



**Proportional Study of High Irrigation Efficiency over Conventional Irrigation Method on Yield Potential and Water Use Efficiency of Sunflower Crop at Lower Kohistan of Sindh**

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**Abstract:** The paper is based on investigations for the proportional outcome of High Irrigation Efficiency system of drip technique over Conventional method of furrow irrigation technique on potential of seed yield and water use efficiency, the study was carried out during the year 2007. The crop was sown on April 15, 2007 and harvested on July 8, 2007. The results revealed that the higher potential of yield with slighter water application was recorded in drip technique over furrow technique of irrigation system. Consequently, water use efficiency in drip was 189.5% more than furrow technique of irrigation. The water saving in drip technique was recorded as 56% over furrow technique of irrigation method along with an increase of 25.6% in potential of crop yield. Taken as a whole, it is proved that drip technique dominated over furrow technique of irrigation system in respect of water use, potential yields, water use efficiency and water saving. The approach on scientific data generated through this study would serve as a bench mark and would help to those scientists, irrigation and agriculture engineers, researchers and students who are engaged in similar type of activities for further research. To achieve the optimum targets of growing demand in reflection of increasing populations, more land can be taken under cultivation from the limited water resources.

**Keywords:** Proportional outcome, Drip technique of irrigation, Furrow technique irrigation, sunflower yield.

**1. INTRODUCTION**

The Sunflower, (*Helianthus annuus* L) is solitary of the most imperative globally oil crops and is cultivated worldwide on over 22 million hectares, with a production of 26 million tons/year (Skoric *et al.* 2007), introduced in Pakistan in the 60's. Sunflower has become a major oilseed crop of Pakistan and the crop was sown on an area of 457.30 thousand hectares during the year 2007-2008, which resulted seed production of 683 thousand tons and oil production of 264 thousand tons (Anonymous, 2008).

The edible oil available in the country from all sources was 3.066 million tons during 2007-08. Local production of edible oil stood at 833 thousand tons during 2007-08, which is 27.2% of the total availability in the country; while the remaining 72.8% was made available through imports. Demand of edible oil is increasing at a rate of 5.4% annually.

The lack of irrigation water has reduced area under cultivation, has hit the entire major crops in Sindh. However, due to shortage of water most of the sugarcane area has been shifted towards cultivation of sunflower, particularly in the lower part of Sindh (SBP, 2007). Rabi season faced more shortage of water than Kharif during 2007-08. The water availability during Rabi season as on end-March 2008 was, however, estimated at 27.9 MAF, which was 23.4% less than the normal availability, and 10.5% less than last year's Rabi, adversely affecting the Rabi crop

production, which has decreased by 6.6% over 2007 (MINFAL, 2009). Effective use of irrigation, under these circumstances, the micro irrigation systems, such as drip irrigation, pitcher irrigation and polyethylene irrigation can be more useful for small scale agriculture and cultivation of crops in the arid regions.

Since fertilizer is also applied through this system, therefore split doses of fertilizer application is also achieved, additionally, weed problem is minimized and land leveling requirements are reduced, thereby minimizing labor costs. Yaseen *et al.* (1992) reported that under drip irrigation, higher yield of vegetables was achieved as compared to furrow method of irrigation. Drip irrigation is one such irrigation technique that has been successfully used in combination with saline water (Shallhevet, 1994), while conducting research on vegetables under drip and furrow methods of irrigation, found that higher yields, higher water use efficiency and considerable water saving were recorded in drip system of irrigation over furrow method. However, salts were found accumulated at wetted periphery in drip irrigation method which after two to three years needed leaching either naturally i.e. rainfall or artificially i.e. through flooding water in the affected areas (Goldberg and Shamuli, 1970). Another option for improving water use efficiency is relatively old traditional method being practiced since centuries and is popular for row crops. Under this system, only one half to one fifth of the surface area is wetted. The water is applied in furrows where as the ridges are left dry. Efficient irrigation by

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furrow method is obtained by selecting proper combination of spacing, length and slope of furrows and suitable size of irrigation stream and duration of water application. The above study was carried out to investigate comparative effect of drip irrigation and furrow irrigation systems on the water use efficiency and subsequent sunflower production in the arid region of lower Kohistan of Thana Boula Khan, district Jamshoro.

## 2. OBJECTIVES

The main objectives of this study are as under:

1. To evaluate the proportional outcome of drip technique over furrow technique of irrigation system on sunflower crop for potential yield and water use efficiency.
2. To recommend the suitable irrigation technique for the environment of water scared areas of lower Kohistan

## 3. MATERIALS AND METHODS

The experimental study was conducted at progressive farmer's field, which is situated in Deh Desvi, Taluka Thana Boula Khan of district Jamshoro. This is the agricultural farm, where the WRII / NARC - Research Field Station of Pakistan Agricultural Research Council has installed drip technique of irrigation system under National Research and Development Project (NRDP) on Water Management of Spate Irrigation Systems in Rod - Kohi areas of Pakistan.

### 3.1 Drip and Furrow Techniques of Irrigation System

To achieve the research goals, above study area has been proportionally irrigated through drip and furrow technique of irrigation systems. The details of drip components and preparation of furrows and ridges are described as follows:

### 3.2 Drip technique of irrigation system

The layout map of drip irrigation system used in this study is shown in (Fig-1). Under drip technique of irrigation system, water is delivered to the plant root zone directly at a slow and low pressure rate in small amounts through emitters or drippers having tiny holes for watering to retain moisture within the crop canopy.

### 3.3 Furrows and Ridges preparation:

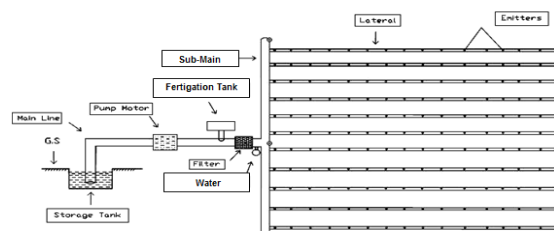


Fig. 1: Layout map of Drip technique of irrigation system

Above and beyond the drip irrigation plot, furrows and ridges were prepared on the same size of plot as that of the drip irrigation plot. The bed of the furrow was 30 cm wide and ridge was also 30 cm wide and 30 cm high from bed of the furrow. Length of each furrow was kept 30 m. There were 11 numbers of furrows and 12 numbers of ridges. The total area under furrow system of irrigation was 10m x 30 m (i.e. 300 m<sup>2</sup> or 0.03 hec) (Fig. 2).

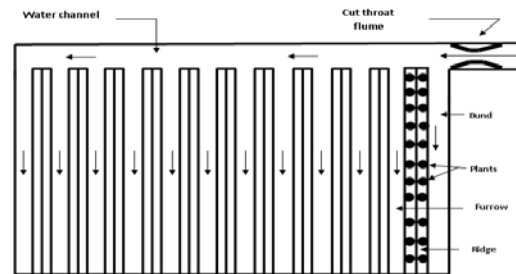


Fig. 2: Layout map of Furrow technique of irrigation system

### 3.4 Under-cultivation Area of Sunflower Crop

The sunflower was cultivated under drip and furrow irrigation. For the study purpose, the land under experiment (0.06 ha) was ploughed thoroughly and divided in two equal parts Field-A and Field-B. Area of Field-A for 0.03 ha was kept under drip and Field-B for 0.03 ha was brought under furrow technique of irrigation system.

Subsequent to the installation of laterals on Field-A, the emitters were inserted in the laterals at a running distance of 30 cm apart. Therefore, the total numbers of emitters on one lateral were 100. The total 11 number of laterals were used. Thus, the total numbers of emitters on 11 laterals were 100 x 11 = 1100. The distance between each lateral was kept uniformly 90 cm. A soaking dose of 5.4 m<sup>3</sup> was then applied through emitters. The soil, after two days came at field capacity. The DAP fertilizer at the rate of one bag (123.5 Kg) per hectare was applied for the plot under study i.e. 3.72 Kg (recommended by ARI, Tando Jam). The sunflower (Hybrid Australian Variety) seed then was sown on both sides of the laterals near the trickling point. Hence, the total numbers of plants under one lateral were 100 x 2 = 200, and the total plant population under drip system of irrigation was 200 x 11 = 2200 plants.

Likewise, in Field-B, 11 numbers of furrows were prepared keeping same row-to-row and plant-to-plant distances as those in the drip irrigation method. The soaking dose 38.125 m<sup>3</sup> was applied in the furrows. For the measurement of water, a cutthroat flume (4" x 8" size) was installed in the watercourse. The furrows were filled with water at half of the height of the ridges. The water applied was recorded accordingly. When the soil

was in workable conditions at Field Capacity, DAP fertilizer was applied as per recommendations and sunflower seed was sown on either side of the ridges keeping the same plant-to-plant distance to that of drip irrigation system. Thus, the plant population under drip system and furrow method of irrigation was identical i.e. 2200 plants under each method of irrigation. All the other cultural practices, such as weeding, interculturing, fertilization, tenting of birds etc were carried out as per recommendations of Agricultural Research Institute (ARI), Tandojam. The crop was sown on April 15, 2007 and harvested on July 8, 2007.

The sunflower plants were air dried under the sun after their harvest. The dry plants were manually threshed and the seeds were weighed for yield (kg/ha) from the above two tested techniques of irrigation system.

### 3.5 Water Use Efficiency and Water Saving Water Use Efficiency (WUE)

The Water Use Efficiency (WUE) for sunflower under drip and furrow systems of irrigation was computed as given by Majumdar (2002):

$$WUE = \frac{Y}{WR}$$

Where,

Y = Crop yield kg/ hectare

WR = Total water used for crop production m<sup>3</sup>/ha

The WUE kg/ m<sup>3</sup>.

### Water Saving (%)

The water saving was calculated as under:

$$WS (\%) = \frac{W_a - W_b}{W_a} \times 100$$

Where,

WS = Water Saving (%)

W<sub>a</sub> = Total water used in furrow method of irrigation (m<sup>3</sup>/ha)

W<sub>b</sub> = Total water used in drip irrigation method (m<sup>3</sup>/ha).

### 3.6 Effective Rainfall

The rainfall calculated by using the following table given by Doorenbos and Pruitt (1975). The calculated effective rainfall was added to total water consumed under each irrigation method presented in (Table-1).

Table-1 Computation of Effective Rainfall

Rainfall (mm)	25	50	75	100	125	150	> 150
Effective %	90	85	75	50	30	10	0

## 4. RESULTS AND DISCUSSION

### 4.1 Irrigation Application

Date-wise irrigations applied to sunflower crop from sowing to harvest under drip and furrow technique of irrigation system (Table-2 and 3).

Table-2 Irrigation water applied to sunflower crop under Drip irrigation system

S. No.	Date of Irrigation	Water Applied (m <sup>3</sup> )	S. No.	Date of Irrigation	Water Applied (m <sup>3</sup> )	S. No.	Date of Irrigation	Water Applied (m <sup>3</sup> )
1	06.04.2007	S D =5.4	13	06.05.2007	4.0	25	04.06.2007	4.0
2	10.04.2007	4.6	14	08.05.2007	4.0	26	06.06.2007	4.4
3	15.04.2007	3.3	15	10.05.2007	4.1	27	08.06.2007	4.2
4	18.04.2007	3.1	16	12.05.2007	4.0	28	10.06.2007	4.0
5	20.04.2007	3.5	17	14.05.2007	4.1	29	12.06.2007	4.1
6	22.04.2007	3.8	18	17.05.2007	4.0	30	14.06.2007	4.0
7	24.04.2007	3.9	19	20.05.2007	4.1	31	16.06.2007	4.2
8	26.04.2007	4.2	20	22.05.2007	4.0	32	18.06.2007	3.9
9	28.04.2007	4.2	21	25.05.2007	4.1	33	20.06.2007	4.0
10	30.04.2007	4.0	22	29.05.2007	4.8	34	22.06.2007	4.2
11	02.05.2007	4.0	23	31.05.2007	4.8		Total:	139.7
12	04.05.2007	4.2	24	02.06.2007	4.5			
Effective Rainfall								31.11
Total								170.8

S D = Soaking Doze

Table-3 Irrigation water applied to sunflower crop in Furrow Irrigation System

No. of Irrigation	Date of Irrigation	Water Applied (m <sup>3</sup> )	No. of Irrigation	Date of Irrigation	Water Applied (m <sup>3</sup> )
Soaking Doze	06.04.2007	38.125	5 <sup>th</sup>	26.05.2007	40.00
1 <sup>st</sup>	18.04.2007	38.125	6 <sup>th</sup>	03.06.2007	41.00
2 <sup>nd</sup>	28.04.2007	38.125	7 <sup>th</sup>	13.06.2007	42.40
3 <sup>rd</sup>	08.05.2007	40.00	8 <sup>th</sup>	23.06.2007	40.00
4 <sup>th</sup>	18.05.2007	40.00			
Total					357.77
Effective Rainfall					31.11
Total					388.87

SD = Soaking Doze

#### 4.2 Irrigation water applied to sunflower crop in Furrow Irrigation System

Table-2 reveals that total irrigation water used in sunflower crop under drip system of irrigation, was 139.7 m<sup>3</sup>. Where as in June 24 to 28, the total rainfall in the area occurred was 62.5 mm and in July 1<sup>st</sup> to 4<sup>th</sup>, it was 103.8 mm. Accordingly, the effective rainfall was calculated from the Table given by Doorenbos and Pruitt (1975), which came to 50 mm and 52 mm. It was further calculated based on plot size under drip and furrow irrigation. Thus the effective rainfall received was 15.25 m<sup>3</sup> and 15.86 m<sup>3</sup>. Hence, the total effective rainfall received to crop was 15.25 + 15.86 = 31.11 m<sup>3</sup>. This quantity of water was added to total quantity of water applied to sunflower crop under drip and furrow irrigation methods as shown in Tables-2 and 3. The

volume of water was used and further calculated as 5600 m<sup>3</sup>/ha and 12750 m<sup>3</sup>/ha in drip and furrow systems of irrigation respectively (Table-5). Irrigation under drip system was applied on about two days frequency, as the water holding capacity of the sandy loam soil was low. Consequently, the field capacity and available moisture for plant was less than normal soil. In addition to this, sunflower plant is an indicator plant to moisture stress. So after two to three days, the plants started wilting then next light irrigation was applied under drip system of irrigation to crop.

#### 4.3 Effective Rainfall

The rainfall occurred during crop growing season in the months of June and July 2007 was recorded (Table-4).

Table-4 Rainfall received during crop season and its effectiveness

Month / date	Rainfall received (mm)	Month / date	Rainfall received (mm)
June-2007	-	July-2007	-
24.06.2007	17.81	01.07.2007	36.32
25.06.2007	19.05	03.07.2007	21.08
26.06.2007	21.08	04.07.2007	46.48
27.06.2007	2.54	-	-
28.06.2007	2.03	-	-
Total	62.51	Total	103.88
Effective rainfall *	80% = 50 mm	Effective Rainfall*	50% = 52 mm

\*Source: Doorenbos and Pruitt (1975)

The volume of effective rainfall was calculated on field plot basis under drip and furrow methods.

-Plot size = 305 m<sup>2</sup> (in each case) -Effective depth of rainfall = 50 mm + 52 mm = 102 mm = 0.102m

-Volume of effective rainfall = 0.102 x 305 = 31.11 m<sup>3</sup>

Thus, 31.11 m<sup>3</sup> volume of water was added to total water used under drip and furrow methods of irrigation in sunflower crop.

Table-5 Volume of water used for Drip and Furrow irrigation methods

Mode of Irrigation	Irrigation Frequency (Average days)	Amount of Water used (m <sup>3</sup> )	Total No. of Irrigations	Area under cultivation (ha)	Volume of Water used (m <sup>3</sup> /ha)
Furrow	9.75	388.87	8	0.015	12750
Drip	2.0	170.8	34	0.015	5600

The average frequency between two irrigations for Furrow irrigation method was kept at 9.75 days. This may be due to the fact that 30 cm high and 90 cm wide ridge might be stored enough moisture which lasted for 8-12 days.

#### 4.4 Crop Yield

The sun flower, after drying was threshed manually and grain yield obtained from drip and furrow plots were weighed and recorded yield in Kg/ha was calculated (Table 6).

Table-6 Sunflower yield obtained in drip and furrow irrigation systems

Irrigation Method	Yield	
	(Kg per Plot)	(Kg / ha)
Furrow	75.25	2,467.21
Drip	94.50	3,098.36

Table-4 shows that the yield of sunflower in plot under drip irrigation method was 94.50 kg whereas, in furrow plot, it was 75.25 kg. Per hectare yield for drip and furrow methods is calculated as 3098.36 and 2467.21 kg respectively. The result was brought out that

the difference between Furrow and Drip was calculated 25.58% (Table-7).

#### 4.5 Water Use Efficiency, Water Saving and Increase in Yield in Drip over Furrow Method of Irrigation

These results are described in (Table-7). In drip irrigated plot, the yield of sunflower obtained was 3098.36 kg/ha. Where as in furrow method of irrigation,

the yield obtained was only 2467.21 kg/ha, indicating that higher yield was obtained in drip technique of irrigation over furrow technique.

**Table-7 Water use efficiency, water saving and increase in yield in drip over furrow method of irrigation**

Yield kg/ha		Water Used (m <sup>3</sup> /ha)		Water Use Efficiency (WUE) (kg/m <sup>3</sup> ), $\frac{\text{Yield}}{\text{water used}}$		Water saving in Drip over Furrow (%)	Increase in yield in Drip over Furrow (%)
Drip	Furrow	Drip	Furrow	Drip	Furrow		
3098.36	2467.21	5600	12750	0.55	0.19	56.0	25.58

The above (Table-7) shows increase in yield in drip technique over furrow technique was estimated at about 25.58%. Likewise, only 5600 m<sup>3</sup>/ha irrigation water was used in drip against 12750 m<sup>3</sup>/ha in furrow method of irrigation. In drip technique, the water use efficiency (WUE) was also higher (i.e. 0.55 kg/m<sup>3</sup>) as compared to furrow technique of irrigation and 0.19 kg/m<sup>3</sup>. Thus, a considerable quantity of water saving (i.e. 56%) was achieved in drip over furrow technique of irrigation. The results are in agreement to those found by Asgari *et al.* (2007), Aujla *et al.* (2007), Ibragimov *et al.* (2007), Gomez (2006), Yaseen *et al.* (1992), Chandio *et al.* (1995) and Uriel (1985).

Thus the above results, it can be concluded that drip technique of irrigation is far better than furrow technique of irrigation. In drip, higher potential yields and higher water use efficiency could be achieved, where as less water is required in comparison to furrow technique of irrigation. Besides these, substantial quantity of water is saved in drip technique over furrow technique of irrigation. The saved water could be utilized either to bring more area under cultivation.

## 5. CONCLUSION

- Higher sunflower yields with lesser water were recorded in drip system of irrigation over furrow irrigation system.
- Drip system of irrigation dominated over furrow irrigation system in respect of water use, yields, water use efficiency and water saving.

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