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RESEARCH ARTICLE

IMPACT OF DIFFERENT SOIL MOISTURE DEPLETION, NITROGEN AND BIOFERTILIZER APPLICATION LEVELS ON YIELD-WATER PRODUCTIVITY OF WHEAT AND SUNFLOWER AT NORTH DELTA.

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Abstract

Two field trials were carried out at the experimental farm, Sakha Agricultural Research Station, Kafr El-Sheikh governorate during the two growing seasons 2014/ 2015 to investigate the effect of soil moisture depletion, nitrogen and biofertilizer application levels on yield water productivity of wheat and sunflower. The experiments were designed as split split plot with three replicates. The main plots were occupied by soil moisture depletion, while sub plots were devoted to nitrogen rates and sub sub plots were biofertilizer treatments. The main results can be summarized as follows:
-Water applied and water consumptive use by wheat and sunflower were recorded highest values under irrigation I_1.The highest values of water stored in the root zone, were recorded by irrigation I_1 while water application efficiency was achieved under I_2 either by wheat or sunflower crops. Water productivity and the amount of applied water were recorded highest values under irrigation I_2 and N_3.
The net income was recorded the highest value with I2 under N3 and b3. While the economical efficiency was recorded the highest value (2.81) by I2 with N3 for wheat. On the other hand, Net income for sunflower seed and economical efficiency were recorded the highest value 5368 LFed.$^{-1}$ and (2.25) by under irrigation at 50% depletion of available soil moisture (I2) with 50kg Nfed.$^{-1}$and b3.
It could be concluded that application of biotol + phosphorene +75 kgNFed.$^{-1}$ for wheat. While addition of biotol+ phosphorene +50 kgNFed.$^{-1}$ for sunflower under irrigation at 50% depletion of available soil moisture could be economically used for production of wheat and sunflower as well as under water shortage without adverse effect on wheat and sunflower productivity

Introduction:-

Wheat is one of the most important cereal crop used in human food and animal feed in Egypt and overall the world. Recently, a great attention of several investigators has been directed to increase the productivity of wheat to minimize the gap between the Egyptian production and consumption by through increasing the production by

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increasing unit land area productivity and increasing the cultivated area. Increasing wheat yield per unit area could be achieved by breeding high yielding varieties.

The domestic wheat production in 2013 season was estimated by 8.7 million tons, whereas the Egyptian national consumption of wheat is about 17.7 million tons in 2013; there is a great gap between the consumption and production. Egypt imports above five million tons of wheat grains. Unless domestic wheat production increases annually, the deficit will increase due to the increase of birth rate (2%) and present consumption per capita estimated by about 200 kg year^{-1} (**USDA, 2013**).

In Egypt, water was and still the most critical and limited factor in crop production. The Egyptian water budget from the Nile River is 55.5 milliars cubic meters. Under limitation of fresh water resources, the farmers will have to use other resources in irrigation, and we should do our best towards effective rationalization of irrigation water on the farm level. So, effective water management at irrigation sector is the principal way towards the rationalization policy. Therefore, the knowledge of the amount of water required irrigating wheat and sunflower becomes necessary to know about the quantity of water consumed in growing these crops and the efficiency of the applied water. So, the suitable irrigation water regime and nutrition programes are the main effective factors in this field. Tremendous efforts should be implemented towards the aim of such effective water management on the farm level. Some of these efforts include irrigation according to depletion of available soil moisture from the effective root zone and supplying water according to plant requirements to make water enough for wheat and sunflower production.

Water stress may resulted in similar yield or minimize yield reduction, with the benefit that the amount of saved saving irrigation water, which could be used in irrigation of new lands. Many researchers proved the importance of irrigation management to maximize wheat productivity.

The wheat grain yield was (2966.5, 2319 kg ha^{-1}) when irrigation was applied at 50% soil moisture depletion (SMD) and was reduced at 70% (SMD), (**Mahmood and Ahmad, 2005).** The biological yield, grain yield and harvest index were significantly affected by irrigation levels. Grain yield under I_1, I_2 and I_3 produced increasing of 21%, 27% and 29% (**Malidarreh, 2010).** Irrigation applied at 40% depletion of soil moisture, stress treatments irrigation applied at 30%, 50% and 80% depletion of soil moisture acheived the highest values of biological yield 13680 kg ha^{-1} and harvest index (49.41%) (**Shams *et al*., 2010).** The three irrigation of depletion A1, A2, A3 were irrigated at 25%, 50% and 75% depletion of available water. The best irrigation treatments which 50% depletion of available water leads to an increase in yield of wheat about 16.3%, saving of irrigation water 16.1%.

The highest value of grain, straw, and total yield were obtained with 40% depletion of available soil moisture .While the lowest of these traits were acheived under 70% depletion of available soil moisture (**Beshara, 2012**)**.** The delaying irrigation until soil available moisture content reached 65% or 80% depletion decreased grain and straw yields. Increasing soil moisture depletion levels decreased the grain and straw yields compared with 50% depletion **(Hammad-Salwa and Ali, 2014).** Nitrogen (N) is one of the most yield limiting nutrients for crop production in the world. It has been proved as an essential nutrient for plant growth for more than a century. It is also the nutrient which applied in the largest quantity for most of annual crops. Significantly advances emerged in N fertilizer technology during the last half of the 20th century. Furthermore, the essential role of N in increasing crop production and its dynamic nature and property for N loss from the soil plant system create a unique and challenging environment for its efficient management. In addition efficient or optimal management of N in the agroecosystem is still a debatable issue (**Fageria, 2009).** Systems of agriculture that rely heavily on soil reserve to meet the N requirements of plants cannot long be effective in producing high yields of crops. It is usually added as a fertilizer and is required for all types of soils. To increase crop yields, grow worldwide apply over 80 million metric tons of nitrogen fertilizers per year.

Water nitrogen relationships or production functions are considered as useful tools in the management of water and nitrogen application for optimization of crop productivity. These functions could be used in managing water resources for achieving maximum returns with minimum amount of water application as irrigation **(English and Raja, 1996).**If pests and diseases are controlled, yield of any crop in a given environment mainly depends upon irrigation and nitrogen (N) fertilizer management. Both water and nitrogen are subjected to losses by many pathways if not managed properly. Therefore, there is a considerable interest in strategies that enhance nitrogen use efficiency and product use of applied irrigation water leading to increasing productivity. Experimental results are used to develop general fertilizer recommendations for the whole region although experiments are conducted on a smaller scale **(Montazar and Mohseni, 2011)**. Soil productivity, water application efficiency and biofertilizer interaction experiments, which carry out in salt affected soils can be considered as an important issue in soil sciences. A more systematic research is required to observe the responses of crops to this interaction at the field level where extreme variability in soil moisture depletion. Therefore, the present study deals with the effect of soil moisture depletion, nitrogen and biofertilizer application levels on yield water productivity of wheat and sunflower.

Materials and methods:-

Experimental and treatments:

Field trials were carried out at the Sakha Agricultural Research, station farm, Kafr El-Sheikh, which lies in 134 km north of Cairo. The experiment was conducted during winter season of 2014/2015 and summer season of 2015 to study the effect of irrigation regimes, N-fertilizer and biofertilizer on yield and yield components of wheat and sunflower. The station coordinates are at $31^o05`$ N latitude and $30^o75`$ E longitude. It has an elevation of about 6 meters above the sea level. The experiments were conducted in split-split plot design, with three replicates. The main plots were assigned to irrigation regimes (I_1, I_2 and I_3. Sub plots were devoted nitrogen rates and sub sub plots were biofertilizer treatments. The plot area was 10.5 m^2. The biotol which produced from the Agricultural Research Center (ARC, Giza, Egypt), contains N_2-fixing free living bacterial cultures (*Azotobacter chroococcum and Azospirillium lipoferum*). Phosphorene as biofertilizer contains phosphate dissolving bacterial culture (*Bacillus megaterium*), also produced from ARC, Giza, Egypt. Table (1) shows the experimental design.

Table 1:- The experimental design.

Treatments		
Irrigation regimes		
I_1	Irrigation at 35% depletion of available soil moisture	
I_2	Irrigation at 50% depletion of available soil moisture	
I_3	Irrigation at 65% depletion of available soil moisture	
N-fertilizer rates	Wheat	Sunflower
N_1	50 kg N fed^{-1}	30 kg N fed^{-1}
N_2	75 kg N fed^{-1}	40 kg N fed^{-1}
N_3	100 kg N fed^{-1}	50 kg N fed^{-1}
Biofertilizer		
b_0	Without application	
b_1	Biotol (10 L fed^{-1})	
b_2	Phosphorene (4 L fed^{-1})	
b_3	b_1+b_2	

Wheat (Sakha 94) was sown on 15^{th} November in 2014 and harvested on 10^{th} May 2015 and sunflower (Sakha 53) was sown on 25^{th} May, 2015 and harvested on 10^{th} October 2015. The N was applied as urea (46.5% N). The other required cultural practices for growing wheat and sunflower were followed properly as recommended for the region. Wheat plant samples were taken from all treatments for determinations of 1000-grain weight (g.), biological, grain , straw yields (ton $Fed.^{-1}$) and harvest index.100-seed weight (g), seed yield (kg fed^{-1}) and seed oil content (%) were determined for sunflower. The meterological data from Sakha Station during the two growing seasons are presented in Table (2).

Table 2:- Climatological data for the growing seasons in 2014/2015.

Season	Month	Air temp. ^oC		Mean	RH%	Wind velocity km/day	Pan evap., cm/day	Rain, mm
		Max.	Min					
2014/ 2015	Nov.	24.30	13.79	19.05	74.15	78.00	2.77	24.6
	Dec.	22.27	9.72	16.00	76.05	53.00	1.72	5.70
	Jan	18.79	9.46	12.63	74.60	70.80	2.79	7.04
	Feb.	19.01	7.65	13.33	74.75	72.91	2.90	7.34
	Mar.	22.69	11.69	17.19	70.59	87.64	3.23	6.25
	Apr.	25.64	13.70	19.67	63.40	105.90	7.15	11.95
	May	30.19	18.79	24.49	61.70	119.60	7.15	-

Soil sampling analysis:-

Before planting and after harvesting both crops, soil samples (0-15, 15-30, 30-45 and 45-60 cm depth) were collected and composite (Table 3 and 4). Composite soil samples were dried, sieved through 2 mm mesh and were analyzed for salinity which was determined in the saturated soil paste extract according to **Page (1982)**. The bulk density was determined using core-ring method and one core per stratus of each plot was collected and the samples were oven dried for 48 h at 105^{o}C, weighed and bulk density calculated according to reference (**Blak and Hartage, 1986).** Particle size distribution was determined according to **Piper (1950).**

Table 3:- The mean values of some chemical properties of the experimental site before cultivation.

Soil depth (cm)	Soil pH	EC dS m^{-1}	Soil SAR	Soil ESP (%)	Soluble cations (meq L^{-1})				Soluble anions (meq L^{-1})		
					Na^+	Ca^{++}	Mg^{++}	K^+	HCO_3^-	Cl^-	SO_4^-
0-15	7.93	4.89	10.92	12.93	33.3	7.8	10.8	0.9	4.5	25.0	23.3
15-30	8.21	5.26	11.32	13.37	35.8	8.4	11.6	0.9	5.0	26.6	25.0
30-45	8.2	5.35	11.41	13.47	36.43	8.75	11.8	1.0	4.83	27.27	25.49
45-60	8.46	5.91	12.0	14.12	40.20	9.5	13.0	1.2	5.5	30.2	28.1
Mean	-	5.35	11.41	13.47	36.43	8.61	11.80	1.00	4.96	27.27	25.47

According to Natural Resources Conservation Service (NRCS), Oregon State University, USA, the soil of experiment can be classified as saline soil where (EC > 4 dS m-1, SAR < 13, ESP < 15% and soil pH < 8.5) (**Horneck et al. 2007)**

Table 4:- The mean values of some physical properties and some water constants of the experimental site before cultivation.

Soil depth (cm)	Particle size distribution (%)			Texture class	Field capacity (%)	Wilting point	Available water (%)	Bulk density (kg m^{-3})
	Sand	Silt	Clay					
0-15	16.3	33.2	50.5	Clayey	42.80	22.86	19.94	1.18
15-30	14.4	33.9	51.7	Clayey	39.29	21.30	17.99	1.27
30-45	12.8	34.3	52.9	Clayey	38.00	20.21	17.79	1.32
45-60	13.5	34.8	51.7	Clayey	38.00	20.21	17.79	1.32
Mean	14.5	33.8	51.7	Clayey	40.03	21.46	18.57	1.26

Plant analysis and nutrient uptake:-

Plant samples from the measured plants for growth and yield were used for analyzing the N content in grain and straw for wheat and seed yield of sunflower. The grain, straw and seed were dried at 65^{o}C in a hot air oven. The dried samples were ground in a stainless steel Wiley Mill. The N content in grain and straw were determined by digesting the samples in sulfuric acid (H_2SO_4), followed by analysis of total N by Kjeldahl method (**Page *et al*., 1982)**. The uptake of the nitrogen was calculated by multiplying the nitrogen content (%) by respective yield (kg fed^{-1}).

Water relations:-

Amount of irrigation water applied:-

It was measured by using cut throat flume (30 x 90 cm) and calculated as m^3/fed **(Early, 1975)**

Water consumptive use (WCU):-

Water consumptive use was calculated using the following equation (**Hansen *et al*., 1979).**

$$WCU = \sum_{i=1}^{i=n} \left\{ \left[(\theta_2 - \theta_1) x\ D_{bi}\ x\ d_i\ x\ 4200 \right] / 100 \right\}$$

Where:

WCU = Water consumptive use in m^3/fed.
θ_1 = Soil moisture % before next irrigation in the i^{th} layer
θ_2 = Soil moisture % after irrigation in the i^{th} layer
D_{bi} = Bulk density in g/cm^3 of other i^{th} layer
d_i = Depth of the i^{th} layer, m
4200 = irrigated area in m^2 (one feddan).
i = No. of soil layers
n = No. of irrigation.

Water stored in the effective root zone (ws):
Seasonal (ws) was calculated using the following equation:

$$WS = \sum_{i=1}^{i=n} \{[(\theta_2 - \theta_1) x\ D_{bi}\ x\ d_i\ x\ 4200]/100\}$$

Where:
θ_1 = Soil moisture % after irrigation the i^{th} layer
θ_2 = Soil moisture % before irrigation in the i^{th} layer
(i.e. directly, before and after the same irrigation)

Irrigation application efficiency (Ea):
It is defined as a ratio %, between the amount of stored water (m^3 fed^{-1}) and the amount of the applied water (m^3 fed^{-1}) as described by **Downy (1970)**

$$Ea = (Ws/Wa) x 100$$

Where:
Ws, Wa are the volumetric water stored and the volumetric water applied.

Determination of soil moisture percentage:-
Soil samples for moisture determinations were taken from each 20 cm depth for a total depth of 60 cm from the ground surface by a regular auger. The soil samples were weighed after sampling immediately and dried in an electric oven to a constant weight at 105^{o}C. Percentage of soil moisture content at the three soil depths was calculated on oven dry basis. The amount of water consumed and water stored in each irrigation was obtained from the difference between soil moisture content after and before the following irrigations:

Water productivity (WP):-
It was calculated according to **Ali *et al*. (2007).**

WP = Gy/ET

Where:
Gy = is grain yield (kg fed^{-1}) and
ET = Total water consumption of the growing season (m^3 fed^{-1})

Productivity applied irrigation water (PIW) (Ali *et al*., 2007):-
Was calculated as follows:

PIW = GY/I

Where I is irrigation water applied (m^3 fed^{-1})

Statistical analysis:
The results were analyzed statistically by a general linear model procedure and 2-way analysis of variance (ANOVA) using cohort computer program according to the method of **Gomez and Gomez (1984)**. Mean separation procedure was performed using LSD's test at a 0.05 and 0.01 level of significance.

Results and Discussion:-

Water measurements:-

Amount of seasonal water applied:-
Data presented in Table (5) show that the values of seasonal water applied during the first growing season were decreased by 9.39 and 14.24 % with irrigation at 50 and 65% depletion of available soil moisture and 5.81 and 10.85% during the second growing season, respectively. Whereas the highest seasonal water applied (2289 and 2718 m^3 fed^{-1}) was recorded with irrigation at 35% depletion (I_1) during the two growing seasons, respectively. Increasing the amount of seasonal water applied under irrigation treatment I_1 comparing with other irrigation treatments I_2 and I_3 is due to the decrease in irrigation intervals between irrigations. Consequently, increasing number of irrigation under the conditions of this treatment and hence, increasing amount of seasonal water applied. These results are in accordance with those reported by **Ahmad (2002), Mahmood and Ahmad (2005, Malidarreh (2010), Badel *et al*. (2013), El-Agrodi *et al*. (2016) and Khalifa (2016).**

Table 5:- Effect of irrigation, nitrogen and biofertilizer levels on seasonal water applied of wheat and sunflower in the two growing seasons, 2014 and 2015.

Irrigation treatments	Seasonal water applied			
	1st growing season		2nd growing season	
	m^3 fed^{-1}	cm fed^{-1}	m^3 fed^{-1}	cm fed^{-1}
I_1	2289	54.50	2718	64.71
I_2	2074	49.38	2560	60.95
I_3	1963	46.74	2423	57.69

Water consumptive use (WCU) (m^3 fed^{-1}):-

Data in Table (6) show that the mean values of water consumptive use were decreased with irrigation treatments I_2 and I_3. The highest mean value of WCU (1587 and 1890 m^3 fed^{-1}) was recorded under irrigation treatment I_1 during the two growing seasons, respectively. On the other hand, the lowest mean value (1490 and 1763 m^3 fed^{-1}) was recorded under irrigation treatment I_3 for the two growing seasons, respectively. This effect of irrigation treatments on water consumptive use might be attributed to the increase for water applied. So, the values of water consumptive use were decreased as soil available water decreased. These results are in agreement with those obtained by **Ooudal *et al*. (2008), Zhang *et al*. (2009), El-Arqan *et al*. (2010), Beshara (2012), Rizk and Sherif (2014) and El-Agrodi *et al*. (2016).**

Table 6:- Actual water consumptive use as affected by different soil moisture depletion levels in 2014/2015.

Season	Irrigation treatments	Actual water consumptive use (m^3 fed^{-1})				Total
		Soil depth, cm				
		0-15	15-30	30-45	45-60	
1st growing season	I_1	577.78	419.25	337.32	252.65	1587
	I_2	573.48	383.41	309.18	235.93	1502
	I_3	568.24	381.83	306.15	233.78	1498
2nd growing season	I_1	615.92	522.12	445.67	306.29	1890
	I_2	600.71	498.49	414.55	296.25	1810
	I_3	587.38	489.92	410.65	275.05	1763

Water stored in the effective root zone (m^3 fed^{-1}):-

Data presented in Table (7) revealed that the values of water stored in the effective root zone were decreased by 12.47 and 11.79% under irrigation at 65% depletion of available soil moisture during the two growing seasons, respectively. Increasing the amount of water stored in the effective root zone under irrigation treatment I_1 might be attributed to the increase in the number of irrigation hence, increasing the amount of water applied. So, large amounts of water still stored in root zone over plants requirements. These results are in a great harmony with those obtained by **El-Agrodi *et al*. (2016) and Khalifa (2016).**

Water application efficiency (%):-

Data in Table (7) showed that the values of water application efficiencies were affected by irrigation treatments. The highest percentage (74.51 and 72.80%) was recorded under irrigation 50% depletion of available soil moisture (I_2), respectively. whereas, water application efficiency could be arranged in descending in order $I_2 > I_1 > I_3$.

Table 7:- Water stored and water application efficiency as affected by different soil moisture depletion levels in the two growing seasons of 2014 and 2014/2015

Season	Irrigation treatments	Actual water consumptive use (m^3 fed^{-1})				Total	Water application efficiency (%)
		Soil depth, cm					
		0-15	15-30	30-45	45-60		
1st growing season	I_1	675.44	523.86	391.37	285.33	1876	73.05
	I_2	618.48	489.70	378.83	266.99	1754	74.51
	I_3	576.86	456.04	362.12	249.98	1642	73.20
2nd growing season	I_1	618.89	527.62	450.34	319.15	1916	70.49
	I_2	611.14	519.87	432.59	301.40	1865	72.80
	I_3	599.89	508.62	411.34	280.15	1800	69.75

Water productivity (WP) and productivity of irrigation water (P/W) (kg m^{-3}):-

Data in Table (8) showed the effect of irrigation at different soil moisture depletion, nitrogen fertilizer rates and biofertilizers on water productivity and productivity of irrigation water; whereas the highest values for WP and PIW were acheived under irrigation treatment I_2 compared with I_3 and I_1. These increasing for WP and PIW might be due to decrease in amount of water applied under the conditions of irrigation treatments I_3 and over irrigation for I_1. Whereas, the highest average of WP and PIW (2.006 and 1.457 kg.grain m^{-3}) for wheat and (0.633 and 0.455 kg. seeds m^{-3}) for sunflower was recorded with I_2 treatment. Regarding N-fertilizer rates, the highest mean value of WP and WIP (1.961 and 2.372 kg. grainm^{-3}) for wheat and (0.719 and 0.512 kg. seedsm^{-3}) for sunflower was recorded under N_3 treatment. Concerning biofertilizers, the highest values of WP and WIP were (1.987 and 1.444 kg.grain m^{-3}) for wheat and (0.719 and 0.512 kg.seeds m^{-3}) for sunflower. These results are in the same line with those obtained by **Mahamed *et al*. (2011), Beshara (2012) and El-Agrodi *et al*. (2016).**

Table 8:- Mean values of water productivity and productivity of irrigation water as affected by different treatments under cultivation of wheat and sunflower crops

Treatments	Wheat crop				Sunflower crop	
	WP (kgm^{-3})		PIW (kgm^{-3})		WP (kgm^{-3})	PIW (kgm^{-3})
	Grain	Straw	Grain	Straw	Seeds	Seeds
Irrigation regimes (I)						
I_1	1.828	2.188	1.270	1.520	0.587	0.409
I_2	2.006	2.436	1.457	1.773	0.633	0.455
I_3	1.757	2.220	1.340	1.690	0.620	0.455
N-fertilizer rates (N)						
N_1	1.774	2.208	1.290	1.607	0.586	0.423
N_2	1.856	2.264	1.383	1.653	0.613	0.439
N_3	1.961	2.372	1.427	1.727	0.641	0.457
Bio-fertilizers (B)						
b0	1.763	2.154	1.278	1.533	0.524	0.388
b_1	1.890	2.329	1.373	1.692	0.646	0.462
b_2	1.810	2.246	1.319	1.646	0.593	0.406
b_3	1.987	2.396	1.444	1.742	0.719	0.512

Yield and yield components:-

Wheat crop:

As found in Table (9), data showed that the mean values of wheat grain yield were affected by irrigation treatments, nitrogen fertlizer rates and biofertilizers application.Concerning the effect of irrigation treatments, results reveal that wheat grain yield was significantly decreased with irrigation at 65% depletion of available soil moisture, whereas at 50% depletion (I_2) recorded the highest mean value of grain yield (2.960 ton fed^{-1} equal 19.73 ardab/fed.). Increasing wheat grain yield under irrigation treatments I_1 and I_2 comparing with the other I_3 might be attributed to the increase in the number of watering under the conditions of this treatment (I_1) and consequently increasing the amount of water applied, hence, increasing availability of water and nutrients.

Thus, increasing the amount of nutrients uptake,forming strong and healthy plants which gave the high yield in comparison with the other irrigation treatments which always exposed low water stress. So, plants suffer from obtaining their water and nutritional requirements leading in yield reduction. These findings are in an agreement with those obtained by **Abd El-Rheem and Hassan (2011).** Results indicated that under the best irrigation treatment 50% depletion of available water leads to an increase in yield of wheat by 16.3%, saving of irrigation water by 16.1%. **Beshara (2012)** reported that the grain yield of wheat (2.566 ton/fed.) was obtained by 40% depletion of available soil moisture. Application of nitrogen significantly increased grain and straw yields of wheat. Maximum grain and straw yields (2.967 and 3.629 ton fed^{-1}, respectively), 1000-grain weight (60.79 g), and harvest index (44.91%) were found with the application N_3 treatment.

Regarding the effect of N-rates on wheat grain yield, data in the same table show that the grain yield was significantly increased with N application-rate up to N_3. Data revealed that N_2 and N_3 rates increased grain yield by 5.85 and 10.46%, respectively compared to N_1. This increase in wheat grain yield might be due to low soil available N that reflected on response of plants to application of N-rate. These results are in agreement with those obtained by **El-Ramady *et al*. (2013), Youssef *et al*. (2013), Ahmed *et al*. (2015) and El-Agrodi *et al*. (2016).**

Data in Table (9) show also that wheat grain yield was significantly affected by biofertilizer application b_1, b_2, and b_3 treatments which increased grain yield by 7.08, 1.14 and 11.26%, respectively compared without application.

Sunflower crop:-

Data in Table (9) presented the mean values of sunflower yield and their components as affected by irrigation regime, nitrogen and biofertilizer applications.

Results revealed that sunflower seed yield and seed oil content were highly significant increased with irrigation at 50% depletion of available soil moisture (I_2) which recorded the highest mean value of seed yield and oil content (1.150 ton fed^{-1} and 32.41%), respectively. Results indicated that under the irrigation of 50% depletion of available water leads to an increase in yield of sunflower by 13.75% and saving of irrigation water by 5.81%.

Application of nitrogen fertilizer significantly increased seed yield and seed oil content of sunflower. Highest seed yield (1.163 ton fed^{-1}), seed oil content (32.56%), were achieved under application of 50 kg N/Fed. All previous parameters significantly increased due to N-fertilizer (N_3-treatment) as well as, irrigation regime (50% depletion) and N-fertilizer (50 kg N/fed) which represented the maximum values for all previous sunflower yield (Table 9).

Application of bio-fertilizer significantly increased seed yield and seed oil content of sunflower. Maximum seed yield (1.312 ton fed^{-1}) and seed oil content (33.55%). All previous parameters significantly increased with irrigation regime I_2 (50% depletion of available soil moisture), N_3 (50 kg N fed^{-1}) and biofertilizer b_3 (biotol + phosphorene).

Table 9:-Yield and yield components of wheat and sunflower as affected by different treatments

Treatments	Wheat crop				Sunflower crop	
	Grain yield (t fed^{-1})	Straw yield (t fed^{-1})	Harvest index (%)	1000 grain weight (g)	Seed yield (t fed^{-1})	Seed oil content (%)
Irrigation regimes (I)						
I_1	2.90 a	3.486 b	45.48 a	58.58 b	1.011 b	32.49 a
I_2	2.96 a	3.666 a	44.64 ab	59.57 a	1.150 a	32.41 a
I_3	2.63 b	3.356 c	43.90 b	57.90 c	1.086 c	31.69 b
F-test	**	**	*	**	**	**
L.S.D. 0.05	0.055	0.043	1.15	0.17	0.006	0.140
L.S.D. 0.01	0.077	0.071	1.92	0.24	0.011	0.238
N-fertilizer rates (N)						
N_1	2.686 c	3.408 c	44.05 b	56.89 c	1.070 c	31.75 c
N_2	2.843 b	3.462 b	45.05 a	58.36 b	1.110 b	32.29 b
N_3	2.967 a	3.629 a	44.91 a	60.79 a	1.163 a	32.56 a
F-test	**	**	*	**	**	**
L.S.D. 0.05	0.055	0.045	0.65	0.031	0.004	0.120
L.S.D. 0.01	0.077	0.063	0.91	0.065	0.006	0.177
Bio-fertilizers (B)						
b_0	2.699 c	3.334 d	44.72 a	54.03 b	0.948 d	30.76 d
b_1	2.890 b	3.570 b	44.71 a	60.11 b	1.177 b	32.70 b
b_2	2.737 c	3.432 c	44.32 a	57.98 c	1.020 c	32.08 c
b_3	3.003 a	3.661 a	44.94 a	62.61 a	1.312 a	33.53 a
F-test	**	**	NS	**	**	**
L.S.D. 0.05	0.073	0.055	0.083	0.060	0.007	0.150
L.S.D. 0.01	0.097	0.074	1.11	0.109	0.010	0.206
Interaction						
I x N	NS	NS	NS	**	*	NS
I x B	NS	**	NS	**	**	**
N x B	**	NS	NS	**	**	NS
I x N x B	NS	NS	NS	**	NS	**

Nitrogen uptake and nitrogen use efficiency (NUE):-
The increase in crop yield due to N application may be associated with increase in panicles or heads in cereals and number of pods in legumes. Nitrogen improves grain or seed heights in crop plants and reduces grain sterility. Nitrogen also increase shoot dry matter, which is positively associated with grain yield in cereals and legumes. Grain harvest index (grain yield/straw dry weight plus grain yield) and N harvest index (N uptake in the grain/N uptake in grain plus straw) are also reported to be improved by addition of N to crop plants. These two plant traits are reported to be positively associated with yield in field crops (**Fageria, 2009).**

Nitrogen use efficiency (NUE) was decreased with increasing of N-fertilizer levels (from 50, 75 and 100 kg N fed^{-1}) for wheat and 30, 40 and 50 kg N fed^{-1} for sunflower under different irrigation and biofertilizer treatments as shown in Table (10). In contrast, NUE were increased with the irrigation regime treatment I_2 (50% depletion of available soil moisture) and biofertilizers treatment b_3 (biotol + phosphorene). The highest value of NUE was acheived under treatment (I_2, N_1 and b_3) comparing with other treatments.

The total uptake of N was increased with increasing of N-fertilizer rates under different irrigation and bio-fertilizer treatments and the highest values (69.26 and 73.11 kg fed^{-1}) were recorded for I_2 and b_3 comparing with other treatments wheat and sunflower (23.35 and 27.89 kg fed^{-1}). These results were recorded by **Beshara (2012), Hammad-Salwa and Ali (2007) and El-Agrodi *et al*. (2016).**

Table 10:- Effect of irrigation, N rates and biofertilizer treatments on total uptake of grain and straw for wheat and sunflower and nitrogen use efficiency.

Treatments	Wheat crop				Sunflower crop	
	Total N uptake (kg fed^{-1})			NUE (kg grain/ kg N)	N uptake kg fed^{-1}	NUE kg seed/ kg N
	Grain	Straw	Total			
Irrigation regimes (I)						
I_1	54.67	7.98	62.65	36.90	21.23	25.59
I_2	59.76	9.50	69.26	38.39	23.35	26.58
I_3	46.50	7.12	53.62	31.33	19.49	20.02
N-fertilizer rates (N)						
N_1	48.82	7.47	56.29	48.31	18.40	31.86
N_2	53.33	8.06	61.39	33.66	21.19	24.61
N_3	58.78	9.07	67.85	24.65	24.48	20.72
Bio-fertilizers (B)						
b_0	43.16	5.96	49.12	34.30	15.69	21.73
b_1	58.06	9.13	67.19	36.75	23.74	26.72
b_2	50.42	7.52	57.94	35.31	18.11	23.59
b_3	62.92	10.19	73.11	38.48	27.89	30.43

Economical evaluation:-
As shown from Figures (11&12) the highest values of wheat and sunflower yields beside the total net income resulted from the application of nitrogen and biofertilizer, which ameliorated the water stress conditions for crop production. The net income for previous treatments were recorded the highest value (8036 LFed. $^{-1}$) with I2 under N_3 (100kg Nfed.$^{-1}$) and b_3, for wheat. Economical efficiency was recorded the highest value (2.81) by I2 with N3 and b0 for wheat. On the other hand, Net income from sunflower seed was recorded highest value 5368 LFed. $^{-1}$ by I2 with N3and b3. Also economical efficiency took the same trend since it was recorded the highest value (2.25) under irrigation at 50% depletion of available soil moisture (I_2) with N_3 (50kg Nfed.$^{-1}$) and b_3.

Conclusion:-
It could be concluded that application of biotol (10 L fed^{-1}) + phosphorene (4 L fed^{-1}) +75kgNfed.$^{-1}$ for wheat and biotol+ phosphorene +50kgNfed.$^{-1}$ for sunflower under irrigation 50% depletion of available soil moisture can be economically used for production of wheat and sunflower as well as under water shortage without adverse effect on wheat and sunflower productivity

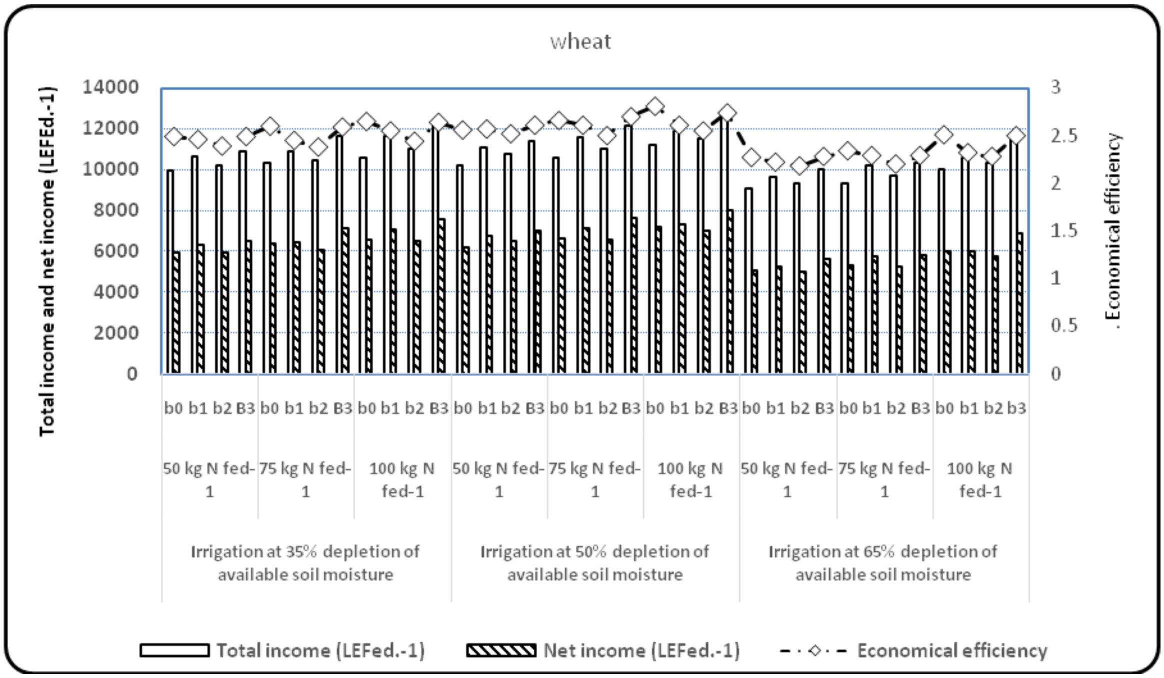
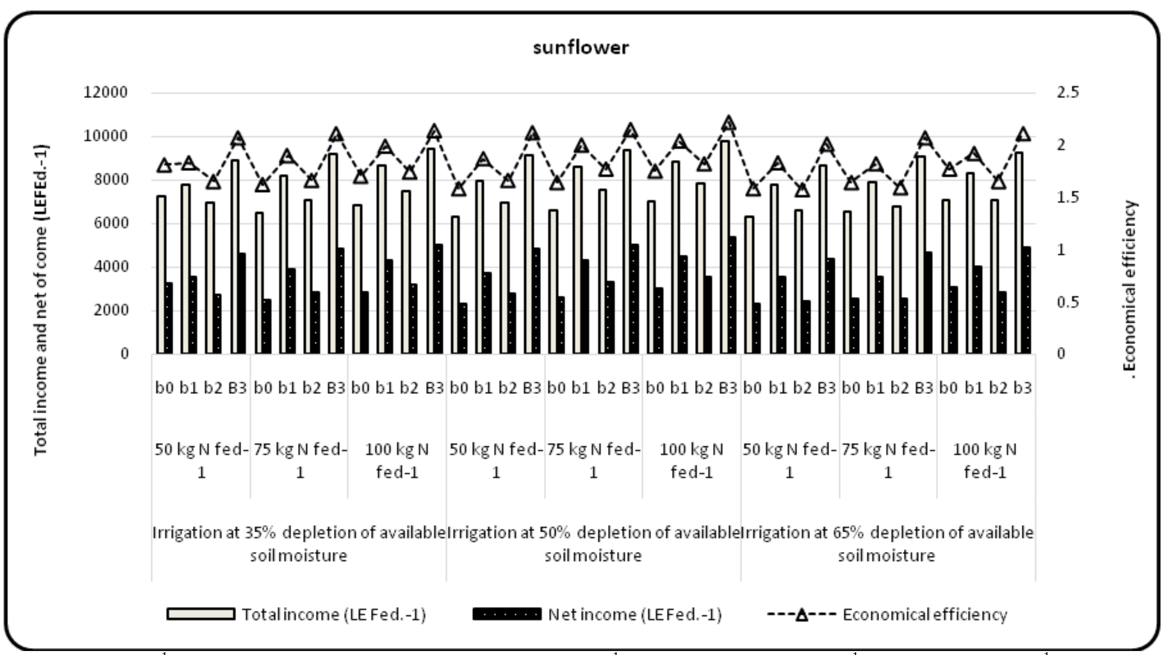


Figure 1: - Total income, net income and investment factor of wheat yield.



Total income (LE Fed.$^{-1}$) = total yield x price (LE), Net income (LE Fed.$^{-1}$) = total income (LE Fed.$^{-1}$)-total cost (LE Fed.$^{-1}$) and Economical efficiency= total net income (LE fed^{-1}) /total cost (LE fed.$^{-1}$)

Figure (2): Total income, net income and investment factor of sunflower yield as affected by different soil moisture depletion, nitrogen and biofertilizer application levels

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