Paper No. 703

FIELD TESTING OF FILM HOLE IRRIGATION ON BORDERS FOR WATER SAVING AND SUNFLOWER PRODUCTION

Muhammad Saeed & Sajid Mahmood

FIELD TESTING OF FILM HOLE IRRIGATION ON BORDERS FOR WATER SAVING AND SUNFLOWER PRODUCTION

Muhammad Saeed[1] and Sajid Mahmood[2]

ABSTRACT

Film Hole Irrigation is relatively reported efficient irrigation technique amongst the others by Chinese's researchers. Film Hole Irrigation refers to bordered field completely covered with plastic sheet having holes of equal sizes through which seedlings comes. Field experiments were conducted at Postgraduate Agriculture Research Station (PARS) to check its effectiveness and performance in terms of advance rate on sunflower crop for various sized borders having Fine Sandy Loam soil. Tube well irrigation water was applied with an average discharge of 21 l/s and field data was collected from each plot during 1st, 2nd and 3rd irrigations. Results of the study revealed that advance time taken during Film Hole method in completing the advance phase was comparatively less compared with the conventional irrigation. Water saving of 37 to 45% was observed by Film Hole Irrigation and the yield of sunflower crop was higher i.e. from 23 to 30% more with Film Hole. The field management issues were also discussed and addressed properly for extension of by researchers.

Key-words: film hole irrigation, sunflower, water saving, Advance time

INTRODUCTION

Application of water to the field wisely and efficiently for maximizing crop production is the main goal in irrigated agriculture. Pakistan is an agricultural country and mostly the water applied for agricultural production is by surface irrigation but still yields per unit of water in Pakistan is in lowest figure contrast to other countries. Water is becoming one of the major resource constraints for agricultural and economic development in future as ever increasing country's population requires parallel increase in food & fiber production. To overcome such alarming situations, the irrigators recently have diverted their attention towards pressurized irrigation systems. But it's too costly and need skilled labour that lacks in the country. Another option to such problem is the adoptability of new innovative irrigation technique.

[1] Muhammad Saeed, Senior Egineer, IWASRI, and PhD Scholar, Centre of Excellence in Water Resources Engineering, University of Engineering and Technology Lahore, Pakistan. E.Mail: engrsaeed_47@yahoo.com, Cell: +92-333-4431183, Phone Office: +92-42-35303391-92, Fax No. +92-42-35303393

[2] Sajid Mahmood, Assistant Professor, Centre of Excellence in Water Resources Engineering, University of Engineering and Technology Lahore, Pakistan.

Film Hole Irrigation is a relatively new irrigation method that refers to the bordered field completely covered with plastic film having holes of equal sizes (Jiao Xiyum et al,. 1999). Water penetrates into soil through holes during irrigation and seedlings come out from these holes. Its advantages over other surface irrigation methods are faster water advance, reduction in infiltration and evaporation, water saving and increased in crop yields. The benefits associated with film hole irrigation are directly related to the tremendous reduction in losses due to field infiltration and evaporation. Furthermore, the faster movement of water on the plastic sheet reduces the opportunity time, thus behaving like drip-flow irrigation by utilizing minimum water for maximizing crop production.

Present study was an attempt to evaluate the impact of film hole irrigation in terms of water advance on borders and to assess the benefits associated with it. The field management issues would be of more interest to the both researchers and farmers and need to be addressed properly.

Material and Methods

Field experiments were conducted on different sized borders (48 x 5m, 48 x 3m, 24 x 5m, 24 x 3m) for sunflower crop production at various sites of Postgraduate Agricultural Research Centre, University of Agriculture Faisalabad. Each site consisted of eight plots having four sets of treatments for different sized widths and lengths of border. Borders layout was the same for the others sets, which was random rather than systematic. A systematic sketch of site is presented in Figure 1**.** The borders were manually prepared having a gentle slope of 0.2 percent. The soil of the experimental sites was found as Fine sandy loam with an average composition of 50% of sand, 20% of silt and 30% of clay. Plastic sheets were spread on the borders in accordance with the size of the borders and holes were prepared on sheet with the help of 5 cm diameter sharpen edge pipe. The plant to plant distance was set as 22 cm and row to row distance was kept as 60 cm during the field experiment (Figure 2). Then Film Hole plots and open field plots were sown with hybrid sunflower seeds. The moisture in the soil was measured with speedy moisture meter and the irrigation water was applied at 12 to 15% of soil moisture level in the field. Water was applied with the help of cut throat flume, permanently installed in the field watercourse to each having an average discharge of 21 l/s (0.75 cfs) as measured. Irrigation was applied after one month of sowing the crop and the advance of flowing water was measured in each plot by placing stakes at 10 m intervals starting from the inlet end of the border with the help of stopwatch. Performance indicators like Volume Ratio (VR), Advance Time Ratio (ATR), and Water Use Efficiency (WUE) were used to test the effectiveness of FHI contrast to Conventional Irrigation in irrigated field environment. Average of data collected is used here in this article to presents the results.

PERFORMANCE INDICATORS

Advance Rate Performance Indicators:

Conceptually, the performance of an irrigation system for an individual application is dependent on the water stored utilized only for beneficial crop growth.

Present study focuses on the advance rate and crop growth both in Film Hole Irrigation and conventional irrigation techniques. Therefore, the efficiencies terms are not considered here and performance indicators like volume ratio and advance-time ratio were used to compare the hydraulic performance of irrigation system (Mahmood, & Latif 2004). These indicators/functions are described as:

Volume Ratio: One measure of the effectiveness of FH irrigation in hastening advance expressed as the volume ratio (Goldhamer, 1987) as given

$$VR = \frac{\sum V_{wfh}}{V_{wc}} \qquad (1)$$

Where ***VR*** is the volume ratio; V_{wfh} is the total volume of water used to advance the wetting front to the end of the field of film hole irrigation and V_{wc} is the volume required for waterfront advance during control conventional treatment in m3.

Advance-Time Ratio: Faster advance during film hole irrigation reduces travel time of the water front advance to the end of the field compared with control water application. To determine the advance-time reduction for film hole irrigation compared with its counter part, the advance time were normalized relative to the distance covered by the advancing waterfront in film hole irrigated borders and during control irrigations and is expressed as 'Advance time ratio (ATR)'

$$ATR = \frac{\Sigma \frac{t_{fha}}{L_{fh}}}{\frac{t_{ca}}{L_c}} \qquad (2)$$

where t_{fha}/L_{fh} is the normalized advance time for all the film hole plots during film hole irrigation and t_{ca}/L_c is the normalized advance time for control plots related to the distance traveled by the advancing waterfront in the control/conventional irrigation.

(Treatment through Random Selection)

Field Channel	Lined Channel			
	Film Hole (48*5) m^2	(T_2)	Path 1.5 m	Replication-1
	Film Hole (24*3) m^2	(T_8)		
	Control (48*5) m^2	(T_1)		
	Control (24*3) m^2	(T_7)		
	Control (48*3) m^2	(T_3)		
	Film Hole (24*5) m^2	(T_6)		
	Film Hole (48*3) m^2	(T_4)		
	Control (24*5) m^2	(T_5)		
	Film Hole (24*5) m^2	(T_6)		Replication-2
	Control (48*3) m^2	(T_3)		
	Control (24*5) m^2	(T_5)		
	Film Hole (48*3) m^2	(T_4)		
	Control (24*3) m^2	(T_7)		
	Film Hole (48*5) m^2	(T_2)		
	Control (48*5) m^2	(T_1)		
	Film Hole (24*3) m^2	(T_8)		
	Path 1.5 m			

Note:

- Widths of Plots are 3 & 5 m.
- Length of Plots are 24 & 48 m.
- T1, T2, T3, T4, T5, T6, T7 & T8 are the Treatment 1, Treatment 2, Treatment 3, Treatment 4, Treatment 5, Treatment 6, Treatment 7 and Treatment 8 in each Replication.
- Area for experiment is 0.4 ha or 1 acre.

Figure 1: Field Layout and Experimental Setup

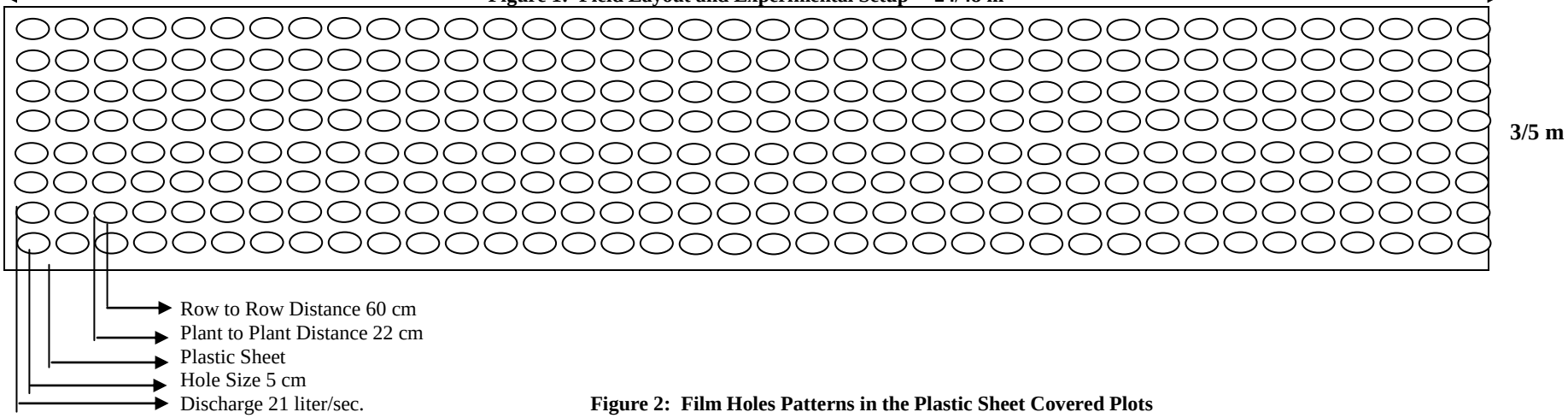

Figure 2: Film Holes Patterns in the Plastic Sheet Covered Plots

RESULTS AND DISCUSSION

Table 1 presents the average advance rate data for both Film Hole and Conventional Irrigations. The data presented in the table is for 1st, 2nd and 3rd irrigations during growing of sunflower crop in the experimental plots. An average discharge of 21 l/s was applied to the irrigated plots. It can be seen from the table that a reduction 10-13% in time occurred during 1st irrigation compared with conventional irrigation. This reduction may be due to faster movement of water over the plastic sheet as compared with open surface of soil.

However, the second irrigation was not applied to the Film Hole Plots because of availability of higher moisture level in the field. This is marvelous benefit of using film hole as compared with conventional and one complete, irrigation was skipped and a 100% saving occurred due to the application of Film Hole Irrigation.

The third irrigation was applied after 78 days of 1st irrigation to the entire experimental plots and a reduction of 15 to 32% in time of water advance observed as expected. The higher reduction in advance time due to the conservation of moisture, negligible evaporation and application of water over the plastic sheet and its entrance to the plants through holes.

Table 1: Advance Time for Different Irrigations

(Time in Minutes)

S.N0	Irrigation	Dis. (m)	CT1 (48*5)	FHT2 (48*5)	CT3 (48*3)	FHT4 (48*3)	Dis. (m)	CT5 (24*5)	FHT6 (24*5)	CT7 (24*3)	FHT8 (24*3)
1	First Irrigation	10	5.33	4.15	1.29	0.93	10	3.5	3.16	1.2	1.1
2		20	10.45	8.85	2.47	1.95	20	6.76	5.89	2.47	2.28
3		30	13.27	12.61	4.13	3.3	24	9.03	8.08	4.35	3.77
4		40	16.65	15.56	5.78	4.82					
5		48	20.15	18.13	8.45	7.53					
1	Second Irrigation	10	1.54	Irrigation was not Required	1.23	Irrigation was not Required	10	2.3	Irrigation was not Required	1.05	Irrigation was not Required
2		20	3.5		2.8		20	4.13		2.27	
3		30	5.75		4.64		24	5.39		3.27	
4		40	7.76		6.81						
5		48	11.73		8.79						
1	Third Irrigation	10	1.15	1.07	0.8	0.79	10	1.12	1.08	0.82	0.4
2		20	2.36	1.66	1.75	1.69	20	2.18	2.17	2.31	1.26
3		30	3.98	2.34	2.83	2.75	24	3.74	3.31	4.15	2.81
4		40	5.76	4.24	4.23	4.02					
5		48	10.25	8	6.89	5.85					

The graphical representations of advance flow time from head to tail of the experimental plot are given in Figures 3, 4, 5 and 6 for first and third irrigations. In these figures it is clear that the less time was taken with film hole irrigation as compared with conventional irrigation method. In all these cases the film hole irrigation method proved that this is the efficient irrigation method as compared with conventional irrigation method.

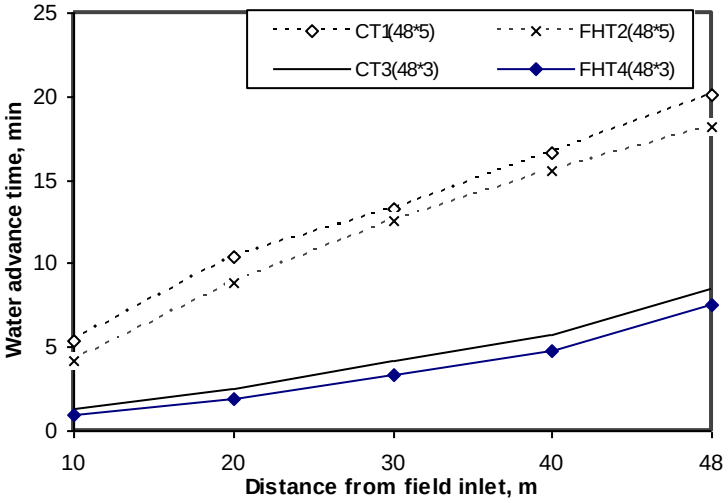

Figure 3: Average Advance Rate Compared with Film Hole (48*5) m^2 , Conventional (48*5) m^2, Film Hole (48*3) m^2 and Conventional (48*3) m^2 during First Irrigation.

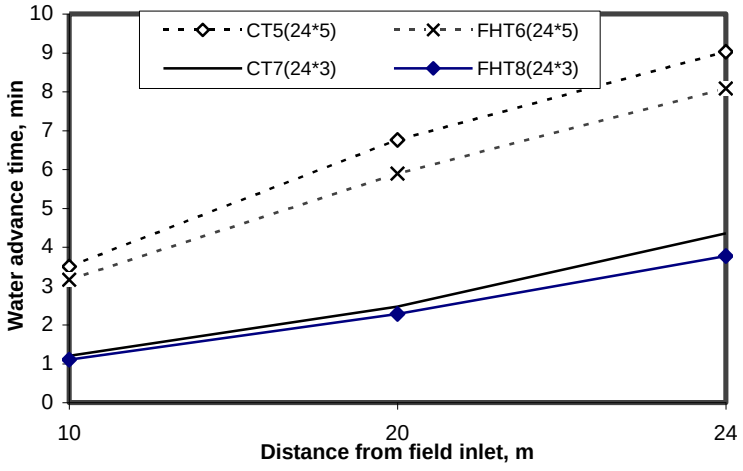

Figure 4: Average Advance Rate Compared with Film Hole (24*5) m^2, Conventional (24*5) m^2, (24*3) m^2, and Conventional (24*3) m2 during First Irrigation

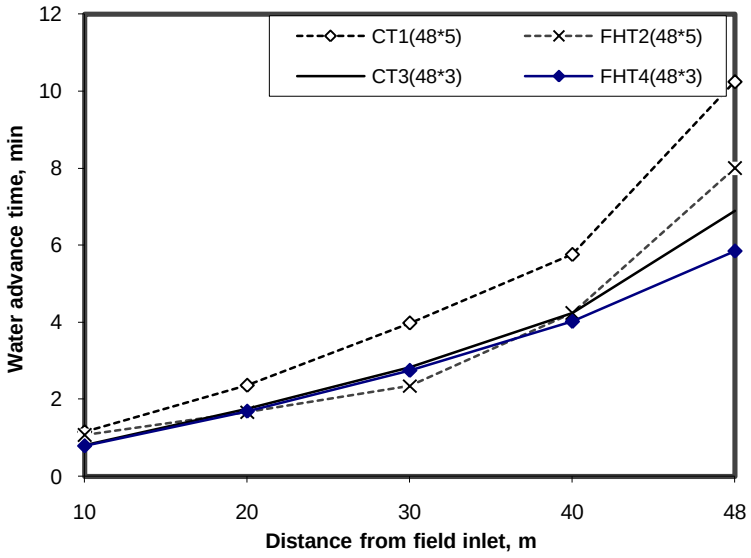

Figure 5: Average Advance Rate Compared with Film Hole (48*5) m^2, Conventional (48*5) m^2, Hole (48*3) m^2 and Conventional (24*5) m^2 during Third Irrigation

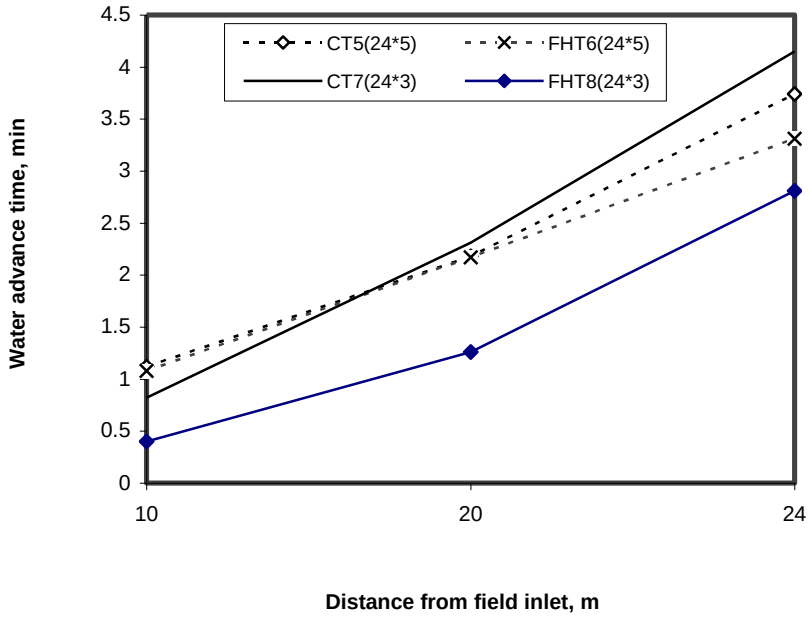

Figure 6: Average Advance Rate Compared with Film Hole (24*3) m^2, Conventional (24*3) m^2, Film Hole (24*3) m^2 and Conventional (24*3) m^2 during First & Third Irrigation

Sun Flower Seed Germination

In the Figures 7&8 the experimental plots are shown with film hole treatment and conventional plots and the germination of the sunflower plants through the holes and open plot. The Figures 9&10 are of grown up plants of sunflower with film hole treatment and control plots, sunflower plants with film hole are very healthy as compared with control plots of sunflower, this was due to the continuous moisture available for the plants as compared with open plots which were not so healthy due to non availability of the moisture continuously. It was also observed that weeds germination was controlled with film hole irrigation as compared to open plots.

Figure 7: A View of Germination of Sunflower Seedlings from the Holes of Plastic Sheet

Figure 8: A View of Germination of Sunflower Seedlings in the Control Field

Figure 9: A Views of Healthy Sunflower Plants Grown in the Holes of Plastic Sheet

Figure 10: A View of Sunflower plants Grown in the Control Experimental Field

Measurements of Girth and Height of Sunflower Crop on 20-12-2009

Measurements of girth and height were made during the second irrigation on 20-12-2009 from all experimental plots. Three different rows in each plot and one plant in each row were measured and it was done after 60 days of sowing of crop. It can be seen from the data that the height and girth of the plants of treated plots were double than the controlled field plants as the data is given in Table 2.

Table 2: Average Height and Girth of Sunflower Plants on 20-12-2009.

Name of Crop: **Sunflower**

Treatment	Row-1		Row-2		Row-3	
	Height	Girth	Height	Girth	Height	Girth
	cm		cm		cm	
CT_1 (48*5)	39.5	4.25	43.5	4.5	36.5	4.5
FHT_2 (48*5)	71.5	7.5	77.5	8.5	70.5	7.75
CT_3 (48*3)	37	3.75	38	4.25	37.5	4
FHT_4 (48*3)	69.5	7	74	8	68.5	7.5
CT_5 (24*5)	38.5	4.5	41.5	4.25	36.5	3.75
FHT_6 (24*5)	78.5	8	75	8.25	76.5	8
CT_7 (24*3)	31	3.75	33	3.5	40	3.5
FHT_8 (24*3)	73.5	8	71.5	7.5	72	8

Measurements of Girth and Height of Sunflower Crop on 07-02-2010

The measurements of height and girth were also made during the third irrigation on 07-02-2010. It was observed from the data that treated plots with Film hole technique, the plants height and girth was double than the height and girth of the plants of conventional plots. The average of the observed data is given in Table 3 after three and half month of sowing date. The graphical representation of height and girth of the sunflower plants are made in Figures 12&13.

Table 3: Average Height and Girth of Sunflower Plants at the Time of Third Irrigation

Treatment	Row-1		Row-2		Row-3	
	Height	Girth	Height	Girth	Height	Girth
	cm		cm		cm	
CT_1 (48*5)	102.5	10.5	102.5	11	109	10.5
FHT_2 (48*5)	143.5	11.5	144.5	12.5	142.5	13.25
CT_3 (48*3)	96	11.5	91.5	10.75	95	10.75
FHT_4 (48*3)	141	11	142	11	139.5	12.5
CT_5 (24*5)	103	11	109	10	90.5	10
FHT_6 (24*5)	140	12.5	149	12	152.5	10.5
CT_7 (24*3)	89	10	93.5	10.5	92.5	10.75
FHT_8 (24*3)	133	13.5	143.5	11	149.5	9.5

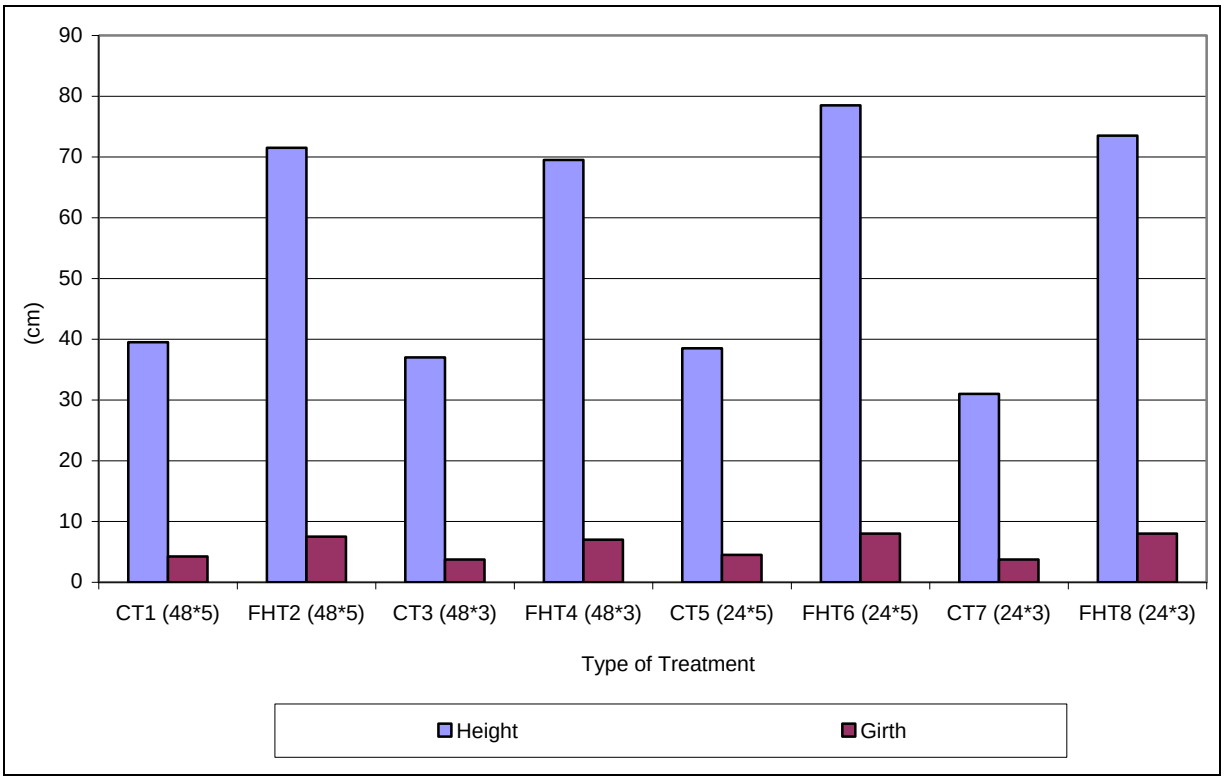

Figure 11: Average Height and Girth of Sunflower Plants with Different Treatments, Row-1 (20-12-2009)

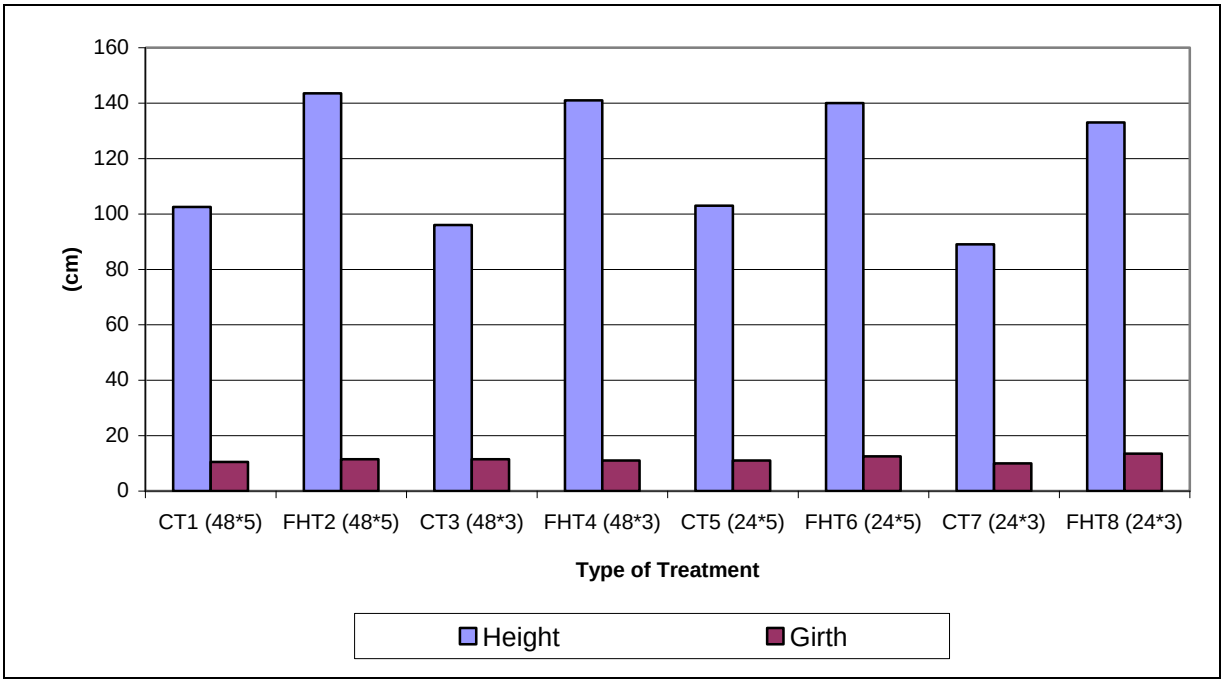

Figure 12: Average Height and Girth of Sunflower Plants with Different Treatments in, Row-1 (07-02-2010)

Water Saving

Water saving can be expressed in terms of volume ratio., i.e., the ratio of water volume applied during film hole irrigation in a border to the volume of water applied in the conventional irrigation method (Goldhamer et al. 1987). It is obvious from the data that less time is required to complete the advance phase in film hole irrigated borders compared with conventional irrigated method. There is very less volume required to complete advance phase under film hole irrigation and more volume of water was required for conventional border type irrigation. The volume of water consumed with film hole and conventional irrigation method is given in Table 4. The percent water saving with film hole and conventional irrigation method is given in Table 5. The data shows that with help of film hole irrigation, we can save 37% to 45% water as compared conventional irrigation method. Figure 14 shows the volume of water used with different treatments up to the harvesting of the crop.

Table 4: Average Volume of Water Used by Sunflower Crop during Different Irrigations

Treatment	Volume of Water Litres)	Volume of Water (Litres)	Volume of Water (Litres)	Total Volume (Litres)	Total Volume (m^3)
	Ist Irrigation	2nd Irrigation	3rd Irrigation		
CT_1 (48*5)	25389.00	14773.50	12908.70	53071.20	53.07
FHT_2 (48*5)	22843.80		10080.00	32923.80	32.92
CT_3 (48*3)	10647.00	11069.10	8675.10	30391.20	30.39
FHT_4 (48*3)	9481.50		7364.70	16846.20	16.85
CT_5 (24*5)	11371.50	6785.10	4706.10	22862.70	22.86
FHT_6 (24*5)	10174.50		4170.60	14345.10	14.35
CT_7 (24*3)	5481.00	4113.90	5222.70	14817.60	14.82
FHT_8 (24*3)	4743.90		3540.60	8284.50	8.28

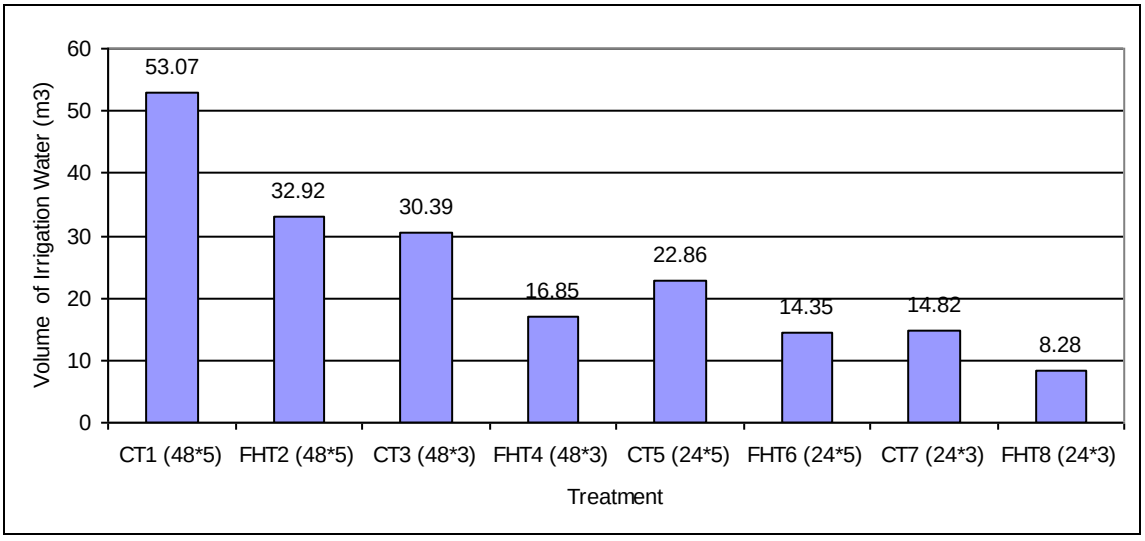

Figure 13: Sunflower Crop Used Volume of Water with Different Irrigations.

Table 5: Percent Saving of Water with Respect to Film Hole and Conventional Irrigations.

Treatments	Discharge ($l\ s^{-1}$)	Volume Applied (m^3)	Volume Ratio	Water Saving (%)
CT_1 (48*5)	21	53.07		
FHT_2 (48*5)	21	32.92	0.62	38
CT_3 (48*3)	21	30.39		
FHT_4 (48*3)	21	16.85	0.55	45
CT_5 (24*5)	21	22.86		
FHT_6 (24*5)	21	14.35	0.63	37
CT_7 (24*3)	21	14.82		
FHT_8 (24*3)	21	8.28	0.56	44

Sunflower Crop Yield

One of the important parameter in the evaluation of any soil-water plant system is crop yield. The sunflower crop yield obtained from the plots in kg/ha which is given in Table 8. The table shows that yield was higher from 23 to 30% with film hole as compared with conventional irrigation method. The grain yield of the sunflower in different experimental plots is given in Figure 15. This is the fact that with film hole irrigation, the water was continuously available for the plants with limited evaporation losses.

Table 6: Sunflower Grain Yield with Film Hole and Conventional Irrigation Method.

Treatment	Discharge (l/s)	Area (m^2)	Yield (kg)	% Increase in Yield
CT_1 (48*5)	21	240	46.8	100
FHT_2 (48*5)	21	240	59	126
CT_3 (48*3)	21	144	28.08	100
FHT_4 (48*3)	21	144	34.56	123
CT_5 (24*5)	21	120	23.4	100
FHT_6 (24*5)	21	120	29.8	127
CT_7 (24*3)	21	72	14.04	100
FHT_8 (24*3)	21	72	18.28	130

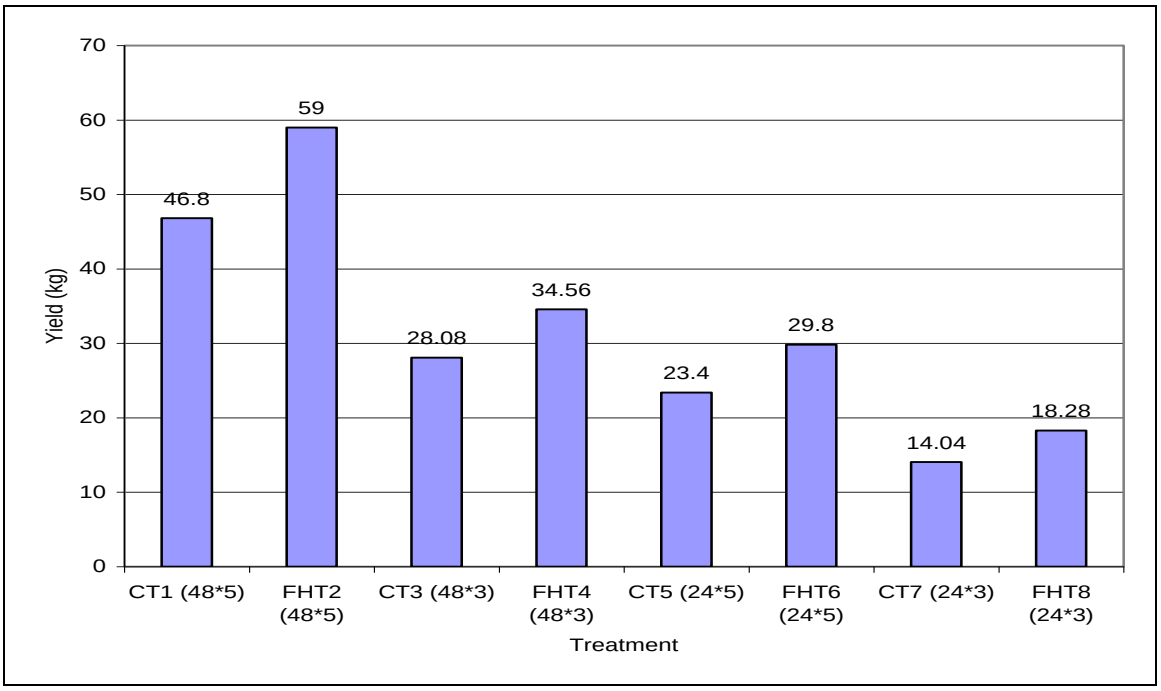

Figure 14: Sunflower Grain Yield in Different Experimental Plots

MANAGEMENT ISSUES RELATED TO FILM HOLE

When properly seedbed was prepared for the crop then spreading of film hole is an important issue so that no open area of the plot should be remained and its corners should also be buried in the soil surface so that water can flow freely over the plastic sheet. Making of holes in film are also very important because these holes should be according to the crop plant to plant and row to row distance. There should be slightly slope from head to tail of the field. The application of fertilizer should not be broadcasted but it can be applied by making solution in water and then that water can be mixed in the irrigation water. The cost of film hole is the extra expenditure for the farmer, but when it is compared with the water savings, the water saving is more than the cost of film hole. The weed growth was very less under the film hole as compared with controlled field.

CONCLUSIONS

In view of the inherent losses and other inefficiencies of irrigation systems, film hole irrigation was evaluated with special emphasis on advance rate with conventional irrigation method. The literature in general advocates the beneficial application of film hole irrigation. The present study also proved its usefulness under border irrigation and it can be considered as a good alternative in the future for water saving and increasing crop production. The main findings of the study are summarized as follows:

- In case of film hole irrigation, is proved to be an efficient advance rate technique as it saves 11% to 32% of time in terms of the waterfront which

accelerate the movement of water over the film. It resulted in better distribution of infiltrated water over the entire length of the border;

- The Volume ratio is an appropriate indicator to assess water saving compared to conventional irrigation method as it is observed that with film hole irrigation we can save 37 to 45% of water as compared with conventional irrigation method.
- Film hole irrigation was applied with 21l/s discharge and it was found to be one of the best options for water saving, improving irrigation performance and increasing crop yield.
- It was also observed that height and girth of the sunflower crop was double with film hole irrigation as compared with conventional irrigation method.
- With the help of film hole irrigation we can suppress the weed growth in the crop as compared with conventional irrigation method.
- Sunflower crop yield was increased from 23 to 30% with film hole irrigation as compared with conventional irrigation method.

Future of Film Hole in Pakistan

Past research and present field experiment confirmed that the advance of the water front during film hole irrigation can be improved and this is the innovative technique and is an alternative to existing irrigation methods resulting reduction in the volume of applied water as compared with conventional irrigation method. But the results presented in the present study limits its adoptability under conditions, as the length normally used in Pakistan for irrigating the field crops is only 61 m, compared with longer field lengths mostly used in the developed countries. Further field studies are needed to determine the parameters and dimensions like different soil type and different weather, longer field length and different discharge levels and advance rates of film hole and performance parameters before making sound recommendations. Beside all these factors, the most important and controllable parameter under field conditions is normally the inflow rate to the bordered field.

REFERENCES

- Goldhamer D.A., Aleemi M.H., Phene R.C., 1987. Surge vs continuous flow irrigation.
- California Agriculture, 41(9/10), 29-32.
- Mahmood S., Latif M., 2004. Field measurement and simulation of advance ratio for continuous and surge irrigation furrows. Irrigation and Drainage ICID 53 (4), 437-447.
- Xiyun, J. et al, 1999. "Experimental Research on Surface Flow Characteristics of Film Hole Irrigation". Proceedings of 99 International Conference on Agricultural Engineering, Beijing, China, December, 1999. Pp 45-49.