J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 10 (7): 389 - 392, 2019

Effect of Planting Methods on some Water Relations and Yield of Wheat at North Nile Delta, Egypt

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ABSTRACT

Wheat is a strategic crop in Egypt because of its association with the bread system in Egypt. The present study was carried in Faculty of Agriculture Farm, Kafrelsheikh University in two growing winter seasons 2014/2015 and 2015/2016 to evaluate the change of planting methods of wheat crop and its effect on yield, some water relations and economic feasibility from production and water unit at North Nile Delta of Egypt. The design of experiment was complete design blocks with 3 replicates and the treatments were: T_1 = flat broadcasting (traditional sowing), T_2 = row broadcasting and T_3 = raised bed broadcasting. The main results in this study can be summarized as follows:* Change planting methods to raised bed broadcasting raise the straw and grain yields compared to traditional method (flat broadcasting) or row broadcasting. The deference between means was highly significant in straw and grain yields of wheat but non-significant in 1000 grain weight and plant height.* Water applied was reduced by change traditional planting method to row broadcasting or raised bed broadcasting and save about 14 and 20.5% of water applied, respectively.* Crop water use efficiency and irrigation water productivity were increased by changing planting method from flat broadcasting to row broadcasting or raised bed broadcasting.* The highest values of net return and economic feasibility from water unit was achieved for wheat crop by using raised bed broadcasting. *Under the status of this study, could be recommend to plant wheat broadcasting on raised bed or rows alternative flat broadcasting as well as highest yields and highest efficiencies of applied irrigation water. Irrigation water was saved by more than 20% compared with flat broadcasting.

INTRODUCTION

Wheat is of great importance in Egypt's cereal crops, which combines the efforts of those working in agriculture sciences to increase the productivity of this crop to meet the deficit. Thinking about changing the cultivation pattern of the crop in order to provide irrigation water and obtain high productivity is an urgent need due to the limited irrigation water available. Hobbs *et al*. (2000) revealed that planting wheat in bed become better water efficiency and distribution and decrease seed rate without reducing yield. Raised bed cultivation system in many parts of the world had used since long ago by farmers. The origin and use have traditionally been correlated with water management affair, either by supplying option to reduce the negative impact of extreme water on crop production in semi-arid and arid regions (Sayre 2004). Choudhury *et al*. (2007) showed that planting wheat –rice in farrow and bed methods can be saved water about 25-35% compare by the basin irrigation beside, increasing yield by 6-52%. Ahmad *et al*. (2010) mentioned that planting wheat in farrow and bed saved about 35.6% of irrigation water and excessed grain yield by 13.4% compared with planting by flat border. El-Hadidi *et al*. (2015) concluded that use of raised bed 70 cm wide and irrigation of wheat after 70% of soil moisture depletion increased yield. Majeed *et al.* (2015) pointed out that in bed planting method, increasing N up to 120 kg ha^{-1} excessed wheat yield up to 5.12 t ha^{-1}, compared with the yield at the same N fertilizer rate (4.45 t ha^{-1}) in flat planting method. Badawi and Kenapar (2017) revealed that it is suitable to irrigating wheat at 80% of available soil moisture depletion when cultivation it on raised beds. This study aims to evaluate the effect of changing wheat planting pattern on sowing grain on lines or raised bed compared to sowing in basins (flat broadcasting).

MATERIALS AND METHODS

A field experiment was conducted at the Faculty farm of Agriculture, Kafrelsheikh University, Kafr El-Sheikh Governorate through winter seasons 2014/2015, 2015/2016 on the wheat crop variety Misr-2. The site is laying at 31° -07¯ N latitude and 30° -57¯ E longitude with a high about 6 meters above sea level. Wheat was sown in 23th and 28th November and harvested in 14th and 25th May in the first and second seasons, respectively. The characteristics of soil are presented in Table (1). Some soil – water constants and particle size distribution were determined according to FAO (1970). Bulk density was determined according to Black and Hartge (1986). Some chemical soil properties were determined according to Page *et al.* (1982). The area of experiment was divided into 3 parts; each part was 10.5×40m, one of them planned as rows with space 0.6 m and the second was planned as raised bed with space 1.2m and other was left as basin without planning and left 3m space as border between parts. The experiment was block complete design at 3 replicates. Treatments were as follow: T_1 = Flat broadcasting (traditional sowing), T_2 = Row broadcasting and T_3 = Raised bed broadcasting. All treatments received the same agricultural practices.

To measuring the amount of irrigation water applied use cut-throat flume (20 x 90 cm) according to Early (1975).

Using the equation of Israelsen & Hansen (1962) to calculate water consumptive use (WCU) as follow:

$$\mathbf{WCU = (\theta_2 – \theta_1)/100 \times B.d \times D \times 4200}$$

Where:

WCU = Consumptive use (m^3/fed)
θ_2 = % Soil moisture content after irrigation.
θ_1 = %Soil moisture content before irrigation.
B.d = Bulk density ($Mg.m^{-3}$).
D = Soil layer depth (m).

Irrigation water productivity for applied water (IWP) and water productivity for water consumptive use efficiency (WUE) were calculated according to El-Bably *et al*. (2015) as follows:

$$\mathbf{IWP} = \frac{\mathbf{yield, kg/fed.}}{\mathbf{applied\ water, m3/fed.}}$$

$$\mathbf{WUE} = \frac{\mathbf{yield, kg/fed.}}{\mathbf{Water\ consumptive\ use\ (m3/fed)}}$$

Economic feasibility: Cash ins and outs for each treatment (at prices of the local market) were calculated, and some economic indices were estimated according to the equations summarize by FAO, (2000).

Analysis of variance was check out according to Gomez & Gomez (1984). Duncan's Multiple Range Test was used to comparing between means, (Duncan, 1955).

Table 1. Some properties of soil before the experiment as mean of two seasons (2014/2015and 2015/2016)

Properties	Value
pH	8.05
EC, $dS.m^{-1}$ (in extract 1:5)	1.02
Particles size distribution: %	
Sand	17.14
Silt	28.57
clay	54.29
Texture type	clay
Field Capacity, %	40.2
Wilting point, %	19.7
Available water, %	20.5
Bulk density, $Mg.m^{-3}$	1.12

RESULTS AND DISCUSSION

A. Plant height, yield and 1000 grain weight of wheat crop as affected by planting method.

Data in Table 2 present the effect of planting method on plant height, yield of wheat and 1000-grain weight.

Plant height was non-significantly affected in two seasons and varied from 95 to 99.7 cm.

Planting method was affected on grain yield with highly significant level in two growing season and take the following order: Raised bed > Row broadcasting > Flat broadcasting. The highest values of wheat grain yield (4628.0 and 3334.1kg/ha) were found under raised bed and the lowest values (2964.7 and 2621.2 kg/ha in 2014/2015 and 2015/2016 seasons, respectively) were recorded in Flat broadcasting treatments. These reductions in production of wheat crop could be due to that under Flat broadcasting or low water amounts treatment; the increasing leaching of fertilizers. On the other hand, under Raised bed treatment which irrigating with lowest water amount. This result was similar by that introducing by El-Hamdi and Knany (2000). Grain yield values were higher in first season than that in second season that, may be due to the previous crop of wheat whereas clover and rice in first and second season, respectively. There are significant references in main of grain yield where, take the following order: Raised bed > Row broadcasting = Flat broadcasting in 1st season and Raised bed > Row Broadcasting > Flat Broadcasting in 2nd season.

Straw yield take the same trend of grain yield in spite of it was non-significant in the two growing season.

1000 grain weight of wheat under studied treatments was non-significantly affected in two growing seasons and varied from 40.7 to 48.0 g. This character was more related with variety of wheat crop. Similar results are showen by El-Hadidi *et al*., (2015).

Table 2. plant height, 1000-grain weight and wheat yield as affected by planting method.

Treat.	Plant height, cm		Grain yield, Kg/ha.		Straw yield, Kg/ha.		1000-grain weight, g	
	1	2	1	2	1	2	1	2
Flat Broadcasting	99.7a	96.3a	2964.7b	2621.2c	3707.1b	3454.4a	42.4	45.3
Row Broadcasting	95.0a	95.0a	3240.5b	2912.3b	3541.8b	2445.5a	40.9	46.3
Raised bed Broadcasting	98.3a	95.6a	4628.0a	3334.1a	4471.4b	3459.2a	40.7	48.0
F-test	ns	ns	**	**	ns	ns	ns	ns

**** and ns indicate p< 0.01 and not significant, respectively. Means for each factor designed by the same letter are not significantly different at 5 % level using Duncan's MRT.**

1= first season, 2= second season.

B. Irrigation water applied, saving water and water consumptive use of wheat crop as affected by planting method.

The effect of planting method on irrigation water applied, saving water and water consumptive use of wheat crop are present in Table (3).

The amount of irrigation water applied is a determining factor in agricultural production due to shortage of water resources.

Water applied was highly significantly affected in two growing seasons. The Raised bed broadcasting treatment takes the lowest quantity of applied irrigation water to be 4466 and 4515.7 m^3/ha.in 1st and 2nd season, respectively. The flat broadcasting treatment takes the highest amount of applied water and found to be 5669.1 and 5701.4 m^3/ha in 1st and 2nd season, respectively. The applied water takes the following order: raised bed < row broadcasting < flat broadcasting.

Egypt's water strategy includes providing irrigation water at the field level. Change planting method from flat broadcasting to row broadcasting or Raised bed broadcasting saved water applied of wheat crop. The amount of water saving is 14 % for row broadcasting and 20.5 % for Raised bed broadcasting compared with flat broadcasting.

Water consumptive use was highly significantly affected under different treatments in 2014/2015and 2015/2016 seasons. The highest water consumptive use found under flat treatment to be 3118.1 and 3021.9 m^3/ha in 1st and 2nd season, respectively. Metwally (2014) revealed to similar results.

Table 3. Effect of planting method on water irrigation applied (IW_a, m^3/ha), % water saving and water consumptive use (WCU, m^3/ha) of wheat crop.

Treat.	IW_a, m^3/ha		% water saving		WCU, m^3/ha	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Flat Broadcasting	5669.1a	5701.4a	-	-	3118.1a	3021.9a
Row Broadcasting	4872.4b	4902.1b	14.1	14.0	2972.1c	2843.3c
Raised bed Broadcasting	4466.0c	4515.7c	21.2	20.8	2992.1b	2935.2b
F-test	**	**	-	-	**	**

**** indicate p< 0.01. Means for each factor designed by the same letter are not significantly different at 5 % level using Duncan's MRT.**

C. Effect of planting method on crop water use efficiency and irrigation water productivity of wheat crop.

Data in Table 4 showed the effect of planting method on crop water use efficiency and irrigation water productivity of wheat crop. Planting methods highly significantly affected water use efficiency and irrigation water productivity in the two seasons. crop water use efficiency and irrigation water productivity values of wheat crop increased with change of planting method and take the following order: raised bed > row broadcasting > flat broadcasting. The increments of irrigation water productivity and crop water use efficiency of wheat crop due to that under Raised bed treatment which takes fewer amounts of irrigation water and high wheat yield.

These results are similar with those obtained by Badawi and Kenapar (2017).

Data (Table 5) pointed out that the highest values of net return, net return from water unit and economic efficiency for biological yield were obtained with Raised bed broadcasting while; the lowest ones were recorded with Flat broadcasting. The average values of net return, net return from water unit and economic efficiency for biological yield were (10564 L.E. ha^{-1}, 2.37 and 1.64 $L.E.m^{-3}$) and (5974 $L.E.ha^{-1}$, 1.32 and 0.93 $L.E.m^{-3}$) in 1st and 2nd seasons, respectively under Raised bed broadcasting. The corresponding values were (5089 $L.E.ha^{-1}$, 0.90 and 0.80 $L.E.m^{-3}$) and and (3882 $L.E.ha^{-1}$, 0.68 and 0.61 $L.E.m^{-3}$), respectively in the second season under Flat Broadcasting.

Table 4. Effect of planting method on crop water use efficiency (CWUE) and irrigation water productivity (IWP) of wheat crop.

Treat.	CWUE		IWP	
	1	2	1	2
Flat Broadcasting	0.95c	0.87c	0.52c	0.46c
Row Broadcasting	1.09b	1.02b	0.67b	0.59b
Raised bed Broadcasting	1.55a	1.14a	1.04a	0.74a
F-test	**	**	**	**

**** indicate p< 0.01. Means for each factor designed by the same letter are not significantly different at 5 % level using Duncan's MRT. 1= first season, 2= second season.**

Table 5. Effect of planting method on net income and economic feasibility of wheat crop.

Variables		Treatments		
		Flat Broadcasting	Row Broadcasting	Raised bed Broadcasting
		1st season		
Grain yield net income ($LE.ha^{-1}$)		8894.1	9721.5	13884
Straw yield net income ($LE.\ ha^{-1}$)		2594.97	2479.26	3129.98
Total net income ($LE.ha^{-1}$)		11489.07	12200.76	17013.98
Costs according to the local market price (LEha-1)	Treatments cost	200	250	250
	Variable cost ($LEha^{-1}$)	3200	3200	3200
	Rent of land	3000	3000	3000
Total cost ($LE.\ ha^{-1}$)		6400	6450	6450
Net return ($L.E.\ ha^{-1}$)		5089.07	5750.76	10563.98
Water applied m-3ha-1		5669.1	4872.4	4466
Net return of water unit ($L.E.m^{-3}$)	Biological yield	0.90	1.18	2.37
Economic efficiency	Biological yield	0.80	0.89	1.64
		2nd season		
Grain yield revenue ($LE.ha^{-1}$)		7863.6	8736.9	10002.3
Straw yield revenue ($LE.\ ha^{-1}$)		2418.08	1711.85	2421.44
Total revenue ($LE.ha^{-1}$)		10281.68	10448.75	12423.74
Costs according to the local market price (LEha-1)	Treatments cost	200	250	250
	Variable cost ($LEha^{-1}$)	3200	3200	3200
	Rent of land	3000	3000	3000
Total cost ($LE.\ ha^{-1}$)		6400	6450	6450
Net return ($L.E.\ ha^{-1}$)		3881.68	3998.75	5973.74
Water applied m-3ha-1		5701.4	4902.1	4515.7
Net return of water unit ($L.E.m^{-3}$)	Biological yield	0.68	0.82	1.32
Economic efficiency	Biological yield	0.61	0.62	0.93

CONCLUSION

Under the status of this study, could be recommend to plant wheat broadcasting on raised bed or rows alternative flat broadcasting whereas it achieved the highest yields of grain and straw and the highest productivity of applied irrigation water. Irrigation water was saved by more than 20% compared with flat broadcasting.

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تأثير طرق الزراعة على بعض العلاقات المائية وانتاجية محصول القمح بشمال دلتا النيل، مصر

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يعتبر محصول القمح أحد أهم محاصيل الحبوب في مصر. أجريت هذه الدراسة في مزرعة كلية الزراعة بجامعة كفر الشيخ خلال موسمين شتويين 2015/2014، 2016/2015 بهدف دراسة أثر تغيير طرق زراعة محصول القمح وتأثيرذلك على الانتاجية وبعض العلاقات المائية والعائد الاقتصادي من الانتاج ووحدة المياه تحت ظروف أراضى شمال دلتا النيل، مصر. وكان تصميم التجربة فى قطاعات كاملة العشوائية مع 3 مكررات وكانت المعاملات : T_1 الزراعة فى أحواض (الطريقة التقليدية) ، T_2 الزراعة على خطوط ، T_3 الزراعة على مصاطب . يمكن تلخيص النتائج الرئيسية في هذه الدراسة على النحو التالي: أدى تغيير طريقة الزراعة إلى البدارعلى مصاطب إلى زيادة محصول القمح من الحبوب والقش مقارنة بالطريقة التقليدية (النثر فى احواض) أو النثر على خطوط. وكانت الفروق بين المتوسطات عالية المعنوية في محصول القمح من الحبوب والقش ولكنها غير معنوية بالنسبة لارتفاع النبات ووزن الـ 1000حبة. انخفضت كمية مياه الرى المضافة مع تغيير طريقة الزراعة الى النثر على خطوط أو النثر على مصاطب حيث تم توفير حوالي 14 ، 20.5 ٪ من المياه المضافة ، على الترتيب مقارنة بالنثر فى أحواض. زادت كفاءة استخدام المياه وإنتاجية مياه الري عند تغيير طرق الزراعة من النثر فى احواض إلى النثر على خطوط أو النثر على مصاطب. افضل قيم للكفاءه الاقتصاديه وكذلك صافي العائد من وحده المياه لمحصول القمح تحققت مع الزراعة بالنثر على مصاطب. تحت ظروف هذه الدراسة ، يوصى بزراعة القمح نثرا على مصاطب أو خطوط بدلا النثر فى احواض ، حيث أنها تعطى أعلى إنتاجية من الحبوب والقش وأعلى إنتاجية لمياه الري المستخدمة وتوفير مياه الري بمعدل من 14-20 ٪ مقارنة بالنثر فى احواض.