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Conjunction use of irrigation water and rainfall with its impact on barley-water productivity in North of Nile Delta.

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Abstract

A field experiment was carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate. The site is located at Middle North of Nile Delta area with 30°-57' N latitude, 31°-07'E longitude and altitude of about 6 metres above mean sea level. The experiment was conducted during the two successive winter growing seasons 2015/2016 and 2016/2017 to study the conjunction use of irrigation with rainfall on water productivity (WP) of barley. Irrigation treatments were; treatment A (rainfall) e.g. given only the sowing irrigation and left to rainfall during the growing season (control), treatment B (given one irrigation following the sowing irrigation), treatment C (given two irrigations after the sowing irrigation) and treatment D (given three irrigations following the sowing irrigation (traditional irrigation). The studied crop was barley cv. Giza 126 in a completely randomized block design with three replications. The highest average values of water applied and consumptive use were 45.7 cm (1914 m^3/fed) and 37.0 cm (1554 m^3/fed) under treatment D in the two growing seasons, respectively. The c ontribution percentages of rainfall to water applied (Wa) were 25.9% and 47.5 % for treatments D and A, respectively. Given only sowing irrigation (rainfall treatment, A) produced about 72% from that received 3 irrigations following the sowing one (Trt.D). The highest mean values of water productively (WP) and productivity of applied water (PWa) were recorded under treatment A in the two seasons and the values were 1.24 and 0.97 kg m^{-3}, respectively. For barley crop; grain yield, plant height, 1000-grain weight and the other yield components were the highest under irrigation treatment D.

Key words: barley crop, conjunction use of irrigation and rainfall, water applied, water productivity and productivity of water applied.

Introduction

Agricultural production in irrigated areas is becoming more water-constrained. For example, domestic and municipal water use is increasing with urban expansion and drought periodically reduces surface water supplies. At the same time, increased costs of irrigation (water, energy, and labor) and other production inputs have reduced the economic return for a grain crop. As a result, it is now more necessary than ever to achieve the best grain yield and quality per unit of water applied.

Irrigation is very important to agriculture in semi-arid regions. By providing water in times of deficit rainfall, irrigation improves the consistency of crop growth. Irrigation also allows the production of crops with water demands that exceed normal rain amounts. However, many challenges are facing farmers who irrigate. Increasing demands for water coupled with dwindling supplies are resulting in restrictions to water access. Increasing crop production costs and lower commodity prices are threatening economic sustainability. Improving irrigation management is critical. If irrigation amounts could be reduced without adversely affecting crop yield and quality, these challenges will be lessened. Water saved from reducing irrigation on land already being irrigated will allow additional land to be irrigated.

Water shortage which facing Egypt becomes a serious problem at the national level. This situation is due to the fact that the Egyptian agricultural production is mainly depending upon irrigation. Annual water share per person for different purposes is less than the water poverty edge of 1000m^3, and it continuously decreasing till reach the scarcity level of less than 500m^3 in the few coming decades. At this prospected water situation it will be difficult to make any progress in any national development sector.

Egypt is located in the semi-arid region with its aridity conditions of low rainfall, except in some areas which received a moderate amount of rainfall such as North Nile Delta, west northern coastal zone as well some parts of Sainai Peninsula. Therefore, in such areas rainfall contribute with a reasonable portion in crops water needs, particularly winter crops such as barley.

On the other hand, barely is one of winter high cash crops in Egypt because it is a favorable animal feeding stuff as well it is the principal raw material for some industrial productions.

Moreover, rainfall in the studied area of North Nile Delta is fairly high comparing with other areas in Egypt. Hence, rainfall could be considered as a principal portion of applied water. In other words, conjunction use of rainfall with irrigation water (supplemental irrigation) in this area is an important way towards effective on-farm irrigation management for winter crops such as barley.

Barley crop- water functions have been studied by several researchers. **Graham Harris (2012)** had pointed out that seasonal water requirement of barley varies from 320 to 470 mm. A full irrigation strategy or limited water irrigation strategy can be used. He also mentioned that the period leading up to and including flowering (which takes place at booting in barley) is the most sensitive to water stress.

As recommended by **Alberta Agriculture and Forestry (2011),** applying irrigation just before the available soil water to depleted to 60 per cent and replenishing available soil water near field capacity in the appropriate root zones will greatly assist in producing a high-quality and high-yielding barley crop.

Belal and Moushumi (2014) stated that irrigation applied twice at tillering and booting stages, showed better performance on growth and grain yield of barley.

Carter and Stoker (1985) reported that barley sown in October and November and irrigated at a high level, out yielded wheat in all seasons. At these 2 sowing dates a maximum of 4 irrigations was required for the increased yield.

Alderfasi (2009) found that low soil moisture content caused an irreversible loss in yield potential.

Consequently, by implementing the conjunction use of irrigation and rainfall technique, pronounced amount of irrigation water could be saved to be used in the horizontal expansion of agricultural sector and/or irrigating other growing crops.

Therefore, the present investigation aimed to maximizing the impact of conjunction use of rainfall with irrigation water on barely-water productivity in North Nile Delta area.

Specific goals were:

- Identifying barley crop-rainfall productivity,
- Maximizing barley water productivity from irrigation and rainfall, (supplementary irrigation).
- Determining water saving and
- Finding out barley yield and its components.

Materials and Methods

A field trial was carried out during the two successive barley growing seasons 2015/2016 and 2016/2017 at Sakha Agricultural Research Station. The site is located at the Middle North of Nile Delta area with 30°-57 / latitude, 31°-07E longitude with altitude of about 6 metres above mean sea level. Table (1) represents the climatic elements of the field trial site during the two barley growing seasons. The soil of the site is clayey in texture as shown in Table 2.

Table 1. Climatic elements of; air temperature (T, C°), mean relative humidity (RH, %), wind speed (U_2, $m.sec^{-1}$) evaporation pan (Ep, $mm.d^{-1}$) and rainfall (Rf, mm).

a. 1st season, 2015/2016

Month	**T,C°**			**RH, %**	**U_2, $m.sec^{-1}$**	**Ep, $mm.d^{-1}$**	**Rf, mm**
	Max	Min	Mean				
Nov.2015	24.75	14.42	19.59	75.62	0.85	2.44	52.4
Dec."	20.36	8.33	14.34	78.27	0.67	2.15	25.0
Jan.2016	18.40	6.30	12.30	74.10	0.80	2.38	42.7
Feb."	22.50	6.70	14.60	70.00	0.67	2.51	-
Mar."	23.67	11.61	17.64	69.76	0.74	3.58	13.20
Apr."	30.03	19.22	24.63	61.72	1.01	5.96	-
Seasonal average	23.29	11.10	17.19	71.58	0.79	3.17	133.3

b. 2nd season, 2016/2017

Month	**T,C°**			**RH, %**	**U_2, $m.sec^{-1}$**	**Ep, $mm.d^{-1}$**	**Rf, mm**
	Max	Min	Mean				
Nov.2016	24.93	17.93	21.43	67.42	0.88	2.02	22.00
Dec."	19.66	10.72	15.19	75.37	0.72	1.47	25.84
Jan.2017	18.17	5.71	11.94	75.11	0.60	1.36	19.60
Feb."	19.61	9.79	14.70	72.96	0.73	1.96	25.20
Mar."	22.45	17.99	20.22	72.61	0.97	2.97	-
Apr."	26.51	21.59	24.05	65.10	1.03	4.54	10.60
Seasonal average	21.89	13.96	17.92	71.43	0.82	2.39	103.24

Physical and chemical characteristics of the studied site:-

Soil samples from successive depths (0-15 cm), (15-30 cm), (30- 45 cm) and (45-60cm) were taken from the studied site. The physical properties of the studied experimental site such as soil field capacity (F.C) and permanent wilting point were determined at the site according to **James(1988)** and soil bulk density was determined according to **Klute(1986).**The soil texture, the particle size distribution was determined according to the International method **(Klute, 1986).** The obtained results indicated that the soil texture is clayey as shown in Table 2. Chemical properties such as total soluble salts (soil EC, dS/ m), soil reaction (pH), both soluble cations and anions were determined according to the methods described by **(Jackson, 1973).** So_4^{--} was calculated by the difference between soluble cations (meq/ L) and anions (meq/ L) as tabulated in Table 3.

Table 2. Particle Size Distribution and some soil water constants for the experimental site:

Soil Depth, cm.	Particle Size Distribution			Texture Class	F.C %	P.W.P %	AW (%)	Bd, kg/m³
	Sand%	Silt %	Clay %					
0 – 15	18.7	39.7	41.6	Clayey	44.61	24.24	20.37	1.05
15 – 30	20.5	39.5	40.0	Clayey	40.20	21.85	18.35	1.11
30 – 45	19.2	39.5	41.3	Clayey	38.70	21.03	17.67	1.16
45 – 60	17.7	39.0	43.3	Clayey	36.30	19.73	16.57	1.20
Mean	19.0	39.4	41.6	Clayey	39.95	21.71	18.24	1.13

Where: F.C, % = Soil field capacity, P.W.P, % = Permanent wilting point (% on weight base) , AW % = Available water and Bd, kg/m³ = Soil bulk density.

Table 3. Some chemical properties of the studied experimental site:

Soil Depth, Cm	Ec, ds/m	PH (1: 2.5) soil water suspension	Soluble ions, meq/l							
			Cations				Anions			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0-15	1.83	8.11	7.31	2.18	8.70	0.22	0.00	4.30	9.00	5.11
15-30	2.45	8.19	9.54	5.10	9.60	0.19	0.00	3.90	8.90	11.63
30-45	2.56	8.15	9.67	5.47	10.02	0.18	0.00	3.70	7.80	13.84
45-60	3.01	7.92	11.50	6.28	12.00	0.17	0.00	3.60	7.00	19.35
Mean	2.46		9.51	4.76	10.08	0.19	0.00	3.88	8.18	12.48

Cultural practices.

All cultural practices (tillage, fertilization, planting population, chemical, and fungicide applications) were the same based on the technical recommendations of Agricultural Research Center (ARC). The cultivated barley (Hordeum vulgare L.) Variety was Giza 126. Sowing date (S) and harvesting date (H) in the two growing seasons were:
First season: (S) 20/11/2015 and (H) 10/4/2016
Second season: (S) 18/11/2016 and (H) 5/4/2017

Irrigation treatments:

Treatment A: rainfall treatment i.e. given only the sowing irrigation and left to rainfall during the growing season (control),
Treatment B: given one irrigation after the sowing irrigation,
Treatment C: given two irrigations following the sowing irrigation and
Treatment D: given three irrigations after the sowing irrigation.

Data collection:

A. Water parameters:

- **Irrigation water (IW)**

Irrigation water was controlled and measured by contracted rectangular weir (**Michael, 1978**):

$$Q = 0.0184(L-0.2H)\ H^{1.5}$$

In which
Q = discharge, litre/second,
L = length of crest, cm and
H = head over the weir, cm.

- **Effective rainfall (Rf_e)**

Effective rainfall (Rf_e) was computed as incident rainfall multiplied by 0.7 (**Novica, 1979**).
This fact is explained by **Allen (1991)** who pointed out that not all rainfall is effective in fulfilling irrigation water requirements. Reasons include:

1. Surface runoff due to high rainfall intensity..
2. Deep percolation from heavy rainfall occurring immediately following an irrigation or previous rainfall event.
3. Evaporation of intercepted rain on plant leaves.

- **Water applied (Wa)**
  Water applied was equaled irrigation water (IW) plus total rainfall (∑ Rf).
- **Consumptive use (CU)**
  Actual consumptive use (CU) or which so-called crop evapotranspiration (ET_c) was determined based on soil moisture depletion in the effective

root zone of 60 cm as follows **(Hansen et al., 1979)**:

Where:

$$Cu = \frac{FC - \Theta}{100} * \frac{Db}{Dw} * d$$

CU = consumptive use or actual crop water consumed, cm.
FC = soil moisture content on weight basis at field capacity
Ѳ = soil moisture content on weight basis before irrigation
Db = bulk density (kg.m^{-3})
Dw = density of water (kg.m^{-3})
d = effective root zone of 60 cm.

It should be notified that soil moisture depletion included the effective rainfall Rf_e as descript before.

Crop-water functions

1. Water productivity (WP):

Water productivity as defined by **Bos (1980)** is the parameter of crop-water functions which reflects the capability of crop water consumed in producing marketable yield as follows:

WP = Y/CU

Where:

WP = water productivity (kg.m^{-3} water consumed),
Y = yield (kg) and
CU = crop-water consumption (or water consumptive use) (m^3).

2. Productivity of applied water (PWa, kg m^{-3}):

Productivity of applied water (PWa) was calculated according to **Ali et al. (2007).**

PWa = Y/ Wa

Where:

PWa = productivity of applied water (kg /m^3),
Y = yield (kg fed^{-1}) and
Wa = water applied (m^3. fed^{-1}).

B. Vegetative, yield and yield components:

1. Plant height at harvest.
2. Number of plants /m^2
3. Spike length
4. Number of spikes/ m^2
5. 1000 grain weight.
6. Biological yield.
7. Grain yield.
8. Straw yield.

Results and discussions:

A – Water parameters

1 – Effective rainfall (Rf_e)

Values of rainfall for the two studied seasons as tabulated in Table (4) cleared out that rainfall are from November through April. In other words, rainfall is distributed during the barley growing season. Therefore, rainfall is considered as a principal component of water applied to barley crop in the studied area of North Nile Delta. Mean values of monthly rainfall for the two seasons as illustrated in table (1) can be arranged in descending order as 37.20> 31.25>25.42>12.60>6.60>5.30 mm for November, January, December, February, March and April, respectively. Mean seasonal rainfall is 118.27 mm or 496.70 m^3/ fed (1fed=0.42ha) which is partially offset water needs of some winter crops such as barley.

2 - Applied water (Wa, m^3 fed^{-1} & mm)

Values of seasonal applied water (Wa) which consists of the two items of irrigation water (IW) and rainfall (Rf) are presented in Table (4) and illustrated in Fig (1) cleared out that the highest Wa was assigned with Treatment D with 3 irrigations excluding the sowing watering. Meaningfully, the high number of irrigations, the high amount of applied water. In this direction, mean values of Wa can be arranged in descending order as; 456.5>382.6>311.1>249.2 mm for treatments D, C, B and A, respectively. The mean contribution percentages of rainfall in applied water (Wa) were 47.5, 38.0, 30.9 and 25.9 % for treatments A, B, C, and D, respectively. This finding is useful in connection with two principal remarks of partially fulfill crop water needs and consequently decreasing the amount of irrigation water should be applied, particularly under the water shortage status facing Egypt.

Regarding water saving, by comparing traditional irrigation (treatment D) with other treatments, average percentages of water saving in the two growing seasons were 45.4, 31.9 and 16.2 % for treatments A, B and C, respectively.

The obtained result is in harmony with that obtained with **Alderfasi and Alghamdi (2010)** who stated that irrigation water has the same direction with number of watering events.

Also, **Graham Harris (2012), Alberta Agricultural and Foresty (2011), Belal and Moushumi (2014)** and **Carter and Stoker (1985)** came to about same results.

Table 4. Seasonal water applied (Wa); irrigation water (IW) and total rainfall (RF) as obtained by irrigation treatments for barley crop.

a- 1st season, 2015/2016

Treatment / Parameters	A (control) S + Rf	B S + 1 Irr. + Rf	C S + 2 Irr. + Rf	D (traditional) S + 3 Irr. + Rf
Wa, m³ fed⁻¹.	1109.9	1359.9	1659.9	1979.9
Wa, mm.	264.3	323.8	423	453
I.W., m³ fed⁻¹.	550.0	800.0	1100.0	1420.0
I.W., mm.	131.0	190.5	261.9	338.1
Rf, m³ fed⁻¹		559.9		
Rf, mm.		133.3		
		B - Season 2016/2017		
Wa, m³ fed⁻¹.	983.4	1253.4	1553.9	1854.4
Wa, mm.	234.2	298.4	370	477
I.W., m³ fed⁻¹.	550.0	820.0	1120.5	1421.0
I.W., mm.	131.0	195.2	266.8	338.3
Rf, m³ fed⁻¹		433.4		
Rf, mm.		103.2		
		Mean of the two seasons		
Wa, m³ fed⁻¹.	1046.7	1306.7	1607.0	1917.2
Wa, mm.	249.2	311.1	382.6	456.5
I.W., m³ fed⁻¹.	550.0	810.0	1110.3	1420.5
I.W., mm.	125	192.9	264.3	338.2
Rf, m³ fed⁻¹		496.7		
Rf, mm.		118.3		

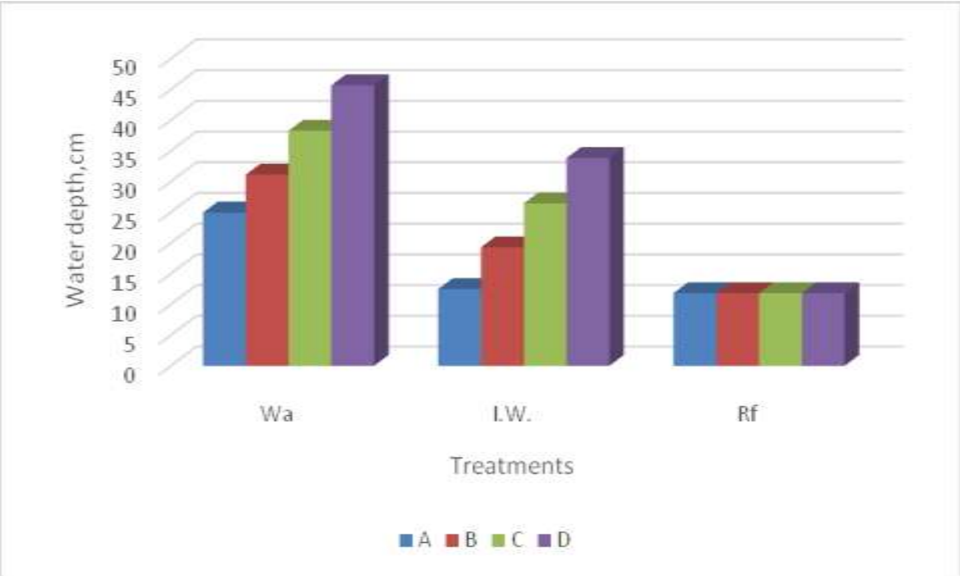

Fig. (1): Mean of the two seasons for water applied (cm); irrigation water and rainfall as obtained by irrigation treatments for barley.

3. Water consumptive use (CU):

The amount of crop water consumptive use (CU) represents the useful portion of applied water in growing the cultivated crops and ultimately in crop production. The seasonal amounts of barley CU with its average rate are shown on Table (5) and illustrated in Fig. (2). Increasing number of irrigations are resulted in increasing CU with its rate. Mean values of CU descended as 442>380>328>291mm, with average rate of CU rate of 2.8, 2.4, 2.1 and 1.8 mm.day^{-1} for treatments D, C, B and A, respectively. The obtained results are emphasized the fact that enough soil moisture content in the effective root zone which resulted from increasing irrigation numbers are reflected in high CU and its rate. This came from increasing the vegetative cover under these conditions by increasing uptake rate. So, forming strong and healthy plants with a good vegetative cover. Therefore, increasing exposed vegetative area to the sunlight and hence increasing water losses by transpiration from plant surfaces, this considers one of the main components for CU. Therefore, increasing the values of it comparing with other irrigation treatments. This finding is in the same trend with that obtained with **Alderfasi and Alghamdi (2010)**.

Table 5. Seasonal water consumptive use (CU) for barley as effected by irrigation treatments in the two growing seasons.

Season / Treatment	1st season			2nd season			Mean		
	CU		Rate average	CU		Rate average	CU		Rate average
	m^3 fed^{-1}.	mm	mm day^{-1}	m^3 fed^{-1}.	mm	mm day^{-1}	m^3 fed^{-1}.	mm	mm day^{-1}
A	859.4	204.6	1.5	606.8	144.5	1.0	815.2	194.1	1.4
B	1071.9	255.2	1.8	1000.4	238.2	1.7	1036.2	246.7	1.8
C	1326.9	315.9	2.2	1255.8	299.0	2.5	1291.5	307.5	2.2
D	1598.9	380.7	2.7	1511.3	359.8	2.2	1555.1	370.3	2.6
Mean	1214.3	289.1	2.1	1093.6	260.4	1.9	1174.5	279.6	2.0

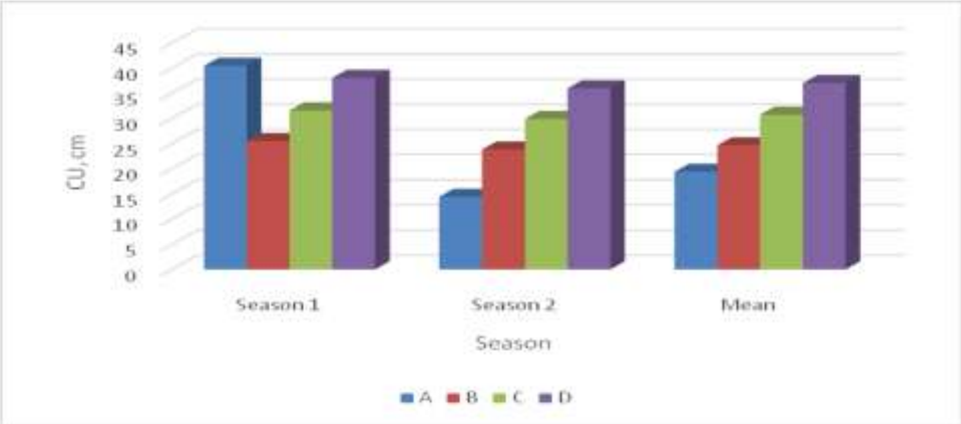

Fig. (2): Seasonal water consumptive use (cm) for barley as obtained by irrigation treatments in the two growing seasons.

4. Crop–water functions

Mean values of WP and PWa as presented in Table (6) and illustrated in Figs (3 and 4) cleared out that the mean values of WP can be arranged in descending order as; 1.24>1.09>0.91=0.91 kg grain m^{-3} consumed for treatments A ,B ,C and D, respectively. The mean values for PWa are; 0.97, 0.86, 0.74 and 0.73 kg barley grain m^{-3} applied water for treatments A, B, D and C, respectively. The obtained result is in harmony with that obtained by **Ashry et al. (2012)** who reported that water use efficiency (water productivity) increased by increasing soil moisture stress.

Table 6. Water productivity (WP) and productivity of applied water (PWa) for barley.

Season / Treatment	1st growing season		2nd growing season		Means of the two growing seasons	
	WP, kg m^{-3}	**PWa, kg m^{-3}**	**WP, kg m^{-3}**	**PWa, kg m^{-3}**	**WP, kg m^{-3}**	**PWa, kg m^{-3}**
A	1.21	0.94	1.63	1.00	1.24	0.97
B	1.09	0.86	1.09	0.87	1.09	0.86
C	0.90	0.72	0.91	0.74	0.91	0.73
D	0.94	0.76	0.88	0.71	0.91	0.74
Mean	1.15	1.04	1.04	0.99	1.10	1.02

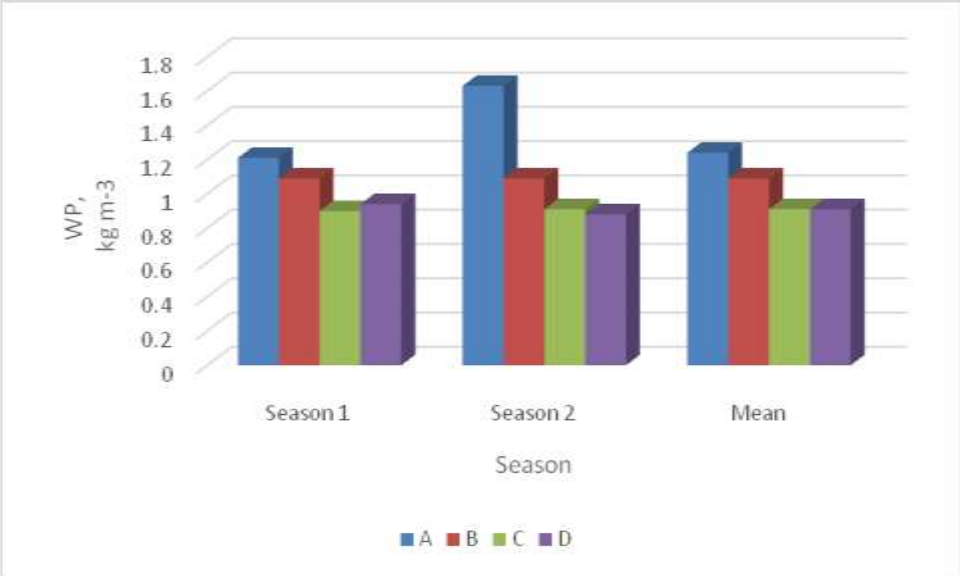

Fig. (3): Effect of irrigation treatments on water productivity (WP) for barley.

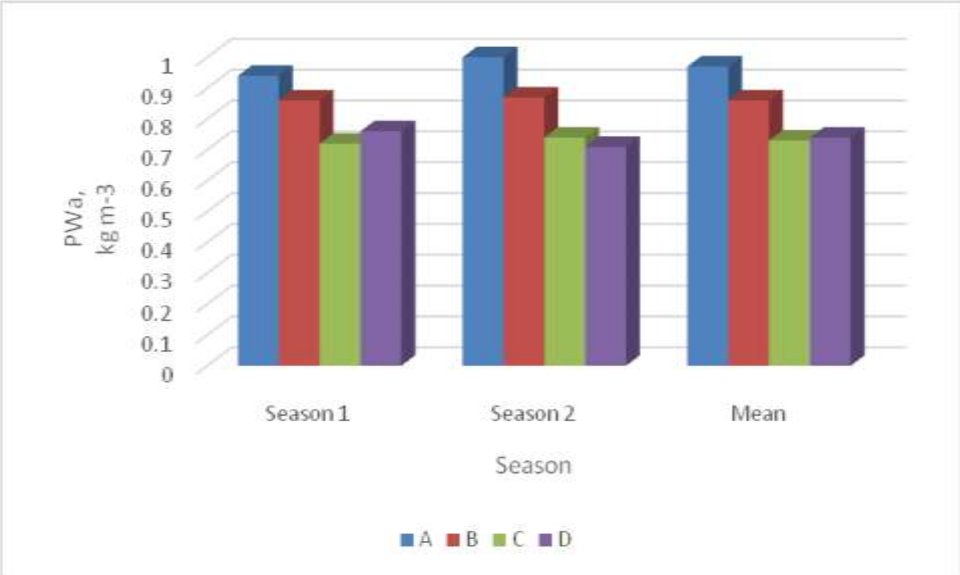

Fig. (4): Effect of irrigation treatments on productivity of water applied (PWa) for barley.

B- Effect of irrigation treatments on yield and yield components for barley crop:

Presented data in Table 7 (a) which illustrated in Fig. (5) showed that irrigation treatments has a significant and a high significant effect on grain yield in the first and second season, respectively. The highest mean value 1411.8 kg fed^{-1}(1fed.= 0.42ha) was obtained with 3 irrigations after sowing (treatment D). While, the lowest value 1012.7 kg fed^{-1} was recorded under rainfall treatment (Treatment A). Generally, increasing grain yield with increasing number of irrigations could be attributed to the sufficient available soil moisture in the root zone and hence, increasing the amount of water uptake by plants. Therefore, increasing uptake nutrients by plants this affects positively on yield. In average, deficit irrigation treatments of A, B and C were resulted in decreasing grain yield by 28.3, 19.9 and 17.1% , respectively comparing with the highest grain yield percentage of 100% obtained from treatment D. Meaningfully, by applying the sowing irrigation in addition to rainfall(Trt.A) gave nearly 72%, one irrigation plus rainfall (Trt.B) gave about 80% and applying two irrigations following the planting plus rainfall (Trt.C) gave about 83% from the maximum yield (100%) of treatment D with three irrigations after sowing. It should be notified that there is no clear difference between grain yield of treatments B and C. This finding could be attributed to rainfall that could be replenish the difference in yield of treatments B and C. Almost, the same trend was observed for biological and straw yields. These results are in the same trend with those obtained by **French (2009), Alderfasi (2009)** they found that low soil moisture content caused an irreversible loss in yield potential. .

For plant height, data in Table 7 (b) which illustrated in Fig. (6) Showed that plant height was significantly affected with number of irrigation treatments. The traditional treatment D has exceeding in plant height with 13.7, 8.2 and 2.6 % in comparison with treatments A, B and C, respectively. These results are in a good agreement with those obtained by **Abd EL Aziz (2008).**

The same Table (7b) showed that 1000-grain weight of barley as well other yield attributes increased by increasing number of irrigations. For example, the decreasing in 1000 grain weight was 13.4, 11.8 and 6.9% for treatments A, B and C comparing with the traditional irrigation (treatment D)..The obtained result is in harmony with that obtained with **Abd EL Aziz (2008)** and **Sara, El-Tobgy (2012).**

Table 7. Effect of number of irrigations on yield, harvest index and yield components for barley in the two growing seasons**.**

a- **Biological, grain and straw yield of barley**

Treatment	Biological yield Kg fed^{-1}.			Grain yield Kg fed^{-1}.			Straw yield Kg fed^{-1}.		
	1st season	2and season	Mean	1st season	2nd season	Mean	1st season	2nd season	Mean
A	4080 b	3733.4 b	3906.7	1039 b	986.3 b	1012.7	3041 a	2747.1 b	2894.1
B	4120 b	3893.3 b	4006.7	1166 b	1095.3 b	1130.7	2967.4 a	2834.1 b	2900.8
C	4186.7 b	4160 b	4173.4	1199.3 b	1142.3ab	1170.8	2987.4 a	3017.7ab	3002.6
D	4933.3 a	4960 a	4946.7	1498.6 a	1324.9 a	1411.8	3434.7 a	3635.1 a	3534.9
F-test	*	*		*	**		n.s	*	
LSD 5%	478.99	712.86		261.997			------	633.45	

b- Yield components

Treatment	Plant height cm.			1000-grain weight g.			No. spikes/ m^2		
	1st season	2nd season	Mean	1st season	2nd season	Mean	1st season	2nd season	Mean
A	96 a	87.7 c	91.9	35.5 b	34.3 a	33.7	154.7 c	181 b	167.9
B	97 a	96 b	96.5	36.5ab	31.9 b	34.3	180.7 b	192.7ab	186.7
C	99.3 a	104.3 a	101.8	38.0ab	32.1 b	36.2	188.7 b	201.0ab	194.9
D	102 a	106.7 a	104.4	39.2 a	38.6 a	38.9	234.7 a	214.7 a	224.7
F-test	n.s	***		n.s	**		***	n.s	
LSD 5%	-----	4.95		3.19	16.24		23.08	25.33	
Treatment	**Spike length cm.**			**Spikes weight/ m^2 g.**			**No. tillers/ plant**		
	1st season	**2nd season**	**Mean**	**1st season**	**2nd season**	**Mean**	**1st season**	**2nd season**	**Mean**
A	14 a	11.7 b	12.9	343.2 b	281 b	312.1	4.7 b	4.0 a	4.4
B	14.3 a	13.3 a	13.8	355.8 b	308 b	331.9	5.0 b	4.7 a	4.9
C	15 a	13.7 a	14.4	383.3 b	325.7 b	354.5	5.3ab	5.0 a	5.2
F-test	n.s	*		*	*		**	n.s	
LSD 5%	-----	1.43		79.81	68.32		1.48	-----	

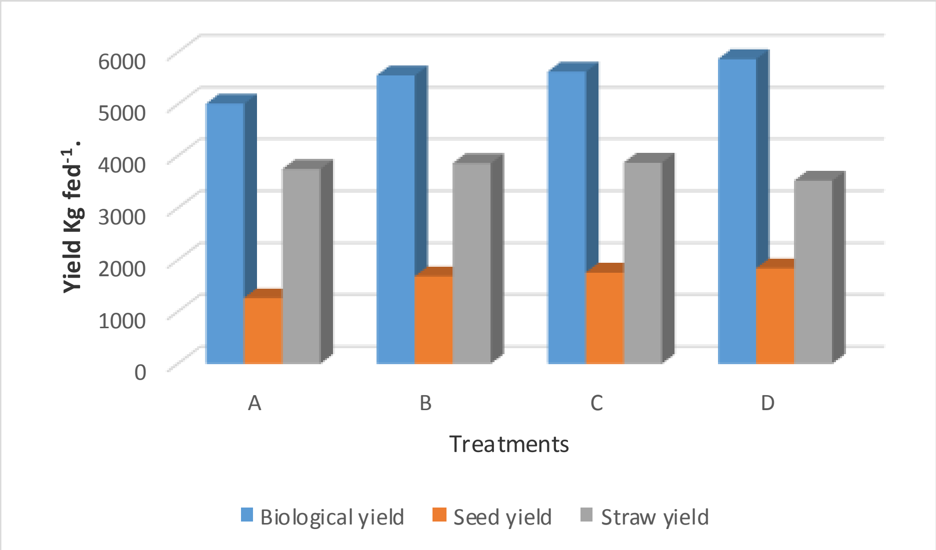

Fig (5): Mean of barley yield as affected with irrigation treatments.

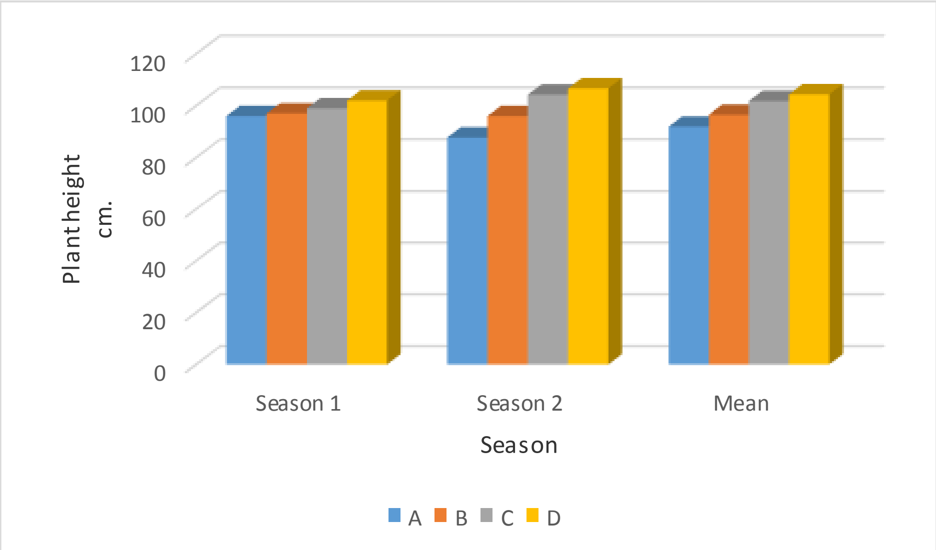

Fig. 6. Effect of irrigation treatments on plant height (cm) for barley.

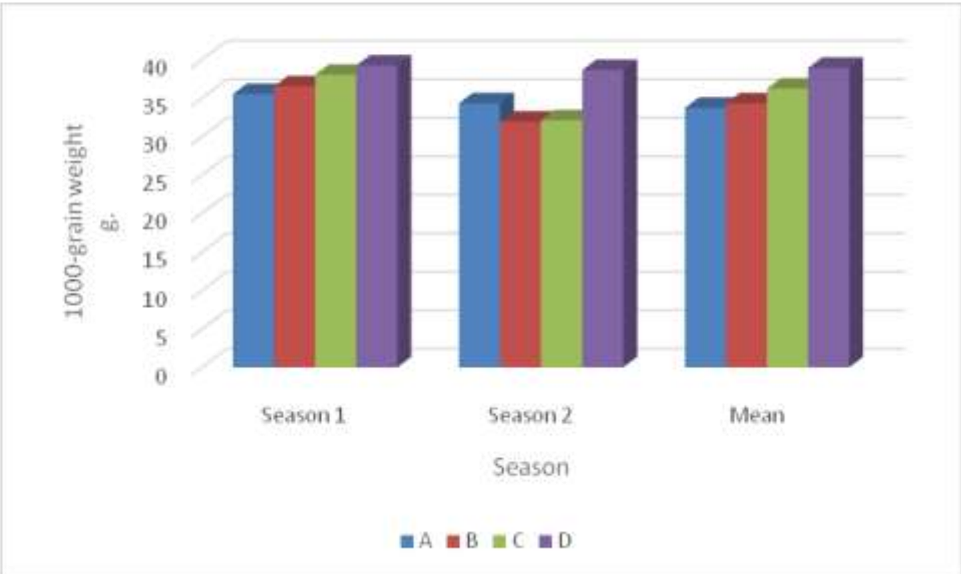

Fig. (7): Effect of irrigation treatments on 1000- grain weight (gm.) for barley.

Conclusion and recommendations

The conjunction use of rainfall with irrigation in North of Nile Delta is an effective way in rationalization of irrigating barley crop. Given only sowing irrigation (rainfall treatment) produced about 70 % from the maximum yield of the traditional watering which received three irrigations after sowing (treatment D), two advantages could be achieved comparing to the traditional treatment:

❖ Water saving of 10.6% which amounted with 206.5 m^3/fed or 496 m^3/ha.

❖ Nearly 90% from the maximum yield could be obtained.

Therefore

, in case of enough water availability, it could be irrigated with barley two or three irrigation events watering following sowing. On the other hand, under less water availability or water shortage status, rainfall treatment of sowing irrigation plus rainfall (treatment A) could be implemented. This water regime produced about 70% of the maximum yield of traditional irrigation of 3 watering (treatment D). More investigations should be carried out regarding the contribution conjunction use of rainfall and irrigation in the studied area for water needs of winter crops such as wheat and barley.

References

Abd El-Aziz, M. (2008). Effects of supplementary irrigation on growth and yield components of faba beans (A). Tishreen Univ., J. for Research and Scientific Studies-Biological Sci. Series. 30 (3): 9-22.

Alberta Agriculture and Forestry (2011). Irrigation Scheduling for Barley in Southern Alberta. www.agriculture.alberta.ca

Ali, M.H., M.R. Hoque: A.A. Hassan and A.khair 2007. Effects of deficit irrigation on yield, water productivity and economic returns of wheat. Agricultural water management, 92 (3): 151-161.

Alderfasi, A. A. 2009. Integrated use of potassium fertilizer and water schedules on growth and yield of two wheat genotypes under Arid Environ. Saudi Arabia. I) Effect on yield and yield component characters. World J. Agric. Sci., 5(2): 221-227.

Alderfasi, A. A. and S. S. Alghamdi (2010). Integrated water supply with nutrient requirements on growth, photosynthesis productivity, chemical status and seed yield of faba bean. American-Eurasian J. Agron, 3(1):08-17.

Allen, R. G. 1991. Irrigation Engineering principles. Utah State Univ.

Ashry, M. R. K., F.R. M. Farrag, S. M. M. Abdou and M. E. I. El-Akram. Rationalization of irrigation water use for faba bean (Vicia faba L.). Fayoum J. Agric. Res. &Dev., Vol. 26(1):26-37.

Belal Hossain and Moushumi Akhtar (2014). Growth and yield of barley (Hordeum vulgare L.) as affected by irrigation, sowing method and phosphorus level. Academia Journal of Agricultural Research 2 (1): 030-035, January 2014.

Bos, M.G. 1980**.** Irrigation efficiencies at crop production level. ICID. Bulletin 29, 2: 189-260 New Delhi.

Carter, K. E., and R. Stoker (1985). Effects of irrigation and sowing date on yield and quality of barley and wheat. New Zealand Journal of Experimental Agriculture, 13:1, 77-83.

French, R. J. 2009. Effect of early water deficit on growth and development of faba bean. Proceeding of Australian Agronomy Conference, Australian Society of Agronomy., 54: 463-471.

Graham Harris (2012). Irrigated barley – best Practice guide. DAFF Queensland

Hansen, V.; W. Israelsen and Q.E. Stringharm 1979**.** Irrigation principles and practices, 4th (ed.), John Willey and Sons, New York.

Jackson, M. l. 1973**.** Soil Chemical Analysis. Prentice Hall of India private, LTD New Delhi.

James, L. G. 1988**.** Principles of farm irrigation system design. John Willey and Sons Inc., New York, 543.

Klute, A.C 1986**.** Water retention: laboratory Methods. In: A. koute (ed.), Methods of Soil Analysis, part 1-2nd(ed.) Agronomy Monogr.9, ASA, Madison, W1 U.S.A, pp. 635 – 660.

Michael, A. M. 1978**.** Irrigation – Theory and practices. Vikas Publishing House, New Delhi.

Sara, M. M. El-tobgy (2012). Effective management of faba bean watering under different irrigation levels. M.Sc., Fac. Of Agric., Mansoura Univ., Egypt.

تلازم مياه الري والامطار وتأثيرهما على إنتاجية وحدة المياه لمحصول الشعير في شمال دلتا النيل

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أقيمت تجربة حقلية بمحطة البحوث الزراعية بسخا بمحافظة كفر الشيخ فى شمال وسط دلتا النيل لموسمين 2016/2015 و2017/2016 بهدف دراسة **تلازم مياه الري والامطار** على انتاجية وحدة المياه وكذا بعض العلاقات المائية لمحصول الشعير.

المعاملات هى: معاملة أ (المطرية بمعنى تعطى رية الزراعة فقط وتترك للأمطار باقى الموسم)، معاملة ب (تعطى رية الزراعة ورية المحاياه)، معاملة ج (تعطى ريتين بعد رية الزراعة) ومعاملة د (تعطى ثلاث ريات بعد رية الزراعة). والصنف المنزرع جيزة 126 والتصميم الإحصائي المستخدم قطاعات كاملة العشوائية فى ثلاث مكررات.

اهم النتائج المتحصل عليها:

- سجلت أعلى قيم لكلا من كمية المياة المضافة والاستهلاك المائى تحت الرى التقليدى (معاملة د) فى موسمى الزراعة وكانت متوسط القيم هي 457 سم و370 مم على الترتيب. (1920 م^3/فدان/موسم , 1554 م^3/فدان/موسم) علي الترتيب.
- مساهمة الأمطار في كمية المياه المضافة تراوحت بين 25.9% بالنسبة للمعاملة د (3 ريات بعد الزراعة)، 47.5% بالنسبة للمعاملة أ (المطرية).
- اعطاء ريتين بعد الزراعة (المعاملة ج) أعطت تقريباً محصول المعاملة د (3 ريات بعد الزراعة) مع توفير رية.
- أعلى متوسط لقيم انتاجية المياة (WP) وانتاجية المياة المضافة (PWa) سجلت تحت المعاملة أ فى موسمى النمو وكانت القيم 1.24 و97, كجم م$^{-3}$.
- من النتائج أيضا وجود معنوية فى معظم صفات المحصول نتيجة لتأثير معاملات الري حيث وجد أن أعلى القيم نتجت من معاملة الرى د.

وعليه: –

– توصى الدراسة بإمكانية الاستفادة من مياه الأمطار في انتاجية الشعير حيث أعطت المعاملة المطرية 72% من المحصول الأعلى للري الكامل التقليدي.

– كما توصي الدراسة بإجراء المزيد من الأبحاث بهدف تلازم الري والامطار بالنسبة للمحاصيل الشتوية في شمال دلتا النيل وأثر ذلك على العائد المحصولي لوحدة المياه.