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RESEARCH ARTICLE

WHEAT PRODUCTION IN THE ARID REGIONS BY USING DRIP IRRIGATION SYSTEM

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Abstract

Efficiency of irrigation method and application of organic amendments are concepts should be followed in Egypt for saving part of the irrigation water due to the limited water resources. Two field experiments were conducted at the Research and Production Station, National Research Centre, El-Nubaria Province, El-Behira Governorate, Egypt, during the two successive winter seasons of 2009/2010 and 2010/2011, to study the effect of different irrigation systems and application of compost on yield, yield attributes and irrigation water use efficiency of wheat under newly reclaimed sandy soil conditions. Studied factors were irrigation systems (drip irrigation with 15, 25, 35, 45, 55, 65 and 75 cm laterals spacing compared with sprinkler irrigation system) and application of compost (without application (control) and the recommended dose (47.62 m^3 ha^{-1})). The following parameters were studied (1) soil moisture distribution, (2) yield and yield attributes of wheat, (3) irrigation water use efficiency of wheat (IWUE), (4) economical analysis. Results indicated that the maximum values were detected at drip irrigation with 15 cm laterals spacing with application the recommended dose of compost. However, no significant difference was observed between 15, 25 and 35 cm laterals spacing under application of the recommended dose from compost, this means that it can be choose 35 cm laterals spacing to reduce the costs and also it can be save 10% from irrigation water. Under these conditions (35 cm laterals spacing with applying the recommended dose from compost), it can be cultivate the intensive crops by using drip irrigation system.

INTRODUCTION

There are three main irrigation methods, namely: Surface (or gravity) irrigation, sprinkler irrigation and drip irrigation. Drip irrigation is highly efficient because only the immediate root zone of each plant is wetted. This system also allows precise application of water-soluble fertilizers and other agricultural chemicals. Drip irrigation is reported to help achieve yield gains of up to 100%, water savings of up to 40-80%, and associated fertilizer, pesticide, and labor savings over conventional irrigation systems (Burney et al., 2009). Several possible approaches such as irrigation technologies and efficient irrigation scheduling (Kirda, 2000) may be adapted for more effective uses of limited water supplies. The great challenge of the agricultural sector in Egypt is produce more food from less water, which can be achieved by increasing crop water productivity. Irrigated agriculture is the largest water consuming sector and it faces competing demands from other sectors (Sander et al., 2004, Kijne et al., 2003). Maximizing irrigation water use efficiency is a common concept used by irrigation project managers; also, the visual quality of the crop yield is the primary criteria on used to assess irrigation systems effectiveness. In recent years, however, growing competition for scarce water resources has led to applying modified techniques for maximizing water use efficiency and improving crop yields and quality, particularly in arid and semi arid regions like Egypt. Drip irrigation system has successfully been used to irrigate wide range of crop patterns, but on the other hand, no studies had been conducted under intensive field crops (Grabow et al., 2004 and 2002).

Wheat (Triticum aestivum L.) is one of the key crops in Egypt with a cultivation area of about 0.85 million hectares (Ministry of Agriculture and Land Reclamation 2012). With increasing human demand for food more efforts had been done to expand wheat cultivation area in sandy soils based on new technologies as using biofertilizers and developed new varieties (Girgis, 2006). Few technically, economically and environmentally feasible studies had been focused on the possibility of the alternative drip irrigation systems (surface and subsurface drip); an evaluation and performance consideration exists under intensive field crop conditions, which had carried out by (Alam et al., 2000, Suarez-Rey et al., 2000, Camp et al., 2000 and Camp 1998). Previous studies showed that the combination of compost with chemical fertilizer further enhanced the biomass and grain yield of crops (Sarwar et al., 2007; Sarwar et al., 2008). Composts provide the 'glues' that lead to enhanced structural stability of the soil, improving water infiltration and water holding capacity, and improving root penetration (Jedidi et al., 2004; Odlare et al., 2008). Structural stability also lessens soil crusting and loss from wind and water erosion. Incorporation of compost increased water use efficiency thus maximizing the benefits of applied irrigation. An increase of over 30% in water use efficiency was achieved in the production of the capsicum crop during the trial (Chan et al., 2007). Furthermore, compost has a high nutritional value, with high concentrations of especially nitrogen, phosphorus and potassium, while the contamination by heavy metals and other toxic substances are very low (Asghar et al., 2006).

The specific objectives of the study were to study the effect of different irrigation methods and compost application on yield, yield attributes irrigation water use efficiency of wheat and net income to recommend an effective irrigation water management strategy for wheat grown under newly reclaimed sandy soil conditions of Egypt.

MATERIALS AND METHODS

1- Site Description:

Two field experiments were conducted at the Research and Production Station, National Research Centre, El-Nubaria Province, El-Behira Governorate, Egypt, during the two successive winter seasons of 2009/2010 and 2010/2011(latitude 30^{o} 30$^{\backslash}$ 1.4$^{\backslash\backslash}$N, and longitude 30^{o}19$^{\backslash}$ 10.9$^{\backslash\backslash}$E, and mean altitude 21 m above sea level) as shown in fig. (1).

The experimental area has an arid climate with cool winters and hot dry summers prevailing in the experimental area. Table 1 summarizes the monthly mean climatic data for the two growing seasons 2009/2010 and 2010/2011, respectively for El-Nubaria city, which are nearly the same. The data of maximum and minimum temperature, relative humidity, and wind speed were obtained from "The Central Laboratory of Meteorology" which is related to the Ministry of Agriculture. There was not rainfall can be take in to consideration through the two seasons, because the amount was very small and the duration wasn't exceed a few minutes.

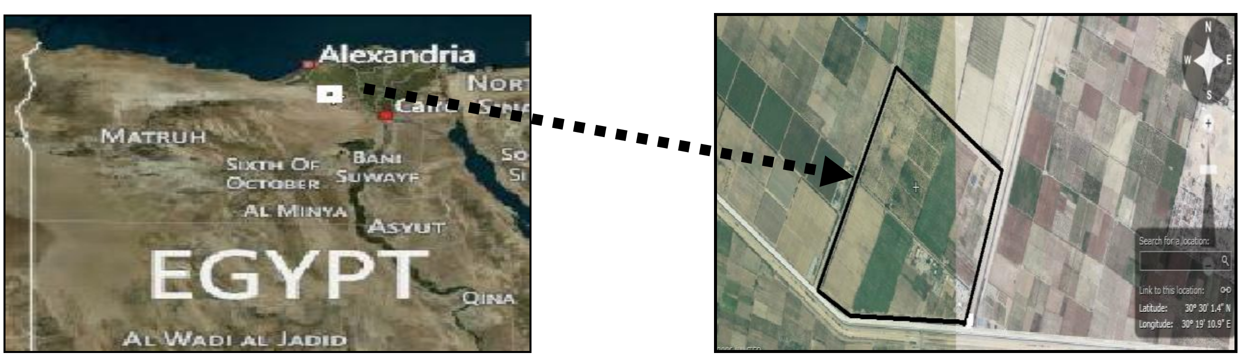

Fig.(1) Location of the Experimental Farm in EL-NUBARIA Region, Egypt

Table (1) monthly and growing season climatic data of the experimental site

Growing seasons	Month	Solar radiation (W/m^2)	Precipitation (mm)	Wind speed (m/sec)		Air temp (°C)			Relative Humidity (%)
				Aver.	Max.	Aver.	Min.	Max.	
2009/2010	November	45.1	2.3	2.0	5.0	20.21	10	30.4	60.1
	December	48.2	0.0	2.0	5.1	19.84	9.12	22.55	63.6
	January	51.0	1.4	2.5	6.0	16.21	7.33	24.13	66.2
	February	67.2	2.7	2.3	6.2	16.50	7.21	26.39	57.1
	March	95.3	0.1	2.5	5.8	17.51	8.16	28.26	56.6
	April	111.0	0.0	2.4	7.7	22.25	11.12	30.55	52.4
2010/2011	November	46.3	1.9	1.9	4.9	20.51	10.1	30.9	60.2
	December	49.4	0.2	1.8	4.7	15.6	8.9	22.2	63.3
	January	49.7	0.0	2.3	6.0	14.7	8.3	21.4	61.0
	February	67.5	0.1	2.1	5.8	16.7	9.3	24.5	57.7
	March	93.5	18.6	2.2	5.5	18.3	11.0	26.2	60.0
	April	111.0	0.0	2.3	7.6	20.8	12.8	28.8	52.3

2- Experimental Details:

The soil of experimental site is classified as sandy soil. Some physical and chemical properties of the experimental soil were carried out as described by Chapaman and Pratt (1978) (Tables 2 and 3), respectively. Irrigation water was obtained from an irrigation channel going through the experimental area, with pH 7.35 and an average electrical conductivity of 0.41 dS m^{-1}.

The water resource for irrigation coming from an irrigation channel under rotational irrigation where the water exist in the channel just for three days every week and the residual four days the channel is empty.

Table (2): Soil physical characteristics of experimental site

Soil depth (cm)	**Particle size distribution**			**Texture class**	**SP (%)**	**F.C. (%)**	**W.P. (%)**
	Coarse Sand	**Fine sand**	**Clay + Silt**				
0-20	47.76	49.75	2.49	Sandy	21.0	10.1	4.7
20-40	56.72	39.56	3.72	Sandy	19.0	13.5	5.6
40-60	36.76	59.40	3.84	Sandy	22.0	12.5	4.6

Table (3) Soil chemical properties of experimental site

Soil depth (cm)	**OM (%)**	**EC (dSm^{-1})**	**$CaCO_3$ (%)**
0-20	0.65	0.35	7.02
20-40	0.40	0.32	2.34
40-60	0.25	0.44	4.68

3- Layout of Experiment Design:

Irrigation system components consisted of control head, pumping and filtration unit. It consists of submersible pump with 45 m^3/h discharge and it was driven by electrical engine and screen filter and back flow prevention device, pressure regulator, pressure gauges, flow-meter, control valves. Main line was of PVC pipes with 110 mm in diameter (OD) to convey the water from the source to the main control points in the field. Sub-main lines were of PVC pipes with 75 mm diameter (OD) was connected to the main line. Manifold lines: PE pipes was of 63 mm in diameter (OD) were connected to the sub main line through control valve 2`` and discharge gauge. Layouts of experiment design consist of two irrigation systems. Sprinkler is a metal impact sprinkler 3/4" diameter with a discharge of 1.17 m^3h^{-1}, wetted radius of 12 m, and working pressure of 250 KPa. Emitters, built in laterals tubes of PE with 16 mm diameter (OD) and 30 m in long (emitter discharge was 4 lph at 1.0 bar operating pressure and 30 cm spacing between emitters and all details about the experiment design as shown in Fig. 2.

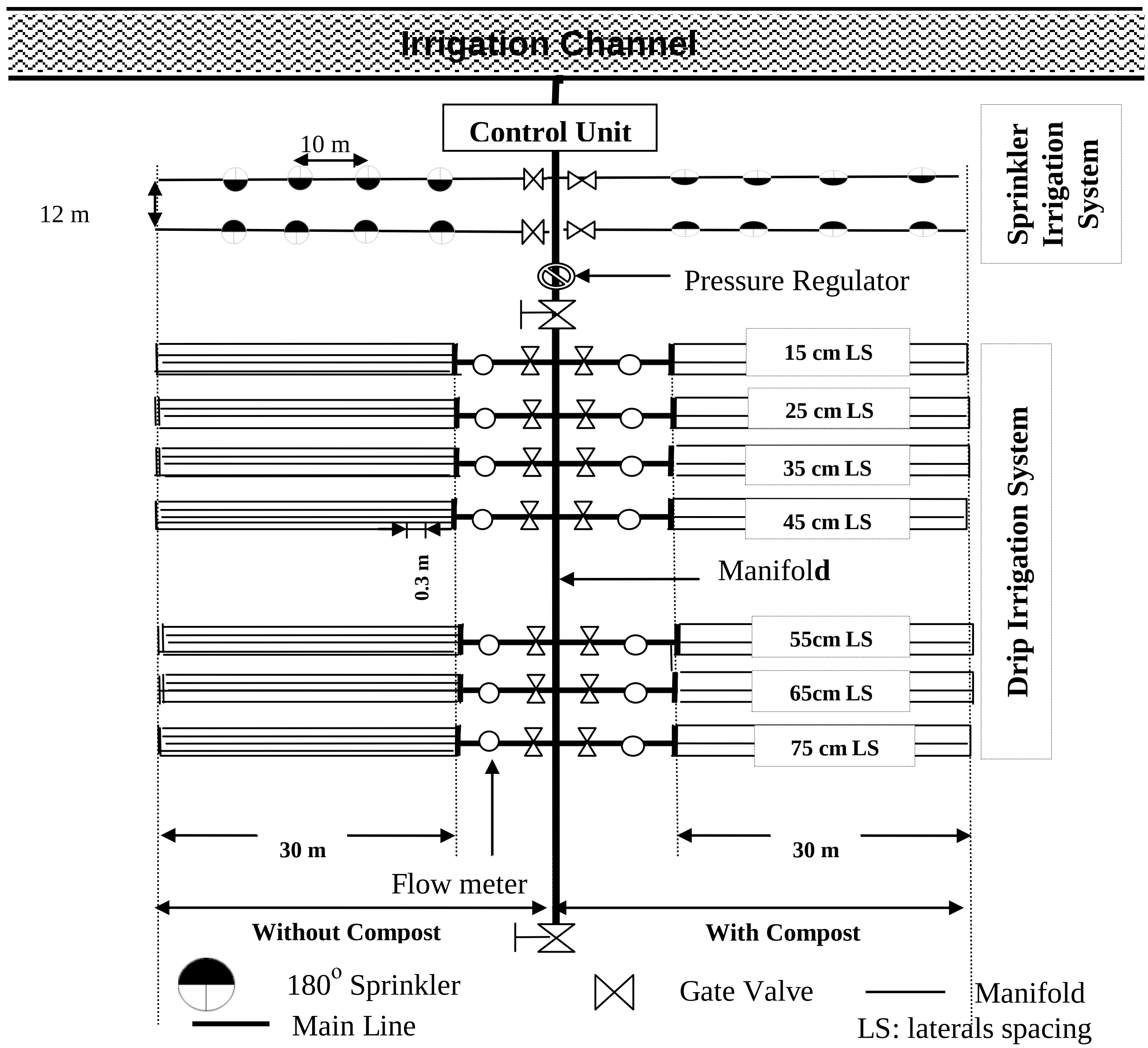

Fig. (2) Layout of Experimental Design

Total water irrigation (m^3 /ha/season) was estimated according to the meteorological data of the Central Laboratory for Agricultural Climate (CLAC) depending on Penman-Monteith equation was found 6009 m^3 ha^{-1}/season for sprinkler irrigation and 5060 m^3 ha^{-1}/season for drip irrigation as shown in Fig. 3.

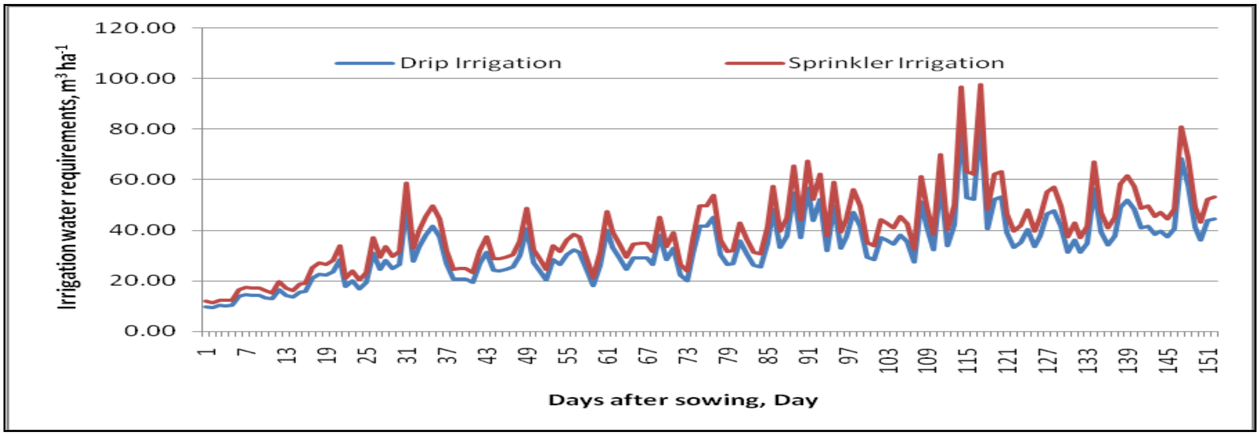

Fig. (3) Daily irrigation water requirements for wheat plant under drip and sprinkler irrigation systems

Seeds of (Sakha 93) at the rate of 168 kg ha^{-1} were sown on the 15 November and the harvest time was 15 April in both seasons 2009/2010 – 2010/2011, respectively. The recommended agricultural practices of growing wheat in Nobaria region were applied. Calcium super-phosphate (15.5 % $P_2 O_5$) at the rate of 240 kg ha^{-1} was applied before sowing to the soil. Nitrogen fertilizer at the rate of 240 kg N ha^{-1} of ammonium nitrate (33.5 % N) was applied at five equal doses before the first, third, fourth, fifth and sixth irrigations. Potassium sulfate (48.52 % $K_2 O$) was applied at the rate of 120 kg ha^{-1} before the first and third irrigations in two equal doses.

Soil moisture distribution: Soil water was measured daily using a profile probe calibrated by using the gravimetric method. The TDR Profile Probe consists of a sealed polycarbonate rod (≈25mm diameter), with electronic sensors (seen as pairs of stainless steel rings) arranged at fixed intervals along its length. Irrigation was carried out between 7:00 h and 12:00 h, based on the readings from the TDR. Soil moisture distribution pattern was plotted according to daily measurements of soil moisture content before and after irrigation for one week. To draw the soil moisture distribution as contour lines and the soil water movement within the whole soil profile, surfer software used. Surfer is a software package transforms 3D data to create contour maps. The data was inserted to the model in XYZ coordinates format, where X represented the profile probe access tubes locations or sites (0, 2, 4, 6, 8, 10 and 12m) with respect to the sprinkler irrigation and between laterals spacing under drip irrigation, Y represented the investigated soil depths (0, 10, 20, 30, 40 cm) which represents the effective root depth, and Z was the soil moisture content values

4- Data recorded:

Yield and yield attributes: At harvest time, a random sample of 1m length x 1m width was taken from each plot to determine spike length (cm), number of spikes/m^2, number of spikelets/spike, grain index. In addition, grain, straw and biological yields "ton ha^{-1}" was determined from the whole area of experimental unit and then converted to yield per hectare.

Water-use efficiency (WUE) and irrigation water-use efficiency (IWUE) values were calculated with Eqs. (1) and (2) (Howell et al., 1990).

$$\mathrm{WUE} = (\frac{E_y}{E_t}) \times 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where WUE is the water use efficiency (kg $_{grain}$ /m^3$_{water}$); E_y is the economical yield (kg $_{grain}$ ha.$^{-1}$); E_t is the plant water consumption, (m^3 $_{water}$ ha^{-1}/season).

$$I\mathrm{WUE} = (\frac{\mathrm{E_y}}{\mathrm{I_r}}) \times 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where IWUE is the irrigation water use efficiency (kg $_{grain}$ /m$^3_{water}$), E_y is the economical yield (kg $_{grain}$ ha.$^{-1}$), I_r is the amount of applied irrigation water (m^3 $_{water}$ ha^{-1}/season).

Economical Analysis: total costs of inputs, total income of outputs, and net income (NI) values were calculated with Eqs. (3) According to Rizk (2007).

NI = TIO – TCI ………………………………. (3)

Where, Total costs of inputs (TCI) as shown as in tables (4) and (5) and total income of outputs (TIO) means [Biomass Yield (Grain yield + Straw yield) x Price].

Table (4): Method of calculating total costs of wheat production under experimental factors.

Items	Compost application (tha^{-1})															
	Compost								Without compost							
	Laterals Spacing (cm)															
	SI	15	25	35	45	55	65	75	SI	15	25	35	45	55	65	75
Cost of Irrigation, L.E/ha	781	658	658	658	658	658	658	658	781	658	658	658	658	658	658	658
Cost of extra Laterals, (L.E./ha/season)	0	2014	1004	572	335	184	76	0	0	2014	1004	572	335	184	76	0
Cost of land preparation, L.E/ha	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Cost of seeds, L.E/ha	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552	552
Cost of mineral fertilizers, L.E/ha	1640	1640	16400	1640	1640	1640	1640	16400	1640	1640	1640	1640	16400	1640	1640	1640
Cost of compost, L.E/ha	1400	1400	1400	1400	1400	1400	1400	1400	0	0	0	0	0	0	0	0
Cost of bio-fertilizers L.E/ha	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
Cost of weed control, L.E/ha	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
Cost of pest control, L.E/ha	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Cost of harvesting, L.E/ha	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Cost of labor, L.E/ha	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440
Total costs, L.E/ha	7493	9384	8374	7942	7705	7554	7446	7370	6093	7984	6974	6542	6305	6154	6046	5970

Y_n = Y is yield and n= number of treatment (from 1 to 8 treatment), T.C.I.= Total Costs for Inputs, The prices according to 2010/2011 where 1$ = 5.85L.E

Statistical analysis

The obtained data was statistically analysis was carried out according to Snedecor and Cochran (1990) and the combined analysis of two seasons was done according to Steel and Torrie (1980) while, the values of least significant differences (L.S.D. at 5 % level) were calculated to compare the means of different treatments.

RESULTS AND DISCUSSION

1- Effect of compost application:

Data presented in Table 5 revealed that application of compost significantly affected all studied characters under this trail. The results indicated that the spike length, number of spikelets/spike, number of spikes/m^2, grain, straw, biological yield of wheat and IWUE were significantly affected with applied compost. It was observed that with application of compost significantly surpassed without compost application. This increase may be due to the increase of soil moisture content in root zone. Adding compost increase from soil ability to hold irrigation water inside root zone hence, the wheat plants will grow healthier with lowest water stress compared with without adding compost, this response will increase from grain yield hence, increasing in IWUE. These results are in agreement with those obtained by **Aly (2002)** and **Chan et al. (2007).** Results in Table 5 also indicated that grain index and net income insignificantly affected with compost application, where, costs of compost was not effected on net income compared with the highest values of straw and grain yield of wheat we get with adding compost.

Table (5) Effect of compost application on yield and yield attributes irrigation water use efficiency and net income (average of two seasons).

Treatments	Spike length, cm.	No. spikelets/spike	Grain index	Number of spikes/m^2	Grain yield, ton ha^{-1}	Straw yield, ton ha^{-1}	Biological yield, ton ha^{-1}	Irrigation Water Use Efficiency, kg/m^3	Total Costs, LE/ha/ season	Total Income, L.E. ha^{-1}	Net Income, L.E. ha^{-1}
With compost	10.73	16.21	4.54	496.59	3.84	4.68	8.52	0.74	7909	11750	3842
Without compost	9.32	13.25	4.23	458.23	3.39	4.13	7.52	0.65	6509	10373	3864
LSD at 5%	0.41	1.02	NS	14.25	0.20	0.30	0.50	0.10			N.S

2- Effect of Laterals Spacing:

The results indicated that the spike length, number of spikelets/spike, seed index, number of spikes/m^2, grain, straw and biological yield of wheat were significantly affected by laterals spacing (Table 6). It was observed that there were no significant difference between the highest values of grain yield under laterals spacing of 15, 25 and 35 cm and sprinkler irrigation (control treatment). This was due to soil moisture distribution (SMD) under laterals spacing at 15, 25 and 35 cm and sprinkler irrigation as shown as in Figs.(4, 5, 6 and 7) was around field capacity and in some places inside root zone more than field capacity and contour lines of SMD are similar or very closed hence, wheat plants had exposed to minimum water stress during the growing stages under 15, 25 and 35 cm laterals spacing and sprinkler irrigation (control treatment) compared with 45, 55, 65 and 75 cm laterals spacing as shown in Figs.(8,9, 10 and 11). IWUE was decreased with increasing laterals spacing, the highest value of IWUE was 1.01 (kg/m^3) with 15 cm laterals spacing and no significant difference between the highest value and the values under 25 and 35 cm laterals spacing which were 0.99 and 0.96 kg/m^3, respectively. Although, the highest value of IWUE occurred with 15 cm laterals spacing but we accepted the value under 35 cm laterals spacing (0.96 kg/m^3) specially the difference between grains yields under 15, 25 and 35 cm laterals spacing and sprinkler irrigation was not significant to reduce the costs of extra laterals. There were no significant difference between the highest values of net income under laterals spacing at 15, 25 and 35 cm and sprinkler irrigation (control treatment) and considering economical view we accepted the value under 35 cm laterals spacing 7587(L.E. ha^{-1}) in addition to saving 10% from irrigation water compared with sprinkler irrigation system.

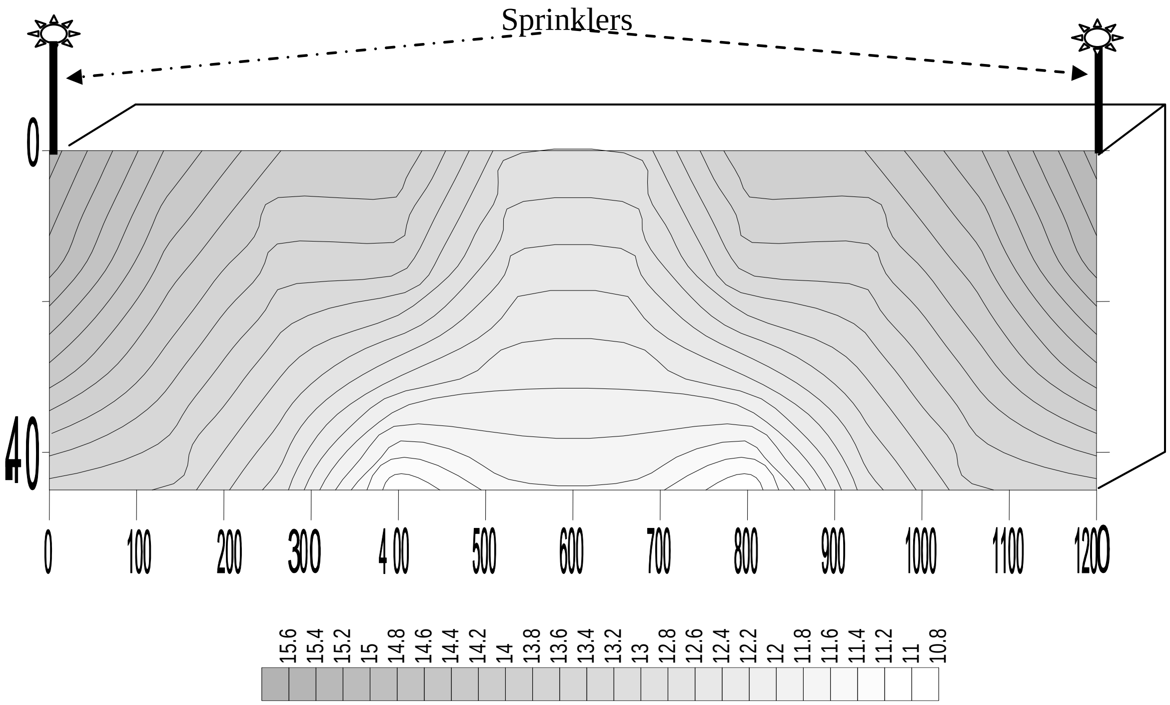

Fig. (4) Soil moisture distribution under sprinkler irrigation system

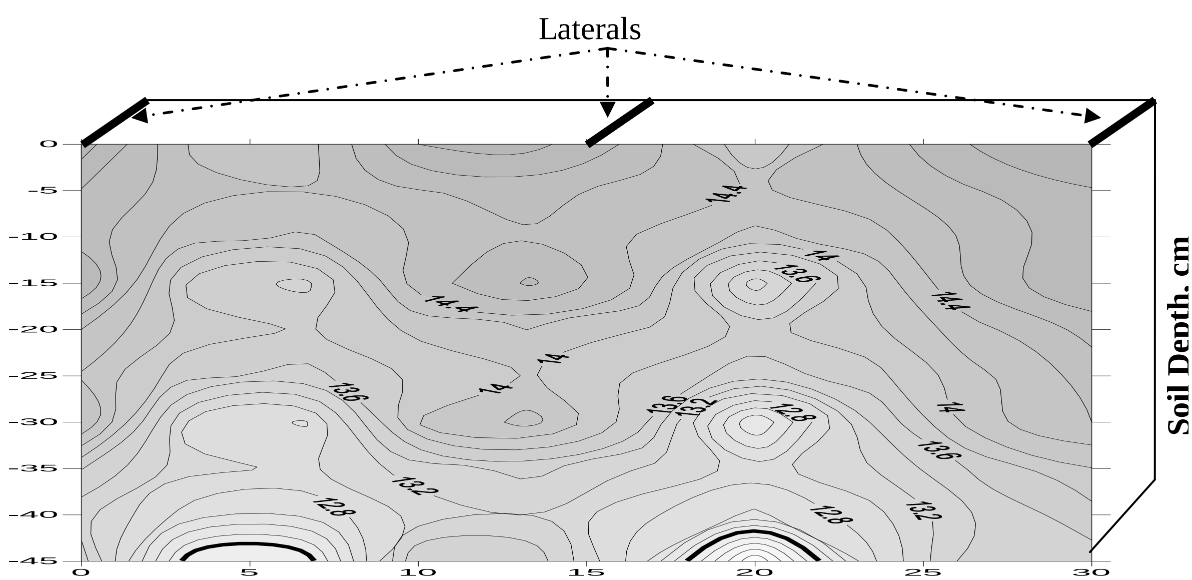

Fig. (5) Soil moisture distribution at 15 cm laterals spacing under drip irrigation system

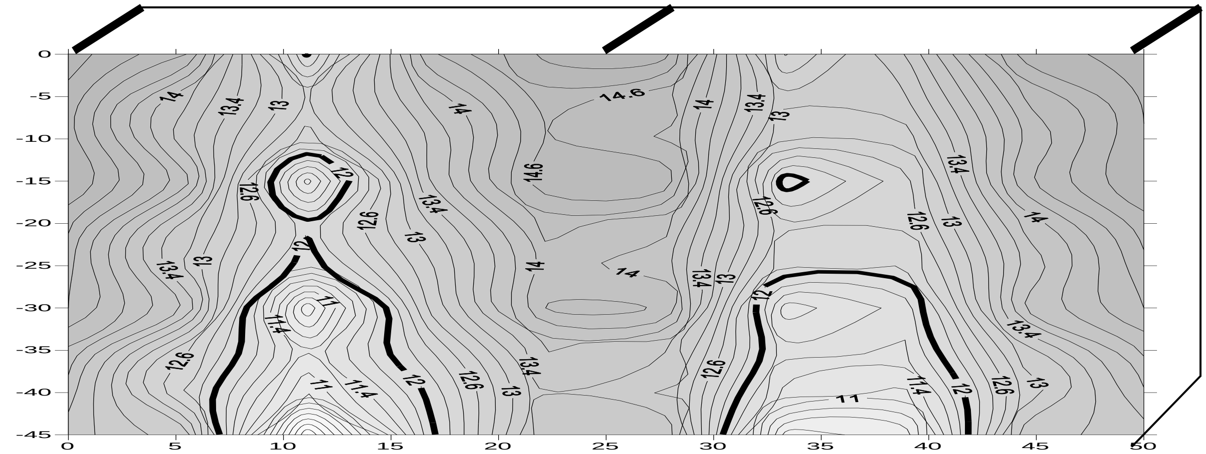

Fig. (6) Soil moisture distribution at 25 cm laterals spacing under drip irrigation system

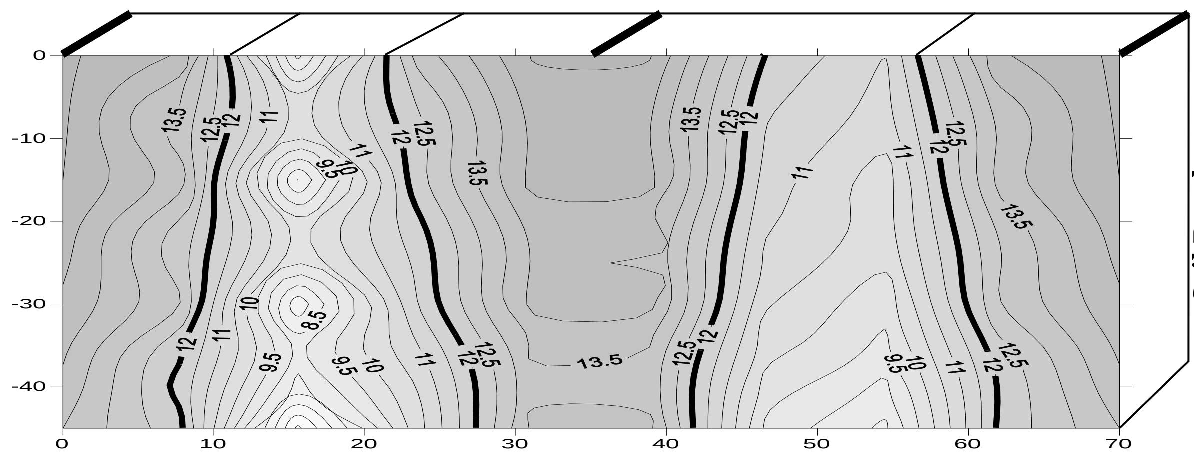

Fig. (7) Soil moisture distribution at 35 cm laterals spacing under drip irrigation system

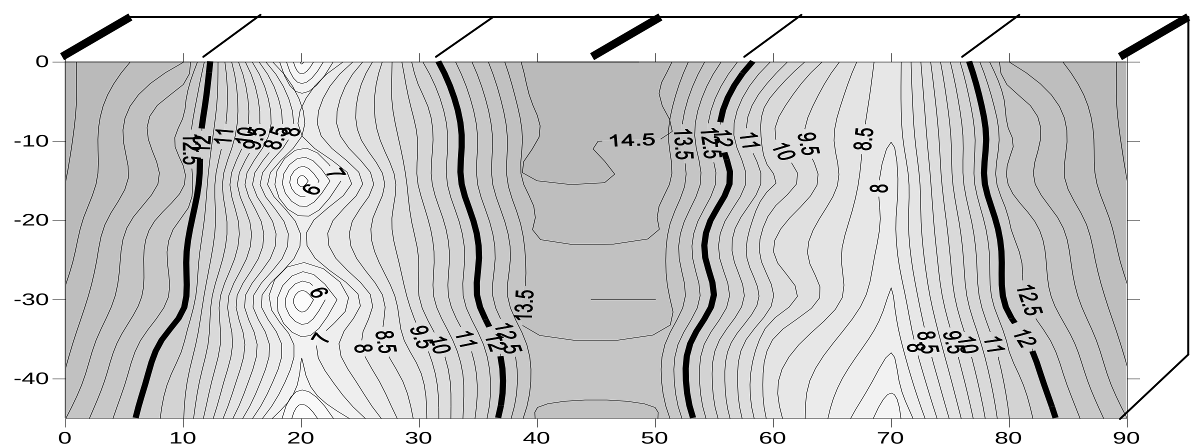

Fig. (8) Soil moisture distribution at 45 cm laterals spacing under drip irrigation system

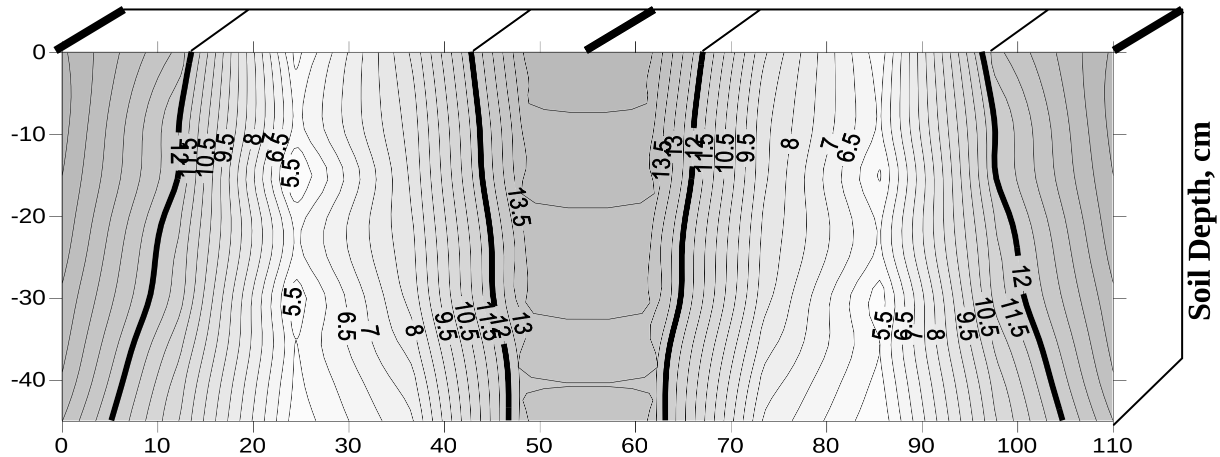

Fig. (9) Soil moisture distribution at 55 cm laterals spacing under drip irrigation system

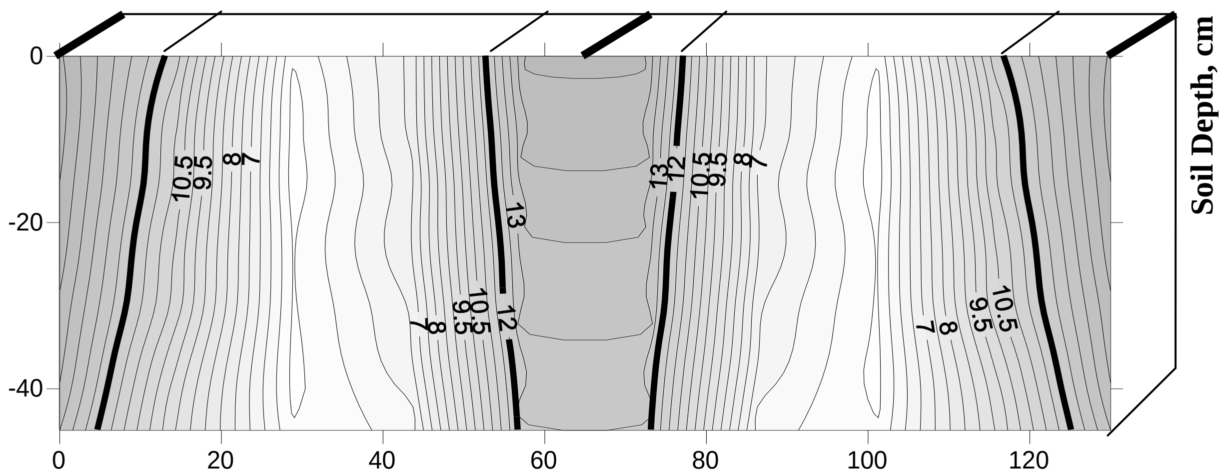

Fig. (10) Soil moisture distribution at 65 cm laterals spacing under drip irrigation system

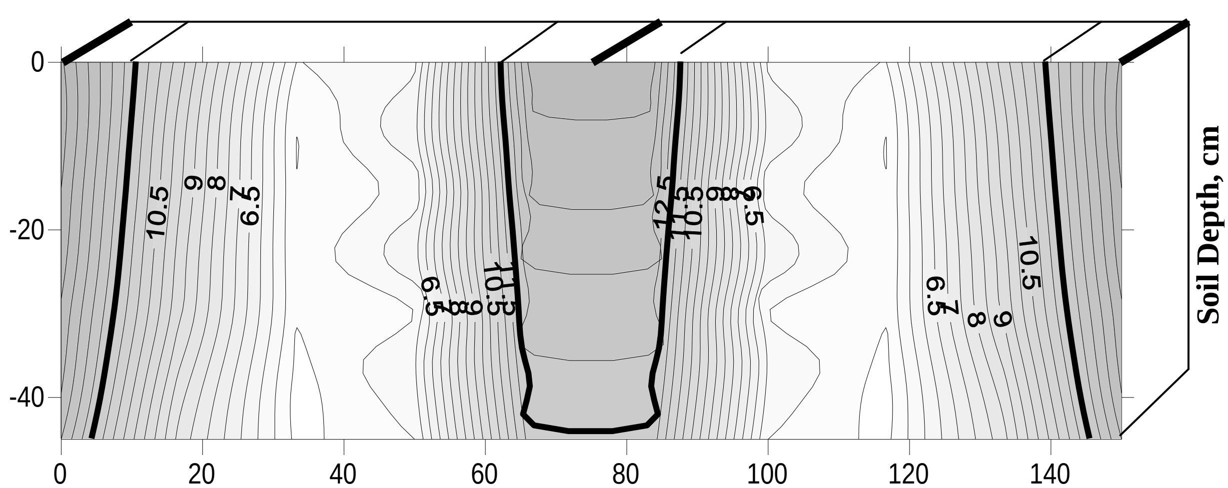

Fig. (11) Soil moisture distribution at 75 cm laterals spacing under drip irrigation system

Table (6) Effect of laterals spacing on yield, yield attributes, irrigation water use efficiency and net income (average of two seasons).

Laterals Spacing, (cm)	Spike length, cm.	No. spiklets/spike	Grain index	Number of spikes/m^2	Grain yield, (ton ha^{-1})	Straw yield, (ton ha^{-1})	Biological yield, (ton ha^{-1})	Water Use Efficiency, (kg/m^3)	Total Costs (LE/ha/ eason)	Total Income, (L.E. ha^{-1})	Net Income (L.E. ha^{-1})
SI	12.25	15.84	4.89	521.25	4.96	6.05	11.00	0.82	6793	15179	8386
15	11.87	15.29	4.77	508.20	5.12	6.25	11.37	1.01	8684	15694	7010
25	11.52	15.08	4.29	472.25	5.00	6.10	11.10	0.99	7674	15321	7647
35	10.15	14.25	4.15	441.25	4.84	5.91	10.75	0.96	7242	14829	7587
45	10.11	14.13	4.11	380.95	2.82	3.44	6.27	0.56	7005	8646	1641
55	9.24	11.24	4.10	374.29	2.68	3.27	5.95	0.53	6854	8213	1359
65	9.20	10.54	4.05	342.27	2.19	2.67	4.87	0.43	6746	6713	-33
75	9.15	10.05	4.04	312.54	1.27	1.55	2.83	0.25	6670	3898	-2772
LSD at 5 %	0.48	1.05	0.24	18.95	0.40	0.50	0.90	0.10			850

SI (Control): Sprinkler Irrigation

3- Effect of interaction between compost application and laterals spacing:

Data presented in Table 7 and Figs. (12, 13 and 14) indicated that the effect of interaction between compost application and laterals spacing on yield, yield attributes, IWUE and net income showed significant differences between treatments except, spike length, number of spikelets/ spike and grain index. The results also illustrated no significant differences between the highest values of grain yields under laterals spacing at 15, 25 and 35 cm and sprinkler irrigation (control treatment) with compost application. Although the highest values of grain yield (5.42 t ha^{-1}), straw yield (6.61 t ha^{-1}) and biological yield (12.02 t ha^{-1}) were produced with 15 cm laterals spacing with compost treatment but we accepted the values under 35 cm laterals spacing with compost application which recorded, grain yield (5.1 ton ha^{-1}), straw yield (6.22 t ha^{-1}) and biological yield (11.31 t ha^{-1}) to reduce the costs of extra laterals. IWUE was decreased with increasing laterals spacing. The highest value of IWUE was 1.07 (kg/m^3) with 15 cm laterals spacing and compost application, while no significant differences was noticed between the highest value and the values under 25 and 35 cm laterals spacing. There were no significant differences between the highest values of net income under laterals spacing at 15, 25 and 35 cm and sprinkler irrigation (control treatment) and considering economical view we accepted the value (7667 L.E. ha^{-1}) under 35 cm laterals spacing with adding compost.

Table (7) Effect of interaction between compost application and laterals spacing on yield, yield attributes, irrigation water use efficiency and net income (average of two seasons).

Treatments AC	Treatments LS	Spike length, cm.	No. spiklets/spike	Grain index	Number of spikes/m^2	Grain yield, (ton ha^{-1})	Straw yield, (ton ha^{-1})	Biological yield, (ton ha^{-1})	Irrigation Water Use Efficiency, (kg/m^3)	Total Costs (LE/ha/season)	Total Income, (L.E ha^{-1})	Net Income (L.E ha^{-1})
With compost	SI	12.84	16.21	5.14	519.15	5.22	6.36	11.58	0.87	7493	15978	8485
	15	12.29	15.57	4.78	511.98	5.42	6.61	12.02	1.07	9384	16589	7205
	25	12.04	15.54	4.64	489.25	5.27	6.42	11.69	1.04	8374	16127	7753
	35	11.24	14.29	4.61	464.19	5.10	6.22	11.31	1.01	7942	15609	7667
	45	11.10	13.75	4.53	441.29	3.05	3.72	6.77	0.60	7705	9347	1642
	55	10.74	13.41	4.51	424.89	2.90	3.54	6.44	0.57	7554	8879	1325
	65	10.21	12.12	4.39	394.12	2.37	2.89	5.26	0.47	7446	7257	-189
	75	10.08	12.10	4.37	371.59	1.38	1.68	3.05	0.27	7370	4214	-3156
Without compost	SI	12.31	15.84	4.91	489.25	4.69	5.73	10.42	0.78	6093	14380	8287
	15	11.84	15.21	4.82	483.21	4.83	5.89	10.73	0.95	7984	14798	6814
	25	11.42	14.84	4.52	471.95	4.74	5.78	10.52	0.94	6974	14515	7541
	35	10.25	13.81	4.51	451.12	4.59	5.60	10.18	0.91	6542	14048	7506
	45	10.21	12.54	4.45	418.25	2.59	3.16	5.76	0.51	6305	7945	1640
	55	9.51	12.21	4.32	389.25	2.46	3.01	5.47	0.49	6154	7547	1393
	65	9.25	10.28	3.89	361.25	2.01	2.46	4.47	0.40	6046	6169	123
	75	9.24	10.04	3.84	342.15	1.17	1.43	2.60	0.23	5970	3582	-2388
LSD at 5 %		NS	NS	NS	18.12	0.71	0.87	1.5	0.10			977

SI(Control): Sprinkler Irrigation, AC: Adding compost, WAC: Without Adding compost, LS: Laterals Spacing

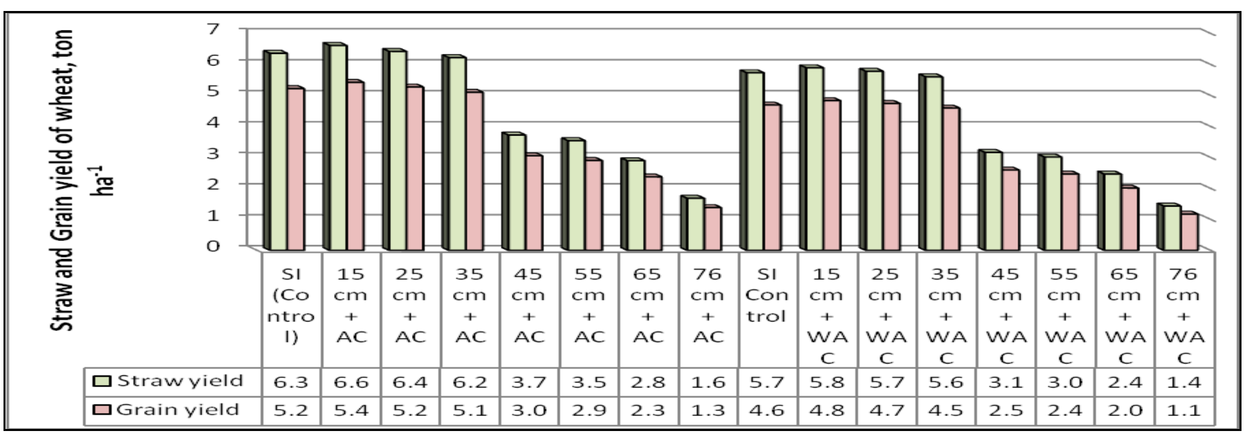

Fig. (12) Effect adding compost and laterals spacing on straw and grain yield of wheat

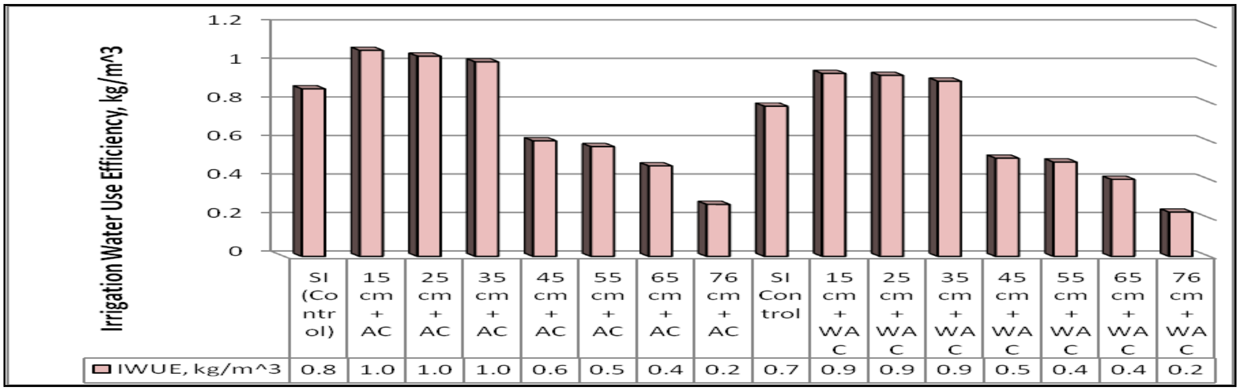

Fig. (13) Effect of compost application and laterals spacing on irrigation water use efficiency of wheat

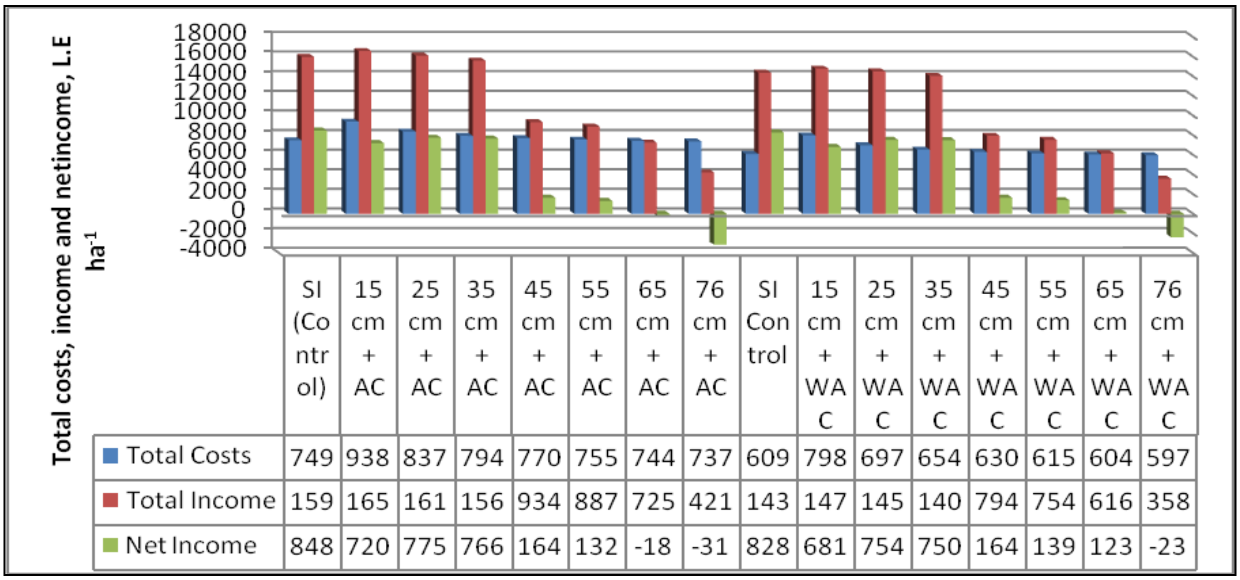

Fig. (14) Effect of compost application and laterals spacing on total costs, total income and net income from wheat cultivation

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