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# Sprinkler irrigation and nitrogen fertilization affecting wheat production in reclaimed soil

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## ABSTRACT

The present work is conducted to study the effect of two irrigation intervals and nitrogen fertilization rates on wheat production under two sprinkler irrigation systems in newly reclaimed sandy soil at EL-Khattara Farm, Sharkia Governorate . The wheat yield and yield components were highly affected by irrigation intervals and nitrogen fertilization. The obtained results showed that the average values of plant height, number of spikes/m$^2$, spike length, grain number/spike, grain mass/spike, 1000 seed mass, total grain and straw yield/fed, increased with decreasing irrigation intervals from 7 to 4 days and increasing nitrogen rates from 40 to 100 kg N/fed. With irrigation intervals of 4 days, the grain yield increased by 14.74, 8.59, 13.1and 16.20 % compared with 7 days at 40, 60, 80, and 100 kg N/fed, under sprinkler system. The average WUE and FUE values for sprinkler system increased by 15.39 and 17.67% with 4 days irrigation intervals; 16.3 and 18.61 % with 7days compared with perforated pipe system .The lowest cost per unit production was obtained under sprinkler system with 4days intervals and 100kg N /fed (0.19 L.E/kg grain) compared with perforated pipe system (0.22 L.E /kg grain)

## INTRODUCTION

Wheat is one of the most important cereal crops in Egypt and all over the world. It is very important to increase wheat production because the local production is not sufficient to supply the annual demand of local requirements. Fertilization is one of the main factors affecting grain and straw yields. Water management with high yield in varieties have formed important part of the research - work done. To obtain potential crop yields the application of adequate amounts of irrigation water and nitrogen fertilizer at the proper time and amount are considered to be of high importance.

Omer and Aziz (1983) reported that for optimum wheat production, five irrigations might be given in addition to that of planting. Total amount of irrigation water reached 2198 m$^3$ /fed.

Proffitt et al. (1985) found that by increasing the irrigation intervals from 4 to 12 days, the wheat grain yield decreased from 7.39 to 6.97 ton/ha, and the water use efficiency decreased from 3.21 to 2.91 kg/mm with the same amount of water used .

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Gad El-Rab et al. (1988) found that the maximum values of grain wheat and straw yields were obtained when six or five irrigations were applied during different growth stages. They also found that the best water use efficiency values of 1.72 and 1.59 kg grain /$m^3$ were obtained under 4 and 5 irrigations.

Badr (1993) found that at the high frequency irrigation of 7-8 days intervals, the grain wheat yield and water use efficiency increased by 41.3, 30, 18.18 and 14.03% and 51.79, 36.11, 58.35 and 18.07% compared with irrigation days intervals of 17-20,12-14,11-13 and 9-10 respectively

El-Bana and Aly (1993) found that increasing N levels from 50 to 100 kg N/fed, the plant height, spike length, number of grain per spike, 1000 grain weight, grain weight per spike, number of spikes per $m^2$, grain wheat yield and straw yield increased from 78.2 to 92.4 cm, 7.42 to 8.67cm, 27.31 to 36.91, 30.1 to 32.19 g, 0.82 to 1.19 g, 238.25 to 314.49 spike /$m^2$, 1.93 to 2.92 ton/fed, and from 5.03 to 10 ton/fed, respectively.

El-Monoufi and Harb (1994) found that irrigation of wheat plants for six times increased number of spike/$m^2$ by 6.9, 9.3 and 11.5% as compared with five, four and three irrigation treatments.

Wahdan et al. (1996) indicated that the highest values of grain wheat and straw yields reached 2.57 and 7.12 ton/fed, under 105 kg N/fed with 14 day intervals, but the minimum values reached 1.25 and 4.32 ton/fed, under control (0 kg N/fed) with 28 day intervals.

Sobh (1997) found that the greatest grain wheat and straw yields were obtained by applying water regime of 80% of conventional water requirement and with 75 kg N /fed, compared with different treatments. He also found that the highest value of water use efficiency of 1.11 kg / $m^3$ was obtained at the same treatment.

Awad (1998) found that the wheat grain yield increased from 764.5 to 822.3 kg/fed, when the irrigation period decreased from 20 to 15 days in loamy clay texture and moderate $CaCO_3$ (amount about 12%).

El-Sherbieny et al. (1999) found that increasing the levels of nitrogen from 80 to 120 kg /fed, the grain wheat and straw yield increased from 1.3 to 2.34 ton /fed and 2.51 to 3.97 ton /fed in sandy soil.

El-Hawary (2000) found that the average values of number of spikes/$m^2$, spike length, number of grains/spike, grains weight/spike, 1000 seeds weight, grain and straw yield /fed, decreased with increasing irrigation at 75% depletion of available soil water caused 31.96 and 31.98%, 49.44 and 46.48%, 50.27 and 47.06%, 25.47 and 25.30%, 30.51 and 28.84%, 34.78 and 30.13%, 54.07 and 56.33% reduction as compared with irrigation at 25% depletion of available soil water (control) in first and second seasons respectively.

This research work was carried out to investigate the effect of sprinkler irrigation systems, irrigation intervals and nitrogen fertilization rates on total yield (grain and straw), yield components, water use efficiency, fertilizer use efficiency and cost per unit production under sandy soil conditions.

## MATERIALS AND METHODS

The field experiments were performed in experimental Farm, Faculty of Agriculture, Zagazig University at EL-Khattara Farm, Sharkia Governorate, Egypt as a newly reclaimed soil during 1999/2000 winter growing season, to study the effect of irrigation intervals and nitrogen fertilization rates on wheat yield, yield components, water use efficiency, fertilizer use efficiency and cost per unite production under sandy soil conditions using the two sprinkler irrigation systems (sprinkler and perforated pipe). The experimental soil was sandy soil texture (96.3% sand, 2.9% silt and 1.3% clay). The average plowing depth with rotary plow in two passes was about 10 cm. The experimental plots were sown using wheat Variety Giza 162 in $19^{th}$ November 1999 in rows 15 cm apart and harvested $29^{th}$ April 2000.

### *Sprinkler irrigation systems*

It is consists of the following components: -

1- Pumping station consisted of three units. Each unit consisted of an electric motor (30 kW), connected to centrifugal pump (6 / 6) for delivering flow rate of 120 $m^3$ /h under operating pressure of 5.0 bar.

2- The control head connected to main line, to regulate the pressure and the delivered water. Pressure manometers, water filter and fertilizing tank.

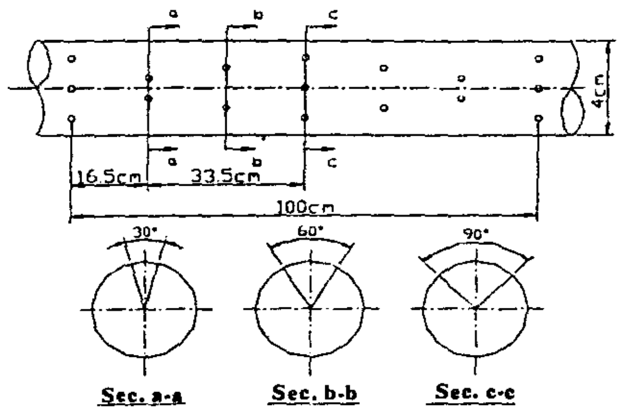
3- Main pipeline of 110 mm diameters of PVC to transmit the water from pump to the submain lines.

4- Submain pipeline of 75 mm diameter of PVC to transmit the water to the laterals. The gate valve and pressure gauge were installed at the beginning of submain lines.

5- Lateral lines:

a-Lateral lines having 50 mm diameter of PVC. Sprinklers with spacing of 12×18 m (12 m between sprinklers on laterals and 18 m between laterals) using a sprinkler of 19 mm in diameter with two nozzles 2 and 3.8 mm in diameter. Sprinkler discharge was 0.9 $m^3$/h at 223 kpa operating pressure. The riser sprinkler was 1.2 m high (40 cm below ground and 80 cm above ground).

b- Lateral perforated pipelines: perforated pipelines having 40 mm diameter of PVC and 28 meter length. Through which holes were drilled in standard pattern having hole diameter of 1.0 mm and different hole angles of $0^{\circ}$,$15^{\circ}$ ,$30^{\circ}$ and $45^{\circ}$ on both sides from the vertical axis of lateral cross section ( $90^{\circ}$ ,$75^{\circ}$ ,$60^{\circ}$ and $45^{\circ}$ on both sides from the horizontal axis of lateral cross section). The holes in the system were distributed in groups, each 14 holes spreading in six rows of 1.0 meter and it was repeated at precise intervals along the length of pipeline as in fig. (1). The main plots represent irrigation system, i.e., sprinkler and perforated pipe systems, while the subplots, represent irrigation intervals, i.e., 4 and 7 days and sub-subplots represent the rates of added in nitrogen fertilization, i.e.,40, 60,80 and 100 kg N/fed. Irrigation was stopped at 4 and 7 days intervals to be help at 20 day before harvesting.




**( Hole distribution )**

**Fig.(1) : The plan and sections of one meter of typical perforated pipe line.**

Nitrogen fertilization ammonium sulfate (20.5% N) at four rates of 40,60,80 and 100 kg N/fed, were added at three equal doses: at tillering, elongation and booting stages respectively.

Calcium superphosphate (15.5% $P_2O_5$) was added at the rate of 200 kg/fed, prior to sowing and before the first irrigation. Potassium sulfate (48%$K_2O$) was added at rate of 100 kg/fed, at three doses : a first dose at planting and remainder two doses were applied before the second and third irrigations.

At harvesting time, number of spikes/$m^2$, plant height, spike length, grains number/spike, grain mass /spike, 1000 grain mass and grain and straw yield were recorded.

**Water use efficiency (WUE):** The water use efficiency was calculated according to Begg and Turner (1976) as follow:

$$WUE = \frac{\textbf{Total yield (kg/fed)}}{\textbf{Total water use (m}^3\textbf{/fed)}}$$

**Fertilizer use efficiency (FUE):** The fertilization use efficiency by crop, expressed in kg of the crop yield produced by each unit of fertilizer used, was calculated as follows:

$$FUE = \frac{\text{Total grain yield (kg/fed)}}{\text{Total nitrogen (kg N/fed)}}$$

# RESULTS AND DISCUSSION

## A-Yield and yield components

### *1- Plant height:*

Data presented in fig. (1) show that the greatest plant height of wheat of 93.97 cm was obtained for plants that received a nitrogen rates of 100 kg N/fed, and irrigation intervals 4 days under sprinkler system. Decreasing the irrigation intervals from 7 to 4 days, the average plant height increased from 87.17 to 93.97 cm and from 84.46 to 87.03 cm under sprinkler and perforated pipe systems. This increase could be due to the increase and uniformity in available soil moisture level and nitrogen fertilization rate .

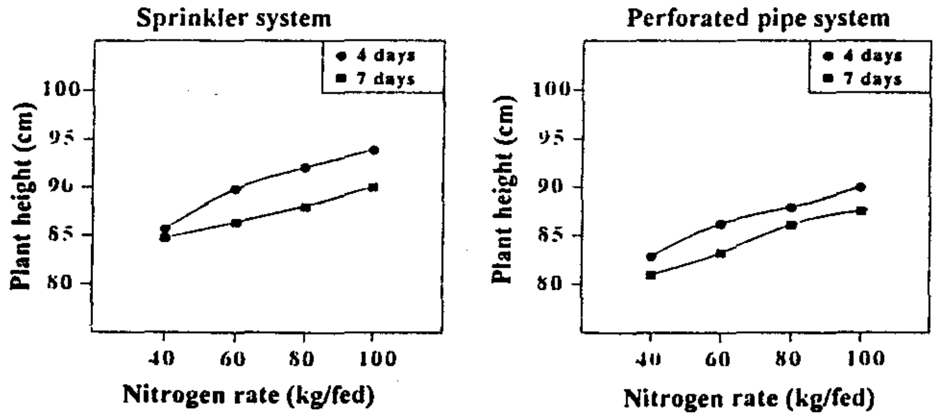



**Fig. (1): Effect of irrigation systems , irrigation intervals and nitrogen rates on plant height.**

### *2- Spike length*

Data related to spike length as influenced by irrigation intervals and nitrogen fertilization are reported in fig. (2). The results show that spike length is highly affected by irrigation intervals 4 days (9.82 cm) compared with irrigation intervals 7 days (9.35 cm) under sprinkler and perforated pipe systems. Increasing nitrogen fertilization rate from 40 to 100 kg N/fed, the spike length increased from 8.58 to 9.35 cm and 8.15 to 9.04 cm under sprinkler and perforated pipe systems, at irrigation intervals 7 days.

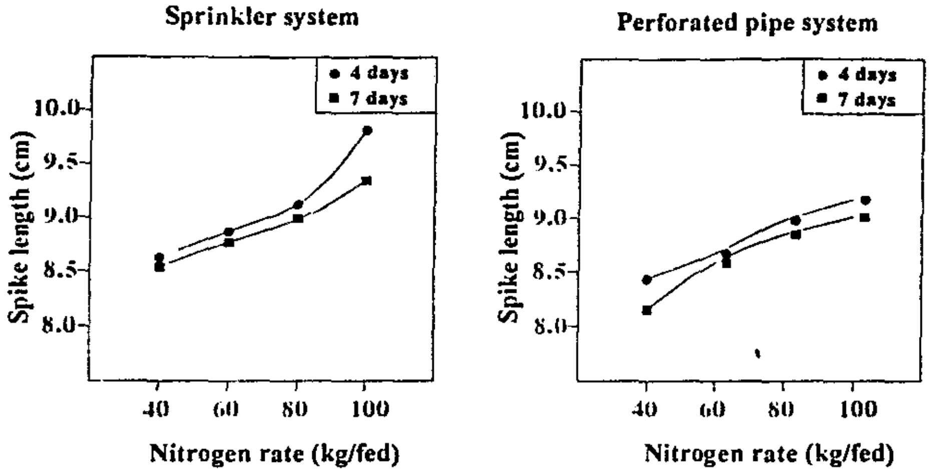



**Fig. (2): Effect of irrigation systems, irrigation intervals and nitrogen rates on spike length.**

*3- Spike number per square meter*

Data related to spike number/m$^2$ of wheat as influenced by irrigation intervals and nitrogen fertilization are shown in fig.(3). Increasing nitrogen fertilization rates from 40 to 100 kg N/fed, the spike number/m$^2$ increased by 33.84 and 35.49% for sprinkler system; 31.73 and 33.10% for perforated pipe

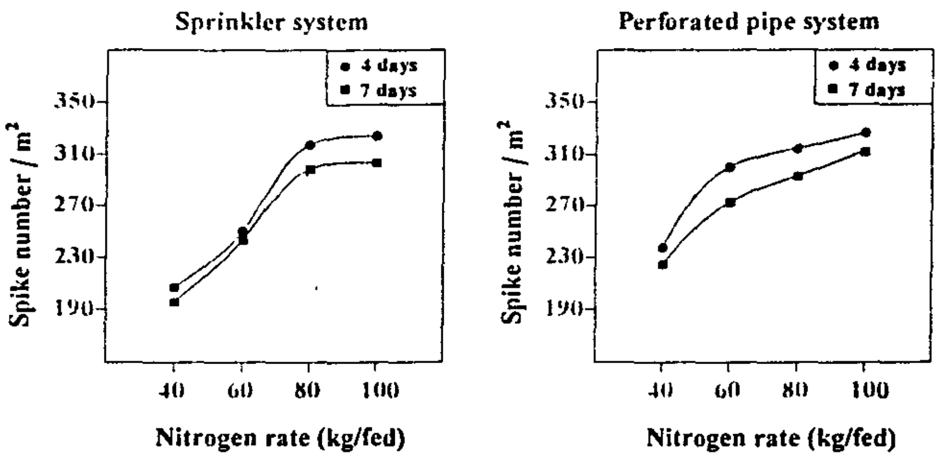



**Fig. (3): Effect of irrigation systems, irrigation intervals and nitrogen rates on spike number per m$^2$.**

system under 4 and 7 days irrigation intervals .Decreasing irrigation intervals from 7 to 4 days, the average spike number/m$^2$ increased by 6.44 and 6.99% under sprinkler and perforated pipe systems. The spike number/m$^2$ increased by decreasing the irrigation intervals and increasing nitrogen fertilization rates.

### *4- Grain number per spike*

Grain number per spike as influenced by irrigation intervals and nitrogen fertilization is shown in fig. (4). The long spike produced for irrigation intervals

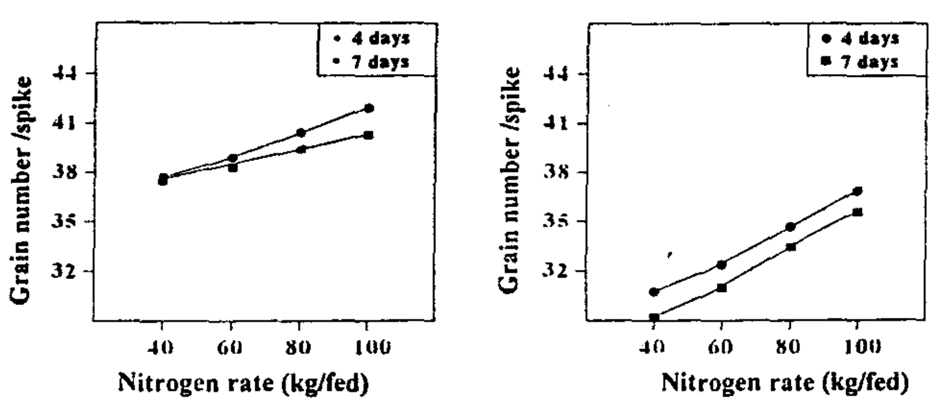



**Fig. (4): Effect of irrigation systems, irrigation intervals and nitrogen rates on grain number per spike.**

4 days and 100 kg N/fed greater number of grains than 7 days irrigation intervals and 40 kg N/fed. The average grain number per spike for sprinkler system is greater than perforated pipe system by 14.56 and 17.07 % at irrigation intervals 4 and 7 days. Increasing nitrogen fertilization rates from 40 to 60 and 80 to 100 kg N/fed, caused increase in grain number/spike by 5.32 to 11.11 and 16.25 % for 4 days irrigation intervals and 5.81 to 12.37 and 17.75 % for 7 days irrigation intervals under perforated pipe system.

### *5- 1000 grain mass:*

Values of 1000 grains mass showed a marked response to irrigation intervals and nitrogen fertilization (fig.5) increases in the mass of 1000 grains were obtained with decreasing the irrigation intervals and increasing nitrogen fertilization rates. The greatest values of 1000 grain mass of 36 g were obtained using at nitrogen fertilization rate of 100 kg and irrigation intervals 4 days under sprinkler system, while the lowest value was 29.8 g for 40 kg N/fed and 7 days irrigation intervals under perforated pipe system.

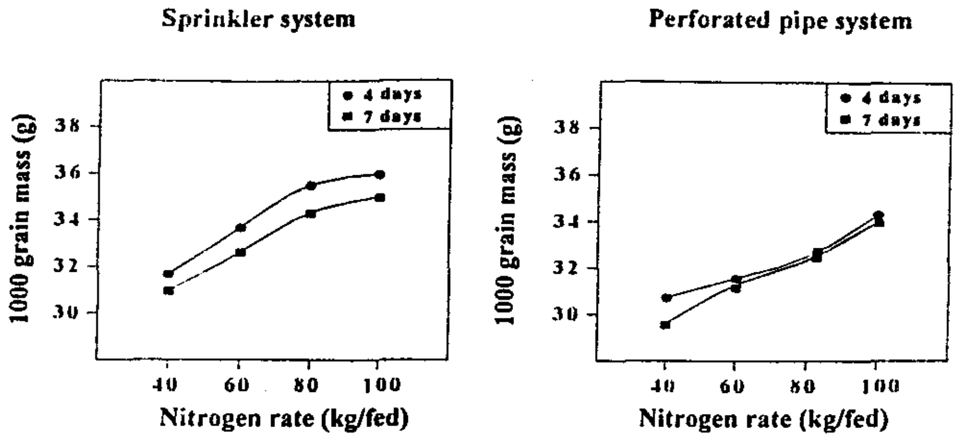



**Fig. (5): Effect of irrigation systems, irrigation intervals and nitrogen rates on 1000 grain mass.**

***6- Spike grain mass:***

Fig. (6) includes data of spike grain mass as influenced by irrigation intervals, nitrogen fertilization and irrigation system.
Spike grain mass is a function of both spike grain number and grain mass. Increasing nitrogen rates has increased both 1000 grain mass as well as spike grain number. The result is reduced spike grain mass under the irrigation intervals (7 days) and nitrogen fertilization rate 40 kg N/fed as compared with irrigation intervals (4 days) and the other three nitrogen rates.

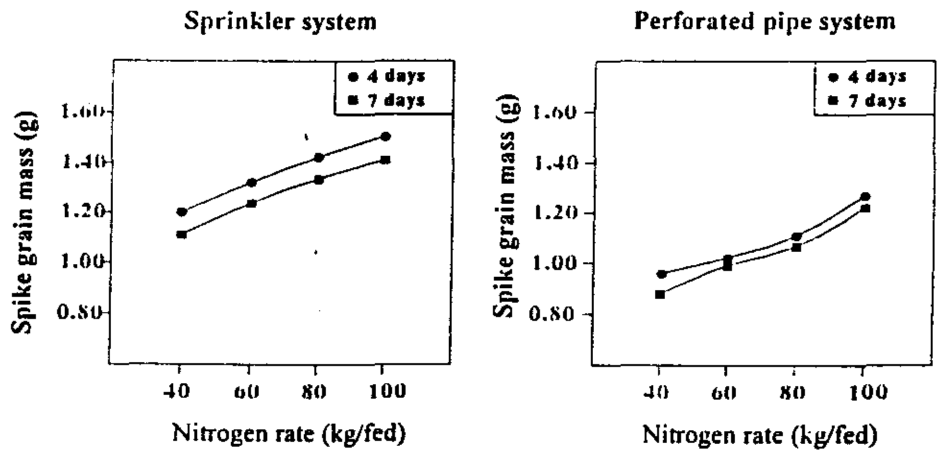



**Fig. (6): Effect of irrigation systems, irrigation intervals and nitrogen rates on spike grain mass.**

*7- Grain yield*

The grain yield recorded in tons/feddan as influenced by irrigation intervals and nitrogen fertilization under sprinkler and perforated pipe systems are presented in fig.(7). Results show that the average grain yield with sprinkler system increased by 15.43 and 16.08 % compared with perforated pipe system under 4 and 7 days irrigation intervals. Decreasing irrigation intervals from 7 to 4 days, the average grain yield increased by 11.73 and 12.41% under sprinkler and perforated pipe systems. The grain yield was affected by nitrogen fertilization. Its highest value was obtained from the plants receiving100 kg N/fed.

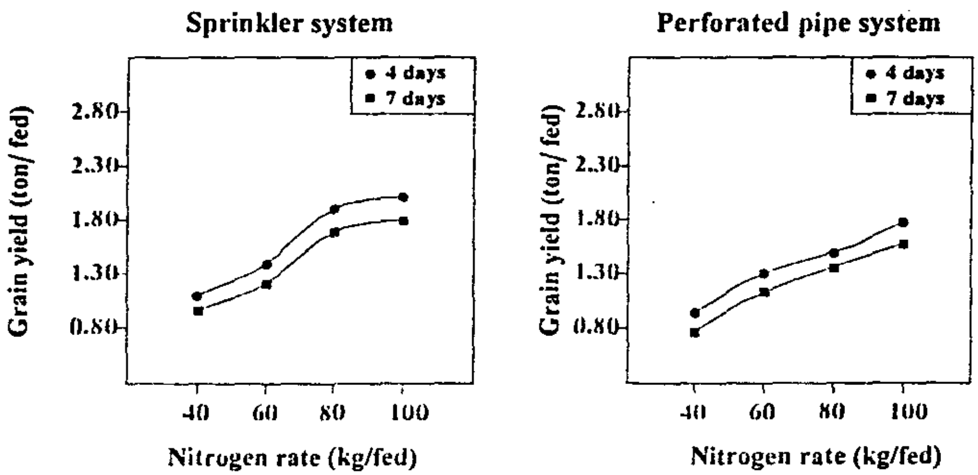



**Fig. (7): Effect of irrigation systems, irrigation intervals and nitrogen rates on total grain yield.**

The highest grain yields of 2.08 and 1.9 ton/fed were obtained by using irrigation intervals 4 days at applying of 100 and 80 kg N/fed under sprinkler system, while the lowest values of 0.76 and 0.92 ton/fed for 4 and 7 days with 40 kg N/fed under perforated pipe system .

*8- Straw yield*

Straw yield, as affected by irrigation intervals and nitrogen fertilization, is presented in fig. (8). Data show increasing the straw yield by decreasing irrigation intervals and increasing nitrogen fertilization rates. The highest values of straw yield of 5.28 and 5.00 ton/fed were obtained with irrigation intervals 4 days at 100 and 80 kg N/fed under sprinkler system. While the lowest values were 3.0 and 3.08 ton /fed for 40 kg N /fed with 7 days under sprinkler and perforated pipe systems respectively.

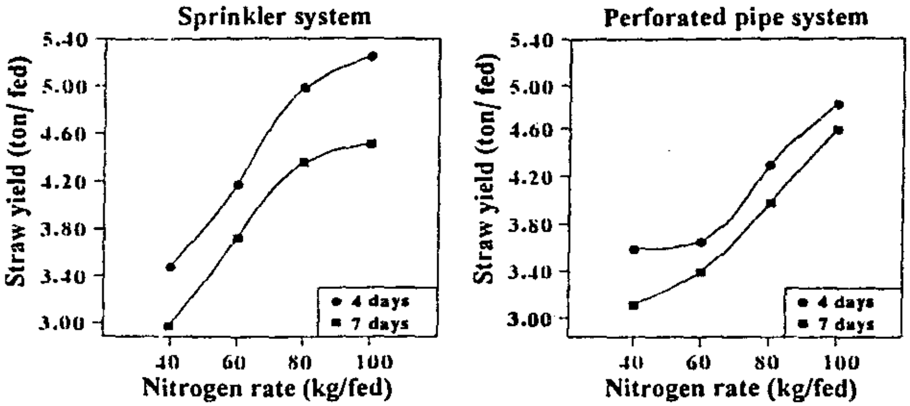



**Fig. (8): Effect of irrigation systems, irrigation intervals and nitrogen rates on straw yield.**

### *B-Water use efficiency "WUE"*

Data in fig. (9) show that WUE increased by decreasing irrigation intervals from 7 to 4 days and increasing nitrogen rates form 40 to 100 kg N/fed, mainly due to the increase in grain yield, but the lowest value was obtained when using 40 kg N/fed at 7 days under perforated pipe system.

The highest WUE of 1.33 kg grain /$m^3$ was obtained when using 100 kg N/fed with 4 day irrigation intervals under sprinkler system . Decreasing irrigation intervals from 7 to 4 days, the average WUE increased by 11.54 and 12.5 % under sprinkler and perforated pipe systems. WUE increased by 15.39 and 16.3 % at sprinkler system compared with perforated pipe system under 4 and 7 days irrigation intervals.

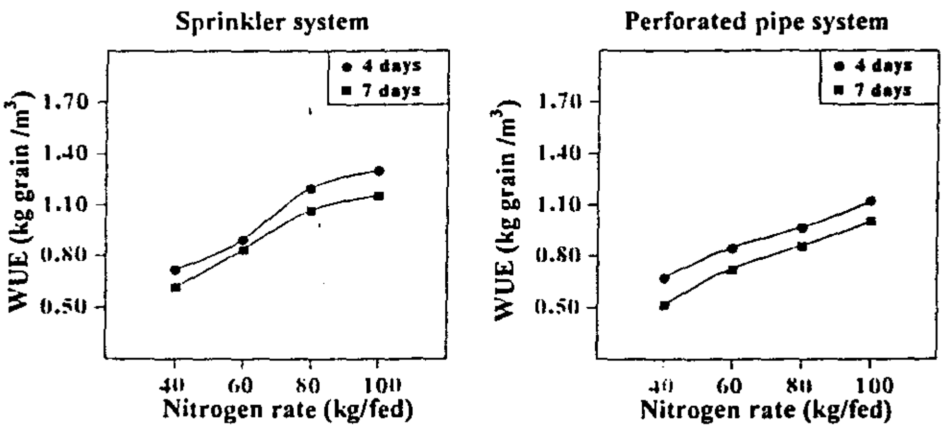



**Fig. (9): Effect of irrigation systems, irrigation intervals and nitrogen rates on water use efficiency.**

### *C- Fertilizer use efficiency "FUE"*

The highest and lowest FUE were obtained by applying 40 and 100 kg N/fed ( fig. 10 ) . The highest FUE values of 27.25 and 24 kg grain /kg N were obtained at nitrogen fertilization rate of 40 kg N/fed for 4 and 7 days irrigation intervals under sprinkler system, but the lowest value of 15.8 kg grain /kg N at 100 kg N/fed for 7 days under perforated pipe system. Increasing nitrogen fertilization rates form 40 to 100 kg N/fed, the FUE decreased by 31.49 and 34.08% for 4 and 7 days irrigation intervals under sprinkler system.

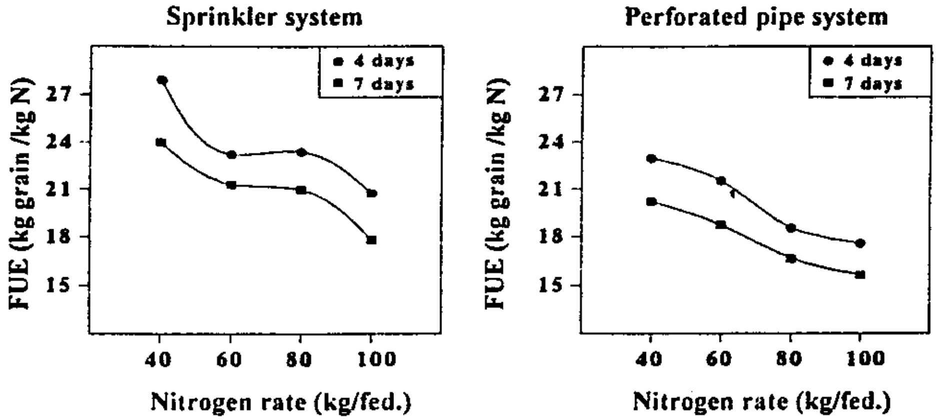



**Fig (10): Effect of irrigation systems, irrigation intervals and nitrogen rates on fertilizer use efficiency.**

~~Increasing~~ irrigation intervals from 4 to 7 days, the average FUE values decreased by 11.40 and 12.42% under sprinkler and perforated pipe systems. The average FUE values with sprinkler system increased by 17.67 and 18.61% compared with perforated pipe system under 4 and 7 days irrigation intervals. The best FUE values were obtained for 40 kg N/fed and 4 days irrigation intervals under sprinkler system.

## D- Cost per unit production

The minimum and maximum values of cost per unit production with sprinkler system of 0.19 and 0.3 L.E / kg grain; 0.22 and 0.34 L.E / kg grain with 100 and 40 kg N / fed under 4 and 7 days irrigation intervals, but the minimum and maximum values with perforated pipe system of 0.22 and 0.34 L.E / kg grain; 0.25 and 0.41 L.E / kg grain respectively.

## CONCLUSION

This research aimed to select the proper sprinkler irrigation system, irrigation intervals and nitrogen fertilization rates in reclaimed soil. The study reverted to the following points, which gives maximum wheat yield, yield components, water use efficiency and lowest cost per unit production.

The main conclusions are summarized as follows:

1- Sprinkler irrigation using sprinklers is considered the suitable system for irrigation.

2- Irrigation intervals were 4 days.

3- Nitrogen fertilization rates ranged from 80 to 100 kg N/fed.

## REFERENCES


Awad, Y.H. (1998): Newly reclaimed soil and wheat yield as affected by FYM and gypsum under different irrigation regimes. Zagazig J. Agric. Res., 25 ( ): 671- 677.

Badr A.E. (1993): Water extraction efficiency and water use efficiency by wheat grown under high and low frequency irrigations. Misr J. Agric. Eng., 10(2): 253-266.

El-Bana A.Y.A. and Aly R. (1993): Effect of nitrogen fertilization levels on yield and yield attrib[illegible] of some wheat cultivars (Triticum aestivum) in newly cultivated sandy soil. Zagazig J. Agric. Res., 20(6): 1739-1749.

El-Hawary M.A.(2000): Evaluation of some wheat varieties under water deficit conditions. Zagazig J. Agric. Res., 27 (4):819-830.

El-Monoufi M.M. and Harb O.M.S. (1994): Grain yield and yield components of wheat as affected by water stress at different plant age. Zagazig J. Agric. Res., 21(4): 1023-1028.

El-Sherbiny A.E; Awad E.A.M.and Soliman K.G.(1999):Effect of different sources and rates of nitrogen fertilizers under different levels of potassium fertilization on wheat crop in Newly cultivated soil. Zagazig J. Agric. Res., 26(6): 1837-1853.

Gad El-Rab G.M.; Ainer N.G and Eid H.M. (1988): Water stress in relation to yield of wheat and some water relations in wheat. Egypt. J. Soil Sci., 28(4) :433-445.

Omer M.S. and Aziz M.A (1983): The effect of soil moisture depletion on wheat production. Egypt J. Soil Sci.,23(1):1-7.

Proffitt A.P.B.; Berliner P.R. and Osterhuis D.M.O (1985): Acomparative study of root distribution and water extraction efficiency by wheat grown under high and low frequency irrigation. Agro. J. 77 (5),: 655- 662.

Sobh, M.M. (1997): Wheat response to nitrogen and Zn-application and different water regimes in northern delta soils. Zagazig J. Agric. Res., 24 (5) : 905-913.

Wahdan A.A, El-Naggar I.M.; Hanna A.M. and El- Awag T.I. (1996): Wheat response to irrigation regime and nitrogen fertilization. Zagazig J. Agric. Res., 23 (5): 851-865.

# تأثير الري بالرش والتسميد النيتروجيني على إنتاج القمح في الأراضي المستصلحة

السادات إبراهيم عبد العال*

يعتبر ضعف خصوبة الأرض الرملية وقلة احتفاظها بالمياه من أهم مشكلاتها وحيث أن القمح أحد المحاصيل الإستراتيجية في مصر . لذلك اتجه التفكير في هذا البحث إلى دراسة تقييم اثر الفترة بين الريات ، وإضافة معدلات من التسميد النيتروجيني تحت نظامي الري باستخدام الرشاشات والأنابيب المثقبة ، بهدف الحصول على أعلى نمو ومحصول وكفاءة استخدام للمياه والتسميد واقل تكاليف لإنتاج الطن من محصول القمح في هذه الأراضي.

وقد اختيرت لهذه الدراسة فترتان بين الريات هما ٤ و ٧ أيام و ٤ معدلات من التسميد النيتروجيني وهي ٤٠ و ٦٠ و٨٠ و١٠٠ كج نيتروجين /فدان تحت نظامي الري بالرش ( باستخدام الرشاشات ) والأنابيب المثقبة .

ولقد دلت النتائج المتحصل عليها أن زيادة الفترة بين الريات من ٤ إلى ٧ أيام تؤدى إلى نقص في المحصول ومكوناته ، بينما أدت زيادة إضافة النيتروجين من ٤٠ إلى ١٠٠ كج/ فدان إلى زيادة في المحصول ومكوناته . كما أعطى الرى بالرش أعلى محصول للفدان وأعلى كفاءة لاستخدام المياه والتسميد النيتروجيني واقل تكلفة لإنتاج الوحدة (كج حبوب) من المحصول مقارنة بالري باستخدام الأنابيب المثقبة .

توصى الدراسة باستخدام نظام الري بالرش باستخدام الرشاشات وبفترة بين الريات ٤ أيام وبمعدل تسميد نيتروجيني يتراوح من ٨٠ : ١٠٠ كج نيتروجين/ فدان ، عند زراعة القمح في الأراضي الرملية المستصلحة حديثاً، للحصول على أعلى محصول ، وكذلك أعلى كفاءة لاستخدام المياه واقل تكلفة لإنتاج كيلو جرام حبوب من المحصول .

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