The Effect of Irrigation Scheduling and Compost Fertilizer Levels on Yield and Water Productivity of Wheat Crop Grown on Newly Reclaimed Loamy Sand Soil

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Abstract: Efficiency of irrigation method and application of organic amendments are concepts should be practiced in Egypt for saving part of irrigation water due to the limited water resources. A field experiment was conducted on a newly reclaimed loamy sand soil at the Experimental Farm of Ismailia Agriculture Research Station, Egypt during winter season 2013/ 2014, to study the effect of irrigation scheduling under sprinkler irrigation method with levels Ir1 (125% application of water from traditional amount), Ir2 (100% application of water at traditional amount) and Ir3 (75% application of water from traditional amount) with application of compost fertilizer at different levels Zero (L0), 5 tonfed^{-1} (fed is a local units is 4200m^2) (L1), 10 tonfed^{-1}(L2) and 15 ton fed^{-1}(L3) on weight of 1000 grain (g), straw yield ton fed^{-1}, grain yield ton fed^{-1}, biological yield ton fed^{-1}, harvest index, N%, N-uptake kg fed^{-1}, and water productivity L.E/m^3 of water under cultivation of wheat plant (*Triticum aestivum* L.) Giza 168 cultivar. Also, to assess and compare farm profitability of all tested variables. The obtained results revealed that compost application at the three levels increased significantly each straw yield tonfed^{-1}, grain yield tonfed^{-1}, weight of 1000 grain (g), biological yield tonfed^{-1}, harvest index %, N%, N-uptake kg fed^{-1} and water productivity L.Em^3 of water over the control treatment. The highest mean values for the studied parameters were recorded for compost application at level L3. On the other hand, the data indicated that the highest means values for 1000 grain weight, straw yield and grain yield were achieved with application of Ir2. At the same time, the difference of mean values for all parameters above mentioned between the amounts of irrigation water applied Ir1, Ir2 and Ir3 were insignificant. On the other site, the beneficial effect of all tested treatments was due to interaction between treatments L1*Ir2 or L1*Ir3 on weight of 1000 grain, straw yield tonfed^{-1}, grain yield tonfed^{-1}, (g), biological yield tonfed^{-1} and harvest index, N%, N-uptake tonfed^{-1} and water productivity L.Em^3 of water. Therefore, data revealed that with application of treatments Ir3 about 25% irrigation water amount could be saved under applying compost at level 5tonfed^{-1} (L1) in loamy sand soil. These results were incorporated with the highest crop yield, water productivity and net income. Whereas, the data indicated that each one m^3 of irrigation water consumed to irrigation wheat crop grown on loamy sand soil by interaction treatments Ir3 (saved 25% irrigation water from traditional water amount) *L1(5tonfed^{-1}) was approximately profitably by 2.3LE pound for farmer. So, it can be concluded that the interaction between the treatments Ir3*L1 leads to rationalize as well as represents a solving for the problem of limited water resources and poor fertility in new reclaimed loamy sand soil in Egypt.

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Introduction

Efficiency of irrigation method and application of organic amendments as concepts should be followed in Egypt for saving part of the irrigation water due to the limited water resources as well as the shortage of organic matter content in the Egyptian soils. The great challenge of the agricultural sector in Egypt is producing 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 and Besti, 2004, Kijne et al., 2003). In recent years, however, growing competition for scarce water resources has led to apply modified techniques for maximizing water use efficiency, improving crop yields and quality, particularly in arid and semi arid regions like Egypt. Hence, utilizing an efficient irrigation method, combined with the appropriate scheduling of irrigation is very important to save water for newly reclaimed areas. Water supply is limiting factor for crop production and sustainable agriculture, it is desirable to obtain higher grain yield using the least amount of irrigation water.

The adequate supply of irrigation water and/or compost fertilizers application are two main factors affecting directly the growth and productivity of wheat crop.

Organic fertilizers as compost is often considered as a key index of soil quality as it determines numerous factors influencing crop productivity, such as the retention capacity of plant available water (Hydraulic conductivity, Infiltration rate, total porosity, aggregate formation and stabilization, bulk density and cation exchange capacity). 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; Azza et al., 2011).

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.

Soil is an important factor and foundation for agricultural production. In Egypt, more desert areas either sandy or calcareous in nature have to be put under cultivation. Such soils are poor with respect to their physical-biochemical properties, soil water-plant relationships as well as their nutritional status.

Therefore, the main objectives of this study were to study the effect of different irrigation scheduling combined with compost application rates on yield and its components, water productivity, net income and economic efficiency to recommend an effective irrigation water amount combined with a compost level for wheat grown under newly reclaimed sandy loam soil conditions of Egypt.

2. Materials and Methods

A field experiment was conducted on a newly reclaimed loamy sand soil at the Experimental Farm of Ismailia Agriculture Research Station during winter season 2013/2014, to study the effect of irrigation scheduling under sprinkler method combined with compost rates on yield and water productivity of wheat crop grown on loamy sand soil.

Some initial physical and chemical characteristics of the studied experimental soil as well as compost fertilizer which were determined according to **Black *et al.* (1965) and Page *et al.* (1982)**, are presented in Tables (1 and 2).

Table (1). Physical-Chemical characteristics of the soil during 2013/2014.

Mechanical analysis		Soluble cations (meq/l)		Available macronutrients (mg kg^{-1})	
Sand (%)	86.71	Ca++	3.06	N	32.26
Silt (%)	4.52	Mg++	1.63	P	3.62
Clay (%)	8.77	Na+	12.46	K	190
Texture grade	Loamy sand	K+	0.86		
Chemical analysis		Soluble anion (meq/l)			DTPA – extractable (mg kg^{-1})
pH (1:2.5)	7.94	CO^{-}_3	Nil	Fe	1.22
EC (dSm^{-1})	1.86	HCO^{-3}	2.70	Mn	0.88
OM (%)	0.61	Cl^-	9.79	Zn	0.55
$CaCO_{3\%}$	1.20	SO^{--}_4	5.52	Cu	0.03

Table (2): Some chemical properties of the compost fertilizer.

Experimental year	pH 1:10	E.C dSm^{-1}	OM %	Total N %	Total P%	Total K%	Available P%	C/N ratio	Θw %
2013-2014	7.53	2.94	66.7	1.8	0.65	0.72	82.31	21.5	19.4

Parameters studied:

A- Irrigation regimes:

Three irrigation scheduling were applied as follows:

- (Ir1) irrigation with 3024 m^3/fed (125% from traditional amount of irrigation water Ir2).
- (Ir2) irrigation with 2268 m^3/fed (100% traditional amount of irrigation water delivered to wheat crop as farmer practices).
- (Ir3) irrigation with 1512 m^3/fed (75% from traditional amount of irrigation Ir2).

Sprinkler irrigation system (sprinkler riser was one meter with discharge of $1m^3$/h, the distance between each sprinkler 10 m so each feddan has 42 sprinkler) is used in application water amount every two days (Ir1)for 1h each time or four days (Ir2) for 1.5 h or six days (Ir3) for 1.5h from planting until maturity stage. Stopping irrigation was after 145 days from sowing and harvesting time was after 155days from sowing.

Studied Attributed:

Irrigation water amount (IWA) was applied as follows:

From the discharge of each sprinkler multiplied by the times of irrigation for each interval and multiplied by the number of sprinkle per fed. The amount of irrigation water applied (IWA) presented above mentioned was calculated from the following equation:

(IWA) = D x TII x NS

D = Discharge of each sprinkler.

TII= Time of irrigation for each interval.

NS= Number of sprinkler / fed.

B- Compost fertilizer rates:

Four rates of compost were applied as following:

- L0 = Zero compost.
- L1 = 5 ton compost.
- L2 = 10 ton compost.
- L3 = 15 ton compost.

The experimental design was split plot with three replications, irrigation amount were devoted to the main plots, while the compost fertilizers rates were assigned to sub- plots. Grain of wheat (*Triticum*.L cultivar) *Giza 168* were sown at the rate of 60 kg/fed on November 25th in 2013. Plot area was 3.0 x 3.5 m. Nitrogen fertilizer at rate of 100kg N/fed in the form of ammonium nitrate 33.5% N was applied in three equal doses for each at 15, 45 and 75 days from sowing, respectively. Phosphorous fertilizer at the rate of 45kg P_2O_5/fed in the form of calcium superphosphate (15.5% P_2O_5) was applied at sowing. The recommended rate in new reclaimed loamy sand soil, 48 kg K_2O in the form of potassium sulphate (48%K_2O) was added in equal four portions. At harvest, ten individual plants were chosen at random from each plot and the following data were recorded:

Weight of 1000 grain, g.

Straw yield /fed, in ton.

Grain yield /fed, in ton.

Harvest Index % calculated as follows:

$$\text{harvest index\%} = \frac{\text{Grain yield (Kg/fed)}}{\text{Biological yield (kg/fed)}} 100$$

N- UPTAKE kg/fed

calculated from the following equation:

N% in grain* grain yield kg/fed / 100.

Total N in plant part (grains) was estimated by using the standard method given by Jackson (1973).

Moreover, soil samples were taken from each treatment after harvesting, air dried, crushed and passed through a 2-mm sieve for estimating both of soil pH according to Thomas (1996), whereas electrical conductivity (EC) according to Rhoades (1996).

C-Economic Evaluation

Table (3) and (4) show the total input production, output and economical assessment of the tested variables under experimental factors.

Total costs of inputs, total income of outputs, and net income (NI) values and economic efficiency (E.E) for all tested treatments were calculated with Eqs. According to Rizk (2007

NI = TIO – TCI ……………………

- TCI =Total cost input,
- TIO = Total income outputs,
- NI = Net income LE
- E.E= Economic Efficiency

E.E= NI /TCI

- **Water productivity LE/m^{-3} of irrigation water** was calculated from the following Eqs.:

W.P =NI / IWA LE m^{-3} of water…………….

- NI = net income LE.
- IWA = irrigation water amount $m^3 fed^{-1}$

All data were subjected to statistical analysis of variance and treatment means were compared according to the Least Significant Differences (L.S.D.) test method as described by Snedecor and Cochran (1980).

Table (3): Total input production items and output of the experiment.

Items	**Treatments**	**Treatment unite**	**Unite Price (L.E)**
Total inputs			
Ammonium nitrate33.5%	100	$Kg(N)fed^{-1}$	9.5
Super phosphate 15.5%	45	$Kg(P_2O_5)fed^{-1}$	10.6
Potassium sulphate 48%	48	$Kg(K_2O)fed^{-1}$	13.3
Compost fertilizes			
	5ton	$tonfed^{-1}$	250
	10ton	$tonfed^{-1}$	
	15ton	$tonfed^{-1}$	
Wheat seeds	60	Kg fed^{-1}	130
Land preparation		Per fed^{-1}	180
Pesticides		Per fed^{-1}	180
Other fixed costs		Per fed^{-1}	285
Outputs			
Wheat yield			3096

The prices according to 2013/2014

Table (4): Economical assessment of tested variables for the experiment

Irrigation period	Comp levels	Grain yield Ton fed^{-1}	Total output LEfed^{-1}	Total input LEfed^{-1}	Net income LEfed^{-1}	Economic efficiency
Ir1	Zero	1.31	4055.76	2840	1215.76	0.43
	5	2.470	7647.12	4090	3557.12	0.87
	10	2.496	7727.62	5340	2387.62	0.45
	15	2.503	7749.29	6590	1159.6	0.18
Ir2	Zero	1.353	4179.6	2840	1339.60	0.47
	5	2.489	7705.94	4090	3615.94	0.88
	10	2.526	7820.49	5340	2480.49	0.46
	15	2.579	7984.58	6590	1394.58	0.21
Ir3	Zero	1.339	4145.54	2840	1305.54	0.46
	5	2.460	7616.16	4090	3526.16	0.86
	10	2.483	7687.37	5340	2347.37	0.43
	15	2.500	7740.00	6590	1150.00	0.17

3. Results and discussion

1-Effect of different treatments on grain weight (g), straw and grain yield (tonfed^{-1}) of wheat crop grown on loamy sand soil:

Compost levels effect:

Data presented in Table (5) revealed that application of compost by their levels were significantly affected 1000 grain weight (g), straw yield tonfed^{-1} and grain yield tonfed^{-1} than the control treatment. The highest means values recorded for 1000 grain weight (g), straw yield tonfed^{-1} and grain yield tonfed^{-1}were 52.83(g), 3.79 ton fed^{-1} and 2.53 tonfed^{-1} for application L3 treatment, respectively. As, the mean value for 1000 weight of grain by applying L3 treatment was increased by 22.5%, 4.7% and 1.5% than the treatments of L0, L1and L2. As well as, the same trend was observed for the means values of grain yield and straw yield. Whereas, the means values of straw yield increased with application L3 treatment by 16.4, 3.13% and 1.15% than the treatments of L0, L1 and L2 respectively. On other hand, the means values of grain yield increased by 89%, 2.18% and 0.99% than the L0, L1 and L2 by applying the treatment L3. The difference between applying treatments L1, L2 or L3 was slightly significant for all parameters above mentioned, this result was in agreement with **Shahien** *et al,.(*2014).

Irrigation water applied (IWA) effect:

As shown in table (5) data indicated that the highest means values for 1000 grain weight (51.06g), straw yield (3.780ton/fed) and grain yield (2.237ton/fed) were obtained with application of Ir2 (2268 m^3/fed irrigation water) under the condition of this study. As well as, the differences between Ir1, Ir2 and Ir3 were approximately insignificantly for mean values of each 1000 grain weight (g), straw yield tonfed^{-1} and grain yield tonfed^{-1}. The positive effect of irrigation regime by applied Ir2 and Ir3 of this study may be due to reduced nutrients loss from sandy soil by leaching under Ir1tratment. These results in agreement with those obtained by Mesbah (2009) and Azza. *et al,.* (2011).

Interaction between compost levels and irrigation water amount (IWA) effect:

Data presented in Table (5) indicated that the effect of interaction between compost application and irrigation water amount (IWA) on 1000 grain weight (g), straw and grain yield

(tonfed^{-1}) of wheat plant showed a significant difference except the treatment of L3*Ir2 and L2*Ir2 had insignificant interaction between them for each of (weight 1000 grain, straw yield and grain yield). Although the highest values of 1000 grain weight (54.55g), straw yield (4.025 ton fed^{-1}) and grain yield (2.579 tonfed^{-1}) were obtained from interaction between L3 and Ir2.

On the other hand, the beneficial effect due to interaction between L3*Ir2 could explained by the effect of Ir2 (2268m^3) with L3 (15ton compost) through maintaining proper soil- water relation for mechanism of nutrients uptake by plant root and enhancing plant growth and protecting soil fertility, Awad *at al.* (2000) and Singh *et al.* (2009**).**

2- Effect of different treatments on Biological yield ton fed^{-1} and Harvest index %, N% of grain and N-uptake kgfed^{-1} by *grain of wheat crop grown on loamy sand soil.*

Compost levels effect:

Data shown in table (6) indicated that the means values of biological yield high significantly increased due to applied the different compost levels compared to the control treatment. As well as, the means values of biological yield for applying L1, L2, and L3 increased by 33.80%, 34.26% and 34.26% than control treatment L0. At the same time, the difference between means values of biological yield by application L1, L2 and L3 was insignificant between them. Moreover, the means values of Harvest index % for treatment L3 was slightly greater than means values of treatments L1 and L2 but low significantly. This was may be due to the grain yield of treatment L3 was increased by 2.18% and 2.5% than the treatment of L1 and L2, respectively. These results are in agreement with those obtained by Mesbah. (2009). Concerning to N% and N-uptake by grain of wheat plant kg/fed as influenced by different levels of compost as shown in table (6), the application of treatments L1, L2 and L3 were significantly affected N% and N-uptake in grain of wheat plants compared to L0 control treatment. The maximum mean value of N% (2.06) and N- uptake in grain of wheat crop (50.22kgfed^{-1}) were achieved by applied treatment L3. Moreover, the difference between means values of applying treatments L1, L2 and L3 was insignificant.

Table (5): Effect of irrigation and compost treatments on weight of 1000 grain (g) grain and straw yields ton fed^{-1} of wheat crop.

Items	Irrigation periods	Compost levels				Mean Ir	L.S.D *At 0.05*
		L0	L1	L2	L3		
1000 grains g	Ir1	42.81	47.29	49.83	49.93	47.47	Ir=0.236
	Ir2	43.7	52.14	53.49	54.55	51.06	L=0.272
	Ir3	43.19	51.93	52.84	53.69	50.41	Ir*L=0.472
	Comp mean	43.25	50.45	52.05	52.83	-	-
Grain ton fed^{-1}	Ir1	1.31	2.470	2.496	2.503	2.195	I=0.038
	Ir2	1.35	2.489	2.526	2.579	2.237	L=0.044
	Ir3	1.34	2.460	2.483	2.500	2.196	Ir*L=0.076
	Comp mean	1.334	2.473	2.502	2.527	-	-
Straw ton fed^{-1}	Ir1	3.257	3.759	3.793	3.859	3.667	Ir=0.371
	Ir2	3.298	3.830	3.967	4.025	3.780	L=0.043
	Ir3	3.219	3.425	3.488	3.493	3.411	Ir*L=0.074
	Comp mean	3.258	3.677	3.749	3.792	-	-

Ir = L.S.D *At 0.05* for water irrigation amounts L = L.S.D *At 0.05* for compost levels Ir*L= L.S.D *At 0.05* for interaction of Ir x L

Table (6): Effect of irrigation and compost treatments on Biological yield tonfed^{-1}, Harvest index %, N% of grain and N-uptake kgfed^{-1} on wheat crop.

Item	Irrigation period	Comp levels				Mean Ir	L.S.D *At 0.05*
		L0	L1	L2	L3		
Biological yield tonfed^{-1}	Ir1	4.567	6.229	6.289	6.362	5.862	Ir=0.075
	Ir2	4.648	6.319	6.493	6.604	6.016	L=0.867
	Ir3	4.559	5.885	5.971	5.993	5.602	Ir*L=0.162
	Comp mean	4.591	6.144	6.164	6.331		
Harvest index %	Ir1	28.68	39.65	39.69	39.34	36.86	Ir=0.506
	Ir2	29.04	39.38	38.90	39.05	36.69	L=0.507
	Ir3	29.39	41.80	41.58	41.71	38.62	Ir*L=0.256
	Comp mean	29.03	40.28	40.06	40.03		
N% of grain wheat	Ir1	1.52	1.80	1.88	1.95	1.78	Ir=0.0332
	Ir2	1.52	1.89	1.95	2.06	1.86	L=0.0383
	Ir3	1.53	1.83	1.90	1.97	1.81	Ir*L=0.066
	Comp mean	1.523	1.84	1.91	1.99		
N-uptake kgfed^{-1}	Ir1	19.91	44.46	46.92	48.80	40.02	Ir=3.6
	Ir2	20.52	47.04	49.25	53.12	42.48	L=4.8
	Ir3	20.50	45.02	47.18	49.25	40.49	Ir*L=17.8
	Comp mean	20.31	45.51	47.79	50.22		

This result may be due to the treatment of L3 characterized by high quantity of N, which gave a chance for more nitrogen uptake by plant roots through growth stages. These results in agreement with those obtained by Azza. et al,. (2011).

Irrigation water amount (IWA) effect:

Date in table (6) showed different effects for Biological yield, Harvest index and N- uptake in grain wheat crop due to application of different irrigation amount. The means values of Biological yield increased significantly by applied Ir2 than the applied Ir1 and insignificantly between Ir1 and Ir3. Concerning the harvest index of wheat plant, data presented in Table 6 clearly indicated that its value was affected significantly by applied different irrigation water amount. Among the applied treatments, the greatest harvest index values were recorded at Ir3 treatment (38.62%) of irrigation regime. This result may be due to the grain yield of Ir3 was more than the Ir1 and Ir2. These results reported by Awad. et al (2000). Also, data illustrated that both of N% and N-uptake in grain of wheat plant affected by the irrigation regime. The superiority mean values of N% and N-uptake for grain yield (2.06%) and (42.48 $kgfed^{-1}$) respectively were achieved by the treatment Ir2. In addition, increasing irrigation water amount by applying 3024 m^3/fed irrigation water Ir1 may be attributed to a negative effect on whole plant. These results are in agreement with those obtained by Mesbah (2009).

Interaction between compost levels and irrigation water amount (IWA):

The effect of interaction between application of compost levels and irrigation regime (IWA) was presented in tables above mentioned. They illustrated that highest means values due to the interaction treatments for each Biological yield, Harvest index % and N-uptake for grain of wheat crop were insignificant. Although, the highest mean values of Biological yield (6.604 $tonfed^{-1}$), Harvest index % (41.7%) and N% (2.06) or N-uptake by grain of wheat (49.25 $kgfed^{-1}$) were produced by applied the treatments of L3*Ir2.

3-Effect of different treatments on water productivity $LE.m^{-3}$(WP) of irrigation water to wheat plant grown on loamy sand soil

As shown in fig (1) the compost levels application increased highly significantly mean values of WP than the control treatment (L0).

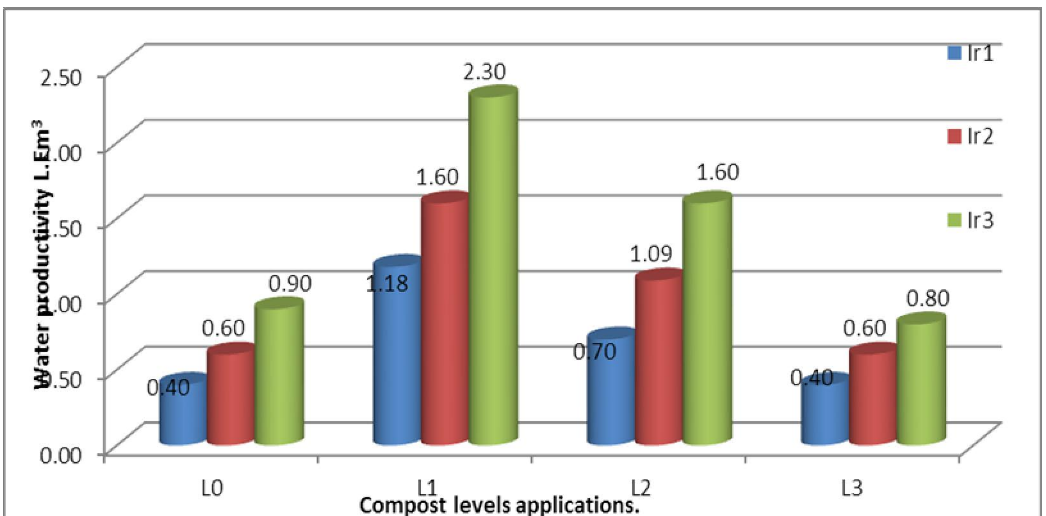

Fig (1) Effect of compost application levels and irrigation water amount on productivity $L.Em^{-3}$ of water.
L.S.D *at 0.05* of W.P for Ir= 0.037 L.S.D *at 0.05* of W.P for L = 0.043
L.S.D *at 0.05* of W.P for L*Ir = 0.074

Moreover, the level L1 was ascertained the highest means values of WP. It was observed that there were high significant difference between the means values of L1, L2 and L3 by applied the different irrigation water amount Ir1, Ir2 and Ir3. At the same time, the amount of irrigation water Ir3 (saved 25% irrigation water from traditional amount) which was recorded significantly the maximum mean values of the WP. It is noticed that, the mean values of WP increased due to application of Ir3 by 114% and 43% than both treatments Ir1(125% irrigation water of traditional amount) and Ir2 (100% traditional amount). These results mean that each one m^3 of irrigation water consumed to irrigation wheat crop grown on sandy loam soil by interaction treatments Ir3*L1 was approximate profitably by 2.3LE pound for farmer.

4-Economic evaluation

Regarding the interaction effect of compost levels and irrigation water amounts on net income, results in fig (2) indicate that the highest net income achieved by applied compost at L1.

($5tonfed^{-1}$) for three irrigation water amount (Ir1, Ir2 and Ir3) which were approximately statistically as the same.

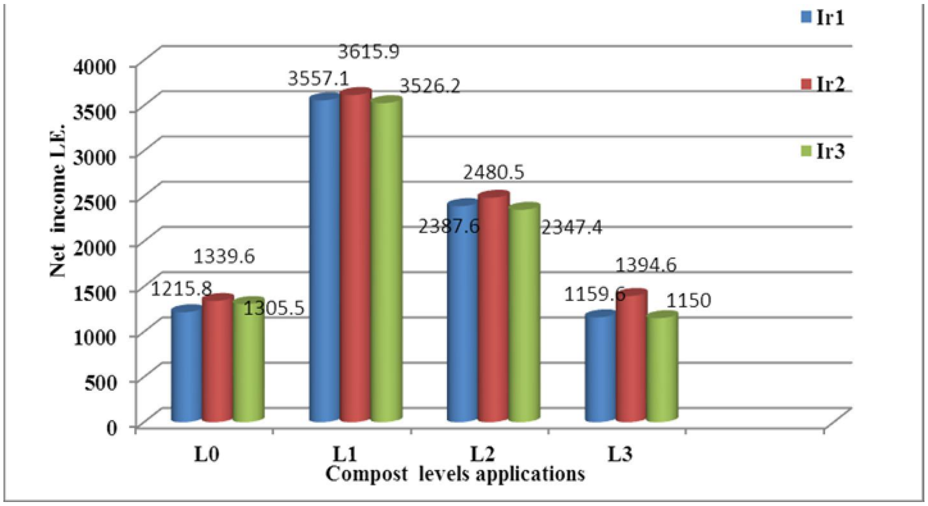

Fig (2) Effect of compost application levels and Irrigation water amounts on net income of wheat crop /fed.
L.S.D *at 0.05* of net income for Ir= 101.4 L.S.D *at 0.05* of net income for L = 117.1
L.S.D *at 0.05* of net income for L*Ir =202.9

*****Economic Efficiency**

Data presented in (fig.3) show that the means values of economic efficiency (E.E) produced by the interaction of the treatments had high level of significance than the control. The highest means values of economic efficiency was obtained by applied the treatment of compost at level L1 (tonfed^{-1}) combined with each one of irrigation water amounts which were 125%Ir1, 100% Ir2 or 75% Ir3. It take into consideration that the difference between means values of economic efficiency (E.E) produced by applying Ir1, Ir2 and Ir3 with compost level L1 was insignificantly. Also results revealed that the lowest values of the same parameters were always related to the increased amount of water applied and increasing levels of compost added.

It was obvious from the previous data that the irrigation scheduling at rate more than 75% water irrigation amount from the traditional water amount when irrigated by sprinkler irrigation combined with the compost at rate more than 5 tonfed^{-1} become higher costs, lower the return and decreased the economic efficiency. This results harmony to report with Abdelraouf, et al., (2014).

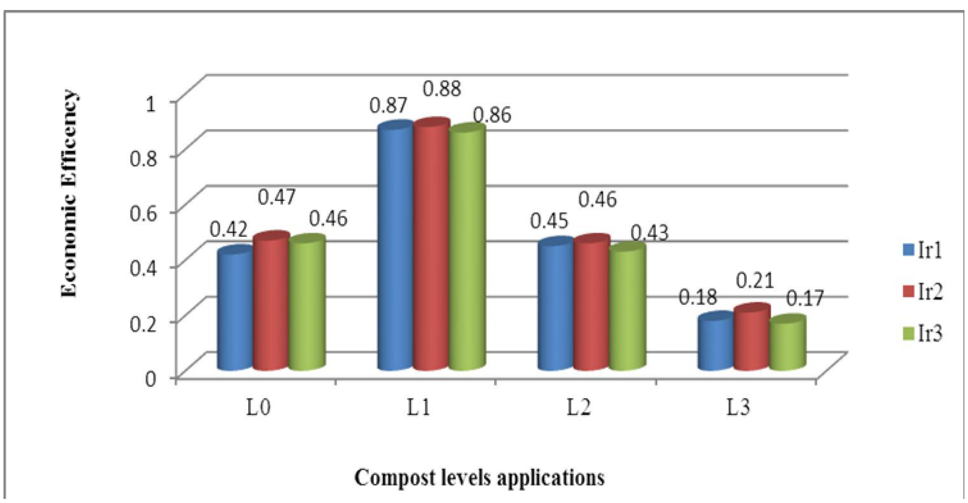

Fig (3) Effect of compost application levels and Irrigation water amounts on Economic Efficiency for wheat crop / fed.
L.S.D *at 0.05* of net income for Ir= 0.026, L.S.D *at 0.05* of net income for L = 0.030, L.S.D *at 0.05* of net income for L*Ir = 0.052

Conclusion:

On the basis of the presented data and under the same of experimental conditions, data indicated that the application of compost markedly improved yield and water productivity of wheat crop than the control. Also data reveled that by applied treatments Ir3 about 25 % amount of water irrigation could be saved under applying compost at level 5tonfed^{-1}to loamy sand soil. These results were incorporated with the height crop yield, water productivity, net income and economical efficiency. Further and more detailed studies are needed on a narrower range of applied irrigation regime in order to formulate a better guideline for combining with compost application.

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