International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:6, No:9, 2012

Comparative Study of Drip and Furrow Irrigation Methods at Farmer's Field in Umarkot

A. Tagar, F. A. Chandio, I. A. Mari, B. Wagan

Abstract**—**An experiment was conducted on the comparative study of drip and furrow irrigation methods at the farmer's field in Umar Kot. The total area under experiment about 4000m^2 was divided into two equal portions. One portion about 40m X 50m was occupied by drip and the other portion about 40m X 50m by furrow irrigation method. Soil at the experimental site was clay loam in texture for 0-60cm depth; average dry bulk density and field capacity was 1.16g/cm^3 and 28.5% respectively. The results reveal that the drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method. Higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water used efficiency about 1.66 was obtained in furrow irrigation method. The present study suggests farming community to adopt drip irrigation method instead of old traditional flooding methods.

Keywords**—**Drip and furrow irrigations methods, water saving, yield of tomato crop.

I. Introduction

WATER is essential substance for sustaining life on the earth. Its consumption by the agriculture sector continues to dominant the overall requirements of water. Moreover the increasing population, urbanization and unsustainable consumption of water have further imposed the greater demands on water in arid and semi regions of the country. Thus it becomes indispensable to properly manage water at all levels in order to fulfill their food and fiber requirements. Management of water resources at macro level is quite costly and time taking, even though unavoidable. On the contrary the management of water at field level is relatively inexpensive, more feasible, and easily workable and can be implemented in short span of time.

In Pakistan, generally traditional flood irrigation methods (basin, border and furrow) are used to irrigate crops, wherein the entire soil surface is almost flooded without considering the actual consumptive requirements of the crops. These practices have created the problems of waterlogging and salinity and reduction in the overall irrigation efficiency hardly up to 30 percent [1].

Therefore it is dire need to adopt modern efficient irrigation methods like sprinkler and drip. Sprinkler irrigation method offers several advantages over surface irrigation methods, including higher water use efficiency, better fertilizer application and high yield [2]. However, high wind velocity and use of saline water may restrict its application in arid regions. Drip irrigation method is not affected by high wind velocity as it applies water directly to the root zone of plants [3]. Its major advantages as compared to other methods include: higher crop yields, saving in water, increased fertilizer use efficiency, reduced energy consumption, tolerance to windy atmospheric conditions, reduced labor cost, improved diseased and pest control, feasible for undulating sloppy lands, suitability on problem soils and improved tolerance to salinity [4].In a study [5] reported that drip irrigation generally achieves better crop yield and balanced soil moisture in the active root zone with minimum water losses. On the average, drip irrigation saves about 70 to 80% water as compared to conventional flood irrigation methods [2]. [6] found from his experiments that the potato yield was 588.0 quintals/ha with drip irrigation method compared to 507.8 quintals/ha with furrow mode and 561.6 quintals/ha with sprinkler irrigation. Moreover [7] found that yield was higher by 18-42% and water use efficiency by 35 to 103% in drip mode. There are some disadvantages inherent with this technology such as; emitter clogging, which may be removed by the use of good quality filtration system and high material and installation cost, this is also solved, because Federal government has introduced a project worth 17.5 billion rupees to help the farmers by paying 80% of total cost. In past many studies have been conducted on drip irrigation method, even this farmers community prefer to adopt traditional flood irrigation methods. Therefore this technology needs extensive publicity among the local farmers in the country for future adoption. Keeping the above facts in view the present study was conducted on the comparative study of drip and furrow irrigation methods at the farmer's field in Umar Kot. Main objective of this study were to compare water saving, increase in yield and water use efficiency of drip and furrow irrigation methods and to suggest guidelines for farming community.

II. Materials And Methods

A. Experimental Site

An experiment was conducted at Dr. Abdul Hafeez Halepoto Farm at Faqeer Ali Bux Halepoto village, taluka Umer Kot, district Umer Kot.

A. A. Tagar is PhD scholar at college of Engineering Nanjing Agricultural University, Nanjing, Jiangsu, P. R. China (phone: 008613914706344; e-mail: tagarahmed@ Hotmail.com).

F. A. Chandio is PhD scholar at college of Engineering Nanjing Agricultural University, Nanjing, Jiangsu, P. R. China

I. A. Mari is PhD scholar at college of Engineering Nanjing Agricultural University, Nanjing, Jiangsu, P. R. China

B. Wagan is PhD scholar at college of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing, Jiangsu, P. R. China.

B. Preparation of land

Since the land at the experimental site was uncultivated for about two years. Therefore it was ploughed twice by disk plough followed by rotavator. Then a soaking-doze of 100 mm was applied to the entire field when the soil came into the workable condition, it was ploughed again with cultivator and then leveled. The aim of the study was to compare the drip and furrow irrigation methods with regard to water saving, increase in yield and water use efficiency of drip and furrow irrigation methods. For this purpose the total area under experiment about 4000 $m^2$was divided into two portions equally. One portion about 40 X 50 m^2 was occupied by drip and the other portion about 40 X 50 m^2 by furrow irrigation method as shown in figure 1 & 2.

C. Installation of drip irrigation system

Drip irrigation system was installed in the experimental field by Jaffer Brothers (PVT) LTD. This system consists of 110 mm PVC pipe mainline connected to 63 mm PVC pipe sub-main line, which was connected to 16 mm Jain Turbo Type lateral line with 0.004 m^3/hr drippers. The distance between row to row and plant to plant was kept 0.9 and 0.5 m, respectively. In all total 44 laterals were laid on the ground surface along the lines of plants each 50 m long with 100 emitters.

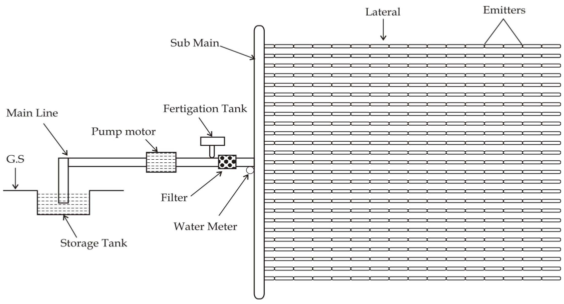

Fig. 1 Layout of drip irrigation System

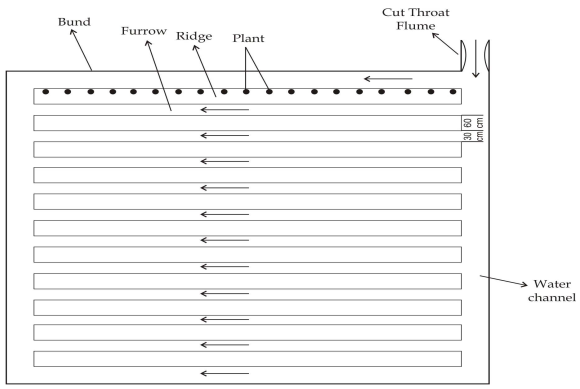

Fig. 2 Layout of furrow irrigation system

D. Performance of drip irrigation system

As mentioned earlier that the drip irrigation system was installed by Jaffer Brothers, therefore its coefficient of variation and emission uniformity was determined in order to ascertain the performance of system.

For this purpose the containers were placed under emitters to collect the water flowing through them. The collected water in a given time was then measured using a graduated cylinder.

E. Coefficient of variation (cv)

There are certain variations in everything in the world; no two things are really identical. Likewise no two emitters are identically manufactured; there would be a little variation between them. Therefore coefficient of variation is used to evaluate the flow rate uniformity of the emitters that was also done in the present research work. Following formula was used to calculate the coefficient of variation [8].

$$Cv = \frac{\sigma}{qav} x100 \quad (1)$$

F. Emission uniformity (EU)

EU is the ratio between the average discharge in the quarter receiving less water and the average discharge at the system level. It is used to describe the predicted emitter flow variation along a lateral line and can be assumed as synonymous to that of distribution uniformity (DU). The formula was used to calculate emission uniformity [9].

$$EU = 100\left[1.0 - 1.27\frac{Cv}{n^{\frac{1}{2}}}\right]\frac{qm}{qa} \quad (2)$$

Where;
σ = Standard deviation

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(qi - qav)^2}{n}} \quad (3)$$

C_v = Coefficient of variation
n = No. of emitters
q_m =Minimum flow
q_a = Average flow

G. Preparation of furrow irrigation system

For furrow irrigation system, furrows and ridges were prepared by furrow maker. The row to row and plant to plant distance was same as in drip irrigation. In all the total number of furrows and ridges was 44 and 44 respectively. The length of each furrow and ridge was 50 m, while each ridge was comprised of 100 plants.

H. Soil sampling

After the preparation of land, composite soil samples were collected at 0-15, 15-30, 30-45 and 45-60 cm depths for the determination of soil texture, dry bulk density and field capacity. The following procedures were adopted for the analysis each parameter.

I. Soil texture

Soil texture was determined by Bouyoucous hydrometer method in the laboratory of land and water management department.

J. Dry bulk density

To determine the dry bulk density of the soil, composite soil samples were taken at the depths of 0-15, 15-30, 30-45 and 45-60 cm with the help of core sampler of known diameter from both plots of the experimental field. These samples were labeled, packed and brought to the laboratory where they were placed in an oven for 24 hours at 105°C. After 24 hours dry weight of each sample was measured with the help of electric balance. Then following relation was used to calculate dry bulk density of the soil.

$$\text{Dry bulk density } (\rho_d) = \frac{\text{Dry weight of soil}}{\text{Total volume of soil}} \quad (4)$$

K. Field capacity

The field capacity of the soil was determined by Veihmeyer and Hendricksen method.

L. Water sampling

In order to determine the quality of irrigation water, three water samples were collected at start, middle and end of the experiment. These samples were analyzed for ECw, pH, SAR and RSC.

M. Sowing of crop and application of water

As recommended by [4] irrigation water was applied at 50% deficit of soil moisture content, and the subsequent irrigations were applied accordingly. Therefore in drip irrigation system, water was applied to soil at the rate of 0.004 m^3 per hour through all the emitters. When the soil reached at field capacity condition, tomato seedlings were sown by hand under each emitter. Likewise in furrow irrigation system, water was applied to all furrows, when the soil reached at field capacity condition, tomato seedlings were sown by hand. Irrigation water was measured using cutthroat flume in furrow irrigation system, while in drip irrigation system water was measured by the flow meter installed in the sub-main.

Following formula was used to identify to soil moisture deficit level;

$$SMD = \theta_f - \theta_o \quad (5)$$

$$\theta = \frac{(Ww - Wd)}{Wd} \times 100 \quad (6)$$

Where,
SMD = Soil moisture deficit level
θ_f = Moisture content at field capacity (%)
θo = Moisture content at 50 % SMD
θ = Moisture content on dry weight basis (%)
Ww = Wet weight of soil (g)
Wd = Oven dry weight of soil (g)

N. Fertilizers and manures

Fertilizers were applied to each plot as recommended by OFWM-VI (2005). The following fertilizers were applied:
(1) 30-50 kg/ac Nitrogen (N)
(2) 40-80 kg/ac Phosphorous (P_2O_5)
(3) 30-60 kg/ac Potassium (K_2O).
Schedule of Fertilizer Application
Fertilizer before transplanting
0% N, 100% P_2O_5 40% K_2O
First top dressing 10 days after sowing
33% N, 0% P_2O_5 30% K_2O
Second top dressing 25 days after sowing
33% N, 0% P_2O_5 30% K_2O
Third top dressing 40 days after sowing
33% N, 0% P_2O_5 0% K_2O

O. Water Saving (%)

The water saving in drip over furrow irrigation system was calculated as under:

$$WS(\%) = \frac{(Wa - Wb)}{Wa} \times 100 \quad (7)$$

Where,
WS = Water saving (in %)
Wa = Total water used in furrow irrigation system (m^3/ha)
Wb = Total water used in drip irrigation system (m^3/ha)

P. Yield of crop

After picking, the tomatoes were packed in the polyethylene bags. The yield was then measured in kg / ha for each drip and furrow irrigated plot.

The increase in yield (%) was computed as under:

$$Increase in yield (\%) = \frac{(Y1 - Y2)}{Y1} \times 100 \quad (8)$$

Where,
Y1 = Total yield obtained in drip irrigation system (kg/ha)
Y2 = Total yield obtained under furrow irrigation system (kg/ha)

Q. Water use efficiency

The water use efficiency (WUE) of drip and furrow irrigation systems were calculated by using following formula;

$$WUE = \frac{Y}{WR} \quad (9)$$

Where;
WUE = Water use efficiency (Kg/m^3)
Y = Yield of crop (Kg/hec)
WR = Total water consumed for crop production (m^3/hec)

III. RESULTS AND DISCUSSION

A. Soil characteristics

Soil characteristics such as soil texture, dry bulk density and field capacity of the experimental site for the depths of 0-15, 15-30, 30-45 and 45-60 cm are depicted in Table I. It is evident from Table 1, that the soil texture of the experimental site was clay loam; av. dry bulk density was 1.16 g/cm^3 and field capacity 28.5%.

TABLE I
SOIL CHARACTERISTICS

Sr. No.	Parameters	Soil Characteristics
1	Soil Texture	Clay Loam
2	Dry Bulk Density	1.16 g/cm^3
3	Field Capacity	28.5%

B. Performance of drip irrigation system

The coefficients of variation and emission uniformity of randomly selected laterals were determined in order to test the performance of the drip irrigation system.

The results are presented in Table 2, which show that the coefficient of variation of randomly selected laterals was 0.64, 0.82, 0.73, 0.78 and 0.71 respectively. Likewise the emission uniformity of randomly selected laterals was 90.85, 88.11, 89.24, 88.5 and 89.5 % respectively. These results suggest that the system was working satisfactorily according to its design.

TABLE II
DATA SHOWING MINIMUM DISCHARGE, AVERAGE DISCHARGE, STANDARD DEVIATION, COEFFICIENT OF VARIATION AND EMISSION UNIFORMITY

Sample No.	ECw (mmhos/cm)	pH	SAR	RSC
1	600	7.6	2.2	0.0
2	560	7.6	2.0	0.0
3	520	7.6	2.1	0.0

C. Water quality

In order to find out the quality of irrigation water used in drip and furrow irrigation methods, three water samples were collected at start, middle and end of the experiment. The results of these samples are shown in Table 3. These results indicate that irrigation water used through the experiment was suitable for irrigation.

TABLE III
IRRIGATION WATER QUALITY

Lateral No.	Minimum Discharge qm (lit/hr)	Average Discharge q_{av}	$\sum(q-qav)^2$	Standard deviation σ	Coefficient of Variation (Cv)	Emission Uniformity (EU)
1	3.92	3.962	0.0651	0.0255	0.6436	90.85
10	3.90	3.962	0.1073	0.0322	0.8253	88.11
20	3.91	3.975	0.085	0.0291	0.73	89.24
30	3.90	3.967	0.0979	0.0312	0.786	88.5
40	3.91	3.974	0.0818	0.0286	0.71	89.5

D. Irrigation water used

Total volume of water applied to the crop under drip irrigation system was 468.95 m3. It was further calculated as 2344.75 m^3/hec. Similarly total volume of water applied to the crop under furrow irrigation system was 1076 m^3. It was further calculated as 5380.0 m^3/hec as shown in figure 3. These results reveal that total volume of water used under drip irrigation system was less as compared to furrow irrigation system.

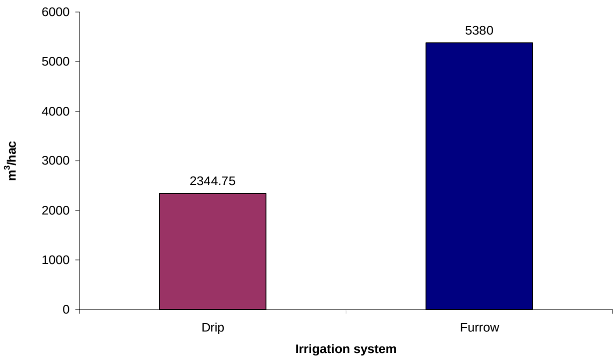

Fig. 3 Total water used in drip over furrow irrigation system

E. Crop yield

Yields of tomato crop under drip and furrow irrigation systems are plotted in Figure 4. It is obvious from Figure 4 that total yield of crop under drip irrigation system was 2288 kg. This was further calculated as 11440 kg/hec. Similarly total yield of crop under furrow irrigation system was 2156 kg. This was further calculated as 8945 kg/hec. These results suggest that total yield of crop under drip irrigation system was more as compared to furrow irrigation system.

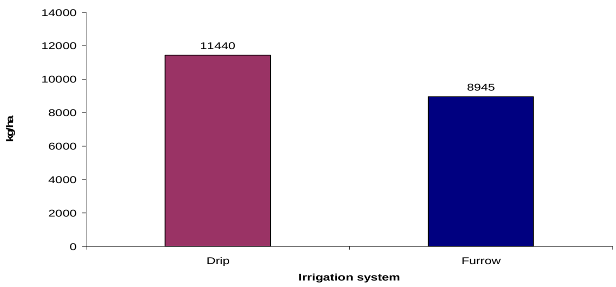

Fig. 4 Yields of crop in drip over furrow irrigation system

F. Water saving, increase in yield and water use efficiency

Drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method as shown in fig. 5.

Likewise higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water use efficiency about 1.66 was obtained in furrow irrigation method as presented in Fig. 6. This may be because in drip irrigation method water is applied directly in the root zone of crop. Hence conveyance, evaporation and percolation losses reduced to larger extent.

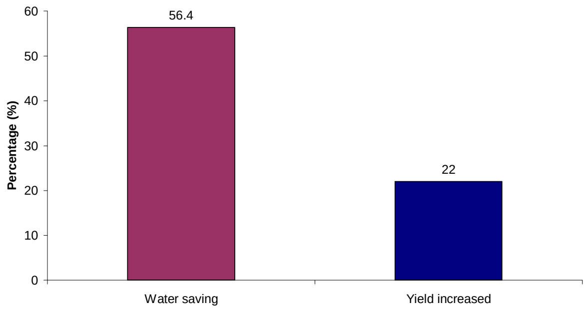

Fig. 5 Water saving and yield of crop in drip over furrow irrigation system

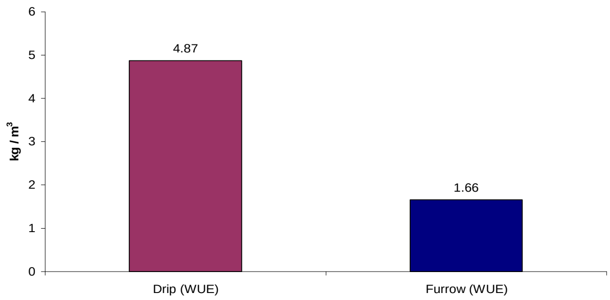

Fig. 6 Water use efficiency in drip over furrow irrigation system

These findings are in agreement with those found by [10] who suggested that drip irrigation is suitable for row crops and all types of soils, even on highly sloping terrain. Crops like chillies, brinjal, radish, beetroot, tomato, Lady's finger, sugarcane, banana and grapes, but no rice, can be grown with drip irrigation. While [11] conducted a study to compare the crop response under trickle and furrow irrigation methods. He reported that the yield under trickle irrigation was more than twice in comparison to the yield by furrow methods. Similarly [12] conducted research on tomato crop. They found that trickle irrigation required 45% less water and produced 22% higher yield than furrow irrigation. In a study [13] reported that yield and water use efficiency of summer and winter vegetable crops was significantly higher in drip than in furrow irrigation method. Also [14] conducted an experiment on mango. They found that 49% water was saved in trickle irrigation as compared to furrow irrigation; moreover; the water use efficiency was higher with trickle irrigation.

IV. Conclusions

Following conclusions and suggestions were drawn from the present study:

- The drip irrigation system was working satisfactorily according to its design.
- Drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method.
- Higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water use efficiency about 1.66 was obtained in furrow irrigation method.

Suggestions

In the present study drip irrigation method gave overall better performance with respect to water saving, increase in yield and water use efficiency. Therefore present study suggests farming community to adopt drip irrigation method instead of old traditional flooding methods.

References

[1] Ishfaq, M. 2002. "Water New Technology". Global Water Institute, Lahore, Pakistan.
[2] Camp, C.R., E. J. Sadler, W. J. Busscher, R. E. Sojlka and D. L. Karrlin (2001) " Experiencing with sprinkler irrigation for agronomic crops in the southeastern USA.
[3] Sharma, B. R. 2001. Availability, status and development and opportunities for augmentation of groundwater resources in India. Proceeding ICAR-IWMI Policy Dialogue on Ground Water Management, November 6-7, 2001 at CSSRI, Karnal pp. 1-18.
[4] Michael, A.M. 2008. "Irrigation Theory and Practice", Second edition (revised and enlarged) Vikas Publishing House PVT. Ltd, Delhi, India.
[5] Yildirim, O. and A. Korukcu, (2000). "Comparison of Drip, Sprinkler and Surface Irrigation Systems in Orchards". Faculty of Agriculture, University of Ankara, Ankara Turkey. 47p.
[6] Singh, N., Sood M.C. and Lal, S.S. (2005. "Evaluation of Potato Based Cropping Sequences under Drip, Sprinkler and Furrow Methods of Irrigation", *Potato Journal*, Vol. 32, No ¾, pp 175-176.
[7] Ibragimov, N., Evtt, S.R. Esanbekov, Y., Kamilov, B.S., Mirzaev, L., and Lamers, J.P.A. (2007), "Water Use Efficiency of Irrigated Cotton in Uzbekistan under Drip and Furrow Irrigation", *Agricultural Water Management*, Vol. 90, No.1/2, pp. 335-238.
[8] ASAE (2002). "Design and installation of micro irrigation systems". *ASAE EP* 405.1 Dec.01, pp. 903–907.
[9] Keller, J., and Bliesner, R. D. 1990. Sprinkler and trickle irrigation, Van Nostrand Reinhold, New York.
[10] Sivanappan, R.K. and D. Chandrasekaran. 1976. "Drip irrigation– A Novel method to save the water". *J. of Indian Central Board of irrigation and Power*, Vol. 33. No. 4.
[11] Sammis. T.W., (1980), "Comparison of Sprinkler, trickle and Furrow Irrigation Method for Row Crops", *Agron. J.*, No. 72, pp. 701-704.
[12] Bogle, C.R. Hartz. T.K. and Nunez, C. (1989) "Comparison of subsurface Trickle and furrow irrigation on Plastic Mulched and Bare Soil for Tomato Production", *Journal of the American Society for Horticulture Science*, Vol. 114, No.1 pp. 40-43.
[13] Yaseen, S.., Rao M. Ishtiaque, and Memon., (1992), "An Evaluation of Trickle Irrigation System under Irrigated Agriculture of Sindh", *Journal of Drainage and Reclamation*, Vol. 5, No. 1 & 2, Drainage and Reclamation Institute of Pakistan, Tanodjam, pp. 14-19.
[14] Nisar. A.M. et al (1995), "Comparative Study of Trickle and Furrow Irrigation Methods on Growth and Water Use Efficiency of Mango Orchard", *Mehran University research journal*, Vol. 15No.2, pp. 243-48.