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WATER USE EFFICIENCY OF SUGAR CANE CROP AFFECTED BY TRANSPLANTING CULTIVATED METHOD COMPARING WITH CONVENTIONAL METHOD

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ABSTRACT

Two field experiments were carried out at Mallawy Water Requirements Research station – El Minia , Governorate; Egypt Water Management Research Institute – National Water Research Center during 2007 and 2008 seasons. The present research was carried out to study the effect of transplanting method on water use efficiency, yield, saving of water and economic evaluation for sugar can crop (*Saccharum officinarum* L.) and compare it with common conventional cultivation practiced in this region. Four treatments were arranged in a split –plot design. Two of them planting method (normal and transplanting) and the others irrigation systems(furrows and beds).

Results indicated that the planting sugar cane crop by transplanting in beds lead to an increase in productivity with rate equals 19.7% and more water saving (24.33%) per year , decreased both the costs of product materials by about 9.37 %, and the irrigation time by about 31.82% and rising the total irrigation's efficiency by 71.97%. It also saved water by about 785.607770 million m^3/ area (Average area cultivated by sugar cane in Egypt) compared with the traditional method in this region. The results indicated also from the economic view point that , the transplanting method recorded the highest values of field and crop water use efficiencies (7.10 and 10.68 kg/m^3) respectively. Moreover the results indicated that the transplanting method decreased the total cost / fed. The highest values of total income, production, financial benefits (L.E/ area), net return of each and water irrigation (L.E /m^3) and economic efficiency were gained with it. Therefore , the economics of irrigation water becomes very important for planting irrigation management project where the over irrigation practices by farmers usually lead to low irrigation efficiency , water logging and high losses of water.

It could be recommended to application of transplanting method to produce high yield with less amount of water applied under El-Minia province conditions .

INTRODUCTION

Water in Egypt, perhaps more than in any other country , acquires a very high and special economic and social value. Almost all aspects of peoples life and work are centered on water. The quantity and quality of water available to the country is the limiting factor for all development activities. Agriculture, in particular, is totally dependent on irrigation. Water in Egypt is inherently scarce as a result of naturally arid climatic conditions. Population increase and economic growth have acquired higher demands for the limited water resources. The underlying historical perception by people in Egypt and elsewhere in the world that water is free natural resource supports the dominating influence of traditional political and social factors in the management and use of the resource. The increased use of the fixed resource in response to rising demands is not only reducing its availability, but also jeopardizing its quality. In view of the vital importance of water for sustaining life ad prompting development, appropriate approaches and policies are needed to deal with the problems of water scarcity , and the challenges ahead. We certainly need continuing innovation and rationalization in our handling of water, but foremost and above all, we need to develop and put into place, a balanced system for the management of resources . We must work toward a framework for management functions that will integrate considerations of the present and the future , of technology and democracy , of economics and environmental preservation , of growth and security , into informed management and governance practices regarding water .

On other hand , sugar cane (*Saccharum officinarum* L.) is considered to be one of the most important sugar crops all over the world. But in Egypt, sugar cane production faces some problems which developed by time. The main problems nowadays are the limited freshwater supply and water requirements which increased accompanying the increase in temperature degrees and wind speed as well as the reduction in the relative humidity . In addition , soils with low productivity have high water needs .So , it was found that crops grown in the same soil and the same season almost have equal water needs (Moursi, *et al*. 1977, El-Shafai 1996, Chapman and Egan 1997, CCSC, 2003 and ESST, 2006)

Sugar cane is repeatedly accused with having the highest water requirements among field crops. Therefore, some voices have lately risen up demands of the replacement of sugar cane with sugar beet which has relatively lower water needs .

On the other hand the farmer endeavors to increase the productivity of his crop , without putting consideration the limits of water and he does not care with the recommended rates of the required fertilizers . So the transplanting sugar cane crop is considered one of economical benefits methods for increasing plant density compare it with the normal traditional method . The use of transplanting method becomes very important to save water and gained high yield but the high investment of application this method requires well trained skilled labor .Therefore , the introduction of this method lies primarily on the shoulder of government institution , cooperatives and large companies then in the future the transplanting method will started to e widely introduced in Egypt. The aim of this work is to study the effect of transplanting method on water use efficiency , yield , saving water and economic evaluation for sugar cane crop .

MATERIALS AND METHODS

Two field experiments were carried out for two seasons summer and winter of 2007 and 2008 at Mallawy, Water Requirements Research Station – El Minia Governorate; Water Management Research Institute- National Water Research Center to study the effect of transplanting methods on water consumptive use, water applied, water use efficiency, economic evaluation, yield and quality of sugar cane crop .

The experiments were included two planting methods (A) (transplanting method & conventional method) and two irrigation systems (B) (furrow & beds) with four replications, the experiment was arranged in a split plot design. The treatments of planting methods were randomly distributed in the main plots and system irrigation treatments were randomly distributed in the sub-plots. The nursery was prepared beds . The nursery area was about 350 m^2 (20m x 17.5m) which enough to cultivate one feddan of sugar cane in permanent soil. Plastic beds were covered with soil mixture of 2/3 same soil permanent + 1/3 sand planting the nursery as done on 15^{th} of March, while, the time of transplanting was carried out at 90 days after planting in the nursery.

The quantity of water applied was measured in nursery area by cut throat Flum Size (20 x 90 cm) where water applied was added during every irrigation at the end of each growing season the total quantity of water applied was estimated by (m^3/fed.)

Some chemical and physical properties of the experiments soil before soil preparation were estimated according to the procedures outlined by Jackson (1967) are shown in Table (1)

Table (1): Some physical and chemical properties of the experimental soils.

Properties	Season 2007	Season 2008
Clay%	36.92	36.15
Silt%	55.43	54.50
Sand%	7.65	9.35
Texture grade :	**Silty clay loam**	**Silty clay loam**
Organic metter %	1.22	1.18
pH (1:2.5 suspention)	8.10	8.00
Ec m.mohs /cm	1.8	1.6
Soluble cations :		
Ca^{++} (meq/L.)	9.78	8.45
Mg^{++} (meq/L)	2.72	2.75
K^{++} (meq/L)	0.24	0.23
Na^{++} (meq/L)	4.95	4.45
CO_3^{-2} (meq/L.)	-	-
HCO^{-2} (meq/L.)	3.86	3.25
Cl^- (meq/L.)	5.80	4.90
SO_4^{-2} (meq/L.)	8.03	7.70
Available N mg /kg soil	21.1	19.35
Available P (ppm)	8.50	7.85
Exchangeable K mg / kg soil	175	180
Available S (ppm)	7.50	7.25

Soil- water relationships

Recorded data :

Water Measurements

In the two growing seasons , water was measured by using a rectangular sharp crested weir. The discharge was calculated using the following formula :

$$\mathbf{Q = CLH^{3/2}} \quad \text{(Masoud, 1967)}$$

Where:

Q : The discharge in cubic meters per second.

L : The length of the crest in meters.

H : The head in meters.

C: An empirical coefficient that must be determined from discharge measurements .

The quantity of water was measured in studied area (the farmer practices) by cut throat Flume size (20 x 90 cm) where applied water was added during each irrigation and at the end of each growth season the total quantity of water applied was estimated (m^3/ fed.)

Water consumptive use (CU) :

The quantities of water consumptive use were calculated for the 60 cm soil depth which was assumed to be the depth of the root zone as reported by many investigators

Monthly and seasonal water consumptive use were calculated by the summation of water consumed for the different successive irrigation through the whole growth season (Serry *et al*. 1980).Calculation of CU was repeated for all irrigations until the harvesting date

Water consumptive use per feddan (4200m^2) can be obtained by the following equation .

$$CU = \frac{\theta_2 - \theta_1}{100} \times b.d \times \frac{depth}{100} \times area\ (4200 m^2)$$

which described by Israelsen and Hansen, (1962)

Where :

CU= Amount of water consumptive use(m^3/fed) .

θ_2 = Soil moisture content % by weigh after irrigation .

θ_1= Soil moisture content % by weigh before the next irrigation

b.d = Bulk density (g/ cm^3)

Crop water use efficiency (C.W.U.E)

The crop water use efficiency is the weight of marketable crop produced per unit volume of water consumed by plants or the evapotranspition quantity . It was computed for the different treatments by dividing the yield(kg / fed) on units of evapotranspiration expressed as cubic meters of water per fed. (Abd El- Rasool *et al*. 1971) It was calculated by the following formula .

$$C.W.U.E = \frac{\text{Yield (kg / fed.)}}{\text{Water consumptive use (} m^3 \text{ / fed.)}} = (kg/m^3)$$

Field water use efficiency (F.W.U.E .)

Field water use efficiency is the weight of markertable crop produced per the volume unit of applied irrigation which was expressed as cubic meters of water (Michael , 1978).

It was calculated by the following equation :

$$F.W.U.E. = \frac{\text{Yield (kg/fed.)}}{\text{Water applied } (m^3\text{/fed.})} = (kg/m^3)$$

Water application efficiency (E_a) :

The values of water application efficiency (E_a) in percent for each treatment were obtained by dividing the total consumptive use on the applied irrigation water (**Downy , 1970)**

$$E_a = \left(\frac{Ws}{Wd} \times 100 \right)$$

Where :

Ea = Water application efficiency .   (%)
Ws = Water stored in the root zone . ($m^{3/}$ fed.)
Wd= Water applied to the field plot . ($m^{3/}$ fed.)

Water distribution efficiency (Ed) :

It was calculated according to Jame (1998) as follow :=

$$E_d = (1- \frac{y}{d}) \times 100$$

where :-

E_d = Water distribution efficiency (%)

d- Average of soil water depth stored in long the furrow during the irrigation.(cm)

y = Average numerical deviation from d (cm)

Storage efficiency (E_s) :

Values of storage efficiency (E_s) in percent for each treatment were obtained by dividing the total water storage on the amount quantity of irrigation water that must be added before irrigation (Sharl Sh.S. 1991)

$$E_s = \left(\frac{W_s}{W_m} \times 100 \right)$$

Where :

E_s = water storage efficiency (%) .
W_s = water storage in the root zone (m^3/ fed.)
W_m= the amount of irrigation water that must be added before irrigation (m^3/fed.)

Economic efficiency :

The economic efficiency refers to the combination of inputs that maximize individual or social objectives . Economic efficiency is defined in terms of two condition : necessity and sufficiency . Necessary conditions are met in the production process when they are is producing the same amount with fewer inputs or producing more with the same amount of inputs .But , the sufficient condition encompasses individual or social goals and values (John and Frenk 1987) It was calculated by the formula :

$$\text{Economic efficiency} = \frac{\text{Net profit (L.E/ fed)}}{\text{Total costs (L.E /fed)}}$$

Quality determination

1-Millable cane yield (ton /fed) : cane stalks of the four inner rows were harvested topped , cleaned , weighed and cane yield was calculated as ton/ fed.

2-Recoverable sugar yield (ton / fed) : was estimated according to the Recoverable sugar yield (ton / fed) = Millable cane yield (ton/ fed) x Purity % Pol %

3-Purity % juice was calculated as in Satisha *et al* . (1996) using the follow formula :

Purity % = Surose % x 100 ÷ TSS % (Total soluble solids) was determined using " Brix hydrometer" standardized at 20C° as in A.O.A.C . (1995)

4-Pol % cane of cane stalks was calculated y the following equation after determination of sucrose % in the cane juice using succharometer according to AOAC (1995).

Pol% = { Brix % -(Brix % -sucrose %)0.4} 0.73

Statistical analysis :

The proper statistical analysis of all data was carried out according to Gomez and Gomez (1984) . Homogeneity of variance was examined before combined analysis the differences between means of the different treatments were compared using the least significant difference (LSD)at 5% level .

RESULTS AND DISCUSSION

1-Total yield (ton/ fed) and quality :

Total yields (ton / fed.) as well as its quality properties expressed as pol % cane and purity % juices % as influenced by the different planting methods and irrigation systems were presented in Table (2) . The results show the planting method and system irrigation had a significant effect on millable cane and recoverable sugar cane crop The highest values of millable cane and recoverable sugar yields were obtained from transplanting method in beds (55.800 and 6.58 ton / fed.) respectively . While the lowest values of millable cane and recoverable sugar yields of sugar cane were obtained from conventional method in furrow (common method in experimental region) (46.60 and 5.66 ton / fed) respectively. These results are in agreement with those reported by El- Monoufi (1993), Tantaway (1999) and Abdel Rheem *et al* (2008) . In general , the transplanting method in (furrow & beds) produced highest values of total yield and recoverable sugar yield, so planting the sugar cane by transplanting method solves the problem of decreasing of the productivity, which faces the farmers planting sugar cane in late planting (in the end of May) after wheat crop . So many farmers using chemicals fertilizer , with rates higher than the recommended to increase the yield , that leads to increase the product costs in condition of high prices of the current chemical fertilizers add to that negative effect , of using the chemical fertilizer on the environment, soil and quality of ground water over the years .So transplanting method is responsible for obtaining a high productivity of sugar cane with least possible amount of water applied .

Generally, it can be concluded that the planting method is preferable under the Egyptian conditions for sugar cane because it gaves higher values of millable cane, recoverable sugar yield, pol% cane and purity % juice of sugar cane. In addition there was a positive correlation between both millable cane and recoverable sugar yields of sugar cane .Transplanting can be consider as an important criterion in improvement of sugar cane productivity.

Table (2): Productivity and sugar cane quality as affected by planting method and irrigation system (combined between 2007 and 2008 seasons)

Property	Planting method (A)						LSD 0.05		
	Transplanting methods			Normal planting (common conventional method)					
	Irrigation system (B)						A	B	AB
	Furrow	Beds	Mean	Furrow	Beds	Mean			
Cane yield, ton/ fed	55.50	55.80	55.65	46.60	47.10	46.85	2.06	-	1.07
Sugar yield, ton/ fed	6.55	6.58	6.85	5.66	5.78	5.72	0.46	-	0.19
TSS%	21.33	21.50	21.42	21.83	22.17	22.00	-	-	-
Sucrose %	17.46	17.65	17.56	18.08	18.31	18.20	-	-	-
Purity %	81.86	82.09	81.98	82.82	82.59	82.71	0.51	-	-
Pol %	14.44	14.57	14.51	14.84	15.06	14.95	-	-	-
Sugar recovery %	11.63	11.77	11.70	12.10	1226	12.18	0.44	-	-
Reducing sugar %	0.32	0.35	0.34	0.41	0.40	0.41	0.10	-	-

2-Seasonal irrigation water applied :

Average of the amounts of water applied delivered (m^3/ fed) to different planting methods of sugar cane crop are shown in Table (3) . the irrigation water applied for sugar cane plants were 10382.5 and 8565.57 m^3/fed for normal planting method under (furrow & beds), respectively and 9671.45 and 7856.43 m^3/ fed. for transplanting method in (furrow & beds) respectively. It is obvious that the lowest values of water applied was 7856.43 m^3/fed obtained from transplanting method in beds, whereas the highest values were 10382.5 m^3/ fed. obtained form normal planting in furrow.

Table (3): Average of the quantity of water applied (m^3/fed) for different treatments during the two studied seasons for sugar cane crop .

No.of irrigation	Normal planting (convention method)		Transplanting method	
	Irrigation in furrow	Irrigation in beds	Irrigation in furrow	Irrigation in beds
1	678.10	564.6	641.77	520.22
2	454.05	340.55	417.72	300.17
3	481.21	367.71	444.88	330.21
4	632.85	519.35	596.82	475.50
5	596.79	483.29	560.46	438.91
6	650.95	537.45	614.63	493.07
7	677.48	563.98	641.15	519.6
8	764.98	651.48	598.57	607.10
9	687.28	573.78	650.95	529.40
10	741.25	627.75	705.01	583.37
11	703.35	589.85	667.02	545.47
12	669.05	555.54	632.72	511.17
13	680.24	566.74	643.91	522.36
14	749.15	635.65	712.82	591.27
15	631.94	518.44	595.61	474.06
16	583.83	469.41	547.5	414.55
Total/season	**10382.5**	**8565.57**	**9671.45**	**7856.43**

3-Water saving (m^3/ area) :

Data in Table (4) show the average quantity of water applied (m^3/ fed.) for the best transplanting method (A_1 , B_1) which produced the high yield with compared to other planting methods in both studied seasons.

The obtained results in present study show that when the best method is use(Transplanting method in beds) the irrigation water is saved more than the normal planting in furrow (common method in region) by about 24.33% .The results show also that , the amount of irrigation water which can be saved (as average) is 785.607770 million m^3/ area compared to normal planning in furrow . This amount of saving water enough to cultivate area of (generally) 122751.21 feddan in old land or cultivate different areas of horticulture and field crops under El-Minia conditions . These results reflex how much irrigation water can be saved when using the transplanting method . In general , it could be concluded that water fast becoming an economically scarce resource in many area of the world . So , the use of transplanting method is very important to save water . The best method to plant sugar cane should give favorable crop yield and optimum amount of irrigation water . Therefore , estimating economic of irrigation water becomes very important for planning irrigation management where the over irrigation by the farmers usually leads to low irrigation efficiency and high loss of water and fertilizer . These results reflex how much irrigation water can be save to produced the highest yield with least possible amount of water applied where the farmer's practices in sugar can be (conventional irrigation treatment) utilized much water without giving higher productivity .

4-Daily , monthly and seasonal actual water consumptive use :

Daily, monthly and seasonal water consumptive use values are presented in Table (5). The data obtained indicated that mean values of seasonal water consumptive use were (136.94 , and 129.66) cm/season for normal planting method in (furrow & beds), respectively while were (132.91 and 124.42) cm/ season for transplanting method under furrow and beds respectively. Generally it clear that the planting method in furrow (transplanting or normal planting) have high values of actual water consumptive use (132.94 and 136.94) cm/ seasons respectively while, planting in beds (transplanting or normal planting methods) gave lowest values of actual water consumptive use which (124.42 and 129.66) cm/ seasons respectively. It could be noticed that water consumptive use starts with small amount because the needs small amount of water plants at initial growth stage , therefore , soil moisture are mainly affect by evaporation from soil surface at this time , with the advance with plant age, evapotranspiration increase and consequently the monthly consumptive use increased as plant foliage develops . The monthly water consumptive use reaches its peak value in the middle off growing (May – August) season which is considered the critical period in water demands of sugarcane crop .

5-Irrigation efficiencies :

Irrigation efficiency for different planting methods of sugar cane are shown in Table (6).

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It is obvious that the highest values of total irrigation efficiency (71.79%) were obtained from transplanting method in beds while the lowest values (51.58%) were obtained from normal planting in furrow (common method in experimental). So it could be concluded that when transplanting method used in beds the total irrigation efficiency increased from (51.73%) to (71.79%) compared with the conventional method in region where the over irrigation practiced by the farmers usually lead to low irrigation efficiency and high losses of water .

6-Water use efficiency (WUE) :

The water use efficiency is obtained by evaluating the two parameters of total yield per unit of water applied and water consumptive use. WUE is a tool for maximizing crop production per each unit of water irrigation. Effect of the different planting methods and system irrigation on WUE is presented in Table (7). From the presented data , it is clear that values of WUE of sugar cane differed from one treatment to anther .

The highest values of field and crop water use efficiencies (7.10 and 10.68 kg/m^3) were obtained with transplant method in beds respectively. This is mainly due to the higher yield of sugar cane and decrease water applied and water consumptive use in the transplanting method compared with the other treatments . While the lowest value were (4.49 and 8.10 kg/m^3 respectively) were obtained from normal planting in furrow . These results indicated that the transplanting method in beds is the best treatment from the view point of water management for sugar cane yield .

Table (7) : Values of applied water(m^3/fed) , total yield (kg/ fed.), water consumptive use (m^3/fed.), field and crop water use efficiencies of sugar cane crop, in both two studies seasons.

Treatments		Water applied (m^3/fed)	Total yield (kg/ fed.)	Field water use efficiency (kg/ m^3)	Water consumptive use (m^3/fed)	Crop water use efficiency (kg/m^3)
Normal planting (A_1) method	In furrow (b_1)	10382.5	46600	4.49	5751.48	8.1
	In beds (b_2)	8565.57	47100	5.50	5445.75	8.65
Transplanting method (A_2)	In furrow (b_1)	9671.45	55500	5.74	5582.22	9.94
	In beds (b_2)	7856.43	55800	7.10	5225.64	10.68

7-The Economic Evaluation :

Total costs , production and total income (L.E / fed.)

Data in Table (8) presented the average values of total cost , production, total income (L.E / fed.) and net return from unit of irrigation water (L.E/ m^3) as influenced by different planting methods and irrigation system of sugar cane in both studied seasons .

The maximum values of total income net profit and return from a unit of irrigation water applied and consumptive were 10602, 5169 , 066 and 0.99 L.E/ m^3 respectively obtained from plants which grow with transplanting method in beds (A_2b_2) .While , the lowest values of total income (L.E/ fed) , net profit and net return from a unit of irrigation water (applied and consumptive use) were 8854, 5859, 0.27 and 0.49 L.E/ m^3 respectively obtained from the normal planting in furrow (A1b2).

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From these results it could be concluded that the transplanting method in beds lead to increase in total income , not profit and net return of irrigation water. The data in Table (8) show also that the highest values of yield (55.800 ton/ fed) were obtained from transplanting method in beds. Moreover the results indicted that the maximum values of total cost/fed obtained from conventional method in experimental region normal planting in furrow (5995 L.E) while, using transplanting method can be decreased it by about 9.37% from production requirements for sugar cane crop compared to conventional method (normal planting in furrow). These results reflex how much irrigation water can be saved to produce the highest yield with least possible amount of water applied .

8-The economic efficiency :

Increasing net return or profit for crops refers to the decreasing of production costs or for increasing crop production. So the economic efficiency index refers to agricultural and irrigation activities, which can gave the highest return from each L.E unit which can spend on crop production .

The economic efficiency data are presented in Table (9). From these results it could be concluded that the lowest values of economic efficiency was obtained from normal planting method in furrow (0.48) for each Egyptian pound (L.E) spend for production while, the highest economic efficiency (0.95) was obtained from transplanting method in beds . These increase in economic efficiency due to the enhancement of net profit in the transplanting method in beds compare with other treatments .

Table (9): Average values of the economic efficiency under lifting irrigation system for various treatments of sugar cane crop per feddan in both studied seasons .

Treatments		Total return	Total cost LE/fed	Net profit (L.E/fed.)	Economic efficiency
Normal planting method	In furrow	8854	5995	2859	0.48
	In beds	8949	5865	3084	0.52
Transplanting method	In furrow	10545	5523	5022	0.91
	In beds	10602	5433	5169	0.95

9-The financial benefits (LE/ area)

Data in Table (10) show that the average values of financial benefits (L.E/ area) as a result of saving of water , yield , irrigation costs and irrigation time (L.E/ area). From these results it could be concluded that using the best method (transplanting method in beds A_2b_2) get total of financial benefits of saving water by about (29.267487 L.E / area) + saving of yield (543.62800 L.E/ area) + saving of irrigation costs (20.252320 L.E/ area) + saving of irrigation time (20.92500 L.E/ area) = 613.940307 million L.E / area .

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Conclusion

Considering the previous discussion and conclusion the use of transplanting method has a positive effect on increasing agricultural production in both vertically and horizontally ; vertically by increasing yield per unit of land area , horizontally by saving water in order to irrigate more old or new lands . Thus the method becomes very important in saving water and obtaining high yield but the high investment of application this method requires well trained skilled labour. Therefore, the introduction of this method lies primarily on the shoulder of government institutions, cooperatives and large companies then in the future the transplanting method will started to be widely introduced in Egypt. So we have search for applicable solutions and how to limit the sugar cane consumption of water and keep the planted land as it is , and to expand the producing sugar from sugar beet in new lands . One of these solutions is the point of our study which study the effect of transplanting method in beds on water consumptive use and the water use efficiency for the crop in order to have a high yield and good quality with least quantities of water.

The transplanting method decrease irrigation water requirements by about 24.33 % and increases yield by about 19.7 %, the total costs fed. decreased by about 9.37 % compared with others treatments. At the end of this study it may be recommended by application transplanting method to produce high yield and quality with the least possible amount of water applied under El-Minia province conditions .

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تأثير طريقة زراعة محصول قصب السكر بالشتل على كفاءة استخدام المياه ومقارنتها بالزراعة التقليدية

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جريت تجربتين حقليتين خلال المواسم الزراعيه لعامى 2007 ، 2008 م بمحطة مقننات رى ملوى البحثيه التابعه لمعهد بحوث ادارة المياه - المركز القومى لبحوث المياه وذلك بهدف دراسه مدى امكانيه زراعة محصول قصب السكر بطريق الشتل وتأثيرها على الاحتياجات المائية الفعليه والاستهلاك المائى الفعلى وكفاءات الرى المختلفة وكفاءات استخدام والكفاءة الكليه للرى الحقلى وانتاجيه وجوده محصول قصب السكر بالاضافه الى تقييم ومقارنه طريق الشتل تقييماً اقتصادياً ومقارنتها بالطريقه التقليديه للزراعه السائده فى المنطقة .

فقد اشتملت التجربه على معاملتان رئيسيتين لطريق الزراعه (الزراعه بالطريقه العادية – والزراعه بطريقه الشتل) وعلى معاملتان منشقتين لاسلوب الرى (الرى فى خطوط – الرى فى مصاطب) وبذلك اشتملت التجربه على اربع معاملات × 4 مكررات لذا صممت التجربه قطع منشقه Split–plots

وقد اظهرت النتائج فى هذه الدراسه على الاتى :

1 - ادت طريقه الزراعة بالشتل تحت نظام الرى فى مصاطب الى الحصول على اعلى انتاجيه من المحصول وحققت زياده قدرها 19.7 % وذلك عند مقارنتها بالزراعه التقليديه السائده فى المنطقة .

2 - كان متوسط الاستهلاك المائى الفعلى خلال موسمى الدراسة بمقدار 136.94 ، 129.66 ، 132.91 ، 124.42 سم / موسم لمحصول قصب السكر المنزرع بالطريقه العادية فى خطوط والطريقه العاديه فى مصاطب وطريقه الشتل فى خطوط وطريق الشتل فى مصاطب على التوالى .

3 - اعطيت طريق الزراعه لمحصول قصب السكر المنزرع سواء بالطريقه العاديه أو بطريقه الشتل تحت اسلوب الرى فى خطوط اعلى قيم للاستهلاك للمائى الفعلى بمقدار 5751.48 ، 5582.22 م3/ ف بينما اعطيت طريقه الزراعه سواء بالطريقه العادية أو بطريق الشتل تحت نظام الرى فى مصاطب اقل القيم للاستهلاك المائى الفعلى طول المواسم بمقدار 5445.72 ، 5225.64 م3/ ف على التوالى.

4 - أوضحت النتائج أن أقل القيم التى تم الحصول عليها لاجمالى كميات المياه المضافه طوال الموسم كانت نتائجه عند اتباع طريقه الزراعه لمحصول قصب السكر تحت اسلوب الرى فى مصاطب حيث كانت بمقدار 7856.43 م3/ ف بينما اعطيت الطريقه العاديه لمحصول القصب تحت اسلوب الرى فى خطوط (الطريقه التقليديه السائده فى المنطقة) اعلى القيم لكميات المياه المضافه طوال الموسم حيث كانت بمقدار 10382.50 م3/ ف

5 - أوضحت النتائج من وجهه النظر المائية بان اتصل افضل اسلوب للزراعه ورى محصول قصب السكر هى اتباع طريقه الشتل تحت نظام الرى فى مصاطب والذى من خله تم الحصول على وفر مائى قدره 24.33% سنويا مقارناً بالزراعه التقليديه لزراعه محصول قصب السكر السائده بالمنطقة .

6 - أوضحت النتائج أيضاً بأن هذا الوفر المائى الذى تم الحصول عند اتباع طريقه زراعه محصول قصب السكر بطريقه الشتل تحت اسلوب الرى فى مصاطب وذلك عند مقارنتها بالزراعه التقليديه السائدة فى المنطقة قدر بنحو 2526.07 م3/ للفدان سنوياً لذا فاننا نستطيع من خلال هذا الوفر الحصول على اجمالى وفر مائى سنوياً منسوباً الى المساحه المنزرعه قصب حاليا على مستوى الجمهوريه (311 الف فدان) بنحو 785.607770 $م^3$ / مساحه وان هذه الكميه من المياه تكفى لزراعه مساحات مخلفه من المحاصيل الحقليه والبساتنيه الاخرى المطلوب التوسع فيها سواء فى الاراضى القديمة أو الجديدة طبقاً للمعنين المائى لهذه المحاصيل .

7 - أوضحت النتائج ايضاً بأنه تم رفع الكفاءة الكليه للرى الحقلى وذلك عند اتباع زراعه محصول قصب السكر بطريقه الشتل تحت اسلوب الرى فى مصاطب الى 7179% وذلك مقارناً بكفاءة الرى الحقلى الكليه التى تم الحصول عليها للطريقه التقليديه السائدة فى المنطقة والتى قدرت بنحو 51.57% .

8 - أوضحت النتائج ايضاً بأنه تم الحصول على انخفاض فى التكاليف الكليه للرى بنحو 27.13% وكذلك انخفاض فى زمن الرى بنحو 31.82% وكذلك انخفاض فى اجمالى التكاليف الكليه (مستلزمات

الانتاج للمحصول) بنحو 9.23 % وذلك عند زراعه محصول قصب السكر بطريقه الشتل تحت نظام الرى فى مصاطب وذلك عند مقارنتها بالطريقه التقليدية السائدة فى المنطقة .

9 - أوضحت النتائج من الناحية الاقتصادية بأنه تم الحصول على أعلى قيم من اجمالى الدخل (10602 جـ/ ف) وصافى الربح (5169 جـ/ ف) وكذلك مدى الانتفاع بالوحده المائية المضافه والمستهلكه معبر عنها جـ / م3 (66 , ، 99, جـ/ م^3 على التوالى) وكذلك مدى الانتفاع بالوحدة المائية المضافه والمستهلكه معبر عنها كجم / م ^{3} (7.10 ، 10.68 كجم/ م 3 على التوالى) كانت ناتجه عند اتباع طريقه الشتل لزراعه محصول قصب السكر تحت اسلوب الرى فى مصاطب بينما اوضحت النتائج بأن اقل القيم لاجمالى الدخل(8854 جـ/ ف) ،ـ وصافى الربح (2859 جـ/ ف) وكذلك الانتفاع بالوحدة المائية المضافه والمستهلكة معبر عنها جـ/م^3 (27, ، 49 ,على التوالى) وكذلك مدى الانتفاع بالوحدة المائية المضافه والمستهلكه معبر عنها كجم/ م ^{3} (4.49 ، 8.10 كجم/ ف) كانت ناتجه عند زراعه محصول قصب السكر بالطريقة العادية السائدة فى المنطقة.

10 -أوضحت النتائج أيضاً بأن اعلى كفاءة اقتصادية تحت نظام الرى بالرفع لمحصول قصب السكر كانت ناتجه عند زراعه محصول السكر بطريقه الشتل تحت اسلوب الرى فى مصاطب حيث كانت بمقدار 95, جنيه لكل جنيه مصرى تم انفاقه فى مستلزمات الانتاج اللازمه للمحصول بينما اعطيت الطريقه العادية التقليديه السائده بالمنطقة اقل القيم للكفاءة الاقتصاديه حيث كانت بمقدار 48, جـ / جنيه تم انفاقه فى مستلزمات الانتاج ومن ذلك يتضح مدى الجدوى الاقتصادية نتيجه تطبيق طريقه الشتل فى مصاطب لمحصول قصب السكر والعمل على ضرورة تنفيذ هذا الاسبوب على مستوى الحقول الارشادية كمرحله أوليه تم العمل على التوسع فى تطبيقها وتعميمها بعد ذلك .

11 -قدرت العوائد الاقتصادية المتحصل عليها مالياً لجميع معاملات التجربه والناتجه عن الوفر المائى والوفر الانتاجى والوفر فى تكلفه الرى والوفر فى زمن الرى على مستوى المساحة الكليه لمحصول قصب السكر معبرا عنها (جـ/ مساحه) وأوضحت النتائج المتحصل عليها بأنه تم الحصول على اعلى اجمالى للعوائد الاقتصادية الماليه لمحصول قصب السكر وذلك عند اتباع طريقه الشتل تحت اسلوب الرى فى مصاطب حيث كانت بمقدار (20.067487 مليون / جنيه نتيجة الوفر المائى) + (543.628000 مليون / جنيه نتيجة الوفر الانتاجى + (20.992500 مليون جنيه نتيجة الوفر فى تكاليف الرى) +(20.252320 مليون جنيه نتيجة الوفر فى زمن الرى) باجمالى قدره 613.940307 مليون جـ/ المساحه وذلك مقارناً بالزراعه التقليديه السائده فى المنطقة .

قام بتحكيم البحث

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Table (4): Water saving (m^3/ fed) which obtained from the best treatment (transplanting method in beds) compared with other treatments for sugar can crop during the both studied seasons .

Treatment	Increase of yield		% of increase in yield	Water applied (m^3/fed)	Saved water		Average area cultivated cultivated plan cane crop in Egypt	To total of water saving m^3/ million /area	The area (fed.) of old land which can be cultivated as a resulting of saving water
	(Ton/ fed)	(Ton/ fed)			(m^3/fed)	%			
Normal planting in furrow (common method in region)	46.600	8.9	19.1	10382.5	711.05	6.85	311000	221.136550	3552.6
Transplanting method in furrow	55.500			9671.45					
Normal planting in furrow (common method in region)	46.600	0.5	1.07	10382.5	1816.93	17.5	311000	565.065230	88299.4
Normal plants in beds	47.100			8565.57					
Normal planting in furrow (common method in region)	46.600	9.2	19.7	10382.5	2526.07	24.33	311000	785.607770	122751.21
Transplanting method in beds	55.800			7856.43					

Table (5) : Average values of actual water consumptive use (daily , monthly and seasonal) for sugar cane plants as affected by transplanting and normal planting methods (furrow & beds) (average of both seasons)

Months	actual water consumptive use															
	Normal planting in furrow				Normal planting in beds				Transplanting planting in furrow				Transplanting planting in beds			
	mm/ day	mm/ month	cm/ month	m^3/ fed	mm/ day	mm/ month	cm/ month	m^3/ fed	mm/ day	mm/ month	cm/ month	m^3/ fed	mm/ day	mm/ month	cm/ month	m^3/ fed
March	1.94	21.444	2.13	89.46	1.82	20.02	2.00	84	1.91	21.01	2.10	88.2	1.47	16.17	1.62	68.54
April	4.79	143.70	14.37	603.54	4.17	125.10	12.51	525.42	4.34	130.20	13.02	546.84	4.17	125.10	12.51	525.42
May	6.69	207.40	20.74	871.08	6.22	192.80	19.28	809.76	6.39	198.09	19.81	832.02	6.23	193.13	19.31	811.02
June	7.21	216.30	21.63	908.46	6.81	204.30	20.43	858.06	7.16	214.80	21.48	902.16	7.00	210	21.00	882
July	7.52	233.10	23.31	979.02	7.66	229.80	22.98	965.16	7.59	235.20	23.52	987.84	7.43	230.33	23.03	967.26
Agust	7.53	233.43	23.34	980.28	7.67	237.80	23.78	998.76	7.51	232.80	23.28	977.76	7.36	228.16	22.08	927.36
Sept	5.44	163.20	16.32	685.44	5.25	157.50	15.75	661.50	5.42	162.60	16.26	682.92	4.92	147.60	14.76	619.92
Oct .	5.03	150.90	15.10	634.20	4.31	129.30	12.93	543.06	4.48	134.40	13.44	564.48	3.37	101.10	10.11	424.62
Total			136.94	5751.48			129.66	5445.72			132.91	5582.22			124.42	5225.64

Source : Actual field measurements

Table (6) : Average values of irrigation efficiencies (%) (application, storage and distribution efficiency) and total irrigation efficiency for different planting methods for sugar cane crop in both studied seasons .

No.of irrigation	Irrigation efficiency's (%)															
	Normal planting in furrow				Normal planting in beds				Transplanting planting in furrow				Transplanting planting in beds			
	E_a%	E_s%	E_{wd}%	Total irrigation efficiency	E_a%	E_s%	E_{wd}%	Total irrigation efficiency	E_a%	E_s%	E_{wd}%	Total irrigation efficiency	E_a%	E_s%	E_{wd}%	Total irrigation efficiency
1	65.10	76.70	97.13	48.50	75.00	85.00	99.00	63.10	69.00	81.30	97.13	54.50	81.00	90.00	98.50	71.80
2	66.80	76.90	96.90	49.80	74.00	86.00	99.80	63.50	70.00	82.00	99.50	57.10	80.00	89.50	99.80	71.40
3	66.50	78.10	99.80	51.83	77.00	89.00	99.50	68.20	69.00	83.00	99.70	57.40	79.50	91.20	99.80	72.20
4	67.60	69.45	96.40	51.80	76.20	88.60	99.80	67.30	68.90	82.50	99.80	56.40	78.90	92.00	99.80	72.50
5	68.55	82.95	99.10	50.90	77.30	87.90	99.80	67.88	70.20	83.20	99.50	58.11	79.00	93.50	99.70	73.64
6	69.00	74.80	99.10	54.50	75.40	86.90	99.50	65.20	69.20	82.90	99.30	55.70	78.40	92.40	99.50	72.10
7	69.00	75.60	99.70	52.00	74.40	87.00	99.70	64.50	70.40	81.80	99.70	57.41	77.50	90.90	99.60	96.90
8	68.50	72.90	97.88	48.90	75.30	90.10	99.50	67.51	69.90	82.30	99.50	57.24	77.90	92.50	99.50	71.70
9	69.50	75.00	99.53	51.80	74.90	91.20	99.50	67.97	71.20	84.20	99.33	58.94	77.30	93.80	99.50	72.14
10	69.00	75.60	98.32	51.30	75.20	90.30	98.52	66.90	72.20	84.20	98.32	59.80	79.90	93.40	98.52	72.52
11	69.00	76.00	98.20	51.50	76.20	89.90	99.50	68.20	72.40	84.00	99.00	60.20	78.90	94.10	99.50	73.80
12	74.40	82.40	98.50	60.40	75.90	88.90	99.00	66.80	75.30	83.20	98.50	61.72	78.10	92.20	99.00	71.30
13	70.66	77.30	98.10	53.80	74.80	85.30	99.00	63.17	72.60	79.40	98.10	56.60	77.40	90.50	99.00	68.96
14	69.00	74.00	99.00	50.50	76.20	89.40	99.20	67.50	72.50	84.90	99.00	60.90	77.90	93.20	99.20	72.00
15	68.90	71.00	99.00	47.80	75.90	86.20	99.00	65.15	72.30	79.30	99.00	56.90	78.70	91.30	99.00	71.10
16	68.00	73.80	99.50	49.93	74.30	85.90	99.50	63.50	73.10	80.20	99.50	58.30	79.20	90.90	99.50	71.63
Average	68.72	76.41	98.51	51.58	75.50	88.00	99.36	66.01	71.01	82.34	99.10	57.94	78.72	91.8	99.34	71.79

Source : Actual field measurements

$E_{a=}$ application efficiency
E_s = storage efficiency
$E_{wd=}$ water distribution efficiency

Table (8): Average values of total costs , production , total income (L.E) and net return per cubic meter a water (L.E /m^3) (for both studies seasons) by different planting methods and system irrigation for sugar cane crop.

Treatments		The total costs (L.E)											Yield (ton /fed)	Total return L.E / fed.			Water issues L.m3/fed			
		Land preparation	Nursery preparation	Seed	Irrigation Labors	Chemical fertilizer	Pesticides	Labors (cultivate + tillage)	Rent	Overhand expenses	Fuel (Oils + diesel)	Total costs	Average total yield	Market price	Total income	Net profit	Water consumptive use (m3/fed)	from unit water consumptive	Water applied m3/fed	from unit water applied
Normal plants (A_1)	**In furrow (b_1)**	120	-	460	240	760	150	375	3500	150	240	5995	46.600	190	8854	2859	5751.48	0.49	10382.5	0.27
	In bests (b_2)	120	-	460	175	760	150	375	3500	150	175	5865	47.100	190	8949	3084	5445.75	0.47	8565.47	0.36
Transplanting method (A_2)	**In furrow**	120	215	150	220	608	150	190	3500	150	220	5523	55.500	190	10545	5022	5582.22	0.89	9671.45	0.52
	In bests	120	215	150	175	608	150	190	3500	150	175	5433	55.800	190	10602	5169	525.64	0.99	7856.43	0.66

Table (10): The total of finical benefits (L.E) area of the best methods (Transplanting method in beds A_2b_2) in experimental region .

Treatments	Saving of water L.E / area						Saving of yield LE/area					Saving of irrigation time (L.E/are)					Saving of irrigation costs (oils + diesel) (L.E/ area)				
	Water applied (m3/fed)	Saving of water (m3/fed)	Average area cultivate sugarcane in Egypt fed/area	The total of water saving (m3 million/area)	*The cost of transporting cubic meter water	The total of water saving (million L.E/area)	Total yield (ton/fed)	Increase in yield (ton/fed	Market price ton/fed.	Saving of yield (L.E/fed.)	Saving of yield (million L.E/area)	The time fir each irrigation (minute /irrigation)	Saving time of (minute / irrigation)	The total of saving time of irrigation (minute / season)	total of finical benefits (L.E/fed.)	total of finical benefits (L.E/area)	The cost fir each irrigation (L.E /irrigation)	Saving of irrigation costs L.E/ irrigation)	Saving of irrigation costs L.E/ fed.)	Total saving of irrigation costs(L.E / area)	The total of finical benefits (L.E million /area)
Normal planting in furrow (A_1b_2)	10382.50	2526.07	311000	785.607770	0.037 (LE m3)		46.600	9.200	190	190 x 9.2= 1748		308	98	98 x 16= 1568	67.5	67.5 x 31100= 20.992500	15	4.07	4.07 x 16= 65.12	65.12 x 311000= 20.252320	29.067487 + 543.628000 + 20.992500 + 20.252320 = 613.940307
Transplanting method in beds (A_2b_2)	7856.43					29.067 487	\ 55.800				1748 x 311000= 543.628000	210					10.93				

* Resource : Egypt : study on cost Recovery in the irrigation and Drainage sector , Ministry of irrigation and water Resources (KFW.) September 2004 Cairo .