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Impact of Organic Manure, Bio-Fertilizer and Irrigation Intervals on Wheat Growth and Grain Yield

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Abstract: A field experiment in a split-plot design with four replications was conducted on a silty loam soil located at the experimental farm, Faculty of Agric., Al-Azhar Univ., Assuit, Egypt, during two growing winter seasons of 2011/2012 and 2012/2013 to study the effect of organic, bio-fertilizers and irrigation intervals on wheat plant growth and grain yield.The irrigation intervals (every 15, 25 and 45 days) were arranged in main plots whereas, other treatments of organic compost (Compost Tea, CT, 150 l fed.$^{-1}$ and Potassium Humate, KH, 20 l fed.$^{-1}$) and bio-fertilizer (Effective Microorganisms, EM, 10 l fed.$^{-1}$) as well as the recommended mineral NPK fertilizers were used in the sub plots. The results indicated that the irrigation interval positively affected wheat yield and its component. Irrigating wheat plants every 15 days produced the highest values of plant height, biological yield, 1000-grain weight as well as grain and straw yields (ton/fed.) and water consumptive use (WCU). However, the irrigation every 45 days gave the highest value of grain protein content. Moreover, wheat plants irrigated every 45 days increased the soil organic matter content (SOM) and the cation exchange capacity of the soil (CEC). Organic compost and bio-fertilizer positively affect wheat yield and its component. EM + CT treatment gave the highest values of biological yield, 1000-grain weight as well as grain and straw yields (ton/fed.). While, EM + KH treatment recorded the highest value of plant height. Moreover, KH treatment recorded the highest value of grain protein content. Interaction of irrigation intervals and fertilizers positively affected wheat yield and its component.

Key words: Irrigation interval · Organic compost · Bio-fertilizer · EM and Wheat yield

INTRODUCTION

Wheat (*Triticum* sp.) is considered the most strategic crop for Egypt and some other developing countries. Increasing wheat production is a national target in Egypt to fill the gap between wheat consumption and production. Great attention and efforts have been paid by the Egyptian government and scientists to narrow wheat security gap. El-Far and Teama [1] revealed that the highest seed index (54.06 g) and grain yield (4.15 ton/fed.) were achieved using an irrigation interval of 31 days while, the highest straw yield (6.11 ton/fed.) was related to an irrigation interval of 21 days. The plant height, seed index, grain and straw yield of wheat significantly increased with increasing the available soil moisture [2, 7]. Water stress affects physiological processes, growth and yield of wheat plants. Whenever, soil moisture stress increased, the wheat yield decreased [8].

Farmyard manure application with the recommended doses of N and bio-fertilizers increased the growth, yield and water use efficiency of wheat under the limited water supply [9, 10].

Sarwar [11] found that grain yield and yield components of wheat significantly increased with the application of different organic materials resulting in the compost to be the most superior one. Matter *et al*. [12] indicate that wheat yield increased with using the organic fertilization. Moreover, Youssef [10] concluded that using the EM (Effective Microorganisms) bio-fertilizer in the presence of organic and mineral nitrogen resulted in

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increases in the wheat grain yield of wheat. In addition, Yassen *et al*. [13] found that the irrigation at 60 % water holding capacity and applying mineral nitrogen 60 kg/fed., with presence of the chicken manure as an organic fertilizer produced the highest wheat yield through two growth seasons. The efficiency of EM (Effective Microorganisms) as a bio-fertilizer is attributed to its role in accelerating the mineralization processes of organic matter and helping the release of nutrients resulting in, enhancing the utility values of soil organic matter content and cation exchange capacity [14].

The present study aims to investigate the effect of irrigation intervals, organic and bio-fertilization on wheat yield, its components and crude protein content of wheatgrain as well as Silt- loam soil properties.

MATERIALS AND METHODS

The study was carried out during the successive two winter seasons of 2011/2012 and 2012/2013 at the experimental farm, Faculty of Agric., AL-Azhar Univ., Assuit, Egypt which is located at 27 12^{-} 16.67$^{=}$ N latitude and 31 09^{-} 36.86 $^{=}$ E longitude. The aim to assess the influence of the organic fertilization (Compost Tea, CT and Potassium Humate, KH), the bio-fertilization (Effective Microorganisms, EM) and the irrigation interval (every 15, 25 and 45 days) during both growing seasons on the soil properties as well as wheat plant growth and wheat grain yield. Soil physical and chemical properties of the experimental site were determined according to Page *et al.* [15] the obtained data are shown in Table (1). The climatic data were collected and recorded by automatic weather station (Table 2).

Statistical randomized split-plot experimental designs with four replications were used. The irrigation interval treatments were applied to the main plots, whereas the other treatments (organic, bio and mineral fertilizers) were allocated to the sub-plots. NPK mineral fertilizer as ammonium nitrate, calcium super phosphate and potassium sulphate were applied, as they are commonly used for growing wheat plants and recommended by Ministry of Agriculture and Land Reclamation were applied to be the control treatment. Six treatments were used in each main plot (each irrigation intervals) as follows:

- NPK = 100% NPK as a control treatment.
- CT = Compost tea (150 l/fed.) + 25% NPK
- KH = Potassium humate (20 l/fed.) + 25% NPK
- EM = EM (10 l/fed.) + 25% NPK
- EM+CT = EM + Compost tea + 2 5% NPK
- EM+KH = EM + Potassium humate + 2 5 % NPK

The area of each plot was 10.5 m^2 (1/400 fed.). All agriculture practices for growing wheat were applied as recommended.

The compost tea was prepared according to the procedure out lined by Ingham [16]. The potassium humate was extracted using standard method of Valdrighi *et al*. [17]. Chemical analyses of the used organic fertilizers are shown in Table (3). All fertilizers were applied at three equal doses. The first dose was applied with the irrigation water at the planting stage. The second and third doses were applied with 2nd and 3rd irrigation, respectively.

The amount of water consumed from the root zone between each two successive irrigations as a water depth in cm, was calculated from the following equation [18]:

$$C.U. = D \times Pb \times (Q_2 - Q_1)/100$$

where:

C.U. = Actual evapotranspiration.
D = The irrigation soil depth (cm).
*P*b = Bulk density of soil (gm/cm^3).
Q_2 = The percentage of soil moisture at field capacity.
Q_1 = The percentage of soil moisture before irrigation.

The amount of water consumed in each irrigation interval was obtained from the difference between soil content before the following irrigation and field capacity.

Wheat seeds (*Triticumaestivum vulgar.,* CV. Sids 1) by rate 15 kg/fed were sown on the 10th of December under the surface irrigation method and harvested after 158 days from planting date in the two seasons. Plant samples of one square meter from each plot were harvested and ten plants were taken randomly to determine yield attributes (plant height, grain and straw yields, biological yield and seed index). The protein content in wheat grains was determined according to A. O. A. C. [19]. Surface soil samples were collected after wheat harvest to determine the soil organic matter content and the cation exchange capacity.

The obtained data were statistically analyzed using the analysis of variance method according to Snedecor and Cochran [20]. Duncan's multiple range tests at the 5% level of probability was used to compare means of treatments.

Table 1: Physical and chemical properties of the studied soil

Particle-Size distribution								
Sand %	Silt %	Clay %	Texture grade	Saturation capacity (%)	Field capacity (%)	Wilting point (%)	Bulk density (g/cm^3)	Particle density (g/cm^3)
Season 2011/2012								
55.20	29.60	15.20	Silt loam	51.50	25.75	12.87	1.49	2.54
Season 2012/2013								
57.68	27.31	15.01	Silt loam	52.32	26.16	13.08	1.50	2.57
C.E.C (cmolc kg^{-1})	$CaCO_3$(%)	O.M (%)	ECe (dSm^{-1})	pH soil past	Total-N (%)	Ava-N (mg/kg)	Ava-P (mg/kg)	Ava-K (mg/kg)
Season 2011/2012								
13.90	1.29	1.59	1.43	7.12	0.18	62.72	11.57	169.41
Season 2012/2013								
12.84	1.33	1.63	1.38	7.23	0.20	68.98	10.47	156.85

Table 2: Climatic data during growing seasons (2011/2012 – 2012/2013)

	First season					Second season				
Months	Max-Temp	Min-Temp	Max-RH	Min-RH	W S	Max-Temp	Min-Temp	Max-RH	Min-RH	W S
December	20.2	5.7	77	39	2.6	20.1	6.5	78.2	39.7	2.7
January	17.2	3.3	77	40	2.1	27.7	4.8	75.0	39.0	4.1
February	21.5	7.4	69	32	2.8	30.9	2.4	67.0	30.6	3.2
March	23.9	9.0	68	31	3.5	39.4	4.5	66.8	30.3	3.5
April	32.1	14.4	60	26	3.0	39.8	8.3	60.2	25.0	3.8
May	34.9	19.3	65	29	2.9	47.1	15.8	65.0	28.4	4.1

Max-Temp= Maximum Temperature, Min-Temp= Minimum Temperature,
Max-RH= Maximum Relative Humidity, Min-RH= Minimum Relative Humidity, W S= Wind Speed

Table 3: Chemical analyses of organic fertilizers applied

Organic fertilizer	pH (1:2.5)	EC dSm^{-1} (1:2.5)	O.M (%)	N (mgkg^{-1})	P (mgkg^{-1})	K (mgkg^{-1})
Season 2011/2012						
K-Humate	11.92	4.49	14.82	961	48	1462
Compost tea	7.61	1.84	8.61	245	19	206
Season 2012/2013						
K-Humate	12.62	4.69	14.51	954	50	1470
Compost tea	7.73	1.89	7.83	235	18	212

RESULTS AND DISCUSSION

Evaluating the response of crop yield to irrigation intervals in combination with mineral and organic fertilizers help to identify the best allocation of available resources among crops in order to maximize the profit.

Yield Attributes and Quality

Plant Height: Data presented in Table (4) showed the effect of the irrigation interval and the fertilizer type on the wheat plant height. Wheat plants irrigated every 15 days (9 irrigations from planting date till harvesting date) showed the maximum plant height, (95.99 and 93.80 cm) while, wheat plants irrigated every 45 days (3 irrigations from planting date till harvest date) produced the lowest plant height (85.67 and 83.62 cm). The results also showed that the application of mineral and organic fertilizers significantly improved the wheat plant height. The highest and lowest value of wheat plant height in first season was obtained by EM + KH treatment (93.56 cm), while in second season by EM treatment (91.59 cm). Also, data presented that there is no significant different between EM and EM + KH treatments in second season. Moreover, the lowest values of plant height (82.78 and 80.51 cm, respectively) were recorded form the plot treated with KH fertilizers treatment.

As for interaction, the tallest plant heights (104.00 and 100.95 cm) were recorded for wheat plants treated with EM+KH and irrigated every 15 days. However, the shortest plant heights were (73.00 and 70.97 cm) for those treated with KH fertilizer and irrigated every 45 days. This was true during both seasons 2011/2012 and 2012/2013.

It is obvious that the height wheat plants increased with increasing the soil moisture level (short irrigation intervals). These results attributed to the increase in the length of internodes and/or the number of internodes per stem. This increase attributed to the fact that nitrogen encourages the elongation and cell division leading to an overall increase in the plant height. Other results are in an agreement with those reported by El-Kalla *et al*. [21], Atta Allah and Mohamed [22], Sidrak [23], Abdelaziz *et al*. [24], EL-Sayed [5], Javaid and Shah [25] and EL-Sayed [7].

Table 4: Effect of fertilizer type and irrigation interval on the plant height (cm) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	96.33ab	94.00ab	89.00ab	93.11A	94.10c	91.95d	85.89g	90.65BC
CT	94.33ab	91.33ab	86.00ab	90.55A	92.23d	88.87ef	84.42h	88.51D
KH	90.00ab	85.33ab	73.00b	82.78B	88.41ef	82.98ij	70.97k	80.79E
EM	90.33ab	92.67ab	90.00ab	91.00A	87.80f	98.85b	88.12ef	91.59A
EM+CT	101.00ab	84.33ab	91.00ab	92.11A	99.31b	81.78j	89.14e	90.08C
EM+KH	104.00a	91.67ab	85.00ab	93.56A	100.95a	88.79ef	83.16hi	90.97AB
Mean	95.99A	89.89B	85.67C		93.80A	88.87B	83.62C	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

Table 5: Effect of fertilizer type and irrigation interval on the biological yield (g/m^2) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treat.	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	2171.13ab	1804.25cdef	1610.80fg	1862.06B	2103.00b	1688.79d	1536.25efg	1776.01B
CT	1984.13bcde	1555.39fg	1211.63h	1583.72C	1900.80c	1398.58gh	1098.57i	1465.98C
KH	1984.88bcde	2129.81b	1506.73fgh	1873.81B	1899.53c	2096.75b	1475.23fgh	1823.84B
EM	1753.40def	1692.27ef	1337.56gh	1594.41C	1676.25de	1497.56fgh	1189.53i	1454.45C
EM+CT	2473.63a	2036.17bcd	1760.84cdef	2090.21A	2362.32a	1897.67c	1595.60def	1951.86A
EM+KH	2069.85bc	2025.68bcd	1500.09fgh	1865.2 B	1974.64bc	1889.57c	1378.94h	1747.72B
Mean	2072.81A	1873.91B	1487.94C		1986.09A	1744.82B	1379.02C	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

Biological Yield: Data illustrated in Table (5) showed the effect of irrigation interval and fertilizer type on the biological wheat yield during two growing seasons 2011/2012 and 2012/2013. Wheat plants irrigated at a short interval (every 15 days) gave the highest biological yield (2072.81 and 1986.09 g/m^2), while those irrigated at a long irrigation interval (every 45 days) produced the lowest (1487.94 and 1379.02 g/m^2). The results also showed that mineral, organic and bio-fertilizer applications improved the biological wheat yield. The highest value (2090.21 and 1951.86 g/m^2) of the biological yield was recorded for EM + CT treatment. While, the lowest (1583.72 and 1454.45 g/m^2) was observed with CT and EM, in first and second seasons, respectively. Also, results indicated that there is no significant between CT and EM treatments in second season.

Regarding the interaction, the maximum biological wheat yield (2473.63 and 2362.32 g/m^2) was recorded with EM+CT treatment when the plants were irrigated every 15 days. However the minimum values were (1211.63 and 1098.57 g/m^2) shown for CT treatment when the plants were irrigated every 45 days. This held true in both growing seasons 2011/2012 and 2012/2013.

These results are in an agreement with those obtained by Amin [26] Sidrak [23] Khalil *et al*. [3] and EL-Sayed [5] whom reported that the amount of irrigation water applied was closely related to the biological yield due to the increases in the plant height, number of grains/spike, single grain weight, grain yield and straw yield which were greatly affected by the soil moisture condition.

Grain Yield: Irrigating wheat plants at a short interval (15 days) resulted in a significant increase in the grain yield compared to those irrigated at a medium or at a long interval 25 or 45 days (Table 6). The highest grain yield was (3.350 and 3.14 ton/fed.) and the lowest values (1.656 and 1.50 ton/fed.) were recorded for the plants irrigated every 15 and 45 days, respectively. In addition, mineral, organic and bio-fertilizer applications increased the wheat grain yield. The highest value of the grain yield (3.150 and 2.87 ton/fed.) and the lowest (2.093 and 1.96 ton/fed.) were recorded with EM + CT and EM treatments, respectively.

Concerning interaction, the maximum wheat grain yield (4.158 and 3.79 ton/fed.) was recorded for the wheat plants treated with EM + CT and irrigated every 15 days. However the minimum value (1.424 and 1.28 ton/fed.) was found for the plants treated with EM and irrigated every 45 days. Furthermore, data obtained that there is no significant different between plants which irrigated every 45 days and treated with EM and CT fertilizer treatments in second season.

Table 6: Effect of fertilizer type and irrigation interval on grain yield (ton/fed.) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treat.	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	3.718b	3.202c	1.892fg	2.937B	3.56b	2.98d	1.68h	2.74B
CT	2.824d	2.269e	1.444hi	2.179D	2.67ef	2.17g	1.28j	2.04D
KH	3.507bc	3.544bc	1.772ghi	2.941B	3.39c	3.38c	1.59i	2.79AB
EM	2.703d	2.152ef	1.424i	2.093D	2.56ef	2.05g	1.28j	1.96D
EM+CT	4.158a	3.509bc	1.783gh	3.150A	3.79a	3.25c	1.57i	2.87A
EM+KH	3.194c	3.291c	1.624ghi	2.703C	2.87d	2.96d	1.59i	2.47C
Mean	3.350A	2.994B	1.656C		3.14A	2.80B	1.50C	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

Table 7: Effect of fertilizer type and irrigation interval on straw yield (ton/fed.) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	5.400abcd	4.376bcde	4.873bcde	4.883 BC	4.91 cd	3.95 g	4.41 f	4.42 D
CT	5.509ab	4.263cde	3.645e	4.472 D	4.95 bc	3.85 h	3.32 j	4.04 F
KH	4.829bcde	5.401abcd	4.556bcde	4.929 B	4.45 ef	5.05 b	4.39 f	4.63 C
EM	4.661bcde	4.955bcd	4.193de	4.603CD	4.38 f	4.54 e	3.69 i	4.20 E
EM+CT	6.231a	5.042abcd	5.612ab	5.628 A	5.80 a	4.47 ef	4.98 bc	5.08 A
EM+KH	5.499abc	5.217abcd	4.676bcde	5.131 B	4.95 bc	4.81 d	4.48 ef	4.75 B
Mean	5.355 A	4.876 B	4.592 C		4.91 A	4.45 B	4.21 C	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

Irrigation every 15 days supplies sufficient soil moisture in the root zone which, increases the ability of wheat plants for the photosynthesis process and increases in number of grains/spike, spike weight, grain weight/spike, spike index and 1000-grain weight which are reflecting increases in the grain and straw yields. These results were obtained in both seasons 2011/2012 - 2012/2013.

These results coincide with those reported by Mahgoub and Sayed [27], Abd El-Maksoud [28], EL-Sayed [5], EL-Sayed [7] and Youssf [10] whom reported that organic manure application increased the wheat yield by 105 to 128 % pot^{-1}, relative to the control (without manure application).

Straw Yield: The results in Table (7) indicated that wheat plants irrigated at a short interval (15 days) resulted in a significant increase in the straw yield compared to wheat plants irrigated at a medium or at a long interval (25 or 45 days). The highest straw yield (5.355 and 4.91 ton/fed.) and the lowest (4.592 and 4.21 ton/fed.) were recorded for the plants irrigated every 15 and 45 days, respectively. Moreover, the application of mineral, organic and bio-fertilizers increased the wheat straw yield. The highest straw yield (5.628 and 5.08 ton/fed.) and the lowest (4.472 and 4.04 ton/fed.) were shown for EM + CT and CT treatments, respectively.

The interaction between irrigation treatments and fertilizer treatments was significantly affected the straw yield. The maximum wheat straw yield (6.23 and 5.80 ton/fed.) was recorded with EM + CT treatment when the plants were irrigated every 15 days. On the other hand, the minimum value (3.65 and 3.32 ton/fed.) was shown for CT treatment when the plants were irrigated every 45 days. This was true in 2011/2012 and 2012/2013 seasons.

According to the obtained results, it is clear that the availability of water is considered the most important factor that affects wheat straw yield. Similar results were obtained by Abbas *et al*. [8], Sidrak [23], Khalil *et al*. [3] and EL-Sayed [5,7].

Seed Index: Data in Table (8) showed the effect of the irrigation interval and the fertilizer type on the wheat seed index (the weight of 1000 grains). Irrigation of wheat plants at a short interval (15 days) resulted in a significant increase in the seed index compared to those irrigated at a medium or at a long interval (25 or 45 days). The highest value of the seed index (53.47 and 50.77 g) and the lowest (41.87 and 39.91 g) were found for the plants irrigated every 15 and 45 days, respectively. In addition, the application of mineral, organic and bio-fertilizers increased the wheat seed index. The highest seed index (49.43 and 47.59 g) and the lowest (45.57 and 43.37 g) were recorded with EM + CT and EM treatments, respectively.

Table 8: Effect of fertilizer type and irrigation interval on seed index (g) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	55.53 a	48.04 bc	43.33 de	48.97AB	52.73 a	46.02 c	41.13 g	46.63B
CT	49.77 b	46.87 bcd	41.10 e	45.91D	46.98 b	44.83 de	39.05 hi	43.62E
KH	55.30 a	47.37 bc	41.87 e	48.18B	52.64 a	45.59 cd	39.62 h	45.95 C
EM	49.73 b	46.37 bcd	40.60 e	45.57D	47.25 b	44.21 e	38.65 i	43.37 E
EM+CT	55.60 a	49.07 bc	43.63 de	49.43A	52.89 a	47.45 b	42.43 f	47.59 A
EM+KH	54.90 a	45.57 cd	40.70 e	47.06C	52.15 a	44.52 e	38.57 i	45.08 D
Mean	53.47 A	47.21 B	41.87 C		50.77 A	45.44 B	39.91 C	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

Table 9: Effect of fertilizer type and irrigation interval on protein content (%) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	15.06ef	18.90abcd	20.60ab	18.19AB	14.89j	18.70cd	20.46b	18.02B
CT	15.55ef	17.83bcde	19.31ab	17.56B	15.37hi	17.68e	19.06c	17.37C
KH	16.02def	18.17abcde	21.16a	18.45A	15.87g	17.89e	21.00a	18.25A
EM	14.31f	15.21ef	17.81bcdef	15.78D	14.26k	15.00ij	17.63e	15.63F
EM+CT	16.10def	16.86cdef	18.75abcd	17.24C	15.98g	16.65f	18.54d	17.06D
EM+KH	15.04ef	15.60ef	18.08abcde	16.24D	14.84j	15.43h	17.85e	16.04E
Mean	15.35C	17.09B	19.28A		15.20C	16.89B	19.09A	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

Regarding the interaction, the maximum wheat seed index (55.60 and 52.89 g) was shown for the plants treated with EM + CT and irrigated every 15 days. However, the minimum value (40.60 and 38.57 g) was found for those treated with EM and EM + KH and irrigated every 45 days in first and second seasons, respectively. Also, noticed that there is no different significant between plants which irrigated every 45 days and treated with EM and EM + KH in second season. These results were obtained in two growing seasons 2011/2012 and 2012/2013.

This attributed to the positive effect of more available moisture at the grain filling stage which increases in the starch content and organic component are occurred in wheat plants. Such increases in the aforementioned characters of wheat plants are accompanied with increasing N level by adding of organic and bio-fertilizers. Nitrogen increases meristematic regions and stimulates axillary buds (crown) of wheat plants to initiate more tillers/plant [6]. Moreover, nitrogen increase amount of metabolites translocated to spikes and therefore, numbers of fertile tillers are also increased. These results go parallel with those obtained by Rayan *et al*. [29], Sidrak [23], Khalil *et al*. [3] and EL-Sayed [7].

Protein Content: The protein content in the grain was significantly affected by the irrigation interval and fertilizers application (Table 9). Wheat plants irrigated at a medium or at a long interval (25 or 45 days) resulted in a significant increase in the protein content compared to this irrigated at a short interval (15 days). The highest protein content value (19.28 and 19.09%) and the lowest (15.35 and 15.20%) were recorded with the plants irrigated every 45 and 15 days, respectively. In addition, applications of mineral, organic and bio-fertilizers increased the wheat protein content. The highest protein content value (18.45 and 18.25%) and the lowest (15.78 and 15.63%) were found for KH and EM treatments, respectively.

Concerning the effect of interaction between irrigation treatments and fertilizer treatments, the maximum wheat protein content (21.16 and 21.00%) was shown for KH treatment when the plants were it irrigated every 45 days. On the other hand, the minimum value (14.31 and 14.26%) was found for EM treatment when the plants were irrigated every 15 days. These results were true through both seasons 2011/2012 and 2012/2013.

The protein content increases at a long irrigation interval. This increase in wheat grain protein content is mainly attributed to increasing N in the grains with decreasing the grain yield for the plants that exposes to long intervals irrigation (every 45 days). These results due to the increase in the other major nutrients, brought about by the good supply and positive effect of nitrogen uptake of wheat which encourages greater uptake of other

Table 10: Effect of fertilizer type and irrigation interval on water consumptive use (m^3/fed.) of wheat during 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	2315 a	2225 b	2085 c	2208 A	2335ab	2245 c	2115 d	2231 A
CT	2320 a	2195 b	2076 c	2197 A	2342 a	2220 c	2098 d	2220 A
KH	2298 a	2208 b	2082 c	2196 A	2316ab	2230 c	2114 d	2220 A
EM	2290 a	2216 b	2077 c	2195 A	2320ab	2233 c	2090 d	2214 A
EM+CT	2305 a	2199 b	2080 c	2195 A	2325ab	2219 c	2085 d	2209 A
EM+KH	2288 a	2218 b	2090 c	2199 A	2306 b	2236 c	2104 d	2215 A
Mean	2303 A	2210 B	2081 C		2324 A	2230 B	2101 C	

Table 11: Effect of fertilizer type and irrigation interval on soil organic matter (%) of wheat during 2011/2012 and 2012/2013 seasons

	First season 2011/12				Second season 2012/13			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	1.66k	1.83ijk	1.96hij	1.82F	1.67m	1.84l	1.97k	1.83F
CT	2.44bc	2.47bc	2.49b	2.47A	2.46c	2.49bc	2.50bc	2.48A
KH	1.99ghij	2.18defgh	2.32bcdef	2.16D	1.99jk	2.19g	2.35e	2.18D
EM	2.01ghij	1.81jk	2.38bcde	2.07E	2.03ij	1.83l	2.41d	2.09E
EM+CT	2.08fghi	2.77a	2.23cdefg	2.36B	2.10h	2.78a	2.26f	2.38B
EM+KH	2.05ghij	2.15efgh	2.52ab	2.24C	2.07hi	2.17g	2.53b	2.26C
Mean	2.04C	2.2B	2.32A		2.05C	2.22B	2.34A	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45}).

available macro nutrients. These results are in a harmony with those reported by Sidrak [23] Yassen *et al*. [13], Youssef [10] and EL-Sayed [7].

Water Consumptive Use (WCU): Data illustrated in Table (10) showed the effect of irrigation interval and fertilizer type on the water consumptive use (m^3/fed.) for wheat yield. Wheat plants irrigated at a short interval (every 15 days) gave the highest water consumptive use (2303 and 2324 m^3/fed), while those irrigated at a long irrigation interval (every 45 days) produced the lowest (2081 and 2101 m^3/fed). Results showed also that mineral, organic and bio-fertilizer applications had not any significant influences on (WCU) all over two growing seasons.

Regarding the interaction, the maximum water consumptive use (2320 and 2342 m^3/fed) was recorded with CT treatment when the plants were irrigated every 15 days. However the minimum value (2076 and 2085 m^3/fed) was obtained with CT and EM+CT treatments in first and second seasons, respectively when plants were irrigated every 45 days. This held true in both growing seasons 2011/2012 and 2012/2013. Similar results were obtained by EL-Sayed [5, 7], who reported that water consumptive use (WCU) increased as the available soil moisture were increased in the root zone of the plants. While, subjecting wheat plants to soil water deficit caused a decrease in (WCU).

Soil Chemical Properties

Soil Organic Matter (SOM): The effect of irrigation interval and fertilizer application on soil organic matter (SOM) is shown in Table (11). Irrigating of wheat plants at a long interval (every 45 days) led to a significant increase and gave the highest value of (SOM) (2.32 and 2.34%). Furthermore, soil organic matter decreased with the short irrigation interval (every 15 days) (2.04 and 2.05%). In addition, applications of mineral, organic and bio-fertilizers increased the soil organic matter. The highest value of (SOM) (2.47 and 2.48%) and the lowest (1.82 and 1.83%) were recorded in the soil plots received CT and NPK fertilizers, respectively.

The interaction between irrigation treatments and fertilizer treatments was significant during both growing seasons. The maximum soil organic matter (2.77 and 2.78%) was recorded in the soil plots that were received treatment EM + CT fertilizer and when it irrigated every 25 days. However, the minimum value (1.66 and 1.67%) was shown the soil plots that were received NPK fertilizer and irrigated every 15 days. These results were true during the two growing seasons.

Cation Exchange Capacity (CEC): The obtained results in two growing seasons showed that soil cation exchange capacity significantly affected by the irrigation interval and the application of mineral, organic and bio-fertilizers (Table 12). Irrigating soil plots at a short interval (15 days)

Table 12: Effect of fertilizer type and irrigation interval on cation exchange capacity ($cmol_c\ kg^{-1}$) of soil in growing 2011/2012 and 2012/2013 seasons

	First season				Second season			
Treatments	I_{15}	I_{25}	I_{45}	Mean	I_{15}	I_{25}	I_{45}	Mean
NPK	16.82h	18.63cd	18.74bcd	18.06E	17.00l	18.69gh	18.82fg	18.17E
CT	17.44gh	18.59cde	18.77bcd	18.27D	17.48k	18.62hi	18.87f	18.32 D
KH	17.78fg	18.93abcd	18.91abcd	18.54C	17.95jk	18.96ef	19.10e	18.67C
EM	18.57cde	19.39ab	19.56a	19.17A	18.67h	19.42bcd	19.67a	19.25A
EM+CT	18.42def	19.25abc	19.20abc	18.96B	18.48i	19.31d	19.39cd	19.06 B
EM+KH	17.87efg	19.46ab	19.42ab	18.92B	17.97j	19.54ab	19.49bc	19.00B
Mean	17.82B	19.04A	19.10A		17.93C	19.09B	19.22A	

Irrigation interval are every 15 (I_{15}), 25 (I_{25}) and 45 days (I_{45})

resulted in a significant decrease in soil cation exchange capacity compared to those irrigated at a medium or at a long interval (25 or 45 days). The highest (CEC) value (19.10 and 19.22 $cmol_c\ kg^{-1}$) and the lowest (17.82 and 17.93 $cmol_c\ kg^{-1}$) were recorded for the soil plot, irrigated every 45 and 15 days, respectively. In addition, the application of mineral, organic and bio-fertilizers increased the soil cation exchange capacity. The highest (CEC) value (19.17 and 19.25$cmol_c\ kg^{-1}$) and the lowest (18.09 and 18.17$cmol_c\ kg^{-1}$) shown for the soil plots receiving EM and NPK fertilizers, respectively.

As for the effect of interaction, the maximum value of soil cation exchange capacity (19.56 and 19.67$cmol_c\ kg^{-1}$) was recorded the plots receiving EM and were irrigated every 45 days. However, the minimum value (16.84 and 17.00 $cmol_c\ kg^{-1}$) was shown in the plots that received NPK and were irrigated every 15 days. These results held true in 2011/2012 and 2012/2013 seasons. Therefore, adding bio-fertilizers and organic fertilizers increase the colloidal particles, which result in an increase in the surface area and so an increase the cationic exchange capacity of the soil [30].

CONCLUSIONS

Results from this study indicate that irrigating wheat plants every 15 days produced the highest values of plant height, biological yield, 1000-grain weight as well as grain and straw yields (ton/fed.) and water consumptive use (WCU). Moreover, the irrigation every 45 days gave the highest value of grain protein content, soil organic matter content (SOM) and cation exchange capacity (CEC) of the soil. Also, EM + CT treatment recorded the highest values of biological yield, 1000-grain weight as well as grain and straw yields (ton/fed.). However, EM + KH treatment obtained the highest value of plant height, when, KH treatment recorded the highest value of grain protein content. While, the greatest value of (SOM) was obtained with CT treatment and (CEC) with EM treatment. Although, the lowest value of (SOM) and (CEC) was observation with NPK treatment. As for the interaction between irrigation interval treatments and fertilizer applications were significantly affected wheat yield and its component.

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