# BEET CUT-OFF IRRIGATION AS EFFICIENT WAY IN WATER SAVING

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## ABSTRACT

Under surface irrigation, particularly in clay soils cut-off technique is considered as one of the most practical way in saving irrigation water that traditional farmers could be easily implemented. Such farming way is processing through find out the optimum length of irrigation run at which watering should be stopped instead of irrigation till the tail end of the furrows or borders. Such procedure resulting in reducing amounts of water pathways and the advancement movement of the accumulated water after stopping irrigation used in watering the remaining un-irrigated area.

Therefore, a field experiment was conducted during the two successive growing seasons 2002 and 2003 to find out the role of cut-off procedure on beet saving irrigation water and water use efficiencies. Three irrigation run treatments were tested; 100% (A), 90% (B) and 80% (C) from furrow length. Main findings can be summarized as follows:

Seasonal water applied for sugar beet in north Nile delta is ranged between 2979 to 2558 $m^3$ (71-61 cm) for treatments A the traditional without cut-off and C with 80% cut-off depending upon rainfall and length of irrigation run.

Seasonal sugar beet crop- water consumption (ETc) was 52.7, 48.5 and 47.0 cm for treatments A, B and C respectively. Daily Etc for the stated treatments were 2.7, 2.5 and 2.4 mm.

Mean percentage values of consumptive use efficiency which reflects the beneficiary water consumed by the growing plants from the applied water were 74.4, 76.0 and 77.2% for the corresponding treatments respectively.

Irrigation till 90% furrow length resulted in the following pronounced advantages:

1. Highest yield for both root and sugar with corresponding values of 28.7 and 4.8 ton/fed or 68.8 and 11.5 ton/ha (1ha=2.38fed).
2. Highest field water use or so-called water utilization efficiency (W.UT.E) as well as water use efficiency (W.U.E) for both root and sugar beet yield. The corresponding values were 10.8 and 1.8 $kg/m^3$

3. Saving irrigation water amounted with about 300 $m^3$/fed or 24 mil $m^3$ for Kafr El-Sheikh Governorate. In other words saving water at the national beet cultivated area of about 240,000 feddan is 72 mil $m^3$.

## INTRODUCTION

In Egypt, agricultural production is mainly irrigated agriculture. Nile River is the main source of water supply with fixed allocation from its water. At present capita share per annum for different purposes is beyond the water poverty edge of 1000 $m^3$. Moreover, it decreasing rapidly due to the high increasing in population and expected to be less than the water scarcity edge of 500 $m^3$ in the coming two decades. At this situation it is difficult to make any development at any economic sector. Agriculture is the main sector in water consumption with more than 85% from total national water supply.

One of the main national strategies in agriculture is cultivating sugar beet instead of sugar cane the highest water need crop. To produce one ton of sugar from beet, it needs almost one quarter of water in comparison with that for sugar cane (Doorenbos et al., 1979). Kafr El-Sheikh Governorate is the main area in national sugar beet production.

Surface irrigation is the most wide spread irrigation method in Egypt as well as world wide. Cut-off irrigation is considered as the recent developed technique in surface irrigation. This technique is preferable implemented in clay soils with its low infiltration rate resulted in high horizontal lateral water movement comparing with the vertical downward movement. Such procedure could be achieved by find out the suitable length of irrigation run at which irrigation should be stopped instead of watering till the tail end of cultivated furrows or borders.

In this regard, Soares et al. (2008) declared that for continuous and cutting-back irrigation, the application efficiency increased with the discharge, reaching a maximum value and decreased thereafter, the runoff loss increased and the deep percolation loss decreased as the discharge increased. Mostafazadeh and Farzamnia (2000) pointed out that deep percolation ratio and runoff ratio was less in the cut-back method compared to the conventional method. Therefore, the cut-back method had higher application efficiency in heavy textured soils as compared to light textured soils. Azevedo et al. (2003) observed in the 100m furrow length, the application efficiency decreased as the required depth increased, but in the 250 m furrow length, the application efficiency increased as the required water depth increased.

So, the main objective of this study was to find out the impact of cut-off irrigation as a modern effective way of surface irrigation method on beet water saving. Specific goals were:

1. Determination of the length of irrigation run associated with high yield and/or water saving.

2. Comparison analysis between cut-off and conventional irrigation regarding beet crop yield, crop water use as well as some irrigation efficiencies.

## MATERIALS AND METHODS

A field experiment was carried out during the two successive beet growing seasons of 2002 and 2003 at Crops Water Requirement Research Field, Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. The site is located at 31-57/ N latitude and 30-57 longitude with an elevation of about 6 meter above mean sea level. The site represents the conditions and circumstances of North Nile Delta region. Soil of the experimental field is clay in texture as shown in Table (1).

**Table (1): Soil particle distribution and soil water parameters of the experimental field**

| Soil depth (cm) | Soil particle distribution % | | | Textural class | F.C. % | Db Kg/m$^3$ | W.P. % | A.W. % |
|---|---|---|---|---|---|---|---|---|
| | sand | silt | clay | | | | | |
| 0-15 | 14.2 | 32.7 | 53.1 | Clay | 48.0 | 1.03 | 26.2 | 21.8 |
| 15-30 | 20.5 | 35.0 | 44.5 | Clay | 43.1 | 1.4 | 22.0 | 21.1 |
| 30-45 | 20.0 | 41.1 | 38.9 | Clay loam | 40.4 | 1.4 | 21.1 | 19.3 |
| 45-60 | 21.8 | 41.8 | 36.4 | Clay loam | 38.1 | 1.5 | 20.1 | 18.0 |

F.C = Field capacity, Db = Bulk density, W.P = Wilting point and A.W = Available water

All cultural practices in the experimental field were the same as implemented in the area except length of irrigation run treatments which was as follows:

Treatment A= Conventional irrigation till 100% furrow length (F.L.)
Treatment B = Cut-off irrigation at 90% FL.
Treatment C = Cut-off irrigation at 80% FL.

The experimental field consisted of three strips each for each treatment. Area of the strip was 168m2 or 1/25 fed included 4 ridges, 60 cm apart and 70 m length. In average, furrow length was 70 m then irrigation was stopped when water front reached 70, 63 and 56 m for treatments A, B and C respectively.

## Data collections:

### 1- Water parameters:

#### a. Control and seasonal water applied (Wa):

Irrigation water was controlled and measured by a constructed rectangular weir with a discharge of 0.01654 m$^3$/sec at effective head of 10 cm. Water applied was computed as described by Giriappa (1983):

$$Wa = IW + Re + S \quad (1)$$

Where:

Wa = Irrigation water applied
Re = Effective rainfall
S = Amount of soil moisture contributed to consumptive use from the soil profile either as stored moisture in root zone and/or that contributed from the shallow groundwater table.

**b. Crop consumptive use (Etc):**

Crop evapotranspiration (Etc) or so-called crop consumptive use (Cu) could be computed from the soil moisture depletion in the effective root zone and thus is namely with the direct method in computing Cu according to Doorenbos et al. (1979):

$$Cu = (Fc - Ø)/100*Db*D \quad (2)$$

Where:

Cu = Consumptive use (cm),
Fc = Field capacity (%),
Ø = soil moisture before irrigation,
Db = Bulk density ($Kg/m^3$), and
D = Depth of effective root zone (60 cm).

**2- Yield (ton/fed):**

a- Root yield (ton/fed)
b- Sugar yield (ton/fed) which was computed by multiplying root yield with sucrose percentage.

Sucrose percentage was estimated at Delta Sugar Company Limited, Kafr El-Sheikh.

**3- Crop-water efficiencies:**

a- Irrigation water use efficiency (I.W.U.E):
This parameter sometimes defined as water utilization efficiency (W.Ut.E) which computed according to Doorenbos and Pruitt (1975) as:

$$W.Ut.E = Y/Wa \quad (3)$$

b- Water use efficiency (W.U.E):
It was computed according to Doorenbos and Pruitt (1975) as:

$$W.U.E = Y/Etc \quad (4)$$

c- Application efficiency (Ea):
This parameter is so-called consumptive use efficiency (Ecu) and computed according to Doorenbos and Pruitt (1975) as:

$$Ecu = (Etc/Wa)*100 \quad (5)$$

where:

Y = Yield, root or sugar,
Wa = Water applied, and
Etc = Crop evapotranspiration or crop consumptive use.

Data obtained were subjected to statistical analysis according to Snedecor and Cochran (1967) and treatment means were compared by Duncan multiple range test (Duncan, 1955). Combined analysis of the data was obtained by using the procedures outlined of SAS Computer Package Program (1992).

## RESULTS AND DISCUSSION

## 1- Water parameters:

### a- Seasonal water applied (Wa):

Seasonal waters applied are consisting of irrigation water (IW) and effective rainfall (Re). Irrigation till the tail end of the furrow (100% FL, Trt A) received the highest irrigation water. Irrigations number was 6 including the sowing one. Timing of irrigation was occurred according to soil moisture status which in turn was affected with rainfall.

It is notified that under treatment B of 90% cut-off, the un-irrigated distance was 7 meters i.e. irrigation was stopped when water front reached 63 meter of furrow length. This dry distance was irrigated by the advance movement of the accumulated water after stopping irrigation. The elapsed time of the water front to reaching the tail end of the furrows took about 18-19 minutes in average (Table 2). While under treatment C of 80% cut-off, the un-irrigated distance was 14 meter and the accumulated water covered in average about 10 meter which took place about 27-30 minutes.

Mean values of applied irrigation water as shown in Table (3) could be arranged in descending order as; 2650.9, 2354.1 and 2230.3 $m^3$/feddan for Treatments A, B and C, respectively. On the other hand, the mean effective rainfall was 327.6 $m^3$/fed. Therefore, seasonal water applied for the stated treatments are; 2978.5, 2681.7 and 2557.9 $m^3$/feddan.

**Table (2): Un-irrigated soil distance and elapsed time for cut-off irrigation treatments**

| Treatment | Irrigation status | Un-irrigated distance | Water front distance after cut-off | Elapsed time |
|---|---|---|---|---|
| B | 90% furrow length | 7 m | To the end of the furrow =7m | 18-19 min |
| C | 80% furrow length | 14 m | To about 10m from un-irrigated distance | 27-30 min |

**Table (3): Mean of sugar beet -water parameters as affected by conventional and cut-off surface irrigation**

| Water parameter | A | B | C |
|---|---|---|---|
| Wa ($m^3$/fed) | 2978.5 | 2681.7 | 2557.9 |
| IW ($m^3$/fed) | 2650.9 | 2354.1 | 2230.1 |
| Rf ($m^3$/fed) | 327.6 | 327.6 | 327.6 |
| Etc ($m^3$/fed) | 2214.9 | 2037.6 | 1975.3 |
| Daily Etc (mm) | 2.7 | 2.5 | 2.4 |
| W.Ut.E (Kg/$m^3$): | | | |
| Root yield | 9.3 | 10.8 | 10.4 |
| Sugar yield | 1.5 | 1.8 | 1.8 |
| W.U.E. (Kg/$m^3$): | | | |
| Root yield | 12.5 | 14.1 | 13.4 |
| Sugar yield | 2.0 | 2.3 | 2.3 |
| Ecu (%) | 74.6 | 76.0 | 77.2 |

**b- Crop consumptive use (Etc):**

Mean values of beet Etc as tabulated in Table (3) are 52.7, 48.5 and 47.0 cm for treatments A, B and C respectively. The data obtained clearly took the same direction with that of applied irrigation water. The high applied irrigation water, the high crop- water consumed. The average seasonal daily Etc for the mentioned treatments is 2.7, 2.5 and 2.4 mm/day, respectively. Azevedo et al. (2003) obtained similar results.

## 2- Yield (ton/fed):

**a- Root yield (ton/fed):**

From Table (4), it is clear that the length of irrigation run has significant effect on beet yield. The mean highest root yield of 28.657 ton/fed was obtained from 90% cut-off irrigation (Trt.B). On the other hand, treatment C of 80% cut-off produced the lowest mean 26.423 ton/fed. While conventional treatment A of 100% irrigating furrow length resulted in a medium value of 27.559 ton/fed. So, to get maximum root yield of sugar beet in north Nile delta, irrigation should be till 90% furrow length instead of watering tills the tail end of furrow length. Meaningfully, conventional over irrigation till 100% furrow length becomes un-productivity or says excess water compared with cut-off irrigation till 90% furrow length. Therefore, such procedure of modern surface irrigation via cut-off irrigation till 90% furrow length resulted in two main advantages of saving water and highest beet root yield. These findings are in agreement with those obtained by Emara (1996).

**Table (4): Mean yield of roots and sugar (ton/fed) as well as sucrose percentage as affected by conventional and cut-off surface irrigation**

| Characters | A | B | C |
|---|---|---|---|
| Yield (ton/fed.) | | | |
| Root yield | 27.559 a | 28.657 a | 26.423 c |
| F-test | ** | ** | ** |
| Sugar yield | 4.475 a | 4640 a | 4.459 a |
| F-test | ns | ns | ns |
| Sucrose, (%) | 16.25 a | 16.18 a | 16.80 a |
| F-test | ns | ns | ns |

**b- Sucrose percentage:**

Length of irrigation run has no significant effect on sucrose percentage as shown in Table (4). In general, sucrose content increased under the less water applied with highest value 16.8% resulted from treatment C of 80% cut-off irrigation. Therefore, the less amount of irrigation water applied the less water content in foliage and root tissues which enhanced the formation and accumulation of sugar content.

These results stand in the same line with those obtained by Davidoff and Hanks (1989).

**c- Sugar yield (ton/fed):**

Sugar yield is the product of root yield by sucrose percentage. Means of sugar yield over both growing seasons are illustrated in Table (4). Insignificant differences in sugar yield were observed from different length of irrigation run treatments. The highest sucrose yield 4.6 ton /fed was resulted from 90% cut-off of treatment B. On the other hand, the lowest mean sugar yield 4.5 ton/fed was declared from 80% cut-off (Trt C). It should be stated herewith that excess irrigation water applied under the traditional watering till the tail end of cultivated furrow (Trt A) has no effect in increasing sugar yield, the main strategic production of sugar beet crop.

## 3- Crop-Water efficiencies

**a- Water Utilization efficiency (W.Ut.E.):**

From data obtained in Table (3), mean values of this parameter resulted from treatments A, B and C are 9.31, 10.75 and 10.41 kg root/$m^3$ water applied. Regarding sugar yield, the corresponding values are 1.5, 1.8 and 1.8 kg sugar/$m^3$ water applied.

This finding explained that this parameter is affected by yield as nominator and water applied as dominator. So, by increasing the dominator of water applied, decreasing in water utilization efficiency could be attained and vise versa. The highest W.Ut.E for treatment B of 90% cut-off might be attributed to the highest root and sugar yields resulted from the average amount of applied irrigation water.

Similar results were reported by Soares et al. (2000), Mostafazadeh and Farzamnia (2000) as well as AZevedo et al. (2003).

## 4- Water use efficiency (W.U.E.):

The obtained values of W.U.E. as presented in Table (3) emphasized that no clear adverse evidence was observed from the consumed water by beet plants on this parameter. Regarding root yield, mean values for treatments A, B and C are 12.5, 14.1 and 13.4 kg/$m^3$ consumed water. While the corresponding values regarding sugar yield are 2.0, 2.3 and 2.3 kg/$m^3$ consumed water.

In this regard, main target of effective on farm irrigation management is to maximizing the crop yield per unit of water applied. Meaningfully, this target could be achieved through water saving along with increasing crop yield or at least saving water without insignificant decreasing in crop yield. Similar findings were obtained by Azevedo et al (2003).

## 5- Consumptive use efficiency (Ecu):

Consumptive use efficiency reflects the capacity of roots to utilize the moisture stored in the soil between irrigation intervals. Data in Table (3) show that the highest value of Ecu is 77.2% (Trt C). So, the decreasing the dominator of water applied the increasing in Ecu. Such results are agreed with those reported by Doorenbos et al. (1979) who stated that the consumptive use efficiency increased with the increase of consumptive use and with the decrease in water applied.

## CONCLUSIONS

By irrigating till 90% furrow length or so-called cut-off irrigation as modified surface irrigation method in watering sugar beet crop which illustrated in treatment B, following achievements could be resulted:

1. The highest yield of root and sugar with 28.7 ton/fed (68.3 ton/ha) and 4.6 ton/fed (10.9 ton/ha), respectively.
2. Saving in irrigation water amounted with 11 % or 300 $m^3$/fed equaled 72 mil $m^3$ at the national level.
3. Decreasing the press load on drainage network by saving water gained from implementation of cut-off irrigation technique.

So, in conclusion more investigations are needed to verify the role of cut-off irrigation on water saving for different furrow and border cultivated crops.

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