6). The value for the seed yield of common bean was increased under drip irrigation system compared to gated pipe irrigation. The better value for the seed yield of common beanwas occurred with recombinant inbred line "RIL 115" compared to control (Navv bean) cultivar. The highest value for the seed yield of common bean was with the irrigation interval of 7 days combined with drip irrigation system for the inbred line RIL 115 where of the lowest values were recorded with at 9 day interval combined with gated pipe irrigation for Navv common bean cultivar. Moreover, the differences were insignificants for seed yield in two seasons.

Table (6): Effect of irrigation system and interval on the seed yield of common bean for seasons 2018/2019 and 2019/2020

I.I.	I. S	Seed yield/ plant (g) V1	Seed yield/ plant (g) V2	Mean	Seed yield (ton/fed.) V1	Seed yield (ton/fed.) V2	Mean	Bio. yield/plant (g) V1	Bio. yield/plant (g) V2	Mean
Season 2018/19										
9d	S1	31.7	29.8	30.8	1.20	0.95	1.08	184.3	129.7	157.0
	S2	29.8	28.3	29.1	1.15	0.92	1.04	132.0	120.0	126.0
7d	S1	33.5	30.7	32.1	1.46	1.11	1.29	200.0	146.7	173.4
	S2	31.0	29.2	30.1	1.25	0.99	1.12	184.3	150.3	167.3
5d	S1	33.0	31.0	32.0	1.33	1.12	1.23	190.0	147.2	168.9
	S2	30.7	29.0	29.9	1.24	1.15	1.20	127.7	150.7	139.2
Mean		31.6	29.7		1.27	1.04		169.7	124.1	
Mean for I.S	S1		31.6			1.20			166.4	
	S2		29.7			1.12			144.2	
Mean for I. I.	9 d		30.0			1.06			141.5	
	7 d		31.1			1.22			170.4	
	5 d		31.0			1.21			154.1	
LSD 5%										
I.S.			0.8			0.06			2.2	
Var.			0.6			0.06			2.9	
I.I.			0.8			N.S			3.5	
I.SXVar.			N.S			N.S			5.0	
I.S X I.I.			N.S			N.S			N.S	
Var X I.I.			N.S			N.S			5.0	
I.S X Var X I.I.			N.S			N.S			7.1	
Season 2019/20										
9d	S1	32.0	30.5	31.3	1.29	1.11	1.20	139	163	151.0

	S2	30.6	29.9	30.3	1.25	0.98	1.12	155	113	134.0
7d	S1	33.7	31.3	32.5	1.49	1.25	1.32	145	248	196.5
	S2	31.9	30.7	31.3	1.33	1.16	1.25	189	137	163.0
5d	S1	33.5	31.1	32.3	1.47	1.31	1.39	139	198	168.5
	S2	31.8	30.9	31.4	1.31	1.14	1.23	93	163	151.0
Mean		32.3	30.9		1.36	1.16		219	188	
Mean for I.S	S1		32.0			1.30			172.0	
	S2		31.0			1.22			149.3	
Mean for I. I.	9 d		30.8			1.16			142.5	
	7 d		31.9			1.29			179.8	
	5 d		31.9			1.31			159.8	
LSD 5%										
I.S.			0.5			0.04			3.0	
Var.			0.4			0.04			2.9	
I.I.			0.4			0.11			3.5	
I.SXVar.			0.6			N.S			5.1	
I.S X I.I.			N.S			N.S			4.6	
Var X I.I.			N.S			N.S			5.1	
I.S X Var X I.I.			N.S			N.S			21.5	

I.I.: Irrigation interval; d: days; I.S.: Irrigation system; Var.: Variety V1: Recombinant inbred line "RIL 115" ; V2: Common bean (Navv bean) (control) ; S1: Drip irrigation S2: Gated pipe ; Bio. Yield: Biological yield

3.6. Productivity of irrigation water

Values of productivity of irrigation water of common bean were increased under drip irrigation system compared to that under gated pipe irrigation. The value of the productivity of irrigation water of common bean was higher with recombinant inbred line "RIL 115" compared to that with Navv common bean cultivar. The highest value for the productivity of irrigation water of common bean was found at 7 days irrigation interval under drip irrigation for the inbred line RIL 115.

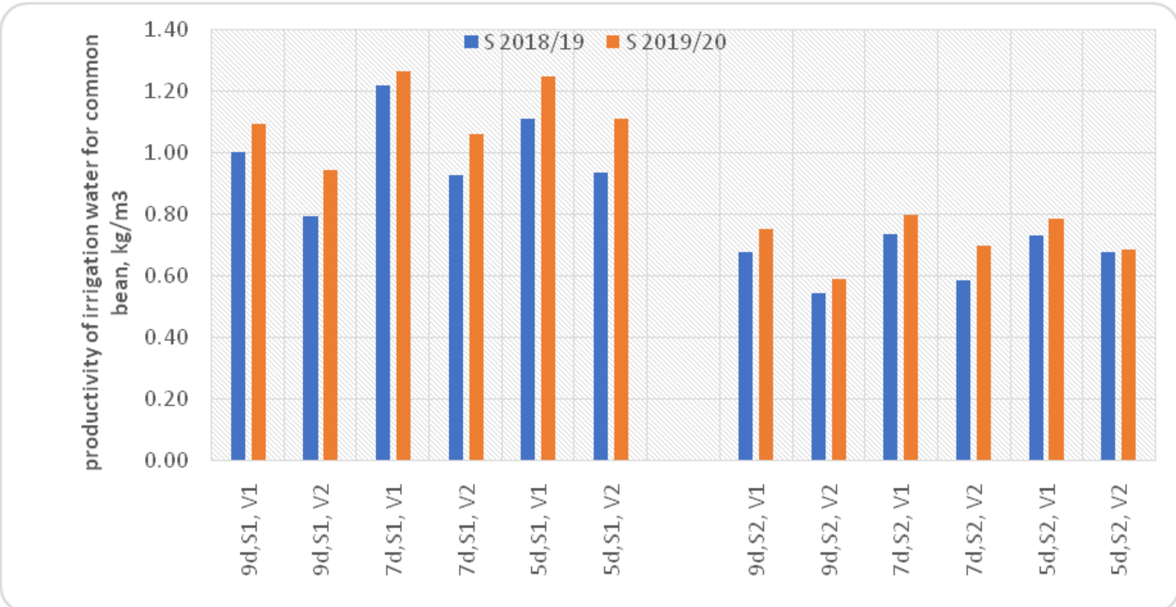

Figure (4): Effect of irrigation system, interval and cultivars on the productivity of irrigation water of common bean (I.I.: Irrigation interval; d: days; I.S.: Irrigation system; V1: Recombinant inbred line "RIL 115" ; V2: Common bean (Navv bean) (control) ; S1: Drip irrigation S2: Gated pipe ; D.W.: Dry weight)

3.7. Quality traits of seeds

The lowest values for the investigated quality traits of common bean (protein % and carbohydrate %) were at 9 days irrigation interval compared to those irrigated at 5 or 7 days (Table 7). These characters were increased under drip irrigation system compared to gated pipe irrigation. In addition, the seeds of recombinant inbred line "RIL 115" had higher values of these traits compared to those of Navv bean cultivar. The highest values for the tested quality traits of common beanwere recorded using 5 or 7 day irrigation interval combined with drip irrigation for the inbred line RIL 115 while the lowest values were noticed by 9 day irrigation interval with gated pipe for Navv bean cultivar.

Table (7): Effect of irrigation system and interval on some quality traits of common bean for seasons 2018/2019 and 2019/2020

I.I.	I. S	Protein (%) V1	Protein (%) V2	Mean	Carbohydrate (%) V1	Carbohydrate (%) V2	Mean
Season 2018/19							
9d	S1	23.4	21.8	22.6	62.1	60.3	61.2
	S2	21.9	21.1	21.5	61.7	60.0	60.9
7d	S1	24.6	22.7	23.7	64.5	62.3	63.4
	S2	22.5	22.5	22.5	64.0	61.5	62.8
5d	S1	24.5	22.5	23.5	64.3	61.5	62.9
	S2	22.5	22.3	22.4	63.8	61.2	62.5
Mean		23.2	22.2		63.4	61.1	
Mean for I.S	S1		23.3			62.5	
	S2		22.1			62.1	
Mean for I. I.	9 d		22.1			61.1	
	7 d		23.1			63.1	
	5 d		23.0			62.7	
LSD 5%							
I.S.			0.6			N.S	
Var.			0.5			0.9	
I.I.			0.1			0.7	
I.SXVar.			0.9			N.S	
I.S X I.I.			N.S			N.S	
Var X I.I.			N.S			N.S	
I.S X Var X I.I.			N.S			N.S	
Season 2019/20							
9d	S1	22.9	22.0	22.5	62.6	61.5	62.1
	S2	22.0	21.6	21.8	63.0	61.1	62.1
7d	S1	25.0	23.0	24.0	64.8	63.2	64.0
	S2	24.0	22.5	23.3	63.4	62.5	63.0
5d	S1	25	23.0	24.0	64.2	62.7	63.5
	S2	23.3	22.9	23.1	63.1	62.2	62.7
Mean		23.7	22.5		63.5	62.2	
Mean for IS	S1		23.5			63.2	
	S2		22.7			62.6	
Mean for I. I.	9d		22.2			62.1	
	7d		23.7			63.5	
	5d		23.6			63.1	
LSD 5%							
I.S.			0.7			N.S	
Var.			1.0			0.6	
I.I.			0.7			0.9	
I.SXVar.			N.S			N.S	
I.S X I.I.			N.S			N.S	
Var X I.I.			N.S			N.S	
I.S X Var X I.I.			N.S			N.S	

I.I.: Irrigation interval; d: days; I.S.: Irrigation system; Var.: Variety V1: Recombinant inbred line "RIL 115" ; V2: Common bean (Navv bean) (control) ; S1: Drip irrigation S2: Gated pipe

4. DISCUSSION

The effect of study factors on some evaluation criteria was studied to determine the best conditions to increase productivity, productivity of irrigation water and quality of bean seed yield under heavy clay soil conditions. The evaluation criteria used were: application efficiency of irrigation water, vegetative growth, yield components, seed yield, productivity of irrigation water and quality traits of common bean.

The highest applied water of the irrigation at 5 days interval was more than 7 days and 9 days intervals, these results may be due to increasing number of watering under the conditions of this treatment comparing with the other treatments and hence increasing amount of irrigation water this happened with under clearly data under the two irrigation systems but the values under gated pipe a modified surface irrigation were higher than drip irrigation system, these results are agreement with [18] they concluded that deficit irrigation strategy can be seen as a feasible and efficient technique to ensure greater crop yield, without putting in jeopardy their physiological processes and their final yield On the other hand, the 7 days interval give a good opportunity to increase nutrient movement in the soil solution more than the short period 5days and the large period 9 days, which raised the availability to plant root absorption and the translocation through plant tissues and consequently reflected on plant growth, development and chemical constituents. These results are the same line with [15] they revealed that among the legumes, common beans are relatively sensitive to drought stress and these results were confirmed by field experiments, greenhouses, and controlled condition. Finally, it can also be determined that, yield is not only function of amount of applied water but it is a function of time of watering. Irrigation scheduling which based on daily evaporation records is more efficient for effective irrigation from point of water view. These results are in agreement with these of [38] they concluded that most suitable irrigation frequencies for pea grown under drip irrigation system under moderate cumulative pan evaporation.

The highest values for water application efficiency were recorded under drip irrigation system compared to the irrigation by gated pipe and this resulted from the lowest amount of applied water irrigation water which occurred under drip irrigation where the transmission source is next to the plant directly but irrigation by gated pipe give more water loss by deep percolation. Water application efficiency values decreased under all systems by increasing the periods between irrigation. The highest value for the water application efficiency for drip irrigation were occurred with 5 days as the period between irrigation, while the lowest value was for gated pipe irrigation at adding irrigation water every 9 days. So, deficit irrigation strategy can be viewed as a feasible and effective technique to ensure increased crop yields, without putting in jeopardy their physiological processes and their final yield. These results are agreement with [16] they recorded that More than 60% of the world's common bean is cultivated under non-irrigated conditions, and drought is estimated to cause up to 80% yield losses in many regions of the world

The lowest values for vegetative growth of bean plant, yield components, seed yield, productivity of irrigation water and quality traits of common bean were at 9 days irrigation interval compared to 5 or 7 day irrigation intervals. This may be due to the relationship between the period between irrigation and movement of water in the soil, water stress of plant roots, and washing of nutrients from the area of root dispersal, especially in clay lands. With an increase in the period between irrigation, the amount of added water increases at each irrigation, when the ground is dry and the volume of air and oxygen in it is large, which will lead to an increase in water movement and a decrease in the period of exposure of the roots of plants to water stress, while a high washing of nutrients occurs from the area of spreading of the roots due to the large amount of added irrigation water. As the period between irrigation decreases, the exact opposite occurs, as the washing process of nutrients from the root spread area is greatly reduced due to the decrease in the amount of added irrigation water, in addition to the fact that the roots of the cultivated plants will not be exposed to a large period of moisture stress resulting from the increase in the moisture content and the lack of air as it is by adding a small amount of water Irrigation at small intervals leads to a decrease in the movement of water in the soil and the volume of air, which will lead to a decrease in the water uptake although there is more irrigation water in the root spread area, and this is known as physiological thirst. Therefore, irrigation every 7 days as a period between irrigation was better treatment compared to irrigation every 9 or 5 days, because the irrigation every 7 days found a balance between washing nutrients and water stress within the area of root spread. These results in the same trend with [23] she included that increasing irrigation intervals decreased yield of okra.

The value for vegetative growth of bean plant, yield components, seed yield, productivity of irrigation water and quality traits of common bean were increased under drip irrigation system compared to gated pipe irrigation. Perhaps there are three reasons for this. The first is that the direction of the salt movement under the drip irrigation system is outside the root spread area, while the salt movement is directed to inside the root spread area with the irrigation by the gated pipe. The second reason is that the roots of cultivated plants grow in the least stressful places of moisture under the drip irrigation system, while the opposite happens with the gated pipe. The third reason is that nutrients are concentrated in the area of root proliferation under the drip irrigation system, while large quantities of nutrients are washed with the gated pipe irrigation system. Only one of the aforementioned reasons can guarantee the superiority of the drip irrigation system over gated pipe irrigation, so what if they combined the three reasons with us. [37] they concludedthat irrigation frequency 4 days were more efficient in water productivity

The best value for the vegetative growth of bean plant, yield components, seed yield, productivity of irrigation water and quality traits of common beanwere occurred with recombinant inbred line "RIL 115" compared to common bean (Navv bean) and this may be due to genetic superiority and drought tolerance.

The highest value for the seed yield and productivity of irrigation water and quality of common bean were with the irrigation interval of 7 days combined with drip irrigation system for the inbred line RIL 115 where of the lowest values were recorded with at 9 day interval combined with gated pipe irrigation for Navv common bean cultivar. [25, 36] they concluded thatgeneral, drought stress has a significant impact on common bean growth and seed yield although the ranges of cuts are highly variable due to differences in timing and severity of stress applied and the genotypes use

Finally, using drip irrigation system and irrigation interval at 7 days and selection RIL 115 are highly recommended to increase and improve the yield, productivity of irrigation water and quality traits of common bean under clay soils conditions.

5. CONCLUSION

Under the study conditions it could be concluded that the highest value for the seed yield and productivity of irrigation water and quality of common bean were with the irrigation interval of 7 days combined with drip irrigation system for the inbred line RIL 115, where of the lowest values were recorded with at 9 day interval combined with gated pipe irrigation for Navv common bean cultivar. So, using drip irrigation system and irrigation interval at 7 days and selection RIL 115 are highly recommended to increase and improve the yield, productivity of irrigation water and quality traits of common bean under clay soils conditions.

Conflict of interest

The authors declare that they have no conflict ofinterest regarding the publication of this paper

6. References

[1] A.O.A.C. (1998) Association of Official Agriculture Chemists. Official Methods of Analysis 16th Ed., Washington, DC, USA.

[2] Abdelraouf, R.E. and R. Ragab (2018). Applying Partial Root Drying drip irrigation in presence of organic mulching. Is that the best irrigation practice for arid regions: Field and Modeling Study Using SALTMED model. Irrig. and Drain. 67: 491–507.

[3] Abdelraouf, R. E., E.M. Okasha, and H.H.H. Tarabye (2016). Modified Design for Drip Irrigation System to Improve the Productivity of Irrigation Water and fertilizers distribution. International Journal of ChemTech Research. Vol.9, No.09 pp 40-52.

[4] Abdelraouf, R.E., S.D. Abou-Hussein, K.M. Refaie and I.M. El-Metwally (2012 b). Effect of Pulse Irrigation on Clogging Emitters, Application Efficiency and Productivity of irrigation water of potato crop under organic agriculture conditions. Australian Journal of Basic and Applied Sciences, 6(3): 807-816.

[5] Abdelraouf, R.E. and M.E. Abuarab (2012). Effect of Irrigation Frequency under Hand Move Lateral and Solid Set Sprinkler Irrigation on Water Use Efficiency and Yield of Wheat. Journal of Applied Sciences Research, 8 (11): 5445-5458.

[6] Abdelraouf, R.E., M.A. El-Shawadfy, A.A. Ghoname and R. Ragab (2020 b). Improving crop production and productivity of irrigation water using a new field drip irrigation design. Plant Archives Vol. 20 Supplement 1, pp. 3553-3564

[7] Abdelraouf, R.E., S. D. Abou-Hussein, A. M. Abd-Alla and E.F. Abdallah (2012 a). Effect of Short Irrigation Cycles on Soil Moisture Distribution in Root Zone, Fertilizers Use Efficiency and Productivity of Potato in New Reclaimed Lands. Journal of Applied Sciences Research, 8(7): 3823-3833.

[8] Abdelraouf, R.E., S. F. El Habbasha, M.H. Taha and K.M. Refaie (2013 c). Effect of Irrigation Water Requirements and Fertigation Levels on Growth, Yield and Water Use Efficiency in Wheat. Middle-East Journal of Scientific Research, 16 (4): 441-450.

[9] Abdelraouf, R.E., S.F. El-Habbasha (2014). Wheat production in the arid regions by using

drip irrigation system. International Journal of Advanced Research, 2: 84-96.

[10] Abdelraouf, R.E., S.F. El-Habbasha, M. Hozayn and E. Hoballah (2013 a). Water Stress Mitigation on Growth, Yield and Quality Traits of Wheat (*Triticum aestivum*L.) Using Biofertilizer Inoculation Journal of Applied Sciences Research, 9(3): 2135-2145.

[11] Abdelraouf, R.E., M.A. El-Shawadfy, Fadl, A. Hashem and B.M..M. Bakr (2020 b). Effect of deficit irrigation strategies and organic mulching on yield, productivity of irrigation water and fruit quality of navel orange under arid regions conditions. Plant Archives Vol. 20 Supplement 1, pp. 3505-3518.

[12] Abdelraouf, R.E., K.M. Refaie and I.A. Hegab (2013 b). Effect of Drip Lines Spacing and Adding Compost On The Yield And Irrigation Water Use Efficiency Of Wheat Grown Under Sandy Soil Conditions. Journal of Applied Sciences Research, 9(2): 1116-1125.

[13] Bakry, A.B., R.E. Abdelraouf, M. A. Ahmed and M. F. El Karamany (2012). Effect of Drought Stress and Ascorbic Acid Foliar Application on Productivity and Irrigation Water Use Efficiency of Wheat under Newly Reclaimed Sandy Soil. Journal of Applied Sciences Research, 8(8): 4552-4558.

[14] Broughton WJ, G. Hernandez, M. Blair, S. Beebe, P. Gepts and J. Venderleyden (2003) Bean (Phaseolus spp) - model food legumes. Plant and Soil 252: 55-128.

[15] Costa-França MG, AT Pham-Thi and C. Pimentel (2000) Differences in growth and water relations among Phaseolus vulgaris cultivars in response to induced drought stress. Environ Exp Bot 43: 227–237.

[16] Cuellar-Ortiz S.M., M. Arrieta-Montiel and J.A. Acosta-Gallegos (2008) Relationship between carbohydrate partitioning and drought resistance in common bean. Plant Cell Env 31: 1399–1409.

[17] Dogan, E., H. Kirnak, K. Berekatoglu, L. Bilgel and A. Surucu (2008). Water stress imposed on muskmelon (Cucumismelo L.) with subsurface and surface drip irrigation systems under semiarid climatic conditions. Irrig. Sci., 26 (2): 131–138.

[18] Du, T., S. Kang, J. Zhang, and W.J. Davies (2015) Deficit irrigation and sustainable water-resource strategies in agriculture for China's food security. J. Exp. Bot. 66, 2253–2269.

[19] Eid, A. R. and A. Negm (2019). Improving Agricultural Crop Yield and Productivity of irrigation water via Sustainable and Engineering Techniques. Book Chapter in "Conventional Water Resources and Agriculture in Egypt. Hdb Env Chem (2019) 74: 561–592, DOI 10.1007/698_2018_259, Springer International Publishing AG 2018, Published online: 1 June 2018. Springer Verlag, (2019), 561-591.

[20] El-Habbasha, S.F., E. M. Okasha, R.E. Abdelraouf and A.S.H. Mohammed (2014). Effect of pressured irrigation systems, deficit irrigation and fertigation rates on yield, quality and water use efficiency of groundnut. International Journal of ChemTech Research, 15 07(01): 475–487.

[21] Elmaloglou, S., E. Diamantopoulos and N. Diamantopoulos (2010). Comparing soil moisture under trickle irrigation modeled as a point and line source. Agric. Water Manage. 49 (97), 426-432.

[22] El-Metwally, I., R. E. Abdelraouf, M. Ahmed, O. Mounzer, J. Alarcón, and M. Abdelhamid (2015). Response of wheat (Triticum aestivum L.) crop and broad-leaved weeds to different water requirements and weed management in sandy soils. Agriculture 61(1) 22-32.

[23] El-Sharkawey, Amal, F (2017) Effect of irrigation intervals, fertilizer levels and planting methods on yield and water use efficiency. Misr J. Ag. Eng., 34 (4-1): 1621 – 1636.

[24] FAO (2005-2006). FAO Statistical Yearbook. Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org/docrep/009/a0490m/a0490m00.htm

[25] Frahm, M.A., J.C. Rosas, N. Mayek-Pérez, E.L ez-Salinas, J.A. Acosta-Gallegos and J.D. Kelly (2004). Breeding beans for resistance to terminal drought in the lowland tropics. Euphytica. 136: 223-232.

[26] Gomez K.A., A.A. Gomez (1984). Statistical Procedures for Agriculture Research, A Wiley – Inter Science Publication, John Wiley & Sons, Inc., New York, USA, 680 pp.

[27] Hozayn, M.. A. A. Abd El Monem, R.E. Abdelraouf and M. M. Abdalla (2013). Do Magnetic Water Affect Water Use Efficiency, Quality and Yield of Sugar Beet (Beta Vulgaris L.) Plant Under Arid Regions Conditions? Journal of Agronomy, (34)1- 10.

[28] Israelsen,O.W and V.E,Hansen. (1962). Irrigation Principles and Practices/3rd edit.JohnJhon Willey and sons Inc, New York.

[29] James, L.G. (1988). Principles of farm irrigation system design. John Willey & sons. Inc., Washington State University. 73: 152-153, 350-351.

[30] Li, X., X. Zhang and J. Niu (2016). Irrigation productivity of irrigation water is more influenced by agronomic practice factors than by climatic factors in Hexi Corridor, Northwest China. – Sci. Rep. 6, 37971; doi: 10.1038/srep37971

[31] Marwa, M. A., R.E. Abdelraouf, S. W. Wahba, K. F. El-Bagouri and A.G. El-Gindy (2017). Scheduling Irrigation using automatic tensiometers for pea crop. Agricultural Engineering International: CIGR Journal, Special issue: 174–183.

[32] Mohamed,E.A., Haitham B.A. Hassan, Heba Y. Abdel Fatah and Karima A. Mohamed. (2018). An analytical economic study of production and export of Green beans in Egypt. Middle East Journal of Agriculture Research. Volume: 07: Issue: 04: Oct.-Dec., Pages:1208-1216.

[33] Okasha, E.M., R. E. Abdelraouf and M. A. A. Abdou (2013). Effect of Land Leveling and Water Applied Methods on Yield and Irrigation Water Use Efficiency of Maize (Zea mays L.) Grown under Clay Soil Conditions. World Applied Sciences Journal 27 (2): 183-190.

[34] Peil R.M.N., A. S. Strassburger and L. A. da Fonseca (2012). Growth, water consumption and use efficiency of summer squash crop in closed rice husk medium growing system. Acta Horticulturae, 952: 645-650.

[35] Rafie, R.M. and F.M. El-Boraie (2017). Effect of Drip Irrigation System on Moisture and Salt Distribution Patterns under North Sinai Conditions. Egypt. J. Soil Sci., 57(3):247 – 260.

[36] Shenkut, A.A. and M.A. Brick, (2003). Traits associated with dry edible bean (Phaseolus vulgaris L.) productivity under diverse soil moisture environments. Euphytica, 133: 339-347.

[37] Silas Alves Souza, JoslannyHigino Vieira, Diego Bispo dos Santos Farias, Gustavo Henrique da Silva and Catariny Cabral Aleman (2020) Impact of irrigation frequency and planting density on bean's morpho-physiological and productive traits. Water journal Vol., 12 (1-13) doi:10.3390/w12092468

[38] Taha, A. A., M. A. M. Ibrahim and A. A. Abdelkhalek (2011). Irrigation scheduling for pea using evaporation pan under drip irrigation at North Nile Delta region. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 2 (2): 203 – 212

[39] Tian, F., P. Yang, H. Hu and H. Liu (2017). Energy balance and canopy conductance for a cotton field under film mulched drip irrigation in an arid region of northwestern China. Agric. Water Manage.179(C),110-121.http://dx.doi.org/10.1016/j.agwat.2016.06.029

[40] Uddling J., J. Gelang-Alfredsson, K. Piikki and H. Pleijel (2007) Evaluating the relationship between leaf chlorophyll concentration and SPAD-502 chlorophyll meter readings. Photosynth Res 91:37–46

[41] Yavuz D., M. Seymen, N. Yavuz and O. Turkmen (2015). Effects of irrigation interval and quantity on the yield and quality of confectionary pumpkin grown under field conditions. Agricultural Water Management, 159: 290-298.

[42] Zwart, S. J. and W.G.M. Bastiaanssen (2004). Review of measured crop productivity of irrigation water values for irrigated wheat, rice, cotton and maize. Agricultural Water Management 69:115–133.