DRIP IRRIGATION MANAGEMENT FOR WHEAT UNDER CLAY SOIL CONDITIONS

R. M. El-Nady[1], H. M. Mostafa[2], M. A. Awad[2] and M. Y. El-Ansary[2]

ABSTRACT

Egypt has been suffering from severe water scarcity in recent years. Uneven water distribution, misuse of water resources and inefficient irrigation techniques are some of the major factors playing havoc with water security in the country, so maximizing water productivity is one of the most important strategies in developing countries like Egypt. Therefore, the aim of this study was to investigate the management of drip irrigation of or wheat grown under clay soil conditions to persuade farmers to use drip irrigation systems in their clay soil fields, at best management, as a tool for maximizing crop yield, increasing water productivity (Water Use Efficiency, WUE) and saving water to irrigate new areas. A field experiment was conducted to study the effect of drip irrigation lateral arrangements (double irrigation lateral lines and single lateral line per bed) and irrigation intervals (4, 8, and 12 days) on yield and water productivity of wheat crop. Results revealed that the grain yield was slightly affected by irrigation intervals under double and single line per bed. However, the highest grain yield was 3.438 ton/fed at 8 days irrigation interval with double irrigation lateral lines. Also, the grain yield obtained at 8 and 12 days intervals with single lateral line (2.914 and 2.802 ton/fed, respectively), were higher compared with 4 days under single line treatment. The highest value of water productivity (Water Use Efficiency, WUE) for grain yield was (1.835 kg/m^3) achieved for treatment of 4 days intervals with double lateral lines, meanwhile the lowest value was 1.25 kg/m^3 at 12 days intervals under single lateral line. Data also revealed that water saving for 8 days under double lines was 13.44% comparing with 12 days under single line per bed.

[1]Post-graduate student of Agric. Eng., Faculty of Agric., Benha Univ.
[2] Agric. Eng., Faculty of Agric., Benha Univ.

It can be concluded that the drip irrigation treatment of 8 days irrigation interval with double lateral lines showed an effective and recommended way for drip irrigated intensive field crops (wheat), under clay soil conditions in old land of Egypt. As well as, applying drip irrigation resulted in 49.2 % of water saving, and WUE increased by 243 % compared with traditional surface irrigation method.

Key words: *Drip irrigation, water productivity, wheat irrigation .*

INTRODUCTION

Egypt faces a very challenging situation regarding decreasing water availability and the area of arable land specified for wheat production **(Boutros, 2013).** Most small farmers (those with land property of 3 fadden or less) tend to cultivate their land (including wheat) for consumption purposes, selling the excess for income generation **(RISE, 2014).** Small farmers are represented by the 70% of Egypt's poor living in rural areas **(IFAD, 2012)**. On the other hand, field application efficiency in most traditional irrigation methods is still very low, typically less than 50 % and often as low as 30 % **(Molden,2007).** Excessive application of water generally entails losses because of surface run-off from the field and because of deep percolation below the root zone within the field. Both run-off and deep percolation losses are difficult to control under surface irrigation system, where a large volume of water is applied at a single instance.

Egypt is the largest wheat (Triticum aestivum, L.) importer worldwide **(Gazette, 2013).** According to **FAO (2012)**, the area of cultivated wheat in Egypt is 1,336,234 hectares and the yield that comes out of it is 6.58 tons per hectare, resulting in a total wheat production of around 8,795,483 tons and domestic wheat consumption in Egypt was 19,100,000 tons. With constant population growth and decreasing arable land in Egypt, the risk to demand levels is ever increasing. In 2010, according to the FAO, Egypt imported 10,593,506 tons of wheat in addition to the consumption of the domestic production **(Boutros, 2013).**

Bashour and Nimah (2004) reported that trickle irrigation saves about 50% of the water used in surface irrigation. **Aujla et al. (2007)** reported a saving of 25% water on drip irrigation as compared with furrow irrigation. **Ibragimov et al. (2007)** compared drip and furrow irrigation, obtaining that 18-42% of the irrigation water was saved with drip systems in comparison with furrow, and the WUE increased by 35-103% compared with furrow irrigation.

The shape and total volume of the wetted soil below an emitter varies widely with the soil hydraulic parameters, number of emitters, discharge rate and irrigation frequency. It needs to be determined so that the crops could be provided with an adequate wetted soil volume to meet their water requirements **(Kao and Hunt, 1996; Al-Qinna et al., 2001).**

Particularly in drip irrigation, the distribution of dissolved salts in the soil profile follows the pattern of the water flux with the tendency for accumulation at the periphery of the wetted soil mass, and the salt accumulation is much greater near the surface than at the deeper layers and increases with distance from the emitters **(Wang et al., 2011).**

The aim of this work was to study the effect of different irrigation treatments (single drip lateral line per bed and double drip lateral lines per bed) and irrigation intervals on soil moisture and salt distribution patterns, vegetative growth, yield and WUE of wheat (Triticum aestivum (vulgare))**.**

MATERIALS AND METHODS

Site Description:

To achieve the objectives of this study, two years field experiment was conducted in a private land at Village Damalo, Banha, Kalyobia Governorate, Egypt, which located at latitude 31º 27` N and longitude 31º 10` E during the growing seasons of years 2013 - 2014 and 2014 - 2015 in winter season. The growing season for wheat extends from mid-November to early -May. The dominant soils of the experimental site were clay textured throughout the profile (21.57% coarse sand, 1.75% fine sand, 27.14% silt and 49.54% clay). The field capacity, wilting point and electric conductivity values were 36%, 17.25% and 0.5 dSm^{-1} respectively.

Irrigation Systems Description:

Polyethylene (PE) laterals of 16mm outer diameter with 18m length, which has built-in drippers with discharge of 4 lh^{-1}/30cm spacing at 1.0

bar operating pressure were installed at a distance of 130 cm apart in the treatment of single lateral line per bed and at a distance of 65 cm apart in the treatment of double line per bed. The irrigation intervals treatments were 4, 8 and 12 days. Each plot had the required volume of applied water according to the water requirements of wheat based on Central Laboratory for Agricultural Climate (CLAL) data. The irrigation time for double line treatments was half the calculated time for single line. Fig (1) shows a schematic of experimental layout.

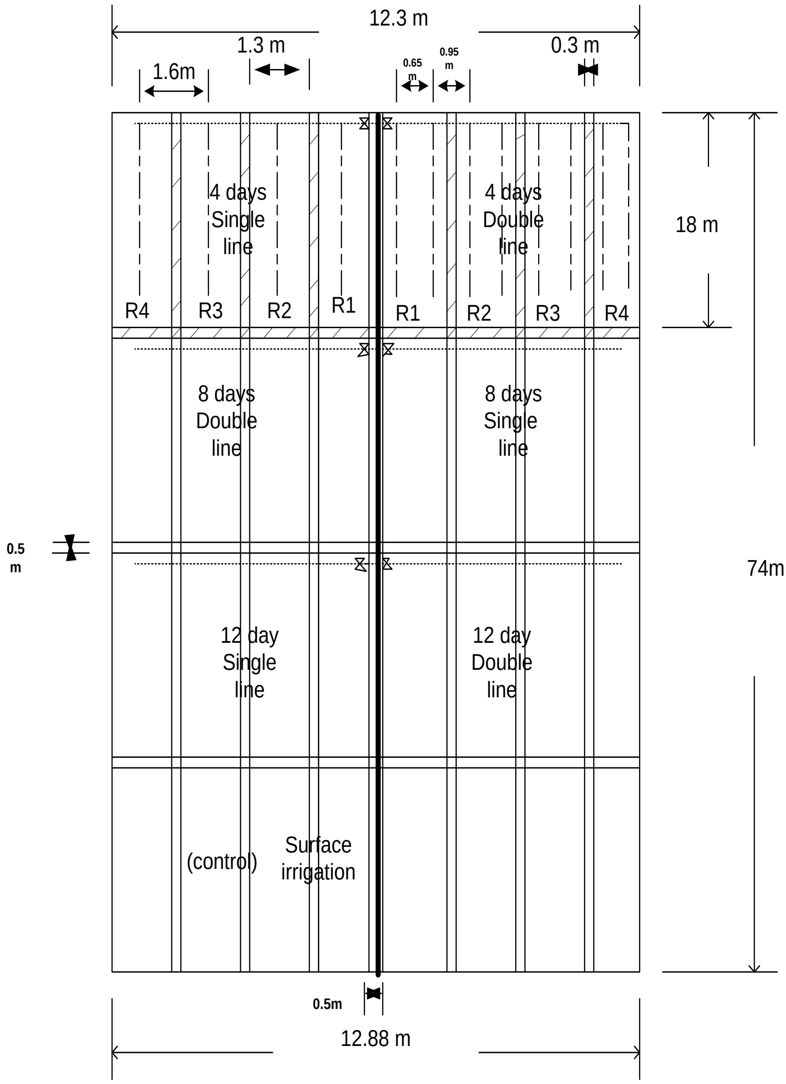

Figure (1): Field layout for experimental area and system design

The experimental plots were planted with wheat (Triticum aestivum (vulgare) Giza 168) on November in the two successive seasons 2014 and 2015. Soil was prepared and planted at a seed rate of 125 kg/ha. The harvest was done on May 6th in 2014 and 2015, after 180 days from sowing of wheat. Yield, yield components and plant characteristics were measured. The maturity data were collected on grain yield, straw yield and harvest index in order to assess wheat crop phenology and evaluate the effects of irrigation treatments on it.

Crop water requirement:

Daily evapotranspiration (ETo) values were obtained from CLAC expected data which always available 5 days in advance. Kc for wheat during the growing season was obtained from **FAO (2001).** The obtained ET_0 and Kc were used to calculate water requirement for wheat (m^3/fed/irrigation) by the following equation of **Keller and Karmeli, 1974**:

$$\mathbf{IW_1} = \left[\frac{ETo * Kc * Kr * I_1}{Ea1} + LR \right] \times 4.2$$

Where:

IW_1 = Irrigation water applied under drip irrigation system, m^3/fed/ irrigation.

ET_0 = Reference evapotranspiration (mm/day).

Kc = Crop coefficient.

Kr = Reduction factor

I_1 = Irrigation intervals with drip irrigation system, day.

Ea_1 = Irrigation efficiency of drip irrigation system, %.

LR = Leaching requirement (10% of the total amount water), m^3/fed/irrigation.

Soil moisture distribution:

Soil moisture distribution "SMD" was determined according to **Liven and Van Rooyen (1979).** Samples were taken by using auger after irrigation throughout the season from perpendicular to the lateral line, at 0, 15 and 30 cm from the emission point throughout the root zone at depths of 0 - 20, 20 - 40 and 40 - 60 cm after irrigation for different irrigation treatments (4, 8 and 12 day under single and double lateral lines per bed). SURFER (Version 10) was used to develop the contour maps for moisture and salt distribution pattern. Soil moisture content was determined as a percentage on dry weight base as follows:

$$\mathbf{S.M.C = 100\ (W_1 - W_2) / W_2}$$

Where:

$\mathbf{W_1}$ = weight of the wet soil sample (g)

$\mathbf{W_2}$ = weight of the oven dried soil sample (g) at 105 ^{0}C for 24 hours.

Salt Distribution Patterns:

Soil salinity content was measured for all treatments in saturated soil extract (1:5) and determined by measuring electrical conductivity for all soil samples. Electrical conductivity (EC) in dS/m for each gravimetric soil sample has been measured using EC meter. The same procedure in deriving moisture pattern for the moisture distribution pattern was used in obtaining the contour maps for the salt distribution pattern for each irrigation treatment.

Growth and yield parameters:

For estimating growth parameters, a random sample of five plants from each plot was taken at 80, 100 and 120 days after planting in both seasons to obtain plant height (cm), number of tillers, number of grains per spike, weight of 1000-grain, grain yield , straw yield and total yield. At harvest, the biological weight of the two beds was taken separately on each treatment and the average of weights used in the calculation. Samples (2kg from each treatment) were harvested to measure grain and straw yield (kg) (**Abdel Aziz, 2013).**

Water use efficiency:

Water use efficiency is an indicator of effectiveness use of irrigation unit for increasing crop yield. Water use efficiency of grain yield was calculated as **(Abd El Rahman, 2009)**:

$$\text{WUE of grain yield (kg/m3)} = \frac{\text{total grain yield (kg/ha)}}{\text{total applied irrigation water } (m^3/\text{ha})}$$

<u>RESULTS AND DISCUSSIONS</u>

Soil moisture distribution

The results in Fig(2) revealed that the soil moisture content of 8 and 12-days interval was higher than soil moisture content of 4-day irrigation interval especially in the treatment of 8 days intervals with double lateral lines. This may be due to the amount of water applied. In 8 and 12-days interval, much amount of irrigation water were applied more than in 4 days interval, as a result, much water was infiltrated and stored in deeper soil layers (40-60 cm depths). But, less amount of water was applied in 4-days interval, infiltrated and stored in the upper soil layers (0-30cm) directly under the emission points (drippers).

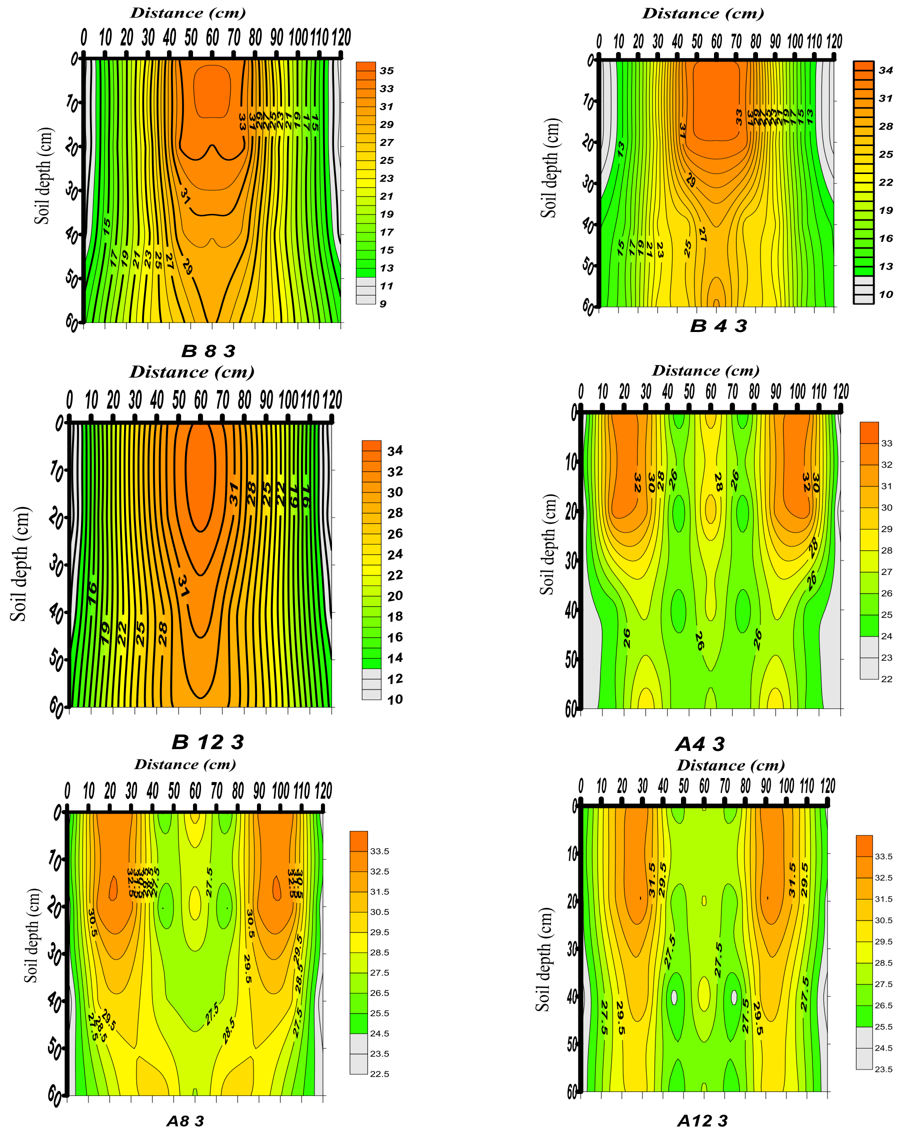

Fig. (2) Soil moisture content% in the soil profile as a function of depth (Z) for three irrigation treatments (4, 8, and 12day) under single line (B) and double lines (A) per bed at flowering stage.

Salt Distribution Patterns:

Data in Fig (3) shows that the average values for the EC under double lateral lines were 0.32, 0.33 and 0.36 dS/m for 4, 8 and 12 days respectively at the beginning of the season. At the end of the season, the average EC values were 0.49, 0.38 and 0.44 dS/m for 4, 8 and 12 days respectively. Also, the single lateral line treatments showed the same trend as the double lateral lines treatments.

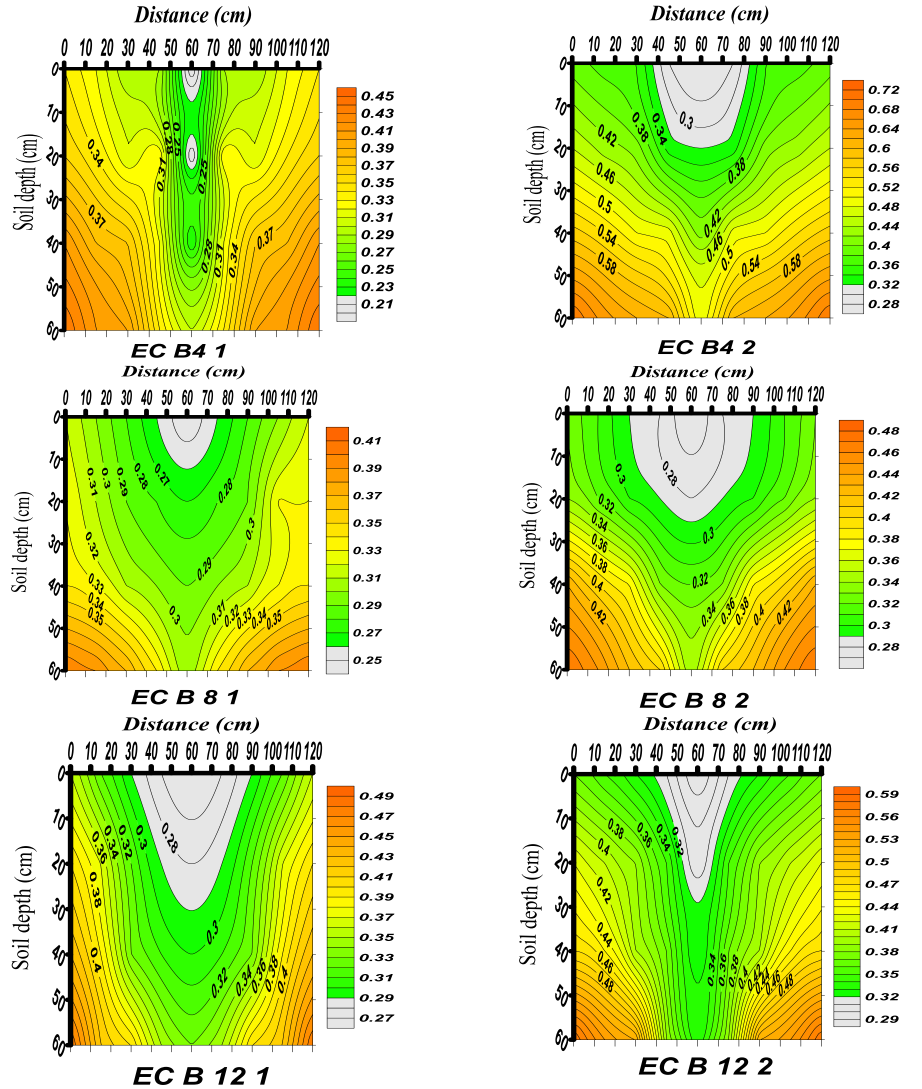

Fig. (3) Salt distribution patterns (EC) after irrigation for three irrigation treatments (4, 8, and 12day) under single line (B) and double lines (A)per bed at the beginning(1) and end of the season(2)

The salt accumulated with low values at the upper depth of all treatments especially under the drippers, while it is evident that the water added with longer irrigation intervals (8 and12 days) with much amount of irrigation water play an important role in leaching salts downwards and sideward from the emission points., The lowest salt concentration was directly under drippers, and it was gradually increased laterally and vertically at deeper soil profile.

Wheat growth and yield parameters:

The effect of irrigation intervals on growth parameters of wheat, showed that 8, and 12 days intervals had the highest values of number of grain per spike (59.70 and 62.35 respectively), and weight of 1000-grain, (44.45 and 44.64 gm, respectively). The highest values of plant height were 104.3 and 105.5 cm, and No. of tillers were 8.028, and 7.750, at 4, and 8 days respectively (table 1).

Table (1): Effect of irrigation systems on harvest characters.

Irrigation intervals	System Layout	Plant height (cm)	Number of grains per spike	No. of tillers	Weight of 1000-grain (g)
4 days	Double	105.1 b	57.82 c	7.833 ab	40.35 d
	Single	103.9 b	65.82 ab	8.333 a	40.60 d
8 days	Double	109.3 a	61.83 bc	7.583 ab	43.44 c
	Single	103.3 b	66.42 a	7.750 ab	45.51 a
12 days	Double	105.1 b	68.21 a	6.333 ab	45.32 a
	Single	94.49 c	67.99 a	6.083 b	44.21 b
Surface irrigation	Control	103.9 b	50.86 d	7.917 ab	44.39 b
L.S.D at 0.05		**3.706**	**4.342**	**2.020**	**0.5369**

Significant differences due to variation in irrigation treatments were detected regarding the yield and yield components parameters. The highest values of biological yield was 6.810 (ton/fed) at 4 days comparing with 8 and 12 day (6.706 and 6.717 ton /fed respectively), and WUE for grain yield was 1.835 kg/m^3 at 4 days followed by 1.66, and 1.365 kg/m^3 for 8, and 12 day respectively. However, the highest values of grain yield was 2.821 (ton/fed) at 8 days followed by 2.693 (ton/fed) at 12 days then 2.413 (ton/fed) for 4 days (table 2).

Table (2): Effect of the irrigation systems on yield and yield components.

Irrigation intervals	System Layout	Grain yield in ton/fed	Straw yield (ton/fed)	Biological yield (ton/fed)
4 days	Double	2.517 d	5.008 a	7.798 a
	Single	2.617 d	4.567 b	7.250 d
8days	Double	3.438 a	4.133 c	7.617 b
	Single	2.914 c	4.200 c	7.233 d
12days	Double	3.163 b	4.300 bc	7.533 c
	Single	2.802 c	4.300 bc	7.100 e
Surface irrigation	Control	2.107 e	3.323 d	5.367 f
***L.S.D* at 0.05**		**0.1410**	**0.2967**	**0.07536**

Effect of irrigation lateral arrangements:

Number of tillers were not significantly affected by changing the number of lateral lines per bed. On the other hand, increasing the number of lateral lines from single to double lateral lines per bed increased significantly plant height, but it significantly decreased the number of grains per spike and weight of 1000- grain.

Effect of irrigation lateral arrangements on yield and yield components parameters revealed that the highest values of yield and yield components parameters were achieved when using double lateral lines. Double lateral lines treatments resulted in the highest significant values of biological yield, grain yield and WUE (kg/m^3) compared with single lateral line treatments, but no difference between them for straw yield.

Effect of interaction of irrigation intervals and lateral lines arrangements:

The interaction between all experimental treatments indicated that irrigation interval of 8 days with double lateral lines per bed gave the highest values of plant height, and grain yield. The irrigation treatment with 12 days intervals with double lateral lines per bed recorded the highest value for number of grains per spike and weight of 1000-grain. There were no differences between the effect of single lateral line with 8 days interval and double lateral line with 12 days interval on plant height, number of grains per spike and weight of 1000-grain.

The grain yield was slightly affected by (4, 8, 12 days) under double and single line per bed. However, the highest yield was 3.438 ton/fed at 8 days interval with double irrigation lateral lines. Also relatively high grain yield values 2.914 and 2.802 ton/fed were obtained at 8 and 12 days respectively with single irrigation lateral line treatments. The lowest yield values were at 4 days intervals under single lateral line.
The highest value of WUE for grain yield (1.835 kg/m^3) was achieved at 4 days under double lateral lines and the lowest value was at 12 days under single line (1.25 Kg/m^3).

Water saving:

Water saving was higher under close irrigation intervals (4days) followed by 8 days comparing with 12 days (higher water use for drip irrigation) under both lateral arrangements (double and single line per bed). It was 13.44% and 10.85% under double lines and 21.8% and 8.39% under single line per bed. As pervious mentioned, water saving was more under double lines than single line per bed.

CONCLUSION AND RECOMMENDATIONS

The aim of this study was to investigate the ability to introduce drip irrigation method to be applied under clay soil conditions in old land of Egypt. Applying such new drip irrigation system needs deep investigations to reach the most appropriate system management for irrigating field crops such as wheat under clay soil conditions. Therefore, three treatments of irrigation intervals (4, 8 and 12days) with two treatments of drip irrigation lateral arrangements (single and double lateral lines per cultivated bed) were selected to study the improved management effect on wheat yield and water productivity. Results revealed that the grain yield was slightly affected by irrigation intervals under double and single lateral line per bed. However, the highest yield was (3.438 ton/fed) at 8 days irrigation interval with double lateral lines per bed) Also relatively high grain yield 2.914 and 2.802 ton/fed were obtained at 8 and 12 days intervals with single lateral line per bed. The highest value of WUE for grain yield (1.835 kg/ m^3) was achieved at 4 days interval with double lateral lines and the lowest value (1.25 kg/m^3) was found at 12 days under single lateral line. Data also revealed that water saving for 8 days under double lines was 13.44% comparing to 12 days under single line per bed. It can be concluded that the irrigation treatment (8 day under double lines) has an effective way for irrigating intensive field crops, but more studies have to be conducted under similar field conditions.

Finally and based on all the previous discussions, it can be concluded that to obtain a maximum yield of grain and to maximize the water use efficiency it is recommended that:

1. In case of availability of water resource (continues flow), using 8 days interval with double line per bed will be applicable and it gave the highest values of yield (3.438 ton/fed) and water use efficiency (1.66 kg/m^3), with the best soil moisture distribution in the upper soil layers, as well as, less change in salt distribution at the end of the season.
2. In case of non-availability of continues water flow (irrigation rotations), using 12 days interval with double line per bed will be applicable since it gave the high values of yield (3.163 ton/fed) and water use efficiency (1.365 kg/m^3), with the good soil moisture distribution in the soil profile, as well as less change in salt distribution at the end of the season.

REFERENCES

Abd El-Rahman, G. (2009).Water Use Efficiency of Wheat under Drip Irrigation Systems at Al-Maghara Area, North Sinai, Egypt. American-Eurasian J. Agric. & Environ. Sci., 5(5): 664-670.

Abdel Aziz, S., (2013). Personal communication. Prof. of Agronomy, Faculty of Agriculture, Benha Uni. Egypt.

Al-Qinna M and AM Abu-Awwad (2001). Wetting patterns under trickle source in arid soils with surface crust J. Agric. Engng. Res., 80(3): 301-305.

Aujla, M.S., H. S. Thind, and G. S. Buttar (2007). Fruit yield and water use efficiency of eggplant (Solanum melongema L.) as influenced by different quantities of nitrogen and water applied through drip and furrow irrigation. Scientia Horticulturae. (112): 142–148.

Bashour.i and M. Nimah (2004). Fertigation potentials in the near east region. IpI regional workshop on potassium and Fertigation development in west Asia and North Africa, Rabat, Morocco.

Boutros, I. (2013). Reducing risks: Wheat supply in Egypt. http://www.dailynewsegypt.com/2013/05/27/reducing-risks-wheat-supply-in-egypt/

FAO, (2001). Crop Water Information: Wheat. http://www.fao.org/nr/water/cropinfo_wheat.html.

FAO, (2012). Egypt production potential. http://www.fao.org/ag/AGP/AGPC/doc/field/Wheat/africa/egypt/egyptagec

Gazette, S. (2013). Egypt remains world's largest wheat importer. http://english.alarabiya.net/en/business/economy/2013/07/07/Egypt-remains-world-s-largest-wheatimporter.html

Ibragimov, N., S.R.Evett, Y. Esanbekov, B.S. Kamilov, L.Mirzaev and J.P.A. Lamers (2007). Water use efficiency of irrigated cotton in Uzbekistan under drip and furrow irrigation. Agricultural water management, 90: 112-120.

IFAD (2012). On-farm Irrigation Development Project in the Old lands (OFIDO). http://www.ifad.org/operations/projects/design/98/egypt.pdf.

Kao CS, Hunt JR (1996). Prediction of wetting front movement during one-dimensional infiltration into soils. Water Resou. Res., 32(1): 55– 64.

Keller, J. and D. Karmeli (1975). Trickle irrigation design, Rain Bird Sprinkler Manu. Co. Glendora, Calif., 91740 USA: 24-26, 62-66.

Liven, P.C. and Van F.C. Rooyen (1979). The effect of discharge rate and intermittent water application by point-source irrigation on the soil moisture distribution pattern. Soil Sci.Amer. J. 43: 8-5

Molden, D. J. (2007). A comprehensive assessment of water management in agriculture. Research report. International Irrigation Management Institute, Colombo.

RISE "Research Institute for a Sustainable Environment" (2014). Wheat Cultivation- Good Practices in Egypt, http://collaborationplatform.net/Download.ashx?File=Rakin_upload/GoodPractice/145.pdf.

Wang, R., Y. Kang, S. Wan, W. Hu and S. Liu (2011). Salt distribution and the growth of cotton under different drip irrigation regimes in a saline area. Agric. Water Manag. 100, 58e69.

الملخص العربي

ادارة الرى بالتنقيط للقمح تحت ظروف الارض الطينية

ريهام النادى[١]، حربى مصطفى[٢] ، منتصر عواد[٢] و محمد الأنصارى[٣]

تجدر الاشارة الى ان مصر تعانى من نقص شديد فى المياه فى السنوات الاخيرة وهذا راجع الى التفاوت فى توزيع المياه، واساءة استخدام الموارد المائية ،وتقنيات الرى الغير فعالة،حيث ان التوسع الافقى فى الزراعة متصلا بقدرة البلاد على توفير المياة اللازمة لهذا التوسع، علاوة على ذلك ان الاقتصاد فى استخدام المياه فى المستقبل على المدى الطويل يتطلب البحث عن بدائل، و تحديد مصادر المياه المتوفرة حاليا، والموارد الاضافية التى يمكن ان نحصل عليها فى المستقبل.

أجريت تجربتان حقليتان خلال موسمى الشتاء عامي ٢٠١٣-٢٠١٤ ، ٢٠١٤- ٢٠١٥ في حقل خاص، قرية دملو، مركز بنها بمحافظة القليوبية، مصر ، والهدف من هذه التجربة استخدام الرى بالتنقيط تحت ظروف الارض الطينية فى الاراضى القديمة فى مصر للوصول الى نظام ادارة ملائم لرى المحاصيل الحقلية مثل القمح .لذلك تم اختيار معاملات الري المختلفة (استخدام خرطوم تنقيط لكل مصطبة زراعة، استخدام خرطومين تنقيط لكل مصطبة زراعة)، وفترات الري (٤،٨،١٢ يوم خلال الموسم) لدراسة تأثير تحسين الادارة على محصول القمح والقدرة الانتاجية للمياه.

أشارت النتائج الى ان محصول الحبوب تأثر بفترات الرى مع خرطوم تنقيط لكل مصطبة و خرطومين تنقيط لكل مصطبة تأثير بسيط، على الرغم من أعلى انتاجية كانت عند استخدام ٨ أيام مع خرطومين تنقيط لكل مصطبة (٣.٤٣٨ طن/فدان). أيضا هناك زيادة فى الانتاجية عند استخدام ٨ و١٢ يوم مع خرطوم واحد لكل مصطبة (٢.٩١٤ و ٢.٨٠٢ طن/فدان) و كانت أعلى انتاجية لكفاءة استخدام المياه المحصولية عند ٤ أيام مع خرطومين (١.٨٣٥ كجم/م٣) و أقل قيمة كانت عند ١٢ يوم مع خرطوم تنقيط لكل مصطبة (١.٢٥ كجم/م٣). أيضا أشارت النتائج الى أن توفير المياه ل٨ أيام مع خرطومين تنقيط لكل مصطبة ١٣.٤٤% بالمقارنة مع ١٢ يوم مع خرطوم تنقيط لكل مصطبة، لذلك من الملاحظ ان استخدام ٨ أيام مع خرطومين له تأثير على رى المحاصيل الحقلية .

بناءا على المناقشات السابقة للحصول على أفضل انتاجية مع أفضل كفاءة استخدام المياه المحصولية :

- فى حالة وجود استمرارية للمياه (مصدر للمياه) فان استخدام ٨ ايام مع خرطومين تنقيط أعطت أعلى انتاجية (٣.٤٣٨ طن/فدان) مع كفاءة استخدام المياه المحصوليه (١.٦٦ كجم/م^{٣}) مع أفضل توزيع للرطوبة فى الجزء العلوى من سطح التربة(٣٠ سم) خلال الموسم، أيضا هناك تغييرات فى توزيع الاملاح بسيطه فى نهاية الموسم.
- فى حالة عدم وجود استمرارية للمياه (الدورة الزراعية) فان استخدام ١٢ يوم مع خرطومين تنقيط فانها تعطى انتاجية (٣.١٦٣ طن/فدن) مع كفاءة استخدام المياه المحصوليه (١.٣٦٥ كجم/م^{٣}) مع توزيع جيد توزيع للرطوبة فى الجزء العلوى من سطح التربة(٣٠ سم) خلال الموسم. ، أيضا هناك تغييرات فى توزيع الاملاح بسيطه فى نهاية الموسم.

[١] طالبة دراسات عليا ، [٢] استاذ مساعد و [٣] أستاذ متفرغ بقسم الهندسة الزراعية - كلية الزراعة بمشتهر - جامعة بنها.