Science, Technology and Development 36 (2): 106-114, 2017
ISSN 0254-6418 / DOI: 10.3923/std.2017.106.114

Impacts of Furrow Cover Plastic Sheet on Crop Water Productivity and Salt Distribution in the Soil Profile

[1, 2]Muhammad Sohail Memon, [1]Fahim Ullah, [2]Kausar Ali and [2]Noreena Memon

[1] College of Engineering, Nanjing Agricultural University, Peoples Republic of China, 210031
[2] Faculty of Agricultural Engineering, Sindh Agriculture University, Tandojam, Pakistan.

Abstract: In this paper, we have discussed about the crop water productivity and salt distribution in the soil profile of semi-arid and arid areas with the increasing demand for water in the country. This necessitates the introduction and development of low input and water saving technologies for sustainable crop production. Keeping in view, the importance of plastic sheet for irrigation water conservation, an experimental study was conducted to minimize crop water productivity and salt distribution in the soil profile from the bottom, using plastic sheet. The seeds of okra were sown manually with a plant to plant spacing of 25 cm and irrigation was applied with an interval of 6-8 days and measured with cut-throat flume. The soil samples were taken at soil depths of 20-80 cm before and after experiment for soil analysis. The experimental results revealed that the soil pH decreased after harvest under T_1 and average dry density of soil was increased as 0.01 g/cm^3 after harvest under both treatments (T_0 and T_1). Similarly, EC_e of the soil profile depth-wise increased slightly under T_0 but there was more increase in EC_e of soil profile under treatment T_1 due to plastic sheet. The okra yield was noted 7,575 kg/ha and 8,332 kg/ha, the total volume of irrigation water applied was 31.09 m^3 and 21.56 m^3 under treatments T_0 and T_1, respectively. Water saving was 52.22% and 31% under T_1 and T_0, respectively, when compared to flood irrigation method. The crop water productivity of 2.5 kg/m^3 was obtained from treatment T_1, followed by T_0, where crop water productivity was only 1.6 kg/m^3. However, an overall improvement, in term of water saving and crop yield, was obtained when plastic sheets were integrated with furrows. Hence, it is recommended that the plastic sheets may be used in furrow irrigation to minimize salt distribution and enhance the crop water productivity in the soil profile from furrow bottoms.

Key words: Irrigation method, Plastic sheet, Crop yield, Crop water productivity, Water saving and salt distribution.

INTRODUCTION

Pakistan belongs to one of the Agricultural countries in the world, which falls within the arid and semi-arid zones of the globe and the irrigation areas are under the pressure of water shortage (Adnan *et al*., 2012). The growing demand for water in the country emphasizes the need to introduce and develop low input and water saving irrigation technologies for sustainable crop production particularly in semi-arid and arid areas (Bainbridge, 2001). The consumption of water by agriculture sector continues to dominate the overall requirements of water. Moreover, the increasing population, urbanization and unsustainable consumption of water have further increased the demand of water in arid and semi-arid regions of the country Ashrafuzzaman *et al.* (2011).

In Pakistan, generally, traditional surface irrigation methods, i.e., Basin, Border and Furrow, are used to irrigate crops (Pravukalyan *et al.*, 2011). In surface irrigation methods, furrow irrigation is an irrigation method, which utilized less amount of water in irrigation. It is a popular technique among farming communities, where the irrigation water shortage is severe (Wang *et al.*, 2011). Furrows provide better on-farm water management capabilities under most surface irrigation conditions. Flow rates per unit width can be substantially reduced and topographical conditions can be more severe and variable (Hezhong *et al*., 2008). However, furrows provide operational flexibility important for achieving high efficiencies for each irrigation throughout a season (Awodoyin *et al.,* 2007).

Rong *et al.* (2012) studied that it is a simple (although labor intensive) matter to adjust the furrow stream size with changing intake characteristics by simply changing the number of simultaneously supplied furrows. Moreover, water application, irrigation cost, leaching of chemicals and increasing

Corresponding Author: Fahim Ullah, College of Engineering, Nanjing Agricultural University, Peoples Republic of China, 210031
E-mail: fahimullah320@yahoo.com

the cropping yield, using furrow irrigation (Robert, 1967), while in most cases, the performance of furrow irrigation can be improved through increasing the speed at which water moves along the field (the advance rate). Increasing the advance rate not only improves the uniformity but also reduces the total volume of water required to complete the irrigation (Nazir and Ghulam, 1988). This will increase irrigation efficiency by diverting the direction of water flow directly into the side walls of the furrow, thereby eliminating direct downward flow below the plastic cover and providing maximum opportunity for water to infiltrate into the side of the furrow and be drawn up into the ridge by capillarity (Kumar and Lal, 2012).

Hatami *et al.* (2012) examined the effects between-row spacing, in-row spacing and mulch treatments and found that these factors had significant effects on yield and yield ingredients (weight of fruit and number of fruit per plant). They also found that water productivity increased by the application of plastic film that was 33 kg/m^3 on 100×30, pattern with the plastic covering at full furrow and half ridge. However, the study on the effects of different furrow without and furrow with plastic sheet combined farming practices on water saving.

Jiang *et al.,* (2012) reported that percentage of saved water and water saving efficiencies of Mung bean increased by 22.73% - 40.38% as compared to those under the flat farming practice under different furrow without and furrow with plastic sheet. Likewise, effect of inter-row polyethylene sheet on the crop water productivity of furrow and drip-irrigated maize indicated that the inter-row polyethylene sheet is an efficient technique for increasing the crop water and plant productivity (Lizarazu and Berliner, 2011).

The use of darker (black, blue, red)-colored plastic sheets increased the early and total yield of okra as compared to bare soil without row cover (Garry *et al.,* 2010), while the black plastic sheet had significant effect on the growth and yield of okra and this conservation of water makes plastic sheet favorable for farmers in dry and arid climates where water is a limited resource (Mamkagh *et al.*, 2009). However, the use of plastic sheet could increase the corn yield significantly compared with straw mulching that could increase the yield and water use efficiency by 6.4% and 21.5 kg/mm, respectively, and maintain the surface of soil from loss of precipitation and structure of soil, using plastic sheet (Fang *et al.,* 2003). The effect of five colored polyethylene sheets (clear, green, steel-colored, black or brown plastic film) on the growth and yield of muskmelons and the muskmelon growth and yield was significantly affected by color plastic sheets (clear, green, steel-colored, black or brown plastic film) as compared to other mulches i.e. newspaper, hay and pine needles (Lloyd and bailey, 2002). Moreover, the effect of plastic sheet on the yield of maize on plastic sheet reduced the amount of irrigation required by maize in the north China plain (Zhang *et al*., 2002). Another research study demonstrated that under plastic film treatment the water deficit during the budding stage could significantly enhance on lint yield and improve water use efficiency under the surface of a plastic film, Zhang and Cai (2001) conducted an experiment to examine the effect of black plastic film on the early fruit and yield of watermelon, which involved multiple cropping of specialty melon transplants, using black plastic film and floating row covers. The results of this study indicated that the watermelon yields from beds planted in plastic film were three times higher than the beds without row cover and "beds without plastic film" (Hill, 1997). The use of plastic sheets (black and white plastic sheet) had significant effect on the number of days to flowering or to prolong the fall growth and average growth per plant as compared to other treatments, i.e., control and straw, which is suitable cultural practice for enhancing tomato production (Daniel *et al.*, 1992). Furthermore, plastic film accelerated germination, increased stalk population, rate of stalk elongation and yield by 25 ± 3.9 tons cane/ha and 2.8 ± 0.68 tons/ha (Millard, 1974).

Keeping in view, the impact of furrow cover plastic sheet on crop water productivity and salt distribution in the soil profile, the present study was conducted, using plastic sheet in furrow irrigation method, for an efficient crop water productivity and salt distribution in soil profile. The aim of the study was to enhance the crop water productivity and minimize salt distribution in the soil profile, using plastic sheet in furrow.

MATERIALS AND METHODS

Description of experimental area: The study was conducted in the experimental field of Sindh Agriculture University, Tandojam, during May-July, 2014, at the area of 150 m^2. The experimental area was located at 25.2535 °N N and 68.3239 °E Latitude and Longitude with the altitude/elevation of 26 m, above mean sea level and the experimental field was irrigated with groundwater.

Description of experimental design and layout: The size of the plot selected for the experiment was 12 m × 11 m (132 m^2) and each treatment (T_0 = Furrow bottom without plastic sheet and T_1 = Furrow bottom with plastic sheet) was replicated six times with two blocks and used Randomized Complete Block Design (RCBD).

Preparation of land: The experimental field was prepared with the application of a soaking dose of irrigation of 80 mm and the seedbed was prepared by ploughing the field with moldboard plough and disc harrow. After preparation of each treatment, the width of each ridge was kept as 0.50 m and the length of each furrow was kept 11 m and the plastic sheets were placed on the bottom of furrows in treatment T_1.

Data collection procedure: Okra crop (lady finger) (*Abelmoschus esculentus* L) was selected for cultivation in the experimental plot, which is an important vegetable crop of two growing seasons, i.e., February-March and June-July (Khoso, 1994). The total water requirement for okra crop throughout the crop season is 500 mm reported by MINFAL (2005).

Before sowing of the crop, the seeds were soaked in water for 6-8 hours to enhance germination. After soaking, the seeds of okra were rubbed thoroughly with fine dry soil and then sown manually on both sides of ridges with plant-to-plant spacing of 25 cm at a soil depth of 4-5 cm. The date of sowing of the crop was 8th May, 2014. After germination, the crop was thinned out at 3-4 leaf stage and the irrigation was applied with an interval of 6-8 days. The water applied to every furrow during irrigation for both treatments was measured with cut-throat flume and installed in upstream and downstream sections of the plot and noted the reading of water depth in cm.

Harvesting of okra crop was started in the first week of July, 2014, and then weighed separately for both treatments and the data were recorded and per plot yield of okra crop was converted into kilogram per hectare (kg/ha).

Data analysis: Auger sampler was used for taking forty-eight soil samples before and after harvesting at soil depths 0-80 cm. Dry density of soil was calculated at a soil depth of 0-20 cm with core sampler because the upper 0-20 cm layer as most was subject to natural, agriculture and human activities. The flow rate was calculated which indicated that the flow of water was submerged flow and the quantity of water was recorded in m^3 with the time taken to fill every furrow to a depth of 70%. Irrigator's equation was used for the calculation of required depth of water. Equations 1 and 2 were used for the calculation of flow rate and depth of water as reported by Rafiq (2005). "*s*" denoted submerged flow, "d" subscript denoting downstream, "Q_s" submerged flow discharge rate, "n_f" Submerged flow exponent = 1.939 (for 8" × 1.5' size flume), "C_s" submerged flow coefficient = 1.606 (for 8" × 1.5' size flume), "h_d" downstream flow depth in ft, "n_s" submerged flow exponent = 1.728 (for 8" × 1.5' size flume), "S" submergence which is defined by the ratio of downstream head with upstream head = hd/hu, "Q" discharge (cumec or m^3/sec), "T" time (second), "A" area (m^2) and "D" depth of water (m).

$$Q_s = \frac{[C_s(h_u - h_d)n_f]}{[(-\log S)n_s]} \quad \text{.........} \ [1]$$

$$QT = AD \quad \text{..................} \ [2]$$

These samples were analyzed for the parameters, shown in Table 1, in order to examine the effect of plastic sheet on salt distribution in furrow cover plastic sheet profile.

Table 1: Physico-chemical soil parameters determined during the study.

S. No	Parameters	Adopted method	For	Reference
1	Soil texture	Bouyoucos Hydrometer		Bouyoucos Hydrometer methods
2	Dry density	Core method	Soil	McIntyre and Loveday (1994),
3	EC_e (dS/m)	Soil saturation extract		Rowell (1994)
4	pH			

Water saving: The main aim of the current study was to minimize the infiltration from furrow bottom by laying plastic sheet on furrow bottom. The water savings obtained with plastic sheet at furrow bottom was compared with flood irrigation as well as normal furrows without plastic sheet, were calculated, using equations 3 and 4. The depth of irrigation water consumed under flood irrigation method for okra crop was taken from literature as reported by Patel *et al*. (2009). The equation represents "WS" water saving in (%), "W_{FL}" total water used for growing okra under flood irrigation (from reference), "W_F" total water used for growing okra with furrow irrigation (mm) and "W_{FP}" total water used for growing okra with plastic sheet at furrow bottom (mm).

$$WS\ (\%) = \frac{(W_{FL} - W_{FP})}{W_{FL}} \times 100 \quad \text{..................} \ [3]$$

$$WS\ (\%) = \frac{(W_F - W_{FP})}{W_F} \times 100 \quad \text{..................} \ [4]$$

Yield of crop: The total okra pod yield obtained from treatment T_1 (plastic covered furrow bottom) was compared to the yield obtained with treatment T_0 (normal furrow irrigation method) as well as with conventional flood irrigation method (from literature) were calculated, using equations 5 and 6 "Y_{FL}" total yield (kg/ha) of okra under flood irrigation (from reference), "Y_F" total yield (kg/ha) of okra with furrow irrigation and "Y_{FP}" total yield (kg/ha) of okra with plastic sheet at furrow bottom.

$$\text{Yield}\ (\%) = \frac{(Y_{FL} - Y_{FP})}{Y_{FL}} \times 100 \quad \text{..................} \ [5]$$

$$\text{Yield}\ (\%) = \frac{(Y_F - Y_{FP})}{Y_F} \times 100 \quad \text{..................} \ [6]$$

Crop water productivity: The Crop Water Productivity (CWP) is a ratio between output and input, usually expressed in percentage, but in term of plant and water, it may be defined as total crop yield per unit depth of applied irrigation water. The CWP under plastic sheet at furrow bottom and normal furrow irrigation method for okra crop was calculated, using equation 7, as reported by Hatami *et al*. (2012. "CWP" denotes crop water productivity (kg/m^3), "Y" is total yield of crop (kg/block) and "WR" is total water consumed for crop production (m^3/block).

$$CWP = \frac{Y}{WR} \quad .... [7]$$

RESULTS AND DISCUSSION

Physico-chemical properties of soil: In order to determine the physico-chemical properties of soil profile under study, the soil samples were taken from randomly selected locations of both plots under both treatments (T_0 and T_1) at 0-80 cm depth, before and after the experiment and soil samples were analyzed in the laboratory for the required soil physico-chemical properties.

Texture of soil profile: The results of soil analysis for texture of the soil profile are given in Table 2. The results of soil analysis before experiment indicate that the soil was loamy throughout the profile (0-80 cm) in both plots which remained unchanged after the experiment. However, a non-significant variation in the relative percentage of soil separates was observed at various depths.

pH: The soil pH at different sampling depths for both treatments (T_0 and T_1) are presented in Table 3, while its statistical analysis of variance showed that the soil pH was non-significantly ($p > 0.05$) affected by treatments. It is evident from the results that the values of pH were in the range from 8.1 to 8.5 before sowing, while after harvest the range is 7.8 to 8.3 at depths of 0-80 cm, respectively. The results show that pH of the soil decreased in both treatments (T_0 and T_1) after harvest at soil depths from 0-80 cm. The main reason of decreasing pH was due to increase of EC_e under T_1 due to salts, were not leached down from upper layers to lower in the soil profile. The leaching of salts was minimized by the plastic sheets laid on the furrow bottom.

Table 2: Texture of the soil profile before and after the experiment.

S. No	Soil depths (cm)	Pre-sowing				Post-harvest			
		Sandy %	Silt %	Clay %	Textural class	Sandy %	Silt %	Clay %	Textural class
1	0-20	55.6	32.0	12.4	Loamy soil	55.5	31.5	12.4	Loamy soil
2	20-40	16.4	59.1	24.5		17.0	59.5	25.0	
3	40-60	65.1	20.7	14.2		65.0	21.2	15.0	
4	60-80	55.1	35.7	9.2		55.8	36.5	10.0	

Table 3: pH of soil profile for the treatments T_0 and T_1.

S. No	Soil depths (cm)	Pre-sowing		Post-harvest	
		T_0	T_1	T_0	T_1
1	0-20	8.2	8.4	**7.8**	7.9
2	20-40	**8.5**	8.3	8.0	8.1
3	40-60	8.4	8.2	**8.3**	8.0
4	60-80	**8.1**	8.2	8.0	7.9

EC_e of soil profile: The results pertaining to electric conductivity of soil saturation extract (EC_e) are presented in Table 4. Statistical analysis of variance showed that the electric conductivity (EC_e) of soil saturation extracted at different sampling depths was significantly ($p < 0.05$) affected by treatments. EC_e of the soil was in the range of 0.30 to 1.15 dS/m before sowing and 0.57 to 1.70 after harvesting at soil depths from 0-80 cm, respectively. The results showed that EC_e was increased significantly in both treatments at soil depths from 0-80 cm, respectively.

The EC_e of soil profile depth-wise increased slightly under T_0 but there is more increase in EC_e of soil profile under treatment T_1, due to plastic sheet used in furrow bottom, which stopped the infiltration from furrow bottom and diverted the downward movement of water into the side of furrow ridge so all the soluble salts present remained there which increased the EC_e of soil profile. These results are in accordance with those of Chen and Katan (1980) who studied the effect of this treatment on the chemical properties and hydraulic conductivity of soil.

Table 4: EC_e of soil profile for both treatments.

S. No	Soil depths (cm)	Pre-sowing (dS/m)		Post-harvest (dS/m)	
		T_0	T_1	T_0	T_1
1	0 - 20	**1.15**	0.39	**1.70**	1.39
2	20 - 40	0.66	**0.30**	1.21	1.60
3	40 - 60	0.47	0.32	**0.57**	1.42
4	60 - 80	0.42	0.60	0.59	0.61

Dry density of soil profile: Dry density of soil calculated at the soil depth of 0-20 cm is presented in Fig. 1. The related statistical analysis of variance showed that the dry density of soil was non-significantly ($p > 0.05$) affected by these treatments. The results showed that the dry density increased in both treatments with the minor changes of 0.01 g/cm^3. The results are in contradiction to Frenkel *et al*. (1978) and Kazman *et al*. (1983). The dry density of soil in upper soil layer might be increased due to a crust layer on the surface, due to the presence of sodium content caused by dispersion of the clay soil with the consequent formation of fine pores, resulting in an increase of the dry density of soil.

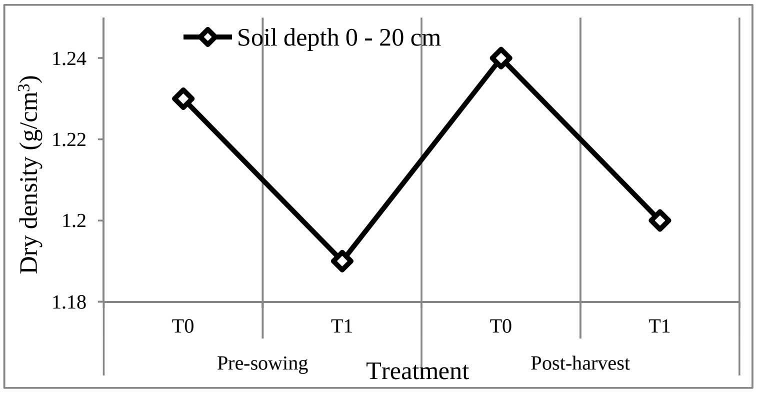

Fig. 1: Dry density of soil profile for pre-sowing and post-harvest treatments T_0 and T_1, respectively.

Crop yield: The results of okra crop yield for both treatments (T_0 and T_1) are presented in Fig. 2. The related statistical analysis of variance showed that the crop yield was significantly ($p < 0.05$) affected by treatments as shown in Table 5.

It may be clearly observed that the overall performance was found best in T_1 treatment under furrow irrigation method using plastic sheets below furrow bottom. It might be due to more availability of soil moisture and soluble nutrients in the root zone whose leaching was stopped by plastic sheets used under furrow bottom which easily facilitate the uptake of sufficient amount of soil moisture and soluble nutrients to plant roots. These create better conditions for the growth and, well development of plant root system it resulting more crop yield under T_1 as compared to T_0 where sufficient amount of soluble nutrients were leached down in connection with infiltration from furrow bottom.

Table 5: (ANOVA) Results of statistical analysis of subject effects.

Source of variation	SS	Degree of freedom	MS	F-value	Prob.
T_1	5849.143	1	5849.143	96.072	0.000
Replication	10.550	2	5.275	0.087	0.918
Error	487.065	8	60.883		

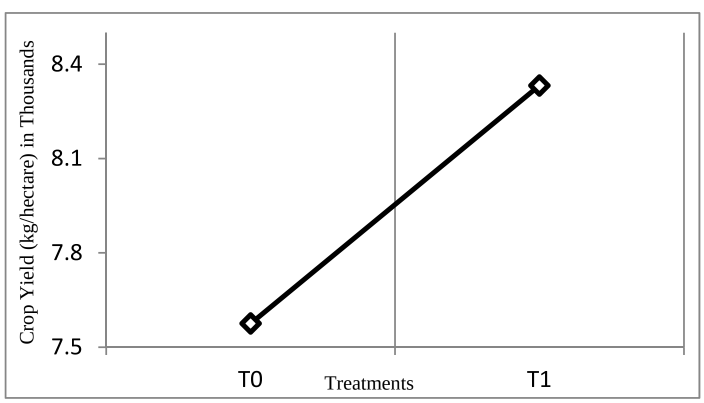

Fig. 2: Crop yield for the treatments (T_0 and T_1).

These results are supported by Hussain *et al.* (2010), who reported that well developed crop yield with furrow irrigation method, might be the reason of more Phosphorus contents in the leaves, roots and grains in furrow sown crop. P uptake is closely related to root growth and morphology. These results are also similar to those reported by Khan *et al.* (2012), who reported better yield with furrow irrigation method although there was non-significant effect of sowing either on ridge or furrow on crop yield. These results are also supported by Awodoyin *et al.* (2007) who reported a healthy effect of plastic mulching on the growth, yield and weed suppression. Hatami *et al.* (2012) also reported significant effects of mulch treatments on yield and yield ingredients (weight of fruit and number of fruit per plant). The experimental results are fully supported by Garry *et al.* (2010) who reported the effect of colored plastic sheets and row covers on the growth and yield of Okra.

Irrigation duration and water volume: The results regarding the average time taken by each furrow to fill to a depth of 70% for treatments T_0 and T_1 were recorded for 780 and 540 seconds, respectively. Cut-throat flume (Q = 0.005 m^3/s) was used for the measurement of water applied to every furrow during each irrigation for both treatments. The total depth and volume of water used in irrigation are presented in Fig. 3 showing that the total depth of irrigation water per block was 496.17 mm and 344.17 mm under T_0 and T_1 respectively. The total volume of water applied was 31.09 m^3 and 21.56 m^3 for treatments T_0 and T_1 respectively. During crop growth period, a total of 0.17 mm of rainfall was recorded which was added to the total depth of water consumed under both irrigation treatments. The amount of seasonal rainfall was included to the volume of irrigation water used for all the plots during the experimental study. The total average time taken by treatment T_1 during each irrigation to irrigate all the furrows to 70% of depth of furrow was less as compared to T_0, this was due to use of plastic sheet at furrow bottom which stopped the infiltration and reduced the time of irrigation application and amount of water as compared to T_0 where large amount of water was lost due to infiltration resulting in increased irrigation time.

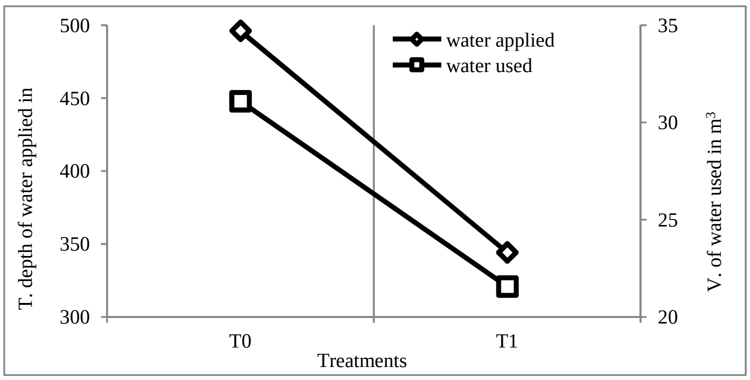

Fig. 3: Volume of irrigation application for both treatments (T_0 and T_1).

Brown and Butcher (1999) also reported that the excess irrigation and deep percolation of the irrigation water in the local sandy loam soil causes low water use efficiency and water shortage in critical growth period of the crop. Harris *et al.* (2004) reported that in soil management, mulch acts as a protective cover placed over the soil to hold moisture, provide nutrients, moderate erosion, encourage seed germination and suppress weed development. These results are in accordance with those reported by Awodoyin *et al.* (2007), who showed the good effect of plastic mulching on infiltration, soil temperature and less moisture loss under field conditions.

Water savings: The data of the water saving for both the treatments are given in Table 6. The total water required by okra crop during entire crop growth period under control flooding for normal furrow irrigation method was 500 mm (MINFAL, 2005), while under control flood irrigation methods, it was 720 mm (Patel *et al*., 2009). The water saving was thus 31% and 52.22% under treatments T_0 and T_1, respectively, when compared to flood irrigation method, while comparing T_0 and T_1, 30.64% water saving was recorded under the treatment T_1. These results are matching with Siyal *et al.* (2012) who reported that placing a plastic sheet on the bottom of the furrow prevents direct vertical infiltration from the bottom of the furrow which increase the water saving efficiency of furrow irrigation method. These results are also similar to those reported by Jiang *et al.* (2012) who reported 22.73%-40.38% increase in water saving efficiency with plastic sheet mulching in furrow irrigation method. Li *et al*. (2001) reported that the percentages of saved water and the water saving efficiencies increased by 22.73% to 40.38% with plastic mulched furrow than un-mulched (control) under furrow irrigation method.

Table 6: Irrigation water savings for treatments T_0 and T_1.

Irrigation method	Irrigation water (mm)	Water savings (%)	
		Compared to flood irrigation	Compared to T_0
T_0	496	31.0	-
T_1	344	52.2	**30.6**
Flood irrigation	720	-	-

Crop water productivity: The results revealed that the crop water productivity was 2.5 kg/m^3 under treatment T_1 followed by T_0 where crop water productivity was 1.6 kg/m^3, respectively, as shown in

Fig. 4. Crop water productivity was increased, using plastic sheets under the bottom of furrow. This is due to less infiltration rate which reduces the amount of water and improve water and nutrient use efficiency that ultimately resulted in higher crop water productivity under treatment T_1. Pravukalyan *et al.* (2011) also reported the yield per unit quantity of irrigation water, was estimated to be the highest (12.3 kg/m^3), using plastic sheet in furrow irrigation method as compared to control. This is in agreement with those reported by Hatami *et al.* (2012), who reported an increased water productivity by the application of plastic film.

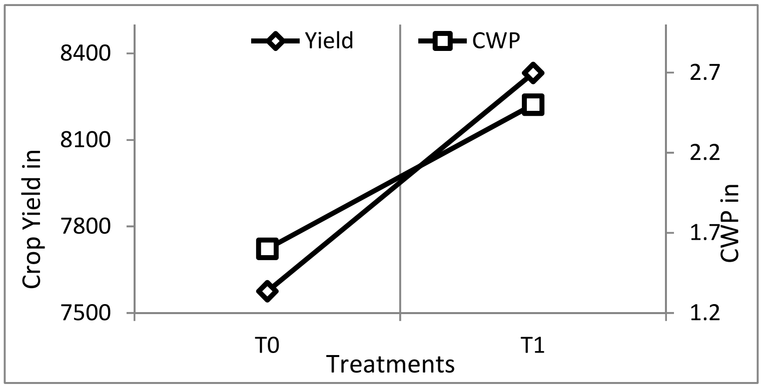

Fig. 4: Comparison between crop yield and crop water productivity for treatments T_0 and T_1.

CONCLUSION

Furrow irrigation method is considered as an efficient traditional irrigation method which is suitable in areas where fresh water resources are limited. The use of plastic sheets for irrigation in arid and semi-arid area of the world is gaining considerable interest due to water saving and salt distribution capability of plastic sheets by minimizing the deep percolation losses. Based on the experimental study, following conclusions are drawn:

- The average pH of soil decreased 0.28 and 0.30 after harvest under T_0 and T_1, while the average EC_e of soil profile increased from 0.34 dS/m and 0.85 dS/m after harvest under T_0 and T_1 respectively in the experimental field. Similarly, the average dry density of soil increased about 0.01 g/cm^3 after harvest under both treatments (T_0 and T_1).
- The yield of the Okra crop was 7,575 kg/ha and 8,332 kg/ha under T_0 and T_1, respectively. The yield of the crop was 757 kg/ha more under T_1 as compared to the yield under T_0.
- Water saving was 52.22% and 31% under T_1 and T_0, respectively, when compared to flood irrigation method, whereas, it was 30.64% under T_1, when compared to T_0.
- Crop water productivity was 0.9 kg/m^3 higher under T_1 as compared to T_0.

In the present study furrow irrigation method gave overall better performance with plastic sheets in relation to water saving, crop water productivity, salt distribution and crop yield. The following are few recommendations based on current study:

- Plastic sheets may be used in furrow irrigation method as it has negligible effect on physical and chemical properties of the soils and it has potential of saving 30.64% of water compared to normal furrow irrigation method.
- Further studies may be conducted on different crops as well as on different soil textures to determine the effect of plastic sheets on water saving and crop yield.

REFERENCES

Adnan, Y., Z. Muhammad, B. Mukhtar, R. Atif, T. Usman, N. Muhammad and A. Muhammad, 2012. Effect of different types mulching on growth and flowering of freesia alba cv. Aurora. Pak. J. Agric. Sci., 49(4):429-433.

Ashrafuzzaman, M., M.A. Halim, M.R. Ismail, S.M. Shahidullah and M.A. Hossain, 2011. Effect of plastic mulch on growth and yield of chili (*Capsicum annuum* L.). Braz. Arch. Biol. Technol., 54(2): 213-218.

Awodoyin, R.O., F.I. Ogbeide and O. Oluwole, 2007. Effects of three mulch types on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) and weed suppression in Ibadan, rainforest-savanna transition zone of Nigeria. Trop. Agric. Res. Extension 10, 53-60

Bainbridge, D.A., 2001. Buried clay port irrigation: a little known but very efficient traditional method of irrigation. Agric. Water Manage., 48(2):79-88.

Brown, J.E. and C.C. Butcher, 1999. Effect of three row covers and black plastic mulch on the growth and yield of 'Clemson Spineless' okra. J. Veg Crop Prod., 5(2): 67–71.

Chen, Y and J. Katan, 1980. Effect of solar heating of soils by transparent polyethylene mulching on their chemical properties. Soil Sci., 130: 271-276.

Daniel, P., H. William and S. Sabrina, 1992. Effect of mulch on the growth and development of late fall tomatoes.. J. Agric. Sci., 7(3): 163-168.

Fang, R., Y. Tong, D. Liang and J. Fang, 2003. Effect of different mulching on spring corn yield and on soil environment in Loess Plateau. Agric. Water Manage., 14(11): 1897-900.

Frenkel, H., J.O. Goertzen and J.D. Rhoades, 1978. Effects of clay type and content, exchangeable sodium percentage, and electrolyte concentration on clay dispersion and soil hydraulic conductivity. Am. J. Soil Sci. Soc. 42: 32-39.

Garry, G., F. Gordon, G. Wheeler, H. Foshee, T. Stewart, E. James and L. Edgar, 2010. The effects of colored plastic film mulches and row covers on the growth and yield of Okra. J. Hort. Sci., 20(10):224-233.

Harris, R.W., J.R. Clark and N.P. Matheny, 2004. Arboriculture. 4th Ed. Prentice Hall Inc., New Jersey.

Hatami, S., A. Nourjou, M. Henareh and L. Pourakbar, 2012. Comparison effects of different methods of black plastic mulching and planting patterns on weed control, water-use efficiency and yield in tomato. Int. J. Agric. Sci., 2(10): 928-934.

Hezhong, D., L. Weijiang, T. Wei and Z. Dongmei, 2008. Furrow seeding with plastic mulching increases stand establishment and lint yield of cotton in a saline field. J. Agronomy, 100(6): 1640-1646.

Hill, D.E., 1997. Effects of multiple cropping and row covers on specialty melons. Connecticut Agricultural Experiment Station, New Haven. Bull., 945, p. 12.

Hussain, M., M. Farooq, K. Jabran and A. Wahid, 2010. Foliar application of glycinebetaine and salicylic acid improves growth, yield and water productivity of hybrid sunflower planted by different sowing methods. J. Agron. Crop Sci., 196: 136-145.

Jiang, S., X. Gao, J. Liang, P. Wang, J. Gao, Y. Qu and B. Feng, 2012. Effect of different furrow and mulched ridge on water moisture conversation and water saving of Spring mung bean planted farmland. J. Agric. Sci., 4 (7):132-141.

Kazman, Z., I. Shainberg, and M. Gal, 1983. Effect of low levels of exchangeable sodium and applied phospho-gypsum on the infiltration rate of various soils. Soil Sci., 135:84-192.

Khan, M.B., R. Rafiq, M. Hussain, M. Farooq and K. Jabran, 2012. Ridge sowing improves root system, phosphorus uptake, growth and yield of maize (*Zea mays* L.) hybrids. J. Anim. Plant Sci., 22(2): 309-317.

Khoso, A.W., 1994. Growing vegetable in Sindh and Balochistan. Published by Mohammed Ismail Khoso, (Ch: 14: 107-110). Allied Printice Corporation Gari Khata, Hyderabad, Sindh, pp.7 - 115

Kumar, S.D. and B.R. Lal, 2012. Effect of mulching on crop production under rain-fed condition: A review. Int. J. Res. Chem. Environ., 2(2): 8-20.

Li, X.Y., J.D. Gong, Q.Z. Gao and F.R. Li, 2001. Incorporation of ridge and furrow method of rainfall harvesting with mulching for crop production under semiarid conditions. Agric. Water Manage., 50(3):173-183.

Lizarazu, W.Z and P.R. Berliner, 2011. Inter-row mulch increase the water use efficiency of furrow-irrigated maize in an arid environment. J. Agron. Crop Sci., 197(3): 237–248.

Lloyd, A. and Bailey, 2002. Effect of mulch types and colors on growth and yield of muskmelon. J. Southern University and A and M College, Baton Rouge, 60(3): 43-48.

Mamkagh, A.M., A. Salmerón, Y. García and A.I. Real, 2009. Effect of tillage time and plastic mulch on growth and yield of okra (Abelmoschus esculentus) grown under rain-fed conditions. Int. J. Agric. Biol., 11(4): 453-457.

Mclntyre, D.S. and J. Loveday, 1974. Bulk density. In: J. Loveday (ed), Methods of analysis for irrigated soils. Common Wealth Agriculture Bureau of Technical Communication No. 54, Farnham Royal, England.

Millard, E.W., 1974. Plastic mulching of sugarcane. Proc. Conf. SA Sug. Tech. Assoc., pp: 53-57.

MINFAL, 2005. Training Manual for the training of On Farm Water Management (OFWM) Staff, Ch: 3, p. 109.

Nazir, A. and R. Ghulam, 1988. Irrigated Agriculture of Pakistan. Published by 61-B/2, Gulberg III. Lahore-II, Pakistan, Ch: 9, pp. 260-362.

Patel, B.R., K.B. Patel and M.M. Parikh, 2009. Evaluation and comparison of drip, sprinkler and surface irrigation methods for water saving and yield improvement with cabbage okra and sugarcane crops. 60^{th} International Executive Council Meeting and 5^{th} Asian Regional Conference New Delhi, India.

Pravukalyan, P., N.S. Narendra and P. Sanatan, 2011. Evaluating partial root-zone irrigation and mulching in okra (*Abelmoschus esculentus* L.) under a sub-humid tropical climate. J. Agric. Rural Dev. Trop., 112(2): 169–175.

Rafiq, M., 2005. Irrigation and drainage practice for agriculture. Published by Study Aid Project University of Faisalabad, Ch: 2, p. 45.

Robert, M.H., 1967. Irrigation of agriculture lands. American Society of Agronomy Published by Madison, Wisconsin, USA, Ch: 7, pp. 868-869.

Rong, L., H. Xianqing, J. Zhikuan, H. Qingfang and Y. Baoping, 2012. Effects of rainfall harvesting and mulching technologies on soil water, temperature, and maize yield in Loess Plateau region of China. Soil Res., 50(2): 105-113.

Rowell, D.L., 1994. The preparation of saturation extracts and the analysis of soil salinity and sodicity. In: soil science methods and applications. ed. D.L. Rowell. Longman Group, UK.

Siyal, A.A., K.L. Bristow and S. Jirka, 2012. Minimizing nitrogen leaching from furrow irrigation through novel fertilizer placement and soil surface management strategies. J. Agric. Water Manage., 115:242- 251.

Wang, H.L., X.C. Zhang, S.Y. Song, Y.F. Ma, X.F. Yu and Y.L. Liu, 2011. Effects of whole field-surface plastic mulching and planting in furrow on soil temperature, soil moisture, and corn yield in arid area of Gansu Province, Northwest China. Ying Yong Sheng Tai Xue Bao, 22(10): 8-14.

Zhang, X.Y., S.Y. Chen and M.Y. Liu, 2002. Evapotranspiration, yield and crop coefficient of irrigated maize under plastic film mulch conditions. Prog. Geogr., 21(3): 583-592.

Zhang, Z.H. and H.J. Cai, 2001. Effects of regulated deficit irrigation on plastic-mulched cotton. J. Northwest Sci-Tech Uni. Agric. For., 29 (6): 9-12.