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EFFECT OF DIFFERENT BORDER WIDTHS, WATER DISCHARGE AND NITROGEN FERTILIZER LEVELS ON SOME IRRIGATION EFFICIENCIES AT NORTH NILE DELTA

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ABSTRACT

Two field experiments were conducted during the two growing seasons of study 2004/2005 and 2005/2006 at Sakha Agricultural Research Station Farm to study the effect of different border widths, water discharge and nitrogen fertilizer on irrigation efficiencies.

The split split plot design with four replicates was used. The main plots randomly assigned to three border width (7, 11 and 15 m), the sub plots to three irrigation discharge (2.5, 3 and 3.5 L. $sec^{-1}m^{-1}$) and the sub sub plots to three nitrogen fertilizer levels; 80, 100 and 120% N from recommended dose (75 kg N fed^{-1}).

The results revealed that the highest values of field and crop water use efficacy by wheat grain yield were obtained from 11 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose. While the highest field water use efficiency by straw yield were achieved from 7 m border width, 3 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose. Moreover, the highest crop water use efficiency by wheat straw yield were obtained from 11m border width, 3 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose.

The highest values of irrigation application efficiency were obtained from 15 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose.

The value of water distribution efficiency was decreased as border width increased specially under water discharge 2.5 and 3 L. $sec^{-1}m^{-1}$. While, it tended to increase under 3.5 L. $sec^{-1}m^{-1}$ water discharge with increasing border width. The opportunity time between advance and recession time of irrigation water to the border end, increased with increasing border width, decreased with increasing irrigation discharge and vice versa.

It could be recommended that the combination of 11 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose achieved the best irrigation performances followed by 15 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose at North Nile Delta.

INTRODUCTION

Border irrigation is a wide practiced method of surface irrigation. It is considered as one of the most important methods of surface irrigation in Egypt. Surface irrigation is currently implemented on most of the irrigated land in Egypt, generally at low levels of performance (e.g., poor application efficiencies).

Improper on-farm irrigation practices lead to poor water distribution, non-uniform crop growth, excessive leaching and insufficient leaching in others (leaching to soil salinity build up), all of which decreased the yield per unit of water applied.

Improvements of irrigation practices such as precision leveling, proper strip length and width and appropriate flow rate lead to good uniform water distribution, soil and water conservation and economic viability of irrigated agriculture. Thus efficient on-farm irrigation methods are necessary for increasing crop production per unit of water applied i.e. crop water productivity.

Low flow rates and long fields, where advance times are long, contribute to large differences in intake opportunity time and reduce uniformity. This is particularly a problem if water disappear at about the same time rather than receding first at the in let and later at the distal end of the field. Hydraulically rough, flat or very gently sloping, trashy or vegetated fields further impede advance and decrease uniformity (Evans *et al.,* 1987).

Saied (1992) summarized that the value of water application efficiencies was increased with the 2.0 m^3 min^{-1}. water discharge rate. Relating to crop and field water use efficiencies the highest values were obtained from 1 m^3 min^{-1}. water discharge rate.

El-Mowelhi *et al.* (1995 a, b and c) found that the border lengths, clearly evident from the data that border length of 100 m achieved the highest values of field water use efficiency being 0.53 and 1.71 kg m^{-3} for wheat and maize, respectively. While the lowest values obtained under the length of 200 m, were 0.44 and 1.29 kg m^{-3} with the same respect. The same trend as with field water use efficiency and water distribution efficiency was obtained.

El-Saadawy and Abd El-Latif (1998) showed that the good leveling gives high water application efficiency (WAE) under 0.1% slope. It is also better to use 50 m irrigation border length because it gives the highest WUE. So, it is very important to make accurate land leveling and border length to rationalize of water use and save each droplet.

El-Mowelhi *et al.* (1999 a, b and c) revealed that the highest values of water storage efficiency were achieved with border length of 50 and 100 m, border width 15 m, stream size of 4 L sec^{-1} m^{-1} under precision land leveling. The stream size of the 6 L sec^{-1} m^{-1} achieved the highest values of water distribution efficiency followed by the 4 L sec^{-1} m^{-1}. While the lowest mean values were achieved by stream size of 2 L sec^{-1} m^{-1}. The values of water distribution efficiency were lower with maize than with wheat.

The best performances were obtained for alternate long furrows adopting the inflow rate of 1.8 L (s furrow), which produced high application efficiency and distribution uniformity, superior to 80 and 83%, respectively, and led to seasonal water savings from 200 to 300 mm when compared with actual water use in every furrow irrigation (Horst *et al.,* 2005).

MATERIALS AND METHODS

Two field experiments were conduced during the two growing seasons of 2004/2005 and 2005/2006 at Sakha Agriculture Research Station Farm to study the effect of different border width, irrigation water discharges and nitrogen fertilizer levels on irrigation efficiencies. Some physical and chemical properties of experimental field are shown in Table (1). They were determined according to Standard Methods after Vomocil (1957), Black (1965), Jackson (1967), and Garcia (1979).

Table (1): Main physical and chemical properties of soil experimental field during the two seasons of study.

Seasons of study	Soil moisture characteristics % (0-60 cm)			Soil pH (1: 2.5)	EC, dSm^{-1}	Bulk density, $g\ cm^{-3}$	Texture class
	F.C.	W.P	A.S.M.				
2004/2005	39.34	21.43	17.90	7.99	1.75	1.22	Clay
2005/2006	39.41	21.01	18.40	8.05	2.1	1.20	Clay

A split split plot design with four replicates was used, the main plots were assigned for border widths, the sub plots were irrigation water discharge and sub sub plots assigned to nitrogen fertilizer levels. These treatments were carried out under cultivation of wheat crop as follows:

- Border widths (W): 7, 11 and 15 m.
- Irrigation water discharges (D): 2.5, 3.0 and 3.5 L. $sec^{-1}m^{-1}$.
- Nitrogen fertilizer levels (N): 80, 100, 120% from recommended dose.

Wheat crop variety Sakha 93 was cultivated on Nov. 18th and harvested on May 7th, 2004/2005 in the first season. While, in the second season the same variety was planted in Nov. 23rd, 2005/2006 and harvested in May 2nd.

Water measurements:

Field water use efficiency (FWUE): It was calculated according to the following equation, after Michael (1978).

$$\text{FWUE} = \frac{Y}{Wa}$$

Where:

Y = Yield in kg/fed.

Wa = Total amount of water applied (m^3/fed.).

Crop water use efficiency (CWUE): It was calculated according to the following equation. After Michael (1978).

$$\text{CWUE} = \frac{Y}{ET}$$

Where:

Y = Yield (kg/fed.)

ET = Evapotranspiration (m^3/fed.)

Determination of advance rates recession time and calculate the opportunity times were recorded at each station, Garcia (1979).

Water application efficiency (Ea): It was obtained by dividing the volume of water stored in the root zone to the applied irrigation (Downy; 1970).

$$Ea = \frac{Wa - (D + R)}{Wa} \times 100$$

Where:

Wa : Water applied (cm).
D : Deep percolation (cm).
R : water run off (cm).

Water distribution efficiency: it was calculated from the following equation, after Michael (1978)

$$Ed = \left(1 - \frac{y}{d}\right) \times 100$$

Where:

Ed = Water distribution efficiency
d = Average depth of water infiltrated along the furrow length.
y = Average numerical deviation form d.

Statistical analysis:

Almost all the data collected were subjected to the statistical analysis according to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

1. Field water use efficiency (kg m^{-3}):

Field water use efficiency as affected by different treatments under cultivation of wheat crop show is in Table (2). The highest values of field water use efficiency by grain yield (1.26 and 1.27 kg m^{-3}) were obtained from 11 m border width, 3.5 L. sec^{-1} m^{-1}) water discharge and 120% N from recommended dose. While, the lowest values 0.80 and 0.81 kg m^{-3} were obtained from 7 m border width, 2.5 L. sec^{-1} m^{-1} water discharge and 80% N from recommended dose in the two seasons, respectively.

The highest values 2.53 and 2.58 kg m^{-3} of field water use efficiency by straw yield were obtained from 7 m border width, 3 L sec^{-1} m^{-1} water discharge and 120% N from recommended dose, while the lowest values 1.31 and 1.22 kg m^{-3} were obtained from 11 m border width, 3.5 L. $sec^{1}m^{-1}$ water discharge and 80% N from recommended dose in the two season of study, respectively. These results are in good agreement with those obtained by Saied (1992).

2. Crop water use efficiency:

Data in Table (3) represent the values of crop water use efficiency (kg m^{-3}) as affected by different treatments for wheat crop. The highest values of crop water use efficiency 1.62 and 1.82 kg m^{-3} for wheat grain was realized under 11 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose, while the lowest values (1.15 and 1.01 kg m^{-3}) were obtained from 15 m border width, 2.5 L. $sec^{-1}m^{-1}$ water discharge and 80% N from recommended dose in the two seasons, respectively.

Table (2): Field water use efficiency (kg m^{-3}) as affected by different treatments

Treatments			2004/2005		2005/2006	
m	L sec^{-1} m^{-1}	N %	Grain	Straw	Grain	Straw
7	2.5	80	0.80	1.55	0.81	1.84
		100	0.87	1.80	0.90	1.86
		120	0.93	1.88	0.98	2.02
	3.0	80	0.93	2.28	0.87	2.47
		100	0.97	2.35	0.98	2.48
		120	1.06	2.53	0.99	2.58
	3.5	80	0.89	1.84	0.87	1.83
		100	1.01	2.04	1.08	2.21
		120	1.02	2.38	1.10	2.37
11	2.5	80	0.85	1.76	0.70	1.85
		100	0.93	2.00	0.76	2.01
		120	0.94	2.01	0.93	2.11
	3.0	80	0.95	1.80	0.95	1.75
		100	0.97	1.98	0.98	1.86
		120	1.08	2.25	1.02	2.06
	3.5	80	1.00	1.91	0.97	2.02
		100	1.00	2.04	1.03	2.13
		120	1.26	2.19	1.27	2.22
15	2.5	80	0.76	1.31	0.69	1.22
		100	0.81	1.55	0.74	1.33
		120	0.85	1.79	0.89	1.69
	3.0	80	0.85	1.58	0.89	1.57
		100	0.87	1.69	0.96	1.93
		120	0.98	1.80	1.09	2.10
	3.5	80	1.04	1.90	0.86	1.68
		100	1.10	2.03	1.04	1.93
		120	1.13	2.13	1.13	2.11

Table (3): Crop water use efficiency as affected by different treatments.

Treatments			Crop water use efficiency kg m^{-3} 2004/2005		Crop water use efficiency kg/m^{3} 2005/2006	
m	L sec^{-1} m^{-1}	N %	Grain	Straw	Grain	Straw
7	2.5	80	1.17	2.29	1.17	2.69
		100	1.29	2.66	1.26	2.60
		120	1.37	2.75	1.37	3.42
	3	80	1.27	3.09	1.18	3.36
		100	1.31	3.18	1.33	3.32
		120	1.44	3.42	1.30	3.54
	3.5	80	1.30	2.67	1.21	2.54
		100	1.37	2.81	1.41	2.88
		120	1.39	3.31	1.43	3.73
11	2.5	80	1.23	2.59	0.99	25.67
		100	1.36	3.01	1.09	2.85
		120	1.53	3.38	1.30	3.23
	3	80	1.37	2.60	1.34	3.09
		100	1.32	3.33	1.34	3.33
		120	1.45	3.62	1.44	3.51
	3.5	80	1.35	2.53	1.25	2.63
		100	1.33	2.64	1.61	3.23
		120	1.62	2.94	1.82	3.44
15	2.5	80	1.15	2.02	1.01	1.80
		100	1.26	2.36	1.08	1.90
		120	1.28	2.72	1.28	2.43
	3	80	1.20	2.21	1.22	2.17
		100	1.29	2.32	1.24	2.49
		120	1.37	2.55	1.45	2.79
	3.5	80	1.36	2.55	1.09	2.04
		100	1.47	2.61	1.30	2.36
		120	1.45	3.13	1.41	2.61

It wheat straw the highest values of crop water use efficiency 3.62 ad 3.51 kg m^{-3} were obtained from 11 m border width, 3 L. sec^{-1} m^{-1} water discharge and 120% N from recommended dose. While the lowest values 2.02 and 1.80 kg m^{-3} were obtained from 15 m border width, 2.5 L. sec^{-1} m^{-1} water discharge and 80% N from recommended dose in the two seasons, respectively. These results agree with those reported by El-Mowelhi *et al.* (1995a, b and d).

3. Water application efficiency:

Data in Table (4) and Fig. (1) show the irrigation application efficiency. The highest 67.85 and 65.36% were obtained from 7 m border width, 3.0 L. sec^{-1} m^{-1} water discharge and 120% N in both seasons. Whereas, the lowest values 58.95% were obtained from 11 m border width, 2.5 L. sec^{-1} m^{-1} water discharge and 80% N in the first seasons. Mean while for the second season the lowest values 53.71% were obtained from 15 border width, 3 L. sec^{-1} m^{-1} water discharge and 80% N. These results agreed with those reported by El-Saadawy and Abd El-Latif (1998).

Table (4): Values of water application and distribution efficiencies (%) under different treatments for wheat crop during the two seasons.

Border Widths	Water discharge L. sec^{-1} m^{-1}	2004/2005		2005/2006	
		Ea %	Ed%	Ea %	Ed%
7	2.5	66.80	72.56	63.36	71.32
	3.0	67.85	73.18	65.36	72.57
	3.5	62.88	68.91	63.35	67.35
11	2.5	58.95	64.15	56.63	65.72
	3.0	64.64	69.72	60.08	68.18
	3.5	66.61	71.09	59.38	70.56
15	2.5	59.10	66.18	53.96	64.56
	3.0	63.25	67.32	53.71	66.73
	3.5	66.09	71.25	58.21	70.54

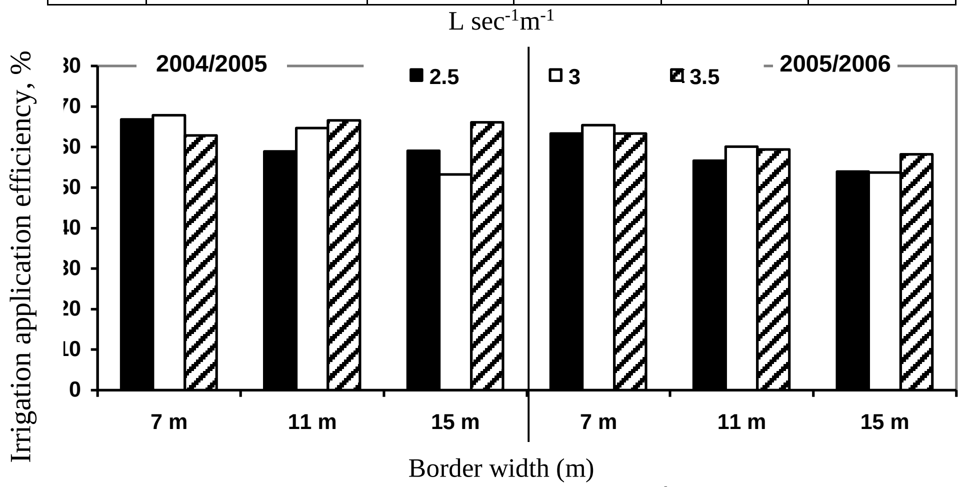


Fig. (1): Irrigation application efficiency %[1].

4. Water distribution efficiency:

Data in Table (4) and Fig. (2) show, data revealed the water distribution efficiency in both seasons. Found that the value of water distribution efficiency was decreased as border width increased specially under water discharge 2.5 and 3 L. sec^{-1} m^{-1}. While it tend to increase under 3.5 L. $sec^{-1}m^{-1}$ with increasing border width. The highest values of water distribution efficiency 73.18 and 72.57% were obtained with 7 m border width and 3 L. $sec^{-1}m^{-1}$ water discharge. The lowest value of WDE of 64.15 and 64.56% was obtained from 2.5 L. $sec^{-1}m^{-1}$ water discharge under width border 11 m and 15 m treatments in the first and second seasons, respectively. These results agree with those reported by Horst *et al.* (2005).

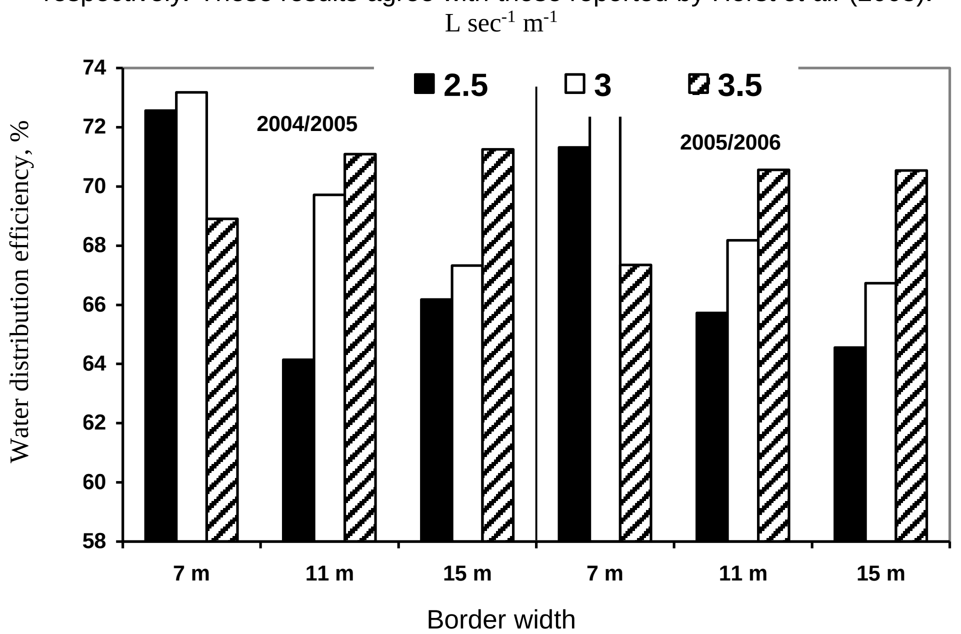


Fig. (2): Values of water distribution efficiency (WDE%) under different treatments for wheat crop during growing seasons 2004/2005 and 2005/2006.

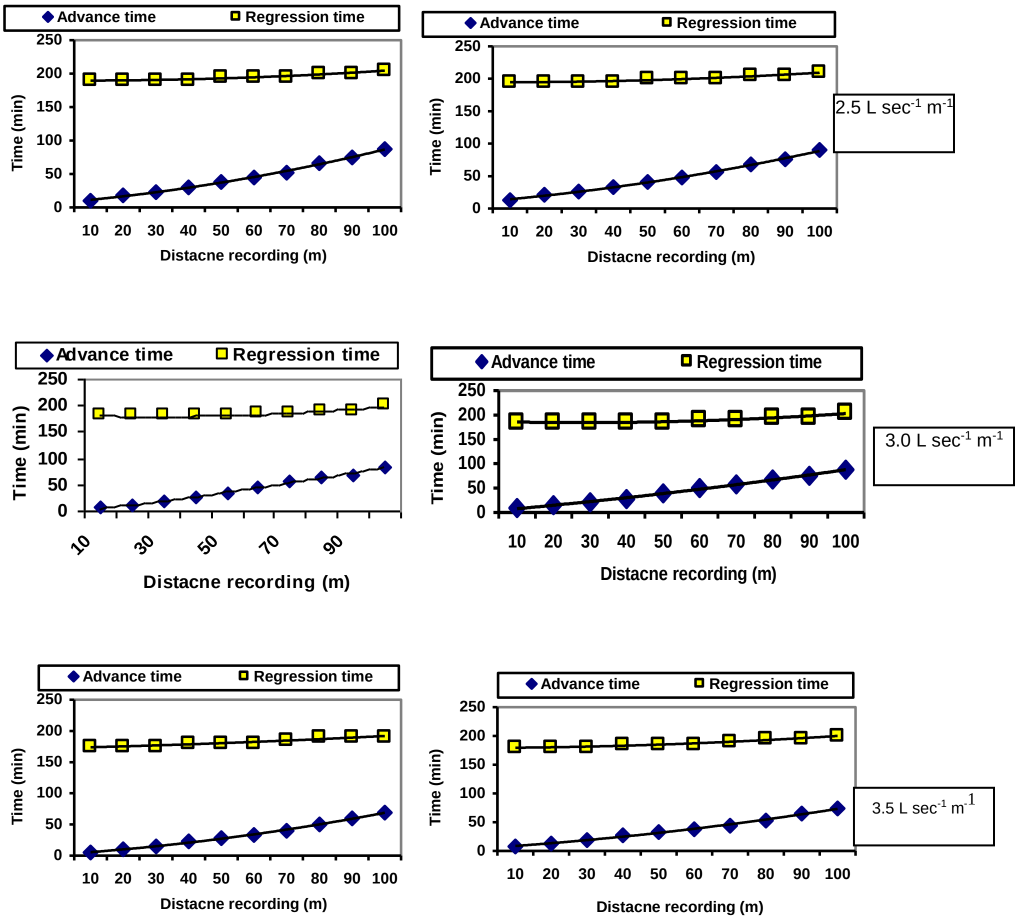
Time of water advance and recession:

Fig. (3) show the effect of width of border and irrigation discharge on advance and recession in the two seasons of study. The irrigation time depended on water advance time while the opportunity intake time depended on both water advance and water recession times. Therefore it is important to study water advance and water recession times.

Fig. (3) show also that the opportunity time raised from advance and recession time of irrigation water to the border end, increased with increasing border width, and decreased with increasing irrigation discharge and vice versa. These results with the same direction with those reported by (Evans *et al.,* 1987).

It could be recommended that the combination of 11 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N achieved the best irrigation performances and highest yield followed by 15 m border width, 3.5 L. $sec^{-1}m^{-1}$ water discharge and 120% N from recommended dose.

Width border 7 m



First season **Second season**

Fig. (3): **The effect of width border and irrigation discharge on advance, recession, and opportunity time in the two seasons.**

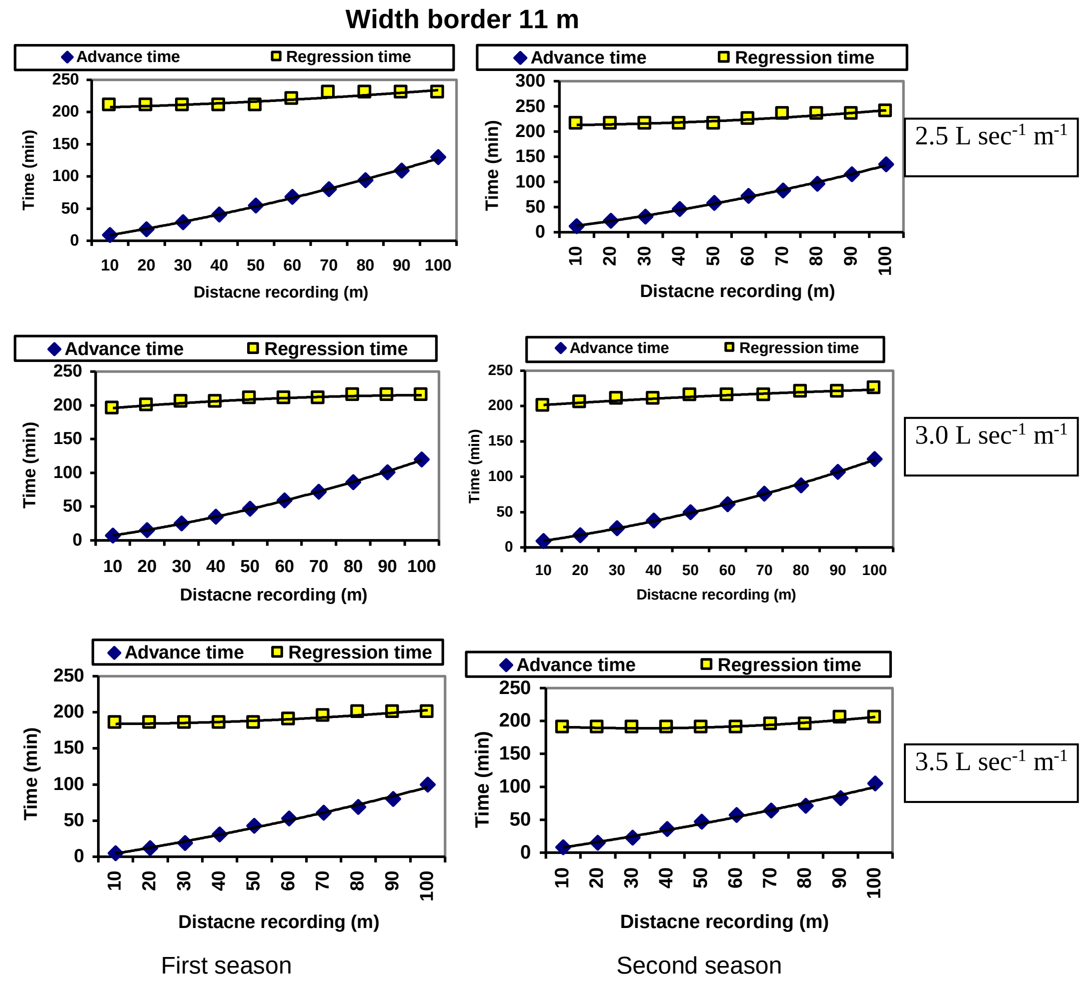
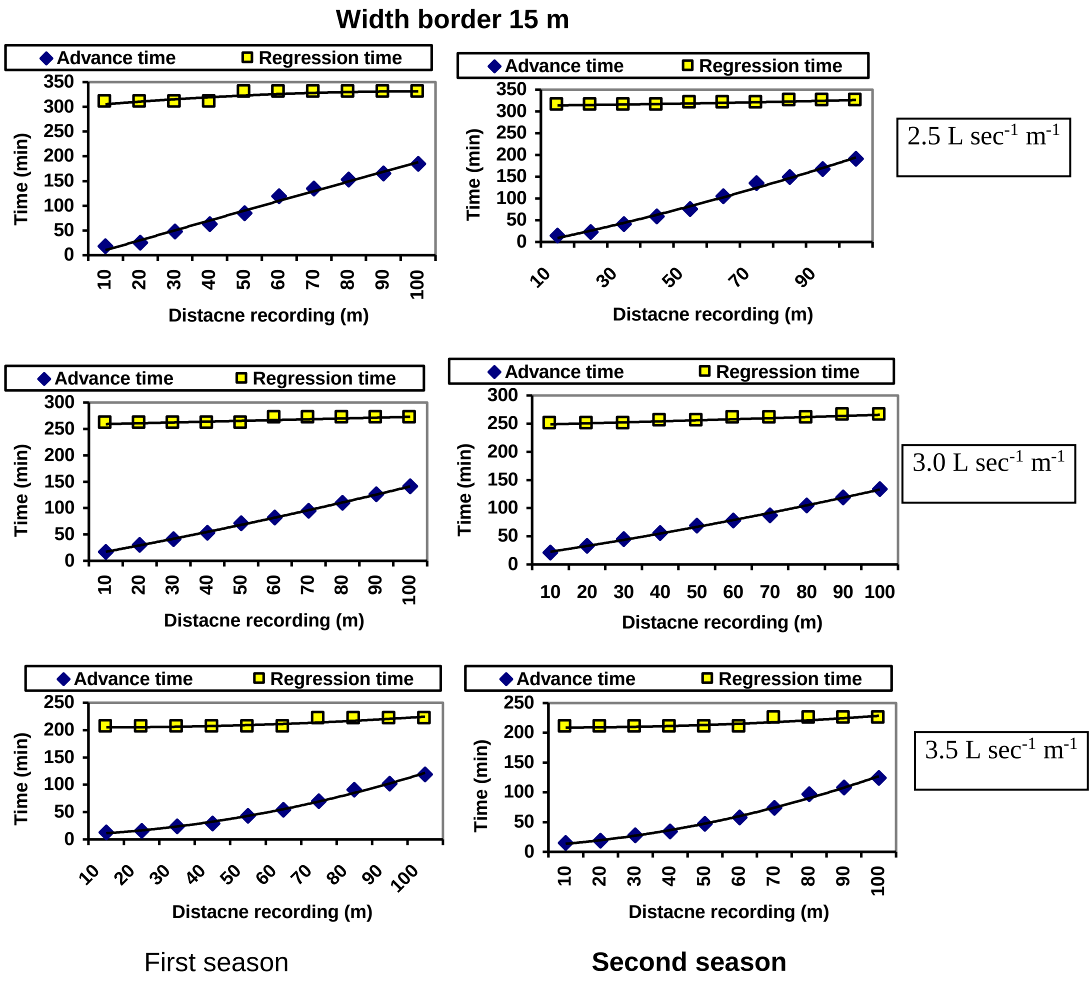

Width border 11 m
Advance time
Regression time
Time (min)
Distacne recording (m)
2.5 L sec-1 m-1
3.0 L sec-1 m-1
3.5 L sec-1 m-1
First season
Second season

Fig. (3) Cont.



Width border 15 m
Advance time
Regression time
Time (min)
Distacne recording (m)
2.5 L sec-1 m-1
3.0 L sec-1 m-1
3.5 L sec-1 m-1
First season
Second season

Fig. (3) Cont.

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دراسة تأثير عرض شريحة الرى وتصرف مياه الرى والتسميد النيتروجينى على كفاءات الرى المختلفة

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أقيمت تجربتين حقليتين بمزرعة محطة البحوث الزراعية بسخا - فى موسمين زراعيين 2005/2004م ، 2006/2005م لدراسة تاثير عروض مختلفة لشريحة الرى وتصرف مياه الرى ومستويات التسميد النيتروجينى على كفاءات الرى المختلفة عند زراعة القمح.

تم تنفيذ التجربة تحت نظام القطع المنشقة مرتين فى أربع مكررات حيث مثلت القطع الرئيسية ثلاث عروض للشرائح (7 ، 11 ، 15 متر) والقطع التحت شقية ثلاث تصرفات لمياه الرى (2.5 ، 3.0 ، 3.5 لتر/ثانية/متر) والقطع التحت شقية ثلاث مستويات للتسميد النيتروجينى (80 ، 100 ، 120%) من الجرعة الموصى بها وهى 75 كجم نتروجين للفدان.

ودلت النتائج على أن أعلى قيمة لكلا من كفاءة استخدام مياه الرى المضاف وكفاءة استخدام المحصول للماء الاستهلاكى فى حبوب القمح عندما كانت عرض الشريحة 11 متر وتصرف مياه الرى 3.5 لتر/ثانية/متر عند مستوى التسميد 120% من الجرعة الموصى بها.

بينما كانت أعلى قيمة لكفاءة استخدام مياه الرى المضافة فى قش القمح عندما كانت عرض الشريحة 7 متر وتصرف مياه الرى 3 لتر/ثانية/متر ومستوى تسميد نيتروجينى 120% من الجرعة الموصى بها وقد كانت أعلى قيمة لكفاءة استخدام المحصول للماء الاستهلاكى لقش القمح عند عرض شريحة 11 متر وتصرف مياه الرى 3 لتر/ثانية/متر عند مستوى تسميد نيتروجينى 120% من الجرعة الموصى بها.

وجد أن أعلى قيمة لكفاءة الرى التطبيقية تحققت عندما كانت عرض الشريحة 15 متر وتصرف مياه الرى 3.5 لتر/ثانية/متر ومستوى تسميد نيتروجينى 120% من الجرعة الموصى بها.

أن كفاءة انتظام توزيع مياه الرى تنقص بزيادة عروض الشرائح خصوصا تحت تصرف مياه 2.5 ، 3.0 لتر/ثانية/متر بينما تزداد تحت تصرف 3.5 لتر/ثانية/متر مع زياد عرض الشريحة.

أن الزمن اللازم لتقدم وانحسار مياه الرى حتى نهاية الشريحة يزداد بزيادة عرض الشريحة ويقل بزيادة التصرف والعكس صحيح.

للحصول على أعلى كفاءات للرى تستخدم شريحة عرضها 11 متر وتصرف مياه الرى 3.5 لتر/ثانية/متر ومستوى تسميد نيتروجينى 120% من الجرعة الموصى بها يلى هذه المعاملة معاملة 15 متر عرض الشريحة 3.5 لتر/ثانية/متر ومستوى تسميد نيتروجينى عند 120% من الجرعة الموصى بها.