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Effect of Irrigation and Furrow Width on Sugar Beet and Faba Bean Productivity under Intercropping Patterns and some Water Relations in Clay Soil

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ABSTRACT

In intercropping system, the utilization of different nutrients and water is an effective, as well as the risk of failure of cultivated crops is lessened. Field experiments were conducted at Sakha Experimental Farm Kafer EL-Sheikh Governorate, Egypt during two successive growing seasons 2017/18 and 2018/19 to investigate the effect of intercropping faba bean (CV. Giza 843) with sugar beet (CV. Geloria) grown under water stress and furrow width treatments on growth, yields, quality and some water relations for both crops .Split-plot design was used in the current investigation, the main plots contained three levels of water stress (two, three and four irrigations through the whole growing season in addition sowing irrigation for all treatment),while the sub –plots contained three furrow width(60, 90and 120cm) for faba bean. Sugar beet seeds were sown on the two sides and faba bean seeds were sown on upper ridge at furrow width 120 cm (C). The highest values for growth traits, yields for sugar beet and faba bean intercropping, applied and consumed water were obtained when plants were irrigated four irrigations (I3) and the furrow width 120 cm, but it was recorded the lowest values of water efficiencies. A significant interaction effect was found between the two factors of irrigation and furrow width on most of studied traits. The highest Land Equivalent Ratios (LER; 1.54 and 1.52) and the highest total income (15399.95 and 15030.45 L.E.) were obtained irrigation treatment (I3) and furrow width 120 cm.

Keywords: intercropping, *Beta vulgaris* L., *Vicia faba* L., water stress, row width, yield and quality, LER

INTRODUCTION

In arid areas, with annual rainfall of less than 250 mm, such as Egypt, irrigation is the principal factor in agricultural production. Agricultural sector uses more than 85% (48 million cubic meter) of the total renewable water supply. Moreover, the annual per capita of water for different purposes is in decreasing gradually to be less than the water poverty limit, 1000 m^3 per annum, *EL-Quosy, (1998)*. On the other hand, capita share from agricultural water is severely decreasing to be less than 504 m^2/ year/ capita (0.12 fed.) which is not feed an individual inhabitant and this decreasing is continuous under the challenge of increasing national population.

Legumes can reduce the emission of greenhouse gases in particular carbon dioxide and nitrous oxide in comparison with the agriculture based on synthetic N fertilization. Also, legumes decrease the total fossil energy inputs in agricultural system *Stagnari et al. (2017)*. Intercropping system is considered the best approach for rising land use and absorbing surplus land labor, in particular with the speedy growth in population and lessening in the cultivable soil *Malik et al. (2016)*. *El-Mansoury (2016)* reported that under enough water availability could be irrigated two or three irrigations after sowing irrigation for faba bean. The interception of solar radiation during intercropping system is enhanced and the use of water and different nutrients is an effective and the risk of failure of the intercropped crops is reduced. Intercropping faba bean (*Viciafaba* L.)with other crops has particular importance to replenish faba bean gap. The cultivated area of faba bean has decreased from 333000 fed to less than 222000 fed in 2009 sowing to the severe competition with wheat and berseem in winter crops. Faba bean is grown world-wide as protein source for food and feed, but at the same time faba bean offers ecosystem services such as renewable inputs of nitrogen (N) into crops and soil via biological N_2 fixation and a diversification of cropping systems. At present, cultivated faba bean area in Egypt was 97906 fed with a total annual production 140000 tons and this is not adequate. The reduction in cultivated faba bean area is due to the increasing of cultivated other winter crops especial wheat (*Triticum aestivum*L.), Egyptian clover (*Trifolium alexandrinum* L.), sugar beet, etc. Therefore, efforts are focused to increase the productivity to narrow the gap between the local production and human consumption through many factors as using different intercropping patterns, cultivar selection, diseases and weeds control.

Sugar beet (*Beta Vulgaris* L.) is one of the most important crops in Egypt and worldwide. So, the agricultural policy has been given much attention to grow sugar beet plants to narrow the gap between production and consumption. The cultivated area for sugar beet in Egypt had increased from 16900 fed in 1982/1983 to 461720 fed in 2015/2016. Moreover, the production of sugar beet contributed about 50% with a total production of 1.25 million tons of sugar and this indicates the strategic

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importance of this crop, particularly when it is grown under new soils conditions. The cultivated area in Egypt is limited and for this reason the agricultural intensification had become very necessity to optimize the utilizing of unit area. Increasing sugar productivity per unit area had an important interest and can be achieved through adopting appropriate agricultural practices. *Besheit et al. (2002)* reported that the highest sugar beet quality and productivity were obtained from beet planted on ridge width (100 cm) and intercropped with two onion rows, while onion intercropped sugar beet ridge width (50 cm) was higher and negativity affected sugar beet quality and quantity.

The main target for this current investigation was to :

- Intercropping faba bean with sugar beet grown in different furrow width with their sole cropping under different number of irrigations.
- Some water relations (water productivity, productivity of irrigation water and both applied and consumed water) for faba bean and sugar beet.

MATERIALS AND METHODS

Two field trials were counted out at Sakha Agricultural Research Station, Agricultural Research Center, Egypt. The site is located at 31°-07N latitude, 30°-57E longitude with an elevation of about 6 meters a above mean sea level. Data presented in Table (1) showed some meteorological parameters during the studied period 2017/2018 and 2018/2019 growing seasons recorded from Sakha Agro-meteorological Station.

Table 1. Mean of some meteorological data for Sakha area during the two growing seasons.

Month	T (C^0)		RH (%)		Ws, m sec^{-1} at 2 m height		Pan Evap., mm day^{-1}.		Rainfall, mm month^{-1}	
	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
Oct.	26.4	25.05	67.9	66.1	0.85	0.66	3.264	3.240	0.00	3.5
Nov.	21.8	20.63	71.86	72.7	0.62	0.29	2.060	1.602	9.3	11.9
Dec.	20.0	15.95	76.52	76.4	0.50	0.33	1.470	0.839	5.6	22.2
Jan.	18.9	15.6	76.9	67.8	0.48	0.38	2.621	1.138	37.4	14.9
Feb.	18.0	17.0	75.64	72.6	0.37	0.33	2.741	1.776	16.6	13.0
Mar.	21.1	19.7	65.33	72.2	0.54	0.53	4.242	2.858	0.00	17.3
April.	23.9	23.2	62.40	64.9	0.85	0.52	5.32	3.695	0.00	3.9
May	30.1	28.7	99.88	57.2	1.10	0.79	6.544	6.829	0.00	0.00

*** Source: Agro-meteorological station at Sakha include; air temperature (T., °C), relative humidity (RH, %), wind speed (Ws, m sec^{-1} at 2 m height), evaporation pan (Ep, mm) and rainfall (mm month^{-1}).**

Effect of intercropping faba bean (CV. Giza 843) with sugar beet (CV. Geloria, a mono-germ cultivar) grown used to three furrow width and three irrigation levels on productivity (growth yield, yield components and some water relations) of both crops. A split plot design with three replications was used in the current investigation. Irrigation levels (I_1= sowing irrigation plus two irrigations; I_2= sowing irrigation plus three irrigations; I_3= sowing irrigation plus four irrigations) were put in main plots, while furrow width treatments (A=60, B= 90 and C= 120 cm) were put in sub-plots. The size of sub-plot area was 42 m^{2}consisting of ten ridges, each of 3.5 m length and 1.2 m furrow width. Seeds of sugar beet either in pure or intercropped system were sown on 20thOctober in first season and on 23th October in second season, while seeds of faba bean either in pure or intercropped system were sown on 12thNovember in first season and on 15thNovemberin second season, while the harvest date was for sugar beet on 15th May and on 18th May in the two seasons but for faba bean was 10th May and 13th May in the two seasons. Sugar beet seeds were planted on both sides of beds at 20-30 cm hill spacing with three-four seed per hill and 30 days after sowing (DAS) were thinned into one plant per hill. Both of intercropping and monoculture systems (control) were used in sugar beet to achieve full stand of about 35000 plants fed^{-1}. However, faba bean seeds were broadcasted on the top of sugar beet bedsat20-25 cm hill spacing with three-four seed balls hill^{-1} at the recommended rate of seeding rate (30 kg fed^{-1}). The plants were hand-thinned to one plant per hill when the plants were at 4 leaves stage.

During seed bed preparation, superphosphate (15.5 % P_2O_5) and potassium sulphat (48%K_2O) fertilizers were applied at a rate of 31 kg P_2O_5 and 24 kg K_2O fed^{-1}, respectively. Mineral N fertilizer in the form of Urea (46% N) at a rate of 100 and 55 kg N fed^{-1} was applied to sugar beet and faba bean plants, respectively in three equal doses at 20, 40 and 60 DAS. At the first N dose, sugar beet plants were also fertilized using potassium sulphat at a rate of 62 kg K_2Ofed^{-1}. Faba bean and sugar beet were sown in monoculture as control to evaluate the yield advantage and economic evaluation, while the yield component traits were not recorded .Weeds in the rows were removed by hands. Diseases and pesticide control were conducted as needed for faba bean and sugar beet crops during growing period. The preceding crop was maize (*Zea mays* L.). All the other agricultural practices were applied as recommended for the crops and area.The particle size distribution and some soil water constants are presented in Table (2) as described by *Klute (1986)* and the chemical analysis of experimental soil before sowing are tabulated in Table (3) as described by *Jackson (1973)*

Table 2. Some physical characteristics and some soil water constants of the studied site before cultivation

Soil Depth,cm.	Particle Size Distribution			Texture classes	F.C %	P.W.P %	AW %	Bd Mg m^{-3}
	Sand%	Silt %	Clay %					
0 – 15	16.6	19.4	64.0	Clay	47.3	25.0	22.3	1.16
15 – 30	19.2	17.9	62.9	Clay	39.9	21.5	18.4	1.19
30 – 45	17.6	19.8	62.6	Clay	38.1	21.1	17.0	1.23
45 – 60	18.8	19.6	61.6	Clay	37.4	20.3	17.1	1.31
Mean	18.1	18.8	62.8	Clay	40.7	22.0	18.7	1.22

Where:-F.C % = Soil field capacity, P.W.P % = Permanent wilting point, AW % = Available water and Bd (Mg m-³) = Soil bulk density.

Table 3. Some chemical characteristics of the soil before cultivation.

Soil depth, Cm	Ec, dSm-1	PH (1: 2.5) soil Water suspension	Soluble ions, meq/l							
			Ca++	Mg++	Na+	K+	CO3--	HCO-	Cl-	SO4 --
0-15	3.15	8.26	13.26	6.50	9.08	2.00	0.00	5.49	9.77	15.58
15-30	3.29	8.13	12.86	5.37	10.40	4.66	0.00	5.50	10.72	17.07
30-45	3.31	8.07	10.97	5.23	10.97	4.95	0.00	5.60	10.81	15.71
45-60	3.00	7.93	8.73	4.51	11.33	5.45	0.00	9.61	11.04	9.57
Mean	3.19	------	11.46	5.32	10.44	4.27	0.00	6.55	10.59	14.35

Note: So_4^{--} was calculated by the difference between soluble cations and anions.

*** Data collection:-**

1-Applied water:

Applied water included an irrigation water plus rainfall. Irrigation water was controlled and measured by rectangular weir. Irrigation water discharge was determined according to *Michael, (1978)* as follows:

$$Q = 1.84\ LH^{1.5}$$

Where: **Q = Water discharge, m^3sec^{-1}, L = width of weir, cm and H = the head above weir crest, cm.**

2-Water consumptive use:

To compute the actual consumed water of the growing plants. Soil moisture percentage was determined (on weight basis) before and after each irrigation as well as at harvesting. Water consumptive use by growing plants was calculated based on soil moisture depletion (SMD) according to *Hansen et al, (1979).*

$$CU = SMD = \sum_{i=1}^{i=N} \frac{\theta 2 - \theta 1}{100} * Dbi * Di * 4200$$

Where: **Cu= Water consumptive use in the effective root zone (60cm), ϴ2= Gravimetric soil moisture percentage after irrigation, ϴ1= Gravimetric soil moisture percentage before irrigation, Dbi= soil bulk density (Mg m^{-3}) for depth, Di= Soil layer depth (20 cm), 1= number of soil layers (1-3), and 4200 = feddan area in m^2.**

3- Productivity of irrigation water (PIW, kgm^{-3}).

Productivity of irrigation water (PIW) is generally denied as crop yield (kg) per cubic meter of applied water. It was calculated according to *Ali et al., (2007)*

$$PIW = \frac{Y}{Aw}$$

Where: **PIW= Productivity of irrigation water (kg m^{-3}), Y= Yield (kg) and Aw =Applied water (m^3).**

4- Water productivity (WP, kgm^{-3}):

Water productivity (WP), is generally defined as crop yield ($kgfed^{-1}$.) per cubic metre of water consumption. It was calculated according to *Ali et al., (2007)*

$$WP = \frac{Y}{Cu}$$

Where: **WP= Water productivity (kgm^{-3}), Y= Yield (kg) and Cu = Water consumptive use.**

At maturity, 10 guarded plants from each crop were randomly taken from inner ridges in each sub-plot for recording the growth and yield traits. While, straw, and seed yields $fed^{-1}$for faba bean and sugar beet were estimated from central area (2.0 m^2) of each sub-plot. The recorded traits included**:**

A-Sugar beet traits:

Sugar beet growth, yield and yield components

Sugar beet plants grown on three inner ridges 3.5 long of each plot were pulled at 180 DAS, topped and counted.

Also, number of leaves per plant, leaf fresh and dry weight $plant^{-1}$ (g), root diameter (cm), root length (cm), root fresh and dry weight $plant^{-1}$(g) and root yield (ton fed^{-1}) were measured and recorded on a random sample of ten plant roots.

Quality traits of sugar beet:

Quality traits were analyzed and determined in the fresh roots using an automatic French system (HYCEL). Sucrose % (pol %) and TSS % were polar metrically measured on a lead acetate of fresh macerated root as described by *McGinnus (1982)*.Sucrose % (pol %) was estimated in fresh samples of sugar beet root using Saccharometer according to the method described by *AOAC (1995).* Purity % was estimated according to the following equation: Purity %= 99.36 – [14.27 (Na%+ K%+ α – amino N%) /sucrose %] *(Devillers 1988).*Sugar yield (ton fed^{-1}) was estimated by multiplying root yield fed^{-1} by root sucrose %.

B-Faba bean characters:

Growth, yield and yield components:

Ten guarded plant were randomly taken from each sub-plot to measure plant height (cm), number of branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1} , seed yield $plant^{-1}$ (g), straw yield $plant^{-1}$(g), 100-seed weight (g), harvest index , seed yield (ton fed^{-1}), straw yield (ton fed^{-1}), biological yield ton fed^{-1}.

Yield advantage:

Land Equivalent Ratio (LER):

The ratio of area needed under sole cropping to that of intercropping at the same management level to produce an equivalent yield was calculated according to *Mead and Willey (1980)* as follows:

$$LER = (Yab/Yaa) + (Yba/Ybb)$$

Where, **Yaa and Ybb are the sole crop yields of crops a (sugar beet) and b (faba bean), respectively; while Yab is the intercrop yield of crop a, and Yba is the intercrop yield of crop b.**

Total return of intercropping cultures (Net income fed^{-1}):

It was calculated for each treatment in price of sugar beet yield by Egyptian pounds + price of faba bean yield by Egyptian pounds using the average farm gate price for the two seasons. The market price for sugar beet was 400 L.E. per ton and for faba bean seeds was 1000 L.E. per ardab (160 kg seeds). The average of sugar beet and faba bean yield price presented by Agricultural Statistics (2018 and 2019) was used.

The statistical analysis was conducted for each crop separately according to *Snedecor and Cochran (1989)* using MSTATC computer V4 (1986). Also, least significant difference (LSD) at 0.05 level of probability was used for comparing different treatment means.

RESULTS AND DISCUSSION

Effect of irrigation and furrow width treatments on:

1- Applied water and water consumptive use:

Presented data in Table (4) and Fig. (1) clearly indicated that, the overall mean values for applied water and water consumptive use for sugar beet which intercropped on faba bean were affected by both irrigation and furrow width treatments. These crops consider winter field crops. So, the seasonal applied water (Aw) of the two studied crops consists of the two main components, irrigation water delivered to the plot (IW) and rainfall. The total amount of the rainfall during the two growing seasons of crops as reported in Table (3) was 6.89 cm. (289.38m^{3}fed^{-1}) and 8.67 cm. (364.14m^{3}fed^{-1}) in the first and second growing seasons, respectively. Water stress treatments were greatly affected irrigation water delivered in two growing seasons. The highest seasonal values for applied water were recorded under irrigation treatment I_3 (sowing irrigation plus four irrigations) where the values are 56.02 cm (2352.73 m^{3}fed^{-1}) and 58.67 cm (2464.22 m^{3}fed^{-1}.) in the first and second growing seasons, respectively. Meanwhile, the lowest seasonal values were recorded under irrigation treatment I_1 (sowing irrigation plus two irrigations) and the values are 39.41 cm (1655.13 m^{3}fed^{-1}) and 39.81 cm (1772.09 m^{3}fed^{-1}) in the first and second growing seasons, respectively. Generally, the seasonal values for applied water can be descended in this order $I_3 > I_2 > I_1$. Increasing the seasonal values for applied water under irrigation treatment I_3 in comparison with other irrigation treatments I_1 and I_2 might be attributed to increasing number of irrigations and hence increasing the amount of applied water. Data in the same table also illustrated that furrow width treatments were affected seasonal applied water where by reducing furrow width the amount of seasonal applied water increased. Generally, the values of applied water can be descended in order A > B > C. respectively.

Concerning, water consumptive use (Cu) data in the same Table (4) and Fig. (2) showed that the highest overall mean value for (Cu) were recorded under irrigation treatment I_3 and the values is 37.39 cm (1595.31 m3fed^{-1}).

Meanwhile, the lowest overall mean values were recorded under irrigation treatment I_1 and the value is 30.89 cm. (1297.54 m^{3}fed^{-1}).

Table 4. Effect of irrigation and furrow width on seasonal amount of applied water (AW) and consumptive use (Cu) for faba bean intercropped on sugar beet in the two growing seasons.

Irrigation Treatment	Furrow Width	1st growing season Aw(m^{3}fed^{-1})	1st growing season Aw(Cm)	2nd growing season Aw(m^{3}fed^{-1})	2nd growing season Aw(Cm)	1st growing season Cu,m^{3}fed^{-1}	1st growing season Cu,Cm	2nd growing season Cu, m^{3}fed^{-1}	2nd growing season Cu,Cm
	A	1785.5	42.51	1899.52	45.23	1345.88	32.04	1440.89	34.31
I_1	B	1659.8	39.52	1785.62	42.51	1251.93	29.81	1355.29	32.27
	C	1520.1	36.19	1631.12	38.84	1152.06	27.43	1239.17	29.50
Mean		1655.13	39.41	1772.09	39.81	1249.96	29.76	1345.12	30.89
	A	2175.9	51.81	2292.42	54.58	1533.18	36.5	1607.5	38.27
I_2	B	2005.3	47.75	2112.32	50.29	1472.02	35.05	1552.77	36.97
	C	1816.8	43.26	1927.22	45.89	1337.52	31.85	1443.1	34.36
Mean		1999.33	47.6	2110.65	50.25	1447.57	34.47	1534.46	36.53
	A	2565.5	61.08	2671.62	63.61	1667.46	39.7	1713.12	40.79
I_3	B	2361	56.21	2477.72	58.99	1559.37	37.13	1668.71	39.73
	C	2131.7	50.75	2243.32	53.41	1434.02	34.14	1529.15	36.41
Mean		2352.73	56.02	2464.22	58.67	1553.62	36.99	1636.99	38.98
Control sugar beet		2565.5	61.08	2671.62	63.61	1648.31	39.25	1698.71	39.85
control faba bean		2085.38	49.65	2176.48	51.83	1136.79	27.07	1154.87	27.28

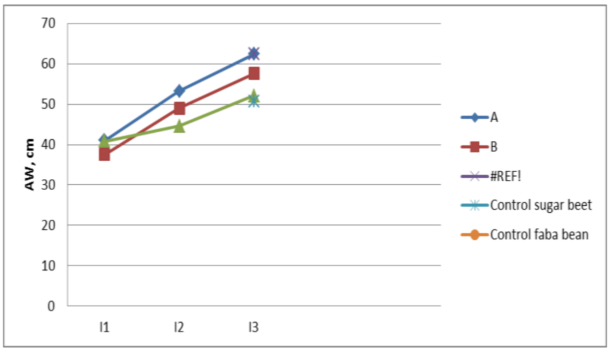

Fig. 1. Effect of irrigation treatments and furrow width on amount of seasonal applied water (AW) for faba bean intercropped on sugar beet in the average two growing seasons.

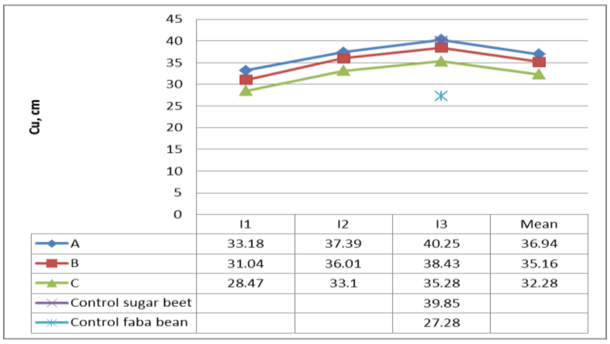

Fig. 2. Effect of irrigation treatments and furrow width on the average of mean consumptive use for faba bean intercropped on sugar beet in the two growing seasons.

Generally, the overall mean values of water consumptive use can be descended in order $I_3 > I_2 > I_1$ and under furrow width treatments A>B>C, respectively. Increasing the values of Cu under irrigations treatment I_3 in comparison with $I_1$and I_2 might be attributed to increasing the amount of applied water under the conditions of this treatment and hence forming strong plants with a thick vegetative growth. Consequently, increasing the exposed area to sunlight, therefore, increasing transpiration from plant surfaces which considers one of the main components of water consumptive use in addition to evaporation from soil surface. These results are in a great agreement with those reported by *Gharib and El-Henawy (2011), Ashry et al. (2012), Mona, S. M. Eid (2012) and Moursi and Darwesh (2014).*

Regarding, the effect of furrow width treatments under all irrigation treatments, the highest overall mean values were recorded under furrow width treatment A (60 cm) and the values are 40.25 cm.(1690.29 m3/fed.), 37.39 cm (1570.34 m3/fed.) and 33.18 cm (1393.39 m3/fed.) under I_3 , I_2 and I_1 irrigation treatments, respectively. Also, as shown in the same Table, with increasing plant densities (intercropping systems) on the raised- bed the values of water consumptive use increased. So, the values of water consumptive use can be descended in order A> B > C under the two growing seasons. Concerning, furrow width control of treatments faba bean, the lowest overall mean values for water consumptive use were recorded in comparison with other treatments A, B and C because control faba bean means (cultivation of faba bean only on the raised-bed without sugar beet). So, the water consumptive use for faba bean is less than for sugar beet only because of the vegetative growth for sugar beet is bigger than that for faba bean. So, the losses by transpiration through this cover will be more than those under cultivation of faba bean only and hence, increasing the values of water consumptive use. These findings are in the same line with those reported by *Kiziloglu et al. (2006) and Moursi, et al. (2014).*

3- Irrigation efficiencies:

Presented data in Table (5) clearly showed that the values of irrigation productivity (PIW and WP) were affected by both the two studied treatments (irrigations and row width). Concerning, the effect of number of irrigations treatments on PIw and WP, the highest mean values were recorded under irrigation treatment I_1 in the two growing seasons and the values are 10.61 kg/ m^3 for PIW, 14.01 kg/ m^3 for WP as average mean in the two growing seasons, respectively. Meanwhile, the lowest mean values were recorded under irrigation treatment I_3 and the values are 9.26 kg/m^3 for PIW 13.91 kg/m^3 for WP in the two growing seasons, respectively. Generally, the mean values for PIW and WP can be descended in order $I_1 > I_2 > I_3$ in the two growing seasons under furrow width treatments. Increasing the mean values of Paw and WP under irrigation treatment I_1 in comparison with other irrigation treatments I_2 and I_3 in the two growing seasons may be attributed to increasing yield and decreasing the amount of applied water and consumptive use under the conditions of irrigation treatment I_3 comparing with irrigation treatment I_1 which recorded the highest value for applied water and recorded the highest value for water consumptive use. Consequently, under these conditions the lowest mean values for PIW and WP were recorded. These results are in a great harmony with those obtained by *Khalifa and Ibrahim (1995), Gharib and El-Henawy (2011) and Moursi and Darwesh (2014).*

Table 5. Effect of irrigation and furrow width on productivity of applied water (PIW) and water productivity (WP) for faba bean intercropped on sugar beet in the two growing seasons.

Irrigation Treatment	Furrow Width	PIW (kg/m^3)			WP (kg/m^3)		
		1st growing season	2nd growing season	Mean	1st growing season	2nd growing season	Mean
I_1	A	9.62	8.67	9.15	12.76	11.43	12.10
	B	10.91	9.89	10.4	14.47	13.03	13.75
	C	12.85	11.68	12.27	16.95	15.38	16.17
Mean		11.13	10.08	10.61	14.73	13.28	14.01
I_2	A	8.40	7.82	8.11	11.92	11.15	11.54
	B	9.65	8.99	9.32	13.15	12.23	12.69
	C	11.27	10.52	10.9	15.31	14.05	14.68
Mean		9.77	9.11	9.44	13.46	12.48	12.97
I_3	A	7.66	7.21	7.44	11.78	11.25	11.52
	B	8.82	8.22	8.52	13.35	12.21	12.78
	C	10.35	13.27	11.81	15.38	19.48	17.43
Mean		8.94	9.57	9.26	13.50	14.31	13.91
Control sugar beet		10.54	10.61	10.58	16.4	16.69	16.55
control faba bean		0.67	0.66	0.67	1.22	1.24	1.23

Yield and yield components for sugar beet and faba bean:

1- Sugar beet crop:

Sugar beet tended to have the highest significant root diameter, fresh and dry for weight roots per plant, number of leaves per plant, dry for weight leaves, total fresh and dry weight of whole plant and root yield per fed when plants were irrigated with I_1 and planted on 120 cm furrow width, while the longest roots, the highest sucrose %, purity % and sugar yield per fed were obtained from plants that irrigated with I_3 and planted on 60 cm furrow width at 180 DAS during both of growing seasons (Table 6 - 11).*Beshay et al. (2000)* revealed that the reduction in sugar beet productivity was not due not only to intercropping system, but also was due to intercropped density of the companion crop.

Irrigation of sugar beet four times plus planting irrigation and bed width 120 cm affected in the heaviest dry root weight, whole dry weight of plant and root yield per fed, while irrigation of sugar beet with two times and furrow width 60 cm resulted in the lowest values for sugar yield per fed, TSS %, sucrose %, and purity % in comparison to other treatments (Table 11). The reduction in yield and growth traits of sugar beet intercropped with faba bean can be attributed to the shad of faba bean plant for the sugar beet plants in comparison to the pure stand plants as reported by *Abd El-All (2002) and Mohammed et al. (2005).*

The sugar beet produced significantly higher root yield when intercropped with faba bean under the four irrigations and sowing on 90 cm bed width, while the sowing under 120 cm bed width the root yield of sugar beet was significantly superior. The highest significant sugar beet root yield was achieved from the pure stands, amounting to 49.99 and 49.08 ton ha-1 in first and second season, respectively. The difference between the sugar beet root yield produced from 60 and 120 bed width amounted in the first growing season to be 11.11 ton ha-1, while in the second growing season the difference amounted to be 11.40 ton ha-1.

The effect of intercropping on the root yield of sugar beet, mainly depends on the nature and growth habit of the companion crop. For instance, *Abdel Motagally and Metwally (2014) and El-Shamy Moshira et al. (2015)* concluded that root yield of sugar beet was not significantly affected when intercropped with onion. However, similar to the current study, it was reported that the maximum significant root yield of sugar beet was achieved for pure stands in comparison to intercropping sugar beet with faba bean *(Mohammed et al., 2005).* Researchers attributed this effect to the arrangement of sugar beet and companion crop plants which resulted in greater exposure of the plant canopy to the solar radiation. This better effect of the solar radiation was reflected on better root growth and higher root yield. On the other hand, the reduction of sugar beet root yield with reducing the bed width to 60 cm may be due to the shading effect, in addition to the high competition for light and nutrients up take which negatively affect the rate of photosynthesis and, thus, reduces the root yield.

The highest number of leaves per plant, root diameter, fresh and dry leaves weight, fresh and dry root weight per plant, and total fresh and dry weight of whole plant when plants were irrigated three irrigations and sown on 120 cm bed width, while the longest roots, and the highest sugar %, were obtained from plants irrigated with I_3 and sown on 120 and 60 cm bed width, respectively (Table 10, 11). The highest yield of sugar beet was obtained when five faba bean plants were sown with sugar beet per m^2 *(Abd El-All, 2002)*. However, there were no significant effect for the interaction between irrigation and bed width treatments on purity %, TSS%, root yield fed^{-1} and sugar yield fed^{-1}.

Table 6. Effect of water stress treatments on root and leaves traits of sugar beet at harvesting during the two growing seasons

Traits	Root plant^{-1}				Leaves plant^{-1}	
Treatments	Length(cm)	Diameter (cm)	Fresh weight(g)	Dry weight(g)	Number	Dry weight(g)
		2017/2018				
I_1	29.48^a	15.44^c	758.58^c	131.75^c	23.28^c	78.84^c
I_2	28.25^b	16.40^b	833.86^b	140.34^b	24.97^b	80.22^b
I_3	28.17^b	17.43^a	882.78^a	143.19^a	27.24^a	81.74^a
$LSD_{0.05}$	0.21	0.12	14.03	0.89	0.36	0.54
		2018/2019				
I_1	29.18^a	15.14^c	758.26^c	131.42^c	23.11^c	78.51^c
I_2	27.95^b	16.10^b	833.58^b	139.80^b	24.74^b	89.46^a
I_3	27.84^b	17.14^a	882.49^a	142.87^a	27.00^a	81.43^b
$LSD_{0.05}$	0.23	0.12	17.68	0.83	1.78	0.94

I_1=Sowing irrigation +two irrigations;I_2= Sowing irrigation +three irrigations; I_3= Sowing irrigation +four irrigations.
Mean values for each season in the same column without a common letter are significantly different (*P*<0.05) according to the Duncan comparison test; LSD = Least significant difference; NS = Not significant

Table 7. Effect of furrow width treatments on root and leaves traits of sugar beet at harvesting during the two growing seasons

Traits	Root plant^{-1}				Leaves plant^{-1}	
Treatments	Length(cm)	Diameter (cm)	Fresh weight(g)	Dry weight(g)	Number	Dry weight(g)
		2017/2018				
60 cm	28.23^a	12.48^c	732.37^c	133.47^c	21.26^c	78.47^b
90 cm	27.38^b	13.26^b	833.96^b	138.10^b	24.64^b	79.35^b
120 cm	26.28^c	14.53^a	908.89^a	143.72^a	26.60^s	82.97^a
$LSD_{0.05}$	0.27	0.15	34.41	0.74	0.33	0.99
		2018/2019				
60 cm	28.93^a	13.18^c	652.99^c	133.14^c	20.44^b	78.05^b
90 cm	27.05^b	14.22^b	745.30^b	137.57^b	24.38^a	78.48^b
120 cm	25.99^c	15.02^a	851.53^a	143.39^a	26.03^a	82.87^a
$LSD_{0.05}$	0.23	0.17	18.17	1.34	1.78	0.94

I_1=Sowing irrigation +two irrigations;I_2= Sowing irrigation +three irrigations; I_3= Sowing irrigation +four irrigations.
Mean values for each season in the same column without a common letter are significantly different (*P*<0.05) according to the Duncan comparison test; LSD = Least significant difference; NS = Not significant

Table 8. Effect of water stress treatments on whole weight per plant, yield per fed and quality traits of sugar beet at harvesting during the two growing seasons

Traits	Total weight plant-1 (g)		Quality traits(%)			Yield fed-1(ton)	
Treatments	Fresh	Dry	TSS	Sucrose	Purity	Roots	Sugar
			2017/2018				
I1	1498.83^c	216.53^c	19.34	17.68^a	82.96^a	18.03^c	3.18^c
I2	1556.95^b	226.71^b	18.52	16.85^b	81.85^b	20.11^b	3.39^b
I3	1647.26^a	235.55^a	17.50	16.28^c	81.02^c	22.16^a	3.60^a
LSD0.05	38.53	1.19	ns	0.12	0.41	0.65	0.13
			2018/2019				
Irrigation							
I1	1495.87^c	216.25^c	19.04	18.37^a	82.64	17.56^c	3.22^a
I2	1556.65^b	226.41^b	18.25	17.51^b	81.51	19.73^b	3.45^b
I3	1646.95^a	235.25^a	17.19	16.90^c	80.69	21.85^a	3.69^c
LSD0.05	37.94	1.35	ns	0.10	ns	0.53	0.15

Table 9. Effect of furrow width treatments on whole weight per plant, yield per fed and quality traits of sugar beet at harvesting during the two growing seasons

Traits	Total weight plant-1 (g)		Quality traits (%)			Yield fed-1 (ton)	
Treatments	Fresh	Dry	TSS	Sucrose	Purity	Roots	Sugar
			2017/2018				
60 cm	1463.98^c	213.31^c	18.90	17.47^a	81.64^b	18.55^c	3.24^b
90 cm	1579.40^b	227.55^b	18.52	16.97^b	82.60^a	20.34^b	3.41^b
120 cm	1659.65^a	237.94^a	17.99	16.49^c	82.64^a	23.18^a	3.82^a
LSD0.05	51.28	2.26	ns	0.11	0.38	1.02	0.23
			2018/2019				
60 cm	1413.72^c	213.05^c	18.61	17.51^a	81.70	18.23c	3.19^b
90 cm	1521.24^b	227.25^b	18.19	16.79^b	81.71	20.05^b	3.36^b
120 cm	1621.13^a	237.62^a	17.69	16.96^c	81.45	22.98^a	3.89^a
LSD0.05	42.24	2.11	ns	0.09	Ns	1.05	0.21

Table 10. Growth traits of sugar beet as affected by the interaction between water stress and bed width treatments under intercropping with faba bean during the two growing seasons

Irrigation	Furrow width	Root plant^{-1} Length(cm)	Diameter (cm)	Fresh weight(g)	Dry weight(g)	Leaves plant^{-1} Number	Dry weight(g)
		2016/2017					
I_1	60	29.18	14.78	683.45	124.57	19.04	76.58
	90	28.15	15.37	743.94	136.84	21.73	78.62
	120	27.52	16.28	769.71	139.00	24.03	80.21
I_2	60	28.29	15.17	762.85	128.62	25.07	77.03
	90	27.28	16.30	840.89	140.39	26.07	78.72
	120	26.58	17.31	898.14	145.28	26.77	80.32
I_3	60	24.42	16.36	829.43	142.07	26.74	80.90
	90	23.31	17.53	916.74	143.79	26.12	83.66
	120	21.96	18.69	980.50	145.29	26.92	84.69
Sole cropping		28.43	17.96	994.34	144.30	26.90	85.44
F test		***	**	***	**	**	**
LSD0.05		0.46	0.31	24.30	3.54	0.63	0.94
		2017/2018					
I_1	60	28.90	14.48	683.14	138.66	18.09	76.26
	90	27.88	15.06	743.69	136.54	21.46	77.99
	120	27.19	15.99r	769.42	124.21	23.78	79.89
I_2	60	27.95	14.80	762.48	144.97	24.78	76.70
	90	26.95	15.99	840.58	139.41	25.86	78.32
	120	26.26	17.00	897.84	128.34	28.50	80.01
I_3	60	24.06	16.07	829.15	144.99	26.47	80.56
	90	23.03	17.26	916.46	143.46	28.91	83.31
	120	21.69	18.41	980.22	141.71	28.72	84.38
Sole cropping		27.83	18.06	990.45	145.10	28.65	86.32
F text		**	***	***	**	**	**
LSD0.05		0.79	0.52	20.34	1.44	0.72	1.62

Table 11. Yield and quality traits of sugar beet as affected by the interaction between water stress and furrow width treatments under intercropping with faba bean during the two growing seasons

Irrigation	Furrow width	Total weight plant^{-1} (g) Fresh	Dry	Quality traits(%) TSS	Sucrose	Purity	Yield fed^{-1}(ton) Roots	Sugar
		2017/2018						
I_1	60	1395.66	203.78	17.18	17.36	80.73	16.54	2.87
	90	1479.43	214.44	18.07	16.23	81.41	17.33	2.81
	120	1516.85	221.69	18.71	16.20	82.65	18.65	3.02
I_2	60	1526.42	218.76	17.19	17.52	81.59	17.34	3.03
	90	1571.86	229.41	18.77	16.91	82.55	18.36	3.10
	120	1639.93	234.48	18.86	16.34	83.65	19.42	3.17
I_3	60	1528.96	227.06	18.14	17.15	80.75	18.63	3.19
	90	1664.99	236.29	18.83	17.35	81.58	19.75	3.34
	120	1784.99	240.47	18.73	16.73	82.57	20.83	3.48
Sole cropping		1789.32	245.23	17.43	18.02	79.40	27.04	4.87
F test		***	**	ns	*	ns	**	**
LSD0.05		82.35	2.05	ns	0.41	ns	1.32	0.23
		2018/2019						
I_1	60	1395.37	203.50	16.86	17.02	80.44	15.85	2.70
	90	1479.12	214.16	17.82	16.95	81.07	16.92	2.87
	120	1516.55	221.48	18.38	16.23	82.29	18.21	2.96
I_2	60	1526.11	218.47	16.86	17.20	81.23	17.11	2.94
	90	1571.51	229.11	18.45	16.55	82.22	18.04	2.99
	120	1639.59	234.15	18.27	16.03	83.34	19.25	3.09
I_3	60	1528.62	226.77	17.86	17.88	80.43	18.45	3.30
	90	1664.71	235.96	18.49	18.02	81.24	19.33	3.48
	120	1784.72	240.13	18.48	16.44	82.30	20.45	3.36
Sole cropping		1779.34	240.58	18.42	18.34	81.23	28.35	5.20
F test		***	**	ns	*	ns	**	**
LSD0.05		65.71	2.39	ns	0.35	Ns	2.05	0.26

2- Faba bean crop:

The results indicated that the highest number of branches per plant, number of pods per plant, number of seeds per pod and seed yield per plant of faba bean were obtained when plants were received four irrigations followed by three irrigations in comparison to those received only two irrigations (Table12). Also, the highest values of those traits were obtained when bed width was 120 cm followed by 90 cm in comparison to those sown on 60 cm. The longest plants were obtained when plants were received two irrigations or were sown on bed width of 60 cm (Table 12).

The highest seed, straw and biological yields of faba bean per fed was obtained from these plants that received four irrigations and sown on 120 cm bed width in intercropping with sugar beet (Table13). However, seed yield of faba bean per fed in pure stand was greater than in intercropping system. Such data are mainly due to the effects of both intra and inter competition between faba bean and sugar beet. The maximum biological yield of faba bean was obtained under mono-cropping, while the minimum biological yield was produced under intercropping when plants were irrigated with I_3 and sown on 60 cm bed width.

The effects of interaction between irrigation and bed width were significant on number of seeds per pod during both of growing seasons. The highest number of seeds per pod (Table 13) and the heaviest 100-seed weight, harvest index, seed yield per fed and biological yield fed^{-1} (Table 14) of faba bean were obtained when plants were grown on bed width of 120 cm (followed by 90 cm) and irrigated with four irrigations. However, the effects of interaction between the irrigation and bed width were not significant on plant height, number of pods plant^{-1}, seed yield plant^{-1} (Table 13), seed and straw yield fed^{-1}(Table 14).

Table 12. Effect of water stress treatments on plant height, number of branches, pods and seeds per plant, number of seeds and seed yield per plant of faba bean at harvest during the two growing seasons

Traits Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of Pods plant^{-1}	No. of Seeds pod^{-1}	Seed yield plant^{-1}(g)
			2017/2018		
I_1	113.74^c	2.70^c	11.66^c	2.24^c	17.52^c
I_2	116.65^b	2.78^b	12.99^b	2.29^b	18.44^b
I_3	126.54^a	2.94^a	14.57^a	2.50^a	18.88^a
$LSD_{0.05}$	0.52	0.06	0.10	0.04	0.22
			2018/2019		
I_1	113.35^c	2.39^b	11.39^c	2.02^b	17.26^c
I_2	116.41^b	2.51^a	12.79^b	2.07^{ab}	18.41^b
I_3	126.28^a	2.58^a	14.29^a	2.16^a	18.63^a
$LSD_{0.05}$	0.59	0.12	0.19	0.06	0.21

Table13. Effect of bed width treatments on plant height, number of branches, pods and seeds per plant, number of seeds and seed yield per plant of faba bean at harvest during the two growing seasons.

Traits Treatments	Plant height (cm)	No. of Branches plant^{-1}	No. of Pods plant^{-1}	No. of Seedspod^{-1}	Seed yield plant^{-1}(g)
			2017/2018		
60 cm	126.83^a	2.53^c	12.04^c	2.16^c	15.01^c
90 cm	120.29^b	2.83^b	13.23^b	2.30^b	17.85^b
120cm	109.80^c	3.07^a	13.95^a	2.57^a	21.98^a
$LSD_{0.05}$	0.75	0.13	0.09	0.03	0.33
			2018/2019		
60 cm	126.53^a	2.19^c	11.79^c	1.98^b	14.78^c
90 cm	119.96^b	2.46^b	12.30^b	2.03^b	17.58^b
12cm	109.55^c	2.82^a	13.75^a	2.24^a	21.94^a
$LSD_{0.05}$	0.83	0.12	0.24	0.08	0.24

Table 14. Effect of water stress treatments on 100-seed weight, seed, straw and biological yields and harvest index of faba bean at harvest during the two growing seasons

Traits Treatments	100-seedweight(g)	Seed yield (ton fed^{-1})	Straw yield (ton fed^{-1})	Biological yield (ton fed^{-1})	Harvest index
			2017/2018		
I_1	51.06^c	0.765^c	1.168^b	1.658^c	34.14^c
I_2	54.60^b	0.964^b	1.169^b	1.969^b	35.11^b
I_3	57.54^a	1.103^a	1.700^a	2.739^a	35.55^a
$LSD_{0.05}$	0.75	0.04	0.02	0.02	0.23
			2018/2019		
I_1	50.83^c	0.737^c	1.241^b	1.630^c	33.90^c
I_2	54.33^b	0.931^b	1.432^{ab}	1.938^b	34.91^b
I_3	57.25^a	1.023^a	1.554^a	2.710^a	35.27^a
$LSD_{0.05}$	0.78	0.09	0.27	0.02	0.26

Table 15. Effect of bed width treatments on 100-seed weight, seed, straw and biological yields and harvest index of faba bean at harvest during the two growing seasons

Traits Treatments	100-seedweight(g)	Seed yield (ton fed^{-1})	Straw yield (ton fed^{-1})	Biological yield (ton fed^{-1})	Harvest index
			2017/2018		
60 cm	50.77^c	0.830^c	1.165^c	1.54^c	34.60^b
90 cm	54.76^b	0.946^b	1.466^b	2.26^b	35.09^a
120 cm	57.67^a	1.055^a	1.784^a	2.57^a	35.10^a
$LSD_{0.05}$	1.24	0.02	0.02	0.02	0.41
			2018/2019		
60 cm	50.54^c	0.751^c	0.940	1.51^c	34.37^b
90 cm	54.50^b	0.916^b	1.540	2.23^b	34.83^a
120 cm	57.37^a	1.023^a	1.747	2.54^a	34.86^a
$LSD_{0.05}$	1.26	0.05	NS	0.02	0.41

Table 16. Plant height, number of branches, pods and seeds per plant, number of seeds and seed yield per plant of faba bean as affected by the interaction between water stress and bed width treatments under intercropping system during the two growing seasons

Traits Treatments		Plant height (cm)	No. of branchesplant^{-1}	No. of Podsplant^{-1}	No. of Seedspod^{-1}	Seed Yield plant^{-1}(g)
			2017/2018			
	60	121.22	2.40	11.11^{h}	2.06^{e}	14.17
I_1	90	115.03	2.76	11.81^{g}	2.24^{c}	17.02
	120	104.95	2.95	12.08^{e}	2.43^{b}	21.37
	60	124.83	2.52	11.99^{f}	2.17^{d}	15.20
I_2	90	117.98	2.77	13.07^{d}	2.22^{c}	17.98
	120	107.14	3.06	13.93^{c}	2.48^{b}	22.15
	60	134.46	2.66	13.02^{d}	2.25^{c}	15.67
I_3	90	127.85	2.97	14.83^{b}	2.44^{b}	18.56
	120	117.32	3.20	15.87^{a}	2.81^{a}	22.41
Sole cropping		120.38	4.85	20.63	3.01	43.86
$LSD_{0.05}$		NS	NS	0.17	0.07	NS
			2018/2019			
	60	120. 91	2.19^{c}	10.78^{g}	1.92^{d}	13.92^{h}
I_1	90	114.56	2.43^{b}	11.47^{f}	1.99^{d}	16.73^{e}
	120	104.59	2.54^{b}	11.92^{e}	2.14^{b}	21.13^{b}
	60	124.56	2.15^{c}	11.81^{e}	2.01^{c}	14.96^{g}
I_2	90	117.76	2.44^{b}	12.85^{d}	2.04^{c}	17.71^{d}
	120	106.91	2.94^{a}	13.70^{c}	2.16^{b}	22.57^{a}
	60	134.17	2.24^{c}	12.77^{d}	1.99^{d}	15.46^{f}
I_3	90	127.57	2.51^{b}	14.46^{b}	2.08^{c}	18.30^{c}
	120	117.15	2.98^{a}	15.63^{a}	2.41^{a}	22.13^{a}
Sole cropping		119.43	4.22	20.01	4.05	42.66
$LSD_{0.05}$		NS	0.21	0.32	0.10	0.45

The highest land equivalent ratio (LER, 1.533) as average of two seasons was obtained when the intercropped sugar beet and faba bean plants were irrigated four times and the furrow width was 120 cm (Table 17). *Abd El-All (2002)* reported that the highest land equivalent ratio was attained when sixteen plants of faba bean were intercropped on sugar beet per m^2. In the same trend, the highest net income for faba bean (7843 L.E.), relative yield for faba bean (0.873) and the highest total net income for both intercropped crops (15215 L.E) as average during both of growing seasons were obtained when plants received four irrigations and sown on furrow width 120 cm (Table 17). However, the highest net income and relative yield for sugar beet (8256 L.E. and 0.739, respectively) in intercropping system were obtained when plants were received two irrigations and sown on furrow width 120 cm (Table 18). Also, intercropped increased markedly farmer net and profitability per unit capital input (one LE). *Mohammed et al. (2005)* indicated that growth, yield and yield components of sugar beet were significantly decreased by intercropping with faba bean as compared with solid sugar beet. The highest LER and K were obtained when 100% sugar beet was intercropped with 33% faba bean.

Table 17. 100-seed weight, harvest index, seed, straw and biological yields and harvest index of faba bean as affected by the interaction between water stress and bed width treatments under intercropping system during the two growing seasons

Treatments		100- Seed weight (g)	Seed yield (ton fed^{-1})	Straw yield (ton fed^{-1})	Biological yield (ton fed^{-1})	Harvest index
			2017/2018			
	60	48.43^{f}	0.64^{f}	1.025^{i}	1.665^{d}	38.43^{c}
I_1	90	51.48^{e}	0.78^{e}	1.122^{h}	2.002^{i}	38.96^{b}
	120	53.26^{d}	0.88^{d}	1.357^{f}	2.237^{f}	39.33^{b}
	60	50.77^{e}	0.84^{d}	1.363^{e}	2.203^{g}	38.12^{c}
I_2	90	55.18^{c}	0.99^{c}	1.533^{d}	2.523^{e}	39.23^{b}
	120	57.85^{b}	1.06^{b}	1.807^{b}	2.867^{b}	36.97^{d}
	60	53.10^{d}	1.01^{c}	1.769^{g}	2.779^{h}	36.34^{e}
I_3	90	57.63^{b}	1.07^{b}	1.743^{c}	2.813^{c}	38.03^{c}
	120	61.89^{a}	1.23^{a}	2.189^{a}	3.419^{a}	35.97^{e}
Sole cropping		84.53	1.39	2.121	3.511	39.58
$LSD_{0.05}$		1.30	0.04	0.01	0.03	0.40
			2018/2019			
	60	48.20^{f}	0.617	1.103	1.720	35.87
I_1	90	51.28^{e}	0.746	1.325	2.071	36.01
	120	53.01^{d}	0.847	1.394	2.241	37.79
	60	50.56^{e}	0.815	1.413	2.228	36.57
I_2	90	54.90^{c}	0.954	1.515	2.469	38.63
	120	57.52^{b}	1.022	1.769	2.791	36.61
	60	52.86^{d}	0.821	1.803	2.624	31.28
I_3	90	57.31^{b}	1.048	1.711	2.759	37.98
	120	61.58^{a}	1.201	2.048	3.249	36.96
Sole cropping		83.45	1.432	2.920	4.352	32.90
$LSD_{0.05}$		1.35	0.15	NS	0.03	0.45

Table 18. Effect of water stress and furrow width interaction on relative yield, land equivalent ratio (LER) and total net income of intercropping sugar beet with faba bean during both of growing seasons.

Irrigation	Bed width	Relative yield (RY)		LER	Net income for (L.E.)		Total net income (L.E.)
		Faba bean	Sugar beet		Faba bean	Sugar beet	
				2017/2018			
	60	0.771	0.586	1.357	6501.6	6616	13117.6
I_1	90	0.766	0.614	1.38	6907.95	6932	13839.95
	120	0.880	0.661	1.541	7939.95	7460	15399.95
	60	0.603	0.614	1.217	5437.35	6936	12373.35
I_2	90	0.709	0.650	1.359	6398.4	7344	13742.4
	120	0.756	0.688	1.444	6817.65	7768	14585.65
	60	0.458	0.660	1.118	4128	7452	11580
I_3	90	0.555	0.700	1.255	5005.2	7900	12905.2
	120	0.628	0.738	1.366	5663.1	8332	13995.1
				2018/2019			
	60	0.592	0.573	1.165	5295.45	6340	11635.45
I_1	90	0.755	0.612	1.367	6759.6	6768	13527.6
	120	0.866	0.659	1.525	7746.45	7284	15030.45
	60	0.587	0.619	1.206	5256.75	6844	12100.75
I_2	90	0.688	0.652	1.34	6153.3	7216	13369.3
	120	0.737	0.696	1.433	6591.9	7700	14291.9
	60	0.445	0.667	1.112	3979.65	7380	11359.65
I_3	90	0.538	0.699	1.237	4811.7	7732	12543.7
	120	0.610	0.740	1.35	5463.15	8180	13643.15

LER= land equivalent ratio; L.E.= Egyptian pound

Total income for solid crops was11292 L.E. for sugar beet, and it was9020 L.E. for faba bean in 2017/2018 season.

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تأثير الرى وعرض الخط على انتاجية تحميل بنجر السكر والفول البلدى وبعض العلاقات المائية فى الارض الطينية

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أجريت تجربة حقلية بمحطة البحوث الزراعية بسخا خلال موسمي 2018/2017 و2019/2018 لدراسة تأثير ثلاث معاملات رى (I_1= تعطى رية الزراعة + ريتين ، I_2= تعطى رية الزراعة +ثلاث ريات و I_3 = تعطى رية الزراعة + أربع ريات منهم رية المحاياه لكل المعاملات) وثلاث قيم لعرض الخط (60، 90 و 120 سم) على الفول البلدى (صنف جيزة 843) المحمل مع بنجر السكر (صنف جلوريا) على النمو والمحصول ومكوناته وصفات الجودة لكلا المحصولين وبعض العلاقات المائية وكان التصميم الاحصائى المستخدم هو القطع المنشقة مرة واحدة في ثلاثة مكررات حيث وضعت معاملات الرى في القطع الرئيسية و عرض الخط بالقطع الشقية وأوضحت النتائج التالى: كانت اعلى القيم بالنسبه للفول البلدى فى جميع الصفات عدا ارتفاع النبات عند المعامله الاولى للرى وعرض خط 120 سم وكانت اعلى القيم بالنسبه لبنجر السكر فى جميع الصفات عدا طول الجذر عند المعامله الثالثة للرى وعرض خط 120 سم فلى كلا الموسمين .أعطيت معاملة الرى I_3 (رية الزراعة + أربع ريات) أعلى قيم للماء المضاف والماء المستهلك للمحصولين مع عرض خط 120 سم ولكنها أعطيت أقل قيم لكلا من كفاءة انتاجية المياه المضافة والمستهلكة فى الموسمين. سجلت أعلى قيم للمكافئ الأرضي (LER) وهى 1.541و1.525عند معاملة الرى الثالثة عند عرض خط 120 سم في الموسم الأول والثاني على التوالي.كانت أعلى قيمه للعائد الاقتصادي (15399.95 و15030.45جنيه/ فدان) تم الحصول عليها عند معاملة الرى الثالثة عند عرض خط 60 سم عند تحميل الفول البلدى مع بنجر السكر في الموسمين الأول والثاني على التوالي مقارنة بالعائد الاقتصادي للبنجر منفرد والذي حقق 11292و 11060جنيه /فدان في الموسمين الأول والثاني على التوالي.