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Improving Some Irrigation Efficiencies, Soil Fertility, Yield and Quality of Wheat under Deficit Irrigation by Integrated N-Fertilization

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Abstract

One of the most agricultural strategies is improving irrigation and fertilization. Two field experiment were conducted for study the effect of deficit irrigation strategy and integrated N-fertilization on the water application efficiencies, soil organic matter content, soil electrical conductivity, yield and quality of wheat were investigated under arid and sandy soils in Egypt and field experiments were conducted during 2018/2019 and 2019/2020 at the Research Farm of National Research Center (NRC). Water application efficiency and the average of soil organic matter content were increased by increasing the amount of organic fertilizers applied and decreased by increasing the volume of applied water but the average of electrical conductivity of soil were decreased by increasing the amount of organic fertilizers applied and increasing the volume of applied water. The values of the grain yield "GY_{wheat}" and protein content "PC_{wheat}"and carbohydrates content "CC_{wheat}" were increased by increasing the amount of organic N-fertilizers applied up to 50% and they decreased with the continued increase in organic N-fertilizers addition. Although most of the characteristics, especially crop yield, decrease with the decrease in the amount of added irrigation water, in this study there were no significant differences when irrigation with 100% or 80% of full irrigation(FI), so a decrease of 80% of FI may not have resulted in any effect on the moisture stress, on the contrary, most of the studied characteristics were slightly higher when irrigation by 80% FI than full irrigation. In spite of the highest values of the water productivity of the wheat crop, it was at irrigation with 60% of the total irrigation, but there were high significant differences in the values of the higher productivity when irrigation with 80% of FI with adding 50% organic N-fertilizers with 50% mineral N-fertilizers. Finally, the results of the study concluded that, the necessity of relying on organic nitrogen fertilization in addition to mineral nitrogen fertilization at 50% organic to 50% mineral in addition to the possibility of irrigation at 80% of full irrigation, i.e. saving 20% of irrigation water without any significant impact on the productivity and quality characteristics of wheat under arid and sandy soils conditions in Egypt.

Keywords: *Deficit irrigation, Integrated fertilization, Water application efficiency, Yield, Water productivity, Wheat*

1. Introduction

The global water crisis has drawn attention around the world to the urgent need to achieve more efficient use of water resources, particularly in agriculture, to increase crop production and achieve global food security. In arid and semi-arid regions with large population densities and limited fresh water, a great pressure on the agricultural sector to reduce the limited consumption of the limited fresh water devoted for irrigation in other sectors [21; 3 and 5]. Water scarcity is one of the serious problems challenges facing crop production in arid regions as in Egypt,, and it is important to reduce irrigation water consumption by developing innovative technologies that can be effective [13 and 4] In Egypt, the agricultural sector faces a serious challenge. Increasing food production with available water for agriculture, which can be achieved by increasing crop water productivity [4]. Increasing water productivity for crops is an important goal of increasing demand with high population growth [31; 9 and 11]. Water resources in Egypt suffer from severe water scarcity, which increase with increasing population growth. Increased competition for scarce water resources is competing with new irrigation techniques to increase water productivity and

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improve crop productivity and quality characteristics [26].Egypt suffers from water shortage in recent years, and in addition to climate change, there is frequent water shortage. Water resources in Egypt are still limited compared to the increasing demand for water. Therefore, modification of water management in both new and old lands is a major component of agricultural development.

Water productivity of crops in Egypt is critical, given the limited water resources, very limited and low rainfall factors [17 and 1]. The application of modern irrigation methods and associated technologies are important concepts that must be followed in arid regions as in Egypt to provide part of the improve application of the available irrigation water [12 and 5]. The biggest challenge facing the agricultural sector is to produce more food with less water, which can be accomplished by increasing crop water productivity (CWP) [39].

Improving crop production is one of the world's most important issues in terms of sustainable agriculture. Other off-site elements such as chemical fertilizers, deep tillage and unsustainable agricultural practices have increased plant production at the expense of soil which may adversely affect soil fertility. Under these conditions, agricultural practices lead to reduce soil organic matter content (SOM), soil biodiversity, and degradation of the physical properties of the soil and the wider environment (for example, increased soil erosion, sediment transport, pollution of surface and groundwater) [21 and 22]. As an alternative method of preserving the environment, several studies have suggested the use of an organic soil amendment approach which is considered the best way to maintain economically viable crop production with minimal environmental pollution. To ensure a high yield of apple trees, it is important that the soil remains fertile by providing adequate elements, and the importance of adding organic matter to increase biological activities and improve soil acidity, to deeply loosen the soil to improve the water and air system, etc. [36]. Promoting apple tree microorganisms through the application of bio-fertilization is a healthy choice of chemical composting. The preparation of microbial organisms including living cells of various microorganisms that are capable of converting plant nutrients in soil from the unavailable form to the available form is called bio-fertilizer. Thus, it increases crop yields by about 30% at an effective cost along with providing good biological activity conditions for the soil [27]. The appropriate soil organic matter (SOM) level by continuous addition of sources of organic matter such as compost is important, which is easily oxidized in Mediterranean conditions [15]. Decaying plant residues have been reported to release significant levels of nutrients and organic matter into the soil [37 and 7]. Studied the effect of adding organic and chemical fertilizers on cucumber yield and fruit properties. It was found that the organic treatment ($10m^3$ compost/$540m^2$) gave much greater early yield and exportable than the inorganic (chemical) treatment. According to [23], one of the main conditions for increasing soil productivity in the sub-Saharan region is to ensure water infiltration and storage in the soil. The ability of soil to retain water is closely related to its texture, structure and content of organic matter [31].Thus, SOM depletion is the main cause of ecosystem degradation and loss of ecosystem resilience [14].

Intensive cultivation of high-yielding crop varieties without adequate nutrient management not only depletes the limited nutrient stocks of the soil but also reduces the efficiency of nutrient use. Moreover, mineral fertilizer requirements cannot be fully met by the fertilizer industry due to the wide margin between production capacity and crop demand. Large quantities of mineral fertilizers, especially micronutrients, are imported. The high cost of mineral fertilizers, low application efficiency and low availability make crop production difficult to manage [29]. Integrated Plant Nutrition Management (IPNM) could be the best alternative approach for improving crop production and sustainable soil fertility. Under IPNM, the various nutrient sources are collectively used in a sustainable way. Combining organic manure with mineral fertilizers can help improve soil properties and reduce nutrient leaching, thus increasing the effectiveness of mineral fertilizers [24; 9 and 35]. Improving soil compost retention capacity, cation exchange capacity, soil aeration, seed germination and plant growth [34]. Likewise, green manure crops such as Sesbania aculeate and cluster beans (Cyamopsistetragonoloba) increased soil organic matter content, nutrient availability, and soil fertility by improving the physical, chemical and biological properties of the soil as well as reducing nutrient loss [28].The Spanish plowing as green manure greatly enhanced the rice yield [25]. Moreover, the incorporation of agricultural manure and green manure with mineral fertilizers in the crop pattern of wheat, rice and wheat increased the yields of both crops [20]. Likewise, another study indicated a marked increase in wheat yield using natural fertilizers and mineral fertilizers [32]. Healthy plants actually produce the highest yield, which is not possible without soil fertility and balanced fertilization. Application of farm manure is a relatively common practice for green manure. Soil nutrient dynamics may vary depending on the type of organic source as well as the rate of mineral fertilizer.

The purpose of this study was to improve water application efficiency, soil fertility, yield, quality and water productivity of wheat under deficit irrigation by integrated N-fertilization under Egyptian arid and sandy soils.

Material and methods

Experimental site: Field experiments were conducted during 2018/2019 and 2019/2020 at the Research Farm of National Research Center (NRC) (latitude 30o 30' 1.4" N, longitude 30o 19' 10.9" E, and 21 m+MSL (mean sea level) at Nubaryia Region, Al Buhayrah Governorate, Egypt. The experimental area has an arid climate with cool winters and hot dry summers. The data of maximum and minimum temperature, relative humidity and wind speed were obtained from the local weather Station at El-Nubaryia Farm

Physical and chemical properties of the soil and irrigation water: Irrigation water was obtained from an irrigation channel passing through the experimental area. The irrigation water had a pH of 7.35 and an electrical conductivity (EC) of 0.41 dS m^{-1}. The main physical and chemical properties of soil were determined in situ and in the laboratory at the beginning of the field trial (Table 1). The main physical, chemical and biological properties of drainage water of fish farms and irrigation water are reported in Table 2.

Table (1): Some physical and chemical characteristics of the site before sowing.

Soil characteristics	Soil layer (cm)		
	0–15	15-30	30-45
Physical parameters			
Texture	Sandy	Sandy	Sandy
Course sand (%)	47.85	56.65	36.65
Fine sand (%)	49.78	39.81	59.50
Silt + clay (%)	2.37	3.54	3.85
Bulk density (t m^{-3})	1.68	1.68	1.69
Chemical parameters			
EC (dS m^{-1})	0.42	0.43	0.45
pH (1:2.5)	8.77	8.70	9.1
Total $CaCO_3$ (%)	7.14	2.36	4.64
Organic matter (%)	0.62	0.43	0.33

Table (2): Some chemical analysis of organic fertilizer and irrigation water

Item		Compost	Irrigation water
pH		5.95	7.35
EC, (ds/m)		0.73	0.43
Anions (meq./L)	HCO_3^-&CO_3^{2-}	1.25	0.11&< 0.01
	Cl^-	3.53	2.73
	SO_4^{2-}	2.92	1.34
Cation (meq./L)	Ca++	2.10	1.04
	K+	2.23	0.22
	Mg+	1.01	0.52
	Na+	2.37	2.42
Organic Matter, (%)		97.3	------
Moisture Content, (%)		18.5	------
Nitrogen, (%)		0.91	< 0.01
Phosphorus, (%)		0.86	------
Potassium, (%)		0.89	0.23

Experimental design: The experiment was established with a split plot design having three replicates. The main plots included three irrigation deficit (100% FI, 80% IF and 60% FI), the sub-main plot was five cases for Integrated N- fertilization [(IN1:100% MN + 0% ON), (IN2:75% MN + 25% ON), (IN3:50% MN + 50% ON), (IN4:25% MN + 75% ON) and (IN5:0% MN + 100% ON)]. Where IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Fertilization method: according to analyses of compost content, 0.91 % nitrogen and wheat requirements from nitrogen was 80 kg nitrogen/ fed [100% chemical nitrogen fertilizer in the form of ammonium nitrate (33.5% N)]. . This mean the total amount from compost =80/9.1= 8.79 ton and more than 50% from applied compost will analyzed during the next year, this mean the total amount from compost at least 17.58 ton/fed. The compost was applied 20 days before seedling. The scheduling of the integrated nitrogen fertilization for all treatments according to the previous information is shown in the table (3).

Irrigation requirements: Irrigation water requirements of wheat under sprinkler irrigation system from 17/ 11/ 2018 to 20/4/ 2019 for first season and from 19/ 11/ 2019 to 22/ 4/ 2020 were calculated according to the following equations 1 that presented in table (4).

$$IRg = [(ET_o \times Kc) / I_E] - R + LR \ldots\ldots(1)$$

Where: IRg: Gross irrigation requirements, mm/day; ET_O: Reference evapotranspiration, mm/day, Kc: Crop factor of common bean (FAO-56); I_E: Irrigation efficiency, %, R:Rainfall, (mm), LR: Amount of water required for the leaching of salts, mm

Table (3): Distribution treatments of the experimental design Treatment distribution through the experimental design

Treatments	2018/2019 and 2019/ 2020		
	DI1	DI2	DI3
IN1:100% MN + 0% ON			
IN2:75% MN + 25% ON			
IN3:50% MN + 50% ON			
IN4:25% MN + 75% ON			
IN5:0% MN + 100% ON			

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Table (4): Net irrigation water requirements for wheat after deduction of the effective volume of rainfall during the crop growth period (m^3/fed) throughout 2018/2019 and 2019/2020 seasons.

Deficit Irrigation	2018/2019	2019/2020
DI 1: 100% Full Irrigation	1400	1350
DI 2: 80% Full Irrigation	1120	1080
DI 3: 60% Full Irrigation	840	810

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation)

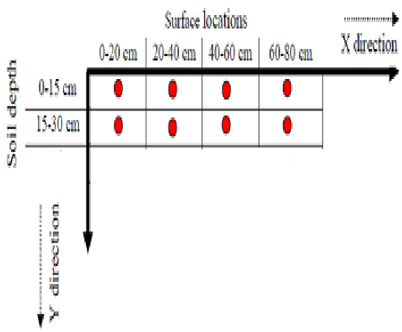
Water application efficiency: Application efficiency of irrigation water (AE_{IW}) is the actual storage of water in the root zone to the water applied to the field. AE_{IW} was calculated using equation 2:

$$AE_{IW} = Ds / Da \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where AE_{IW} is the application efficiency of irrigation water, %, Da is the depth of applied water (mm), Ds is the depth of stored water in the root zone, cm by equation 3

$$Ds = (\theta 1 - \theta 2) * d * \rho \ldots\ldots\ldots\ldots (3)$$

Where:, d is the soil layer depth (mm), θ1 is the average of soil moisture content after irrigation (g/g) in the root zone, θ2 is the average of soil moisture content before irrigation (g/g) in the root zone as shown in figure (3), ρ = bulk density of soil (g/cm^3).



Locations of soil moisture content before and after irrigation   Profile probe

Figure (1): Locations of soil moisture content before and after irrigation and using profile probe for measuring

Organic matter content and Electrical conductivity, EC: The organic matter content and salt concentration were measured before planting, during plant growth stages and after harvesting wheat during the two growing seasons. The average organic matter content was the sum of the values of the estimates over the number of times the estimation, and also that was done for the average salt concentration in the soil.

Grain yield: At the harvesting time, biological yield, some of yield components and grain yield for each plot were harvested and total grain yield were determined.

Water productivity: "WP_{wheat}": The water productivity of wheat was calculated according to [18] as follows by equation 4:

$$WP_{wheat} = Ey/Ir \quad \ldots\ldots(4)$$

Where WP_{wheat} is water productivity of common bean ($kg_{wheat}\ m^{-3}_{water}$), Ey is the economical yield (kg_{wheat}/fed); Ir is the amount of applied irrigation water (m^3_{water}/fed.).

Quality traits: Total nitrogen (TN) was measured using Kjeldahl's method, and total crude protein (TCP) was determined by multiplying TN-content in grains by 6.25 according to [10]. The phenol-sulfuric acid method was used for determination of total carbohydrates (TC) [34].

Statistical analysis: The data obtained were subjected to analysis of variance (ANOVA) according to [16], using Co-Stat Software Program Version 6.303 (2004) and LSD at 0.05 level of significance was used for the comparison between means.

Results

Water application efficiency

Figure (2) indicated that, the values of water application efficiency "WAE" and the average of soil moisture content before irrigation (θ_2) were significantly increased by increasing the amount of organic fertilizers applied. The lowest values were at zero adding organic fertilizers and the highest values were at adding 100% of organic N-Fertilizers.

Figure (2) indicated that, the values of water application efficiency "WAE" were increased by decreasing the amount of irrigation water applied. The lowest values were at 100% full irrigation and the highest values were at adding 60%FI but the values of θ2 markedly decreased by decreasing the amount of irrigation water applied where, the lowest values of θ2were at 60% of full irrigation and the highest values were at adding 100% full irrigation.

Figure (2) indicated that, the interaction between deficit irrigation and integrated N-fertilization on the WAE and θ_2 where, showed insignificant effects.

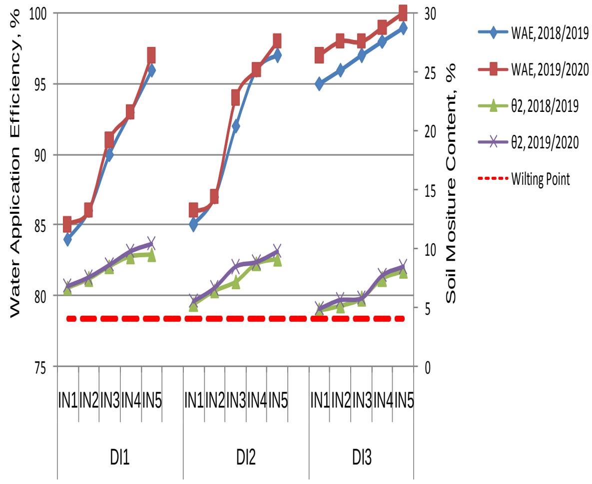


Figure (2): Effect of deficit irrigation and Integrated N- fertilization on the water application efficiency (DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen)

Soil organic matter content

Table (5) indicated that, the values of the average of soil organic matter content during growing season "ASOMC" were significantly increased by increasing the amount of organic fertilizers applied. The lowest values were at zero adding for organic fertilizers and the highest values were at adding 100% of organic N-fertilizers in both seasons.

Table (5) indicated that, the values of "ASOMC" were significantly decreased by increasing the amount of irrigation water applied. The lowest values were at 100% full irrigation and the highest values were at adding 60% of full irrigation.

Table (5) indicated that, the interaction between deficit irrigation and integrated N-fertilization on the "ASOMC" showed insignificant effects.

Electrical conductivity, EC

Table (6) indicated that, the values of the average of electrical conductivity "AEC" of soil during growing season were significantly decreased by increasing the amount of organic fertilizers applied. The lowest values were at 100% of organic N-Fertilizers and the highest values were at no adding.

Table (6) indicated that, the values of "AEC" were markedly decreased by increasing the amount of irrigation water applied. The lowest values were at 100% full irrigation and the highest values were at adding 60% of full irrigation.

Table (6) indicated that, the interaction between deficit irrigation and integrated N-fertilization on the Soil showed insignificant effect. The highest value for "AEC" was under 60% of full irrigation and no adding of organic N-Fertilizers but the lowest value for "AEC" was under 100% full irrigation and adding 100% of organic N-Fertilizers.

Table (5):Effect of deficit irrigation and Integrated N-fertilization on the average of soil organic matter content,% during growing season

Treatment	2018/2019			Mean	2019/2020			Mean
	DI 1	DI 2	DI 3		DI 1	DI 2	DI 3	
IN1:100% MN + 0% ON	0.45	0.46	0.48	**0.46**	0.44	0.45	0.46	**0.45**
IN2:75% MN + 25% ON	0.67	0.70	0.73	**0.70**	0.65	0.73	0.70	**0.69**
IN3:50% MN + 50% ON	1.19	1.23	1.30	**1.24**	1.16	1.26	1.25	**1.23**
IN4:25% MN + 75% ON	1.40	1.47	1.53	**1.47**	1.37	1.45	1.48	**1.43**
IN5:0% MN + 100% ON	1.58	1.65	1.68	**1.64**	1.54	1.62	1.62	**1.59**
Mean	**1.06**	**1.10**	**1.14**		**1.03**	**1.10**	**1.10**	
LSD 5%								
DI	0.02				0.04			
N source	0.				0.06			
DI x N source	N.S				N.S			

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Table (6): Effect of deficit irrigation and organic and Integrated N-fertilization on the average of electrical conductivity of soil (dS m^{-1}) during growing season

Treatment	2018/2019			Mean	2019/2020			Mean
	DI 1	DI 2	DI 3		DI 1	DI 2	DI 3	
IN1:100% MN + 0% ON	0.50	0.51	0.52	**0.51**	0.49	0.50	0.52	**0.50**
IN2:75% MN + 25% ON	0.48	0.45	0.50	**0.48**	0.47	0.49	0.49	**0.48**
IN3:50% MN + 50% ON	0.45	0.46	0.47	**0.46**	0.44	0.46	0.45	**0.45**
IN4:25% MN + 75% ON	0.43	0.44	0.45	**0.44**	0.43	0.44	0.45	**0.44**
IN5:0% MN + 100% ON	0.42	0.43	0.43	**0.43**	0.42	0.42	0.43	**0.42**
Mean	**0.46**	**0.47**	**0.47**		**0.45**	**0.46**	**0.47**	
LSD 5%								
DI	0.01				0.01			
N source	0.01				0.01			
DI x N source	N.S.				N.S.			

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Grain yield of wheat

Figure (3) and Table (7) indicated that, the values of the grain yield of wheat "GY_{wheat}" were significantly increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. The lowest values were at adding 100% organic N-fertilizers with zero mineral N-fertilizers and the highest values of GY_{wheat} were at adding 50% organic N-fertilizers with 50% mineral N-fertilizers. Figure (3) and Table (7) indicated that, the values of GY_{wheat} were decreased by decreasing the amount of irrigation water applied. The lowest values of GY_{wheat} were at 60% of full irrigation and the highest values were at adding 100% full irrigation.

Figure (3) and Table (7) indicated that, the interaction between deficit irrigation and integrated N- fertilization on the GY_{wheat} showed insignificant effects on wheat grain yield.

Water productivity

Figure (4) and Table (8) indicated that, the effect of deficit irrigation and integrated N-fertilization showed significant effects on the water productivity of wheat “WP_{wheat}“ where, the highest values of WP_{wheat} were occurred under 80% and 60% of full irrigation with adding 50% organic N-fertilizers with 50% mineral N-fertilizers. The lowest values of WP_{wheat} were at 100% full irrigation with 100% organic N-fertilizers and zero mineral N-fertilizers.

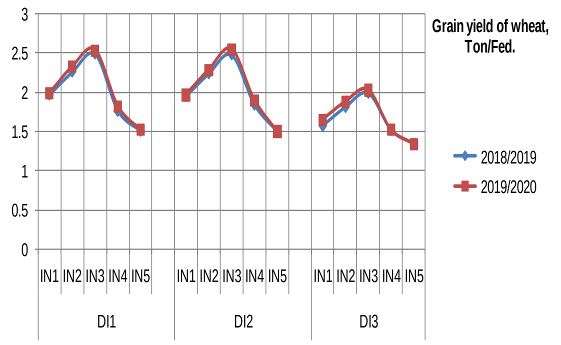


Figure (3): Effect of deficit irrigation and Integrated N- fertilization on the grain yield of wheat (DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); MN: Mineral Nitrogen; ON: Organic Nitrogen)

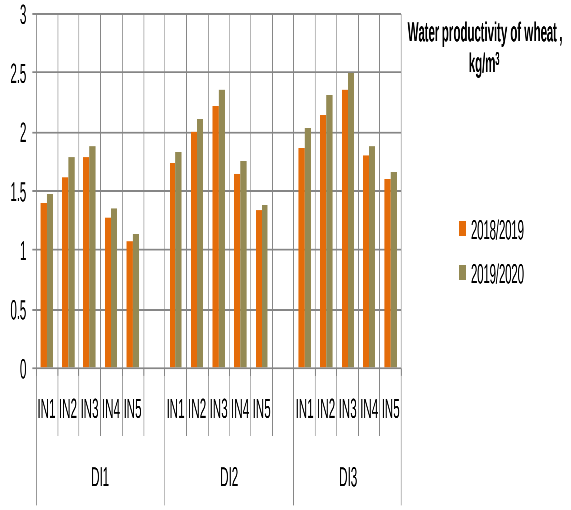


Figure (4): Effect of deficit irrigation and Integrated N- fertilization on the water productivity of wheat (DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N-fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen)

Table (7): Effect of deficit irrigation and Integrated N-fertilization on the grain yield of wheat (ton/fed.) for two seasons

Treatment	2018 – 2019			Mean	2019-2020			Mean
	DI 1	DI 2	DI 3		DI 1	DI 2	DI 3	
IN1:100% MN + 0% ON	1.97	1.95	1.57	**1.83**	1.99	1.97	1.65	**1.87**
IN2:75% MN + 25% ON	2.26	2.24	1.81	**2.10**	2.33	2.29	1.88	**2.16**
IN3:50% MN + 50% ON	2.49	2.48	1.99	**2.32**	2.54	2.55	2.03	**2.37**
IN4:25% MN + 75% ON	1.76	1.84	1.52	**1.71**	1.82	1.90	1.52	**1.75**
IN5:0% MN + 100% ON	1.51	1.50	1.34	**1.45**	1.52	1.50	1.34	**1.46**
Mean	**2.00**	**2.00**	**1.64**		**2.04**	**2.04**	**1.68**	
LSD 5%								
DI	0.057				0.07			
N source	0.12				0.12			
DI x N source	N.S				N.S			

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N-fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Table (8): Effect of deficit irrigation and Integrated N- fertilization on the water productivity of wheat (kg/m^3) for seasons 2018/2019 and 2019/2020

Treatment	2018 – 2019			Mean	2019-2020			Mean
	DI 1	DI 2	DI 3		DI 1	DI 2	DI 3	
IN1:100% MN + 0% ON	1.40	1.74	1.87	**1.67**	1.47	1.83	2.03	**1.78**
IN2:75% MN + 25% ON	1.61	2.00	2.15	**1.92**	1.78	2.12	2.32	**2.05**
IN3:50% MN + 50% ON	1.78	2.22	2.37	**2.09**	1.88	2.36	2.50	**2.25**
IN4:25% MN + 75% ON	1.28	1.65	1.80	**1.57**	1.35	1.76	1.88	**1.66**
IN5:0% MN + 100% ON	1.08	1.34	1.60	**1.34**	1.13	1.39	1.66	**1.39**
Mean	**1.41**	**1.79**	**1.96**		**1.51**	**1.89**	**2.08**	
LSD 5%								
DI	0.12				0.08			
N source	0.11				0.11			
DI x N source	N.S				N.S			

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N-fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Protein content

Table (9) indicated that, the values of the protein content of wheat “PC_{wheat}” were significantly increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. The lowest values were obtained in case of adding 100% organic N-fertilizers and the highest values of PC_{wheat} were achieved when adding 50% organic N-fertilizers with 50% mineral N-fertilizers.

Table (9) indicated that, the lowest values of PC_{wheat} were at 60% of full irrigation and the highest values were occurred at adding 80% of full irrigation and there were no significant differences between 80% and 100% full irrigation.

No significant effects for the interaction between deficit irrigation and integrated N- fertilization on the PC_{wheat} were recorded.

Carbohydrates

Table (10) indicated that, the values of carbohydrates content of wheat “CC_{wheat}” were markedly increased by increasing the amount of organic N-fertilizers applied up to 50% and then decreased with the continued increase in organic N-fertilizers addition. The lowest values were at adding 100% organic N-fertilizers and the highest values of CC_{wheat} were at adding 50% organic N-fertilizers with 50% mineral N-fertilizers.

Data presented in table (10) also indicated that, the lowest values of CC_{wheat} were at 60%of full irrigation and the highest values were occurred at adding80% or 100%of full irrigation since there was no significant differences between 80% and 100% full irrigation.

No significant effects for the interaction between deficit irrigation and integrated N- fertilization on the CC_{wheat} were noticed.

Table (9): Effect of deficit irrigation and Integrated N-fertilization on the protein content of wheat (%) for seasons 2018/2019 and 2019/2020

Treatment	2018 – 2019			Mean	2019-2020			Mean
	DI 1	DI 2	DI 3		DI 1	DI 2	DI 3	
IN1:100% MN + 0% ON	9.86	9.91	8.49	**9.42**	10.09	10.13	8.69	**9.94**
IN2:75% MN + 25% ON	10.00	10.04	8.61	**9.56**	10.22	10.24	8.85	**9.88**
IN3:50% MN + 50% ON	10.07	10.13	8.66	**9.62**	10.30	10.34	8.90	**9.84**
IN4:25% MN + 75% ON	9.17	9.28	7.89	**8.44**	9.32	9.44	8.05	**8.94**
IN5:0% MN + 100% ON	8.18	8.26	7.03	**7.82**	8.67	8.55	7.10	**8.44**
Mean	**9.46**	**9.32**	**8.14**		**9.72**	**9.74**	**8.58**	
LSD 5%								
DI	0.41				0.48			
N source	0.63				0.55			
DI x N source	N.S				N.S			

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Table (10):Effect of deficit irrigation and Integrated N-fertilization on the carbohydrates of wheat (%) for seasons 2018/2019 and 2019/2020

Treatment	2018 – 2019			Mean	2019-2020			Mean
	DI 1	DI 2	DI 3		DI 1	DI 2	DI 3	
IN1:100% MN + 0% ON	62.37	62.63	52.93	**59.31**	63.27	63.00	53.00	**51.51**
IN2:75% MN + 25% ON	65.97	66.20	56.07	**62.52**	66.33	66.33	56.47	**75.11**
IN3:50% MN + 50% ON	70.23	70.67	59.23	**66.71**	71.70	72.07	60.70	**59.74**
IN4:25% MN + 75% ON	59.27	59.80	50.33	**56.47**	60.07	60.63	50.63	**63.27**
IN5:0% MN + 100% ON	53.40	53.90	45.37	**50.89**	53.10	54.70	46.40	**68.19**
Mean	**62.11**	**62.64**	**52.79**		**62.98**	**63.49**	**53.43**	
LSD 5%								
DI	0.27							0.99
N source	1.81							1.47
DI x N source	N.S							N.S

DI: Deficit Irrigation (DI 1: 100% Full Irrigation, DI 2: 80% Full Irrigation, DI 3: 60% Full Irrigation); IN: Integrated N- fertilization, MN: Mineral Nitrogen; ON: Organic Nitrogen

Discussion

Water application efficiency, soil organic matter content, soil electrical conductivity, yield, quality and water productivity of wheat were investigated under deficit irrigation and integrated N-fertilization under sandy soils in Egypt.

Water application efficiency "WAE" were increased by increasing the amount of organic fertilizers applied. This due to that, increasing the content of organic matter in the sandy soils which resulted from improving the soil natural properties and improving the ability of the soil to retain moisture in the area of root spread, which led to an increase in the water application efficiency by the increasing nitrogenous organic fertilizers. This result agreement with [32and 14].WAE were decreased by increasing the added irrigation water and this due to losing a lot of water go out of root zone by deep percolation. We must not be deceived by the increase in the water application efficiency with the decrease in the rate of addition that must be added, as this means that the highest WAE is matched by the highest moisture stress within the area of root propagation and this is confirmed by the above results.

The average of soil organic matter content "ASOMC" were increased by increasing the amount of organic fertilizers applied. the highest values for ASOMC was under 60%FI and adding 100% of organic N-Fertilizers but the lowest value for ASOMC was under 100%FI and adding 0% of organic N-Fertilizers. This may be due to part of the organic matter was decomposed and washed and lost with the excess irrigation water outside the root spread area.

The average of electrical conductivity of soil during growing season "AEC" were decreased by increasing the amount of organic fertilizers applied. This may be due to increasing water holding capacity. This led to a decrease in the rate of evaporation from the soil surface, and thus a decrease in the concentration and accumulation of salts in the soil. AEC" were decreased by increasing the volume of applied water where, as a result, the process of leaching of salts repeated with full irrigation outside the root spread area by deep percolation.

The values of the grain yield "GY_{wheat}" and protein content "PC_{wheat}" and carbohydrates content "CC_{wheat}" were increased by increasing the amount of organic N-fertilizers applied up to 50% and it decreased with the continued increase in organic N-fertilizers addition. This is due to the presence of two types of stress in the case of interaction dynamics, with an increase in one of them, the other decreases, namely the moisture stress and the stress of nitrogen fertilization. On mineral fertilization at the expense of organic fertilization, which resulted in increased moisture stress and decreased fertilization stress, as the rate of nitrogen availability increased with mineral fertilization. Although most of the characteristics, especially crop yield, decrease with the decrease in the amount of added irrigation water, in this study there were no significant differences when irrigation with 100% or 80% of FI, so a decrease of 80% of FI may not have resulted in any effect on the moisture stress, on the contrary, most of the studied characteristics were slightly higher when irrigation by 80% FI than full irrigation. This may be due to the absence of a loss of nutrients by leaching, as happened when irrigation with 100% of FI.

In spite of the highest values of the water productivity of the wheat crop, it was at irrigation with 60% of the total irrigation, but there were high significant differences in the values of the higher productivity when irrigation with 80% of FI with adding 50% organic N-fertilizers with 50% mineral N-fertilizers.

Conclusion

It could be concluded that, the necessity of relying on organic nitrogen fertilization in addition to mineral nitrogen fertilization at 50% organic to 50% mineral in addition to the possibility of irrigation at 80% of full irrigation, i.e. saving 20% of irrigation water without any significant impact on the productivity and quality characteristics of wheat under sandy soils conditions in Egypt.

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