COMMON BEAN GROWTH, WATER USE EFFICIENCY AND SOIL SALINITY AS EFFECT TO DEFICIT IRRIGATION AND MULCHING MATERIALS UNDER DRIP IRRIGATION

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ABSTRACT

This study investigated the combined effects of deficit irrigation and mulches on beans yield, water use efficiency (WUE) and soil salinity under drip irrigation. The treatments of the study comprised different combinations of three irrigation treatments ($I_{100\%}$ =100%, $I_{85\%}$ =85% and $I_{70\%}$ = 70% of crop evapotranspiration (ETc) and three mulching materials (no mulch (NM), rice straw mulch (RSM) and farmyard manure mulch (FYM). The results obtained that the irrigation treatments and mulching materials on yield and WUE were significant. The greatest value of bean yield (941.5and 925.7kg fed^{-1}) were obtained under ($I_{100\%}$) in the first and second season, respectively, while the lowest ones (706.4 and 710.6kg fed^{-1}) were obtained from ($I_{70\%}$) in the first and second season, respectively. 39.6 and 11.1 % than NM and RSM in 2014 seasons, respectively increased the average GY of FYM treatment. The corresponding values in 2015 season were 39.6 and 9.3 % in the same order.

The average of soil salinity value ($I_{70\%}$) was increased by 28.26and 13.50% than those of $I_{100\%}$ and $I_{85\%}$, respectively. 21.9 and 19.7 % than those of FYM and RSM treatments, respectively increased the average EC value of NM.

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The greatest WUE (0.74 and 0.75 kg m^{-3}) value was obtained under $I_{70\%}$ compared to (0.69 and 0.68 kg m^{-3}) under $I_{100\%}$, in two seasons, respectively. 40.3 and 10.6 % than those of NM and RSM, respectively increased the average WUE values of FYM. It could be considered as a suitable under environmental conditions of study area and similar areas, the treatment (I_{100} × FYM) is the most suitable for producing high bean crop yield. Under limited irrigation water supply, application of (I_{85} ×FYM) treatment was found to be favorable to save 15% of the applied irrigation water, with reduction in bean crop yield.

Key word: *Drip irrigation, mulch, WUE, bean crop, soil salinity*

INTRODUCTION

Agricultural irrigation is vital to food production in many parts of the globe and a critical tool for ensuring food security (Liang et al., 2016). More than 80% of water resources have been exploited for agricultural irrigation in Egypt (Egypt in Figures, 2015). Therefore, it is necessary to develop strategies to optimize the efficiency of water use, while maintaining the quantity and quality of the production (Nangareet al., 2016).

Dry bean (Phaseolus vulgaris L.) is a human food high in protein, phosphorus, zinc, iron, vitamin B1, and fiber. It is the most important legume crop worldwide for human consumption because is a source of protein (Ramirez Builes et al., 2011). According to Food and Agriculture Organization (FAO) Statistics (2013), dry bean has been globally cultivated in 29,290,861 ha and produced 23,598,102 tones with an average of 0.806 tones ha^{-1} (o.336 ton fed^{-1}). In Egypt, the total area devoted for the production of dry bean yield was 63,710.4 fed and produced 69,486 tones with an average of 1.09 tones fed^{-1}.

The challenge of irrigated agriculture in our time is how to produce more crops from limited water supply. One way of tackling this challenge is adoption of practices that help improvement water management especially at field scale. The combine practice of deficit irrigation techniques with drip irrigation system (Topaket al., 2016) mulching appears to be very promising in achieving this goal (Igbadun et al., 2012).

In recent years, drip irrigation system has been recommended, not only for reducing irrigation water, but also for increasing crop yield (Geertsand

Raes, 2009). Drip irrigation is often used with mulch, which plays a main role in water conservation, particularly to control soil evaporation, and also contributes to increase the productivity (Mukherjee et al., 2012).Deficit irrigation (DI) as a water saving method is commonly applied in arid and semi-arid regions to increase water productivity (Shahrokhniaand Sepaskhah, 2016). DI, defined as the application of water below full crop-water requirements, is an important tool to achieve the goal of reducing irrigation water use (Fereresand Soriano 2007). DI aims to increase water use efficiency (WUE) by eliminating irrigation events that have little impact on yield. Combine practice of DI and mulching appears to be very promising among the water management practices for increasing WUE especially at field scale. The main advantages associated with mulching are: (i) less water is required for irrigation (Trenoret al., 1998), (ii) advance of harvest (FerrerTalón et al., 2004), and (iii) the bigger size of plants (Melgarejoet al., 1998). Cover crop mulch that remains on the soil surface can be used to add soil organic matter (Dabneyet al., 2001), increase soil water retention (Dabney, 1998), prevent the evaporation, and enhance the soil temperature (LIU et al., 2012). Mulching is an efficient way to reduce evaporation and improve WUE (Hartkampet al., 2004) under different mulches, the amount of salts removed from the soil significantly decreases compared with no mulch (Abd El-Mageed, et al., 2016). (Semidaet al. 2014) found that the addition of organic materials to soil increased the water holding pores and decreased the electrical conductivity of soil (ECe). Application of mulching with different materials could significantly increase available soil water and decrease salinity (Liu et al., 2010). The present investigation was planned to determine the effects of deficit irrigation and mulching materials on common bean yield, yield components, water use efficiency and salinity under drip irrigation system.

2. MATERIALS AND METHODS

2.1. Experimental location

Two field experiments were conducted during the two growing seasons (2014 and 2015) at the private Farm; Ansar graduates village Ihnasiya Sdment mountain Center, Beni Suef, Egypt. Some Physical and chemical properties of the experimental soil are given in tables (1 and 2).

Table (1): Physical properties of the experimental soil.

Soil depth, cm	Particle size distribution				Bulk density, Mg m^{-3}	FC %	WP %	AW %
	Sand, %	Silt, %	Clay, %	Soil Texture class				
0-10	47.2	15.3	37.5	S C	1.46	19.79	4.69	15.10
10-20	46.3	16.8	36.9	S C	1.57	19.42	4.64	14.78
20-30	46.9	17.1	36.0	S C	1.58	18.62	4.37	14.25

SC: Sandy clay, FC: soil moisture retained at 0.33 bar atm, WP: soil moisture retained at 0.15 bar atm AW: Available water.

Table (2): Chemical properties of the experimental soil.

Depth cm	Anions (meq L^{-1})				Cations (meq L^{-1})				EC_e dS m^{-1}	pH
	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+		
0-10	0.00	4.20	35.0	18.20	18.20	14.53	23.25	1.42	5.74	7.40
10-20	0.00	3.89	33.4	19.21	19.21	14.65	21.30	1.34	5.65	7.38
20-30	0.00	3.55	29.8	16.85	17.32	11.76	19.84	1.28	5.02	7.52

2.2. Experimental design and treatments

The experimental layout was a split-plot system in a randomized complete blocks design with three replications. The irrigation treatments were distributed in the main plots whilst and mulching materials were allocated in the sub-plots.

2.2.1. Irrigation treatments:

Three irrigation treatments were applied as a percentage of the crop evapotranspiration (ETc) representing one of the following: $I_{100\%}$ = (100% of Etc), $I_{85\%}$ (=85% of Etc) and $I_{70\%}$ = (70% of Etc).

2.2.2. Mulching materials:

Three mulching materials were used in this study as follow: No mulch (control), Rice straw mulch (RSM) and Farmyard manure mulch (FYM).

2.3. Irrigation water applied (IWA)

The bean plants were irrigated at three days intervals by different amounts of irrigation water.

The daily ETo was computed by equation (1) according to Doorenbos and Pruitt (1992):

$$\text{ETo} = \text{Kpan} \times \text{Epan} \ldots\ldots\ldots (1)$$

Where:

$Epan$ = evaporation from the Class A pan (mm d^{-1}).

$Kpan$ = the pan evaporation coefficient.

Computed E to depend upon monthly mean weather data of 16-years (January 1997 - December 2013) were applied in this study. The average of maximum and minimum air temperature, mean relative humidity, wind speed and class A pan evaporation are shown in Table (3).

Table (3): The average of maximum and minimum air temperature, mean relative humidity, wind speed and class A pan evaporation.

Months	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Wind speed (m s^{-1})	E-pan (mm d^{-1})
Sept.	35.98	21.40	57.93	4.84	6.33
Oct.	31.88	17.94	59.09	4.41	4.69
Nov.	27.68	14.30	62.95	3.77	3.07
Dec.	23.90	10.23	60.44	2.94	2.37

The crop water requirements (ETc) were estimated using the crop coefficient according to equation (2).

$$ETc = ETo \times Kc \text{………..} (2)$$

Where:

ETc = crop water requirements (mm d^{-1}).

Kc = crop coefficient.

The length of the different crop growth stages were 20, 30, 40, and 20 days for initial, crop development, mid-season and late season stages, respectively. The crop coefficients (Kc) of initial, mid and end stages were 0.40, 1.15 and 0.35 respectively according to Allen *et al.* (1998).

The amount of irrigation water applied (IWA) to each treatment was determined by using the equation (3):

$$IWA = \frac{A \times ETc \times Ii \times Kr}{Ea \times 1000} + LR \text{..............} (3)$$

Where:

IWA = irrigation water applied (m^3).

A = plot area (m^2).

ETc =crop water requirements (mm d^{-1}).

`*Ii* = irrigation intervals (d).

Kr = coverage coefficient (Kr = (0.10+G_C) $\leq$1)

Gc = ground cover.

Ea = application efficiency (%) (Ea = 85%).

LR = leaching requirements (m^3).

The amounts of irrigation water applied were 1356, 1153 and 949 m^3 fad^{-1} for treatments $I_{100\%}$, $I_{85\%}$ and $I_{70\%}$, respectively. Irrigation treatments started directly after full plant emergence.

Bean seeds (Nebraska) were hand planted (15 September 2014 and 14 September 2015) in drills 100 cm apart and 15 cm within hill. Plants were thinned to secure one plant per hill three weeks after planting. All other cultural practices were carried out as recommended for bean crop in both seasons.

After 45 days from sowing, random sample of three plants were taken from each experimental unit. Plant height (cm), number of leaves plant^{-1}and number of pods plant^{-1} were measured.

At harvest, random sample of five plants were taken for each experimental unit. 100 seed weight (g) and seed yields were measured per each experimental unit then transferred to seed yield kg in fed^{-1}.

2.4. Soil salinity:

At final harvest, (after the second season) for each treatment experimental unit, soil electrical conductivity (EC) was measured. Soil samples collected at 10 cm intervals from soil surface to 30 cm depth from one position. Approximately 500 g of soil were collected for each sample to be tested. EC values of the saturated soil paste extracts were measured using digital readout conductivity instrument to identify and determination soil salinity in the three layers of soil i.e., 0 – 10 , 10 – 20 and 20 – 30 cm.

2.5. Water use efficiency (WUE):

Water use efficiency values as kg seeds m^{-3} of irrigation water applied were calculated for different treatments after harvest using equation (4) according to (Jensen, 1983).

$$WUE = \frac{\text{seeds yield (kg fed}^{-1})}{\text{irrigation water applied (m}^3\text{ fed}^{-1})} \quad \text{.............(4)}$$

2.7. Statistical analysis.

Statistical analyses of data were performed according to (Snedecor and Cochran 1980).

3. RESULTS AND DISCUSSION

3.1. Bean yield and yield components:

Data presented in Tables (4and 5) indicated that yield and all its components were significantly affected by each soil mulching materials, irrigation treatments and mulching type.

Table (4): Effect of mulching materials, irrigation treatments and their interaction on plant height (cm), number of leaves plant^{-1}and number of pods plant^{-1}.

Irrigation treatments	Mulching treatments	Plant height (m)		No. of leaves plant^{-1}		No. of pods plant^{-1}	
		2014	2015	2014	2015	2014	2015
$I_{100\%}$	NM	26.40	23.10	4.80	4.30	10.20	9.90
	RSM	28.20	27.10	5.60	5.60	11.90	11.90
	FYM	30.20	29.00	7.10	7.30	13.60	13.00
	Average	28.27	26.40	5.83	5.73	11.90	11.60
$I_{85\%}$	NM	23.90	21.30	4.60	4.30	9.20	9.10
	RSM	26.60	24.80	4.30	5.60	10.70	10.70
	FYM	28.80	26.90	6.40	6.40	13.00	12.40
	Average	26.43	24.33	5.10	5.43	10.97	10.73
$I_{70\%}$	NM	25.00	18.00	4.10	4.10	8.10	8.40
	RSM	25.00	21.00	4.90	5.00	9.40	10.10
	FYM	28.40	24.70	6.00	6.00	11.40	11.90
	Average	26.13	21.23	5.00	5.03	9.63	10.13
	NM	25.10	20.80	4.50	4.23	9.17	9.13
	RSM	26.60	24.30	4.93	5.40	10.67	10.90
	FYM	29.13	26.87	6.50	6.57	12.67	12.43
LSD $_{0.05}$ for I		1.4	1.1	0.3	0.3	0.5	0.4
LSD $_{0.05}$ for M		1.1	0.9	0.2	0.2	0.4	0.4
LSD $_{0.05}$ for I × M		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Table (5): Effect of mulching materials, irrigation treatments and their interactions on 100- dry seed weight (g), seed yields (kg fed^{-1}) and water use efficiency (WUE).

Irrigation treatments	Mulching treatments	100- dry seed weight (g)		seed yield (kg fed-1)		WUE (kg m-1)	
		2014	2015	2014	2015	2014	2015
$I_{100\%}$	NM	66.3	67.2	774.1	773.0	0.57	0.57
	RSM	76.5	76.6	963.6	973.8	0.71	0.72
	FYM	80.1	81.5	1086.9	1030.4	0.80	0.76
	Average	74.3	75.1	941.5	925.7	0.69	0.68
$I_{85\%}$	NM	60.2	61.7	711.0	691.3	0.62	0.60
	RSM	72.3	73.4	896.7	879.2	0.78	0.76
	FYM	78.6	78.7	986.3	992.3	0.86	0.86
	Average	70.4	71.3	864.7	854.3	0.75	0.74
$I_{70\%}$	NM	55.0	55.0	578.4	569.4	0.61	0.60
	RSM	61.7	62.4	733.3	745.7	0.77	0.79
	FYM	70.7	71.9	807.5	816.8	0.85	0.86
	Average	62.5	63.1	706.4	710.6	0.74	0.75
	NM	60.5	61.3	687.8	677.9	0.60	0.59
	RSM	70.2	70.8	864.5	866.2	0.75	0.76
	FYM	76.5	77.4	960.2	946.5	0.84	0.83
	Average	69.0	69.8	837.5	830.2	0.73	0.72
LSD $_{0.05}$ for I		1.7	1.5	24.0	29.0	0.02	0.03
LSD $_{0.05}$ for M		1.4	1.2	19.0	24.0	0.02	0.02
LSD $_{0.05}$ for I × M		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Regarding irrigation treatments, all trails were significantly affected by the irrigation treatments. It is clear that the average seed yield of bean crop was increased with increasing amounts of irrigation water applied. Data in Table (4) showed that, the greatest bean yield (941.5and 925.7kg fed^{-1}) were obtained under ($I_{100\%}$) in the first and second season, respectively, while the lowest ones (706.4and 710.6kg fed^{-1}) were obtained from ($I_{70\%}$) in the first and second season, respectively. This may be due to the sufficient available water with in the root zone under ($I_{100\%}$)

which could led to an increase in both water and nutrients absorption and consequently increases in the metabolic mechanisms in plants leading to an increase in number of pods plant^{-1} and 100- dry seed weight (g). The greatest mean values of number of pods plant^{-1} and 100- dry seed weight (11.75and 74.7g) were obtained under ($I_{100\%}$), while the lowest one (9.88and 62.8 g) were obtained from ($I_{70\%}$), respectively, (Tables 4 and 5).

Data in Fig. (1) showed that the graphical relationship between irrigation water application (IWA) and bean yield (Y) was curvilinear (polynomial of 2nd order). This relationship could be expressed as follows:

$$Y = -0.0009 \times IWA^2 + 2.5571 \times IWA - 906.14, \quad R^2 = 1$$

Where Y is bean yield (kg fed^{-1}) and IWA is irrigation water applied (m^3 fed^{-1}).

The relationship between yield and irrigation water applied was curvilinear because part of the water applied went into deep drainage rather than to evapotranspiration.

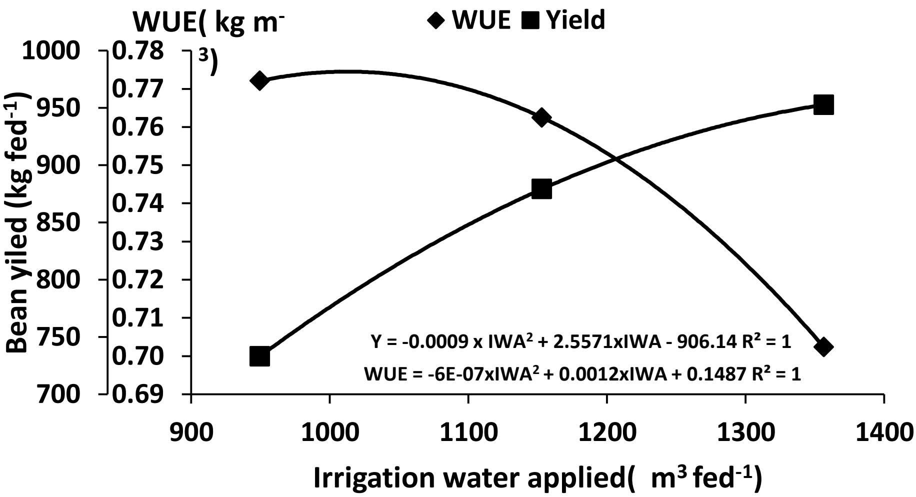

Fig. (1): The relationships between irrigation water applied, bean yield, and water use efficiency.

Regarding mulching treatments, Tables (4 and 5) showed that, the average GY of FYM treatment was increased by 39.6 and 11.1 % than NM and RSM in 2014 seasons, respectively. The corresponding values in 2015 season were 39.6 and 9.3 % in the same order. The increase in yield as a result of the use of mulch treatments compared to the no mulch can be attributed reduction of water evaporation from soil, conserve soil moisture. Therefore, more water is available for the crop and in the same time decreasing salt in the surface soil consequently increases crop yield. Also, the obtained results were in agreement with this obtained by (Abd El-Mageed, et al., 2016).They found that the average squash yield values of FYM were increased by 5.21, 14.81and 25.79% than those of RSM, polyethylene mulch and without mulch, respectively. This result may be due to the organic mulch add nutrients to soil when decomposed by microbes and helps in carbon sequestration (Chattopadhyayaand Mukherjee, 1990) and also, enhanced the availability of certain elements and their supply to onion plants (Salehet al., 2003). In addition, the organic manure, due to the improvement of soil physical properties as well as increasing soil water holding capacity which gave rise to good aeration and drainage that encourage better root growth and nutrient absorption (Abou El-Magdet al., 2008).

Plant height, number of leaves plant^{-1}, number of pods plant^{-1},100- dry seed weight, seed yields and WUE were not significantly affected by interaction between mulching materials and irrigation treatments. The greatest bean yield (1086.9and 1030.4kg fed^{-1}) was recorded for plants irrigated with the greatest level of AIW ($I_{100\%}$) and applied FYM. In contrast, the lowest beans yield (578.4and 569.4kg fed^{-1}) was obtained from plants irrigated with the lowest level of AIW ($I_{70\%}$) and NM in both seasons, respectively, As shown in (Table 5), clear that, average bean yield for $I_{85\%}$ × FYM treatment (989.3kg fed^{-1}) produced similar value for $I_{100\%}$ ×FYM (1058.7kg fed-1).Under FYM treatment, decreasing irrigation water by 15 % from IWA for treatments $I_{85\%}$ reduced the yield by 6.55 % than the $I_{100\%}$ treatment in two seasons, respectively. Therefore, under limited irrigation water, it could be seen that applying the ($I_{85\%}$) and applied FYM was found to be favorable to save 15% of the applied irrigation water accompanied with producing the same bean yield.

3.2. Effect of Soil salt accumulation:

Soil salinity were expressed in terms of Electrical conductivity values of soil past extract (EC_e) in the first season (before plant seeding) initial soil electrical conductivity (EC) was measured. The initial EC values were 5.74, 5.65 and 5.02 dS $m^{-1}$for three depths (0-10, 10-20 and 20-30 cm).

Data presented in Fig. (2) Show that, soil salinity was affected by irrigation treatments and mulching layer materials. There were differences between control (initial soil electrical conductivity) between treatments (irrigation treatments and mulching materials) and the differences were especially clear in the top 10 cm soil layer. This could be attributed to the greater evaporation of water from the soil surface, which would have allowed greater upward movement of salt from the lower soil layer to top soil layer. Data in Fig. (2)Show that, the lowest value of soil salinity was obtained under ($I_{100\%}$), while the greatest one was obtained from ($I_{70\%}$). The average soil salinity value of ($I_{70\%}$) was increased by 28.26and 13.50% than those of $I_{100\%}$ and $I_{85\%}$, respectively. This result may be due to the sufficient available water in the root zone under $I_{100\%}$ compared $I_{70\%}$, and thus decreasing salinity in top soil. In this concern, (Zhang, et al., 2016) reported that, salt concentration varied inversely with the irrigation water amount, i.e., salt concentration was high in the heavy water stress cases, and was relatively with full irrigation.

Regarding mulch treatments, Fig. (2) Showed that, the greatest soil salinity value was observed under NM (no mulch) compared to FYM and RSM treatments. The average EC value of NM was increased by 21.9 and 19.7 % than those of FYM and RSM treatments, respectively. This is in line with the findings by (Abd El-Mageed, et al. 2016). This resulted could be attributed to two reasons, first, under NM higher evaporation of water from the top soil surface, which would have allowed greater upward movement of salt from the deeper soil layers to top soil surface. In addition to under mulching treatments, reduce soil water loss by evaporation from the soil surface, conserve moisture that has prevented run off and permit infiltrated into the soil profile (Li et al., 2013), increasing available soil water (Liu et al., 2010) and leaching the salts accumulated from the topsoil to the deeper soil layers, thus decreasing salinity in top soil.

3.3. Water use efficiency (WUE)

Data given in Table (5) showed that, WUE was significantly affected by irrigation treatments and mulching materials.

Data presented in Table (5) demonstrate that WUE was significantly affected by the irrigation treatments. The greatest WUE (0.74 and 0.75 kg m^{-3}) value was obtained under $I_{70\%}$ compared to (0.69 and 0.68 kg m^{-3}) under $I_{100\%}$, in two seasons, respectively. Water use efficiency was significantly affected by mulching materials.

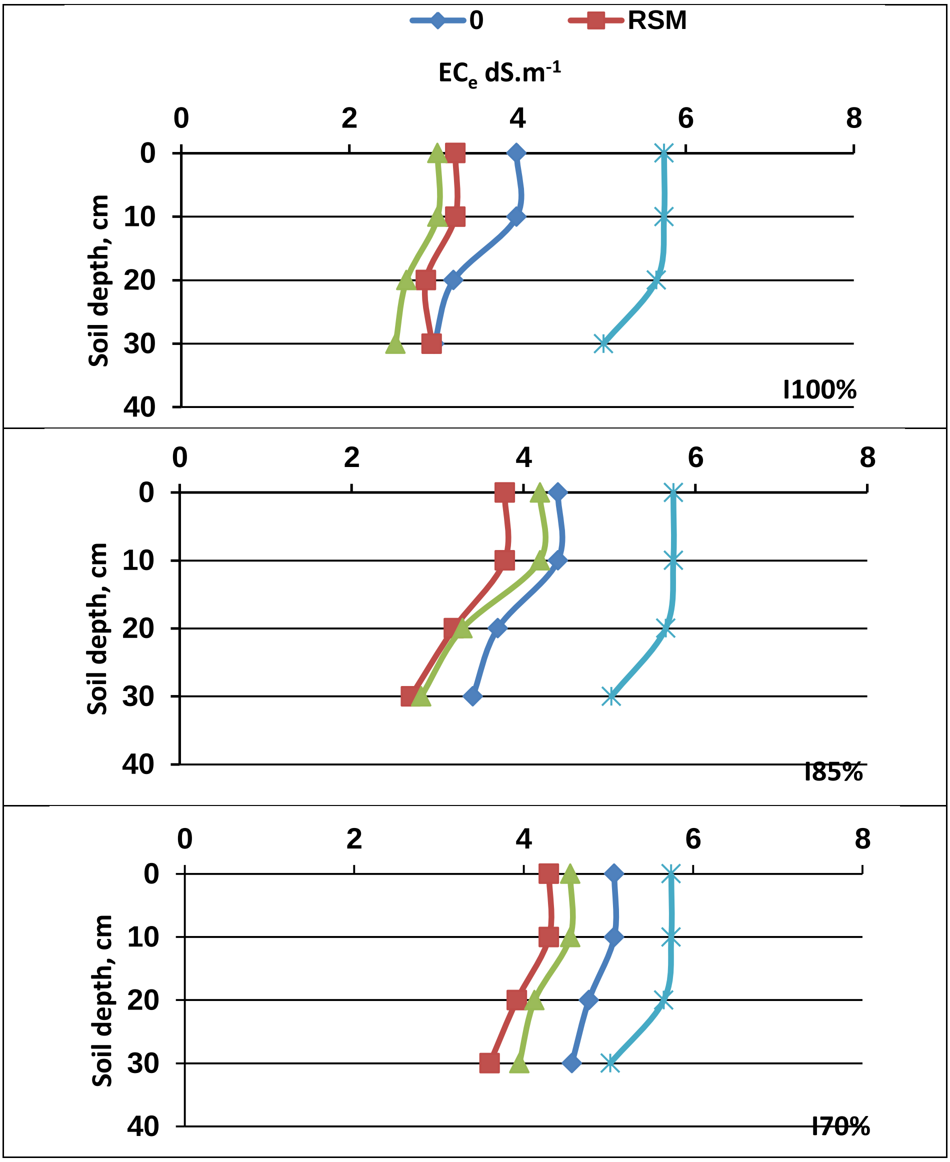

Fig. (2): Effect of irrigation treatments on soil salinity under FYM and RSM.

As presented in Fig. (1), the relationship between IWA and WUE was curvilinear (polynomial of 2^{nd} order). This relationship could be expressed as follows:

$$WUE = -6E\text{-}07 \times IWA^2 + 0.0012 \times IWA + 0.1487, \quad R^2 = 1$$

Where Y is bean yield (kg fed^{-1}), and WUE is water use efficiency (kg. m^{-3}).

Regarding mulching type treatments, Table (6) showed that, WUE was significantly affected by mulching type. The average WUE values of FYM were increased by 40.3 and 10.6 % than those of NM and RSM, respectively. Similar trend was reported by (Abd El-Wahed and Ali, 2013).They found that the average WUE values of FYM20 (20 ton ha^{-1}) were increased by 36.04 and 14.39 % over FYM0 (no mulch) in 2009 seasons, respectively. While the corresponding values in 2010 season were 38.39 % in the same order. Data in Table (6) indicated that WUE was not significantly affected by the interactions between irrigation treatments and mulching materials.

CONCLUSIONS

The effects of deficit irrigation and mulching materials on beans yield, water use and salinity was studied in two field experiments conducted during two seasons (2014 and 2015).

The results showed that the irrigation treatments and mulching materials on yield and WUE were significant. The greatest value of bean yield (941.5and 925.7kg fed^{-1}) were obtained under ($I_{100\%}$) in the first and second season, respectively, while the lowest ones (706.4 and 710.6kg fed^{-1}) were obtained from treatment ($I_{70\%}$) in the first and second seasons, respectively. The average GY of FYM treatment was increased by 39.6 and 11.1 % than NM and RSM in 2014 seasons, respectively. Corresponding values for the second season were 39.6 and 9.3 % in the same order.

Based on the results of the present work it could be stated that treatment (I_{100} × FYM) is the most suitable for producing high bean crop. Under the conditions of the study area, application of (I_{85} ×FYM) treatment was found to be favorable to save 15% of the applied irrigation water, providing the same bean crop.

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الملخص العربي

تاثير الري المتناقص بالتنقيط والتغطية على نمو نبات الفاصوليا وكفاءة استخدام المياه وتراكم الاملاح بالتربه

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اجريت الدراسة الحالية بهدف تقدير تأثير الري المتناقص والتغطية على نمو محصول الفاصوليا ومكوناته وكفاءة استخدام المياه وتراكم الاملاح تحت نظام الري بالتنقيط. تم تنفيذ تجربتين حقليتين خلال موسمي ٢٠١٤ و ٢٠١٥ وذلك بمزرعة خاصة بقرية الانصار للخريجين بإهناسيا مركز سدمنت بمحافظة بني سويف - مصر. وكان التصميم المستخدم القطع المنشقة مرتين في ثلاث مكررات.

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وقد اشتملت التجربة على أربع وعشرين معاملة تتكون من نوعين من التغطية (قش الارز (RSM) والسماد البلدي (FYM) ، وثلاث معاملات للري (١٠٠٪و٨٥٪و٧٠٪من البخرنتح للمحاصيل(ETC) وأربعة اعماق لطبقة التغطيةTML (٠ و ٣ و ٦ و ٩ سم) وتمت الدراسة تحت نظام الري بالتنقيط.

وأوضحت النتائج أنتأثير الري المتناقص ونوع التغطية. حيث زاد محصول الفاصوليا عند اضافة FYM بنسبة ١٠.٨٧ و ٨.٨٤ % مقارنة بإضافة RSM في موسمي الزراعة، بالترتيب.

كما تم الحصول على اعلى محصول للفاصوليا (٩٥٨.٨ و ٩٤٦.٧ كجم فدان$^{-1}$) عند عدم نقص مياه الري (١٠٠٪) في كلا الموسمين، بالترتيب، بينما كان اقل محصول (٧٣٣.٤ و ٧٣٢.٧كجم فدان$^{-1}$) في كلا الموسمين، على الترتيب عند الري بمقدار ٧٠% من قيمه النتح.

وتوضح نتائج هذه الدراسه أن انسب المعاملات تحت ظروف منطقه الدراسة للحصول على أعلى محصول من الفااصوليا هو المعامله عند عدم نقص مياه الري (١٠٠٪) واستخدام FYM بعمق ٩ سم نقص الامداد المائي.

وتحت ظروف نقص الامداد المائي فأن المعاملة ٨٥٪واستخدام FYM بعمق ٩ سم هي أنسب المعاملات لتوفير ١٥% من مياه الري مع الحصول على نفس كمية المحصول.