J Agric. Res., 2017, Vol. 55(1):1-14
ISSN: Online: 2076-7897, Print:0368-1157
http://www.jar.com.pk

EFFECT OF IRRIGATION APPLICATION ON SOIL AND LAND PRODUCTIVITY OF WHEAT UNDER SEMI-ARID ENVIRONMENT

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ABSTRACT

A study was conducted in Sargodha, Pakistan during the year 2011 to testify irrigation practices as a method for reclaiming salt affected soil. Field experiments were conducted on saline-sodic and uncultivated land divided into 12 field plots. Six irrigation treatments, each replicated on two field plots, were applied to test the responses of soil and wheat crop yield. Six irrigation treatments combined two variables: (i) source of irrigation (canal water, brackish groundwater and mixed in 50:50 proportion) and (ii) irrigation scheduling (fixed-rotation or *Traditional Warabandi* (TWB) and 75% management-allowed depletion (MAD)). The electrical conductivity (ECe) and sodium adsorption ratio (SAR) of saturated paste extracts of soil were observed at four depth intervals ranging from zero to 90 cm during the four crop growth stages. Only top 15 cm soil layers of field plots could be reclaimed upto the permissible ECe level of < 4 dS/m where canal water was applied for irrigation. In deeper layers (31 to 90cm) the ECe increased from the ambient levels in response to irrigation treatments. The crop yield (wheat grains in kg/ha) was measured from all individual field plots. Canal water application with 75% MAD scheduling proved to be the optimum treatment giving average yield of 1265 kg per hectare while the treatment with groundwater application under TWB showed the lowest average yield (435 kg/ha).

KEYWORDS: ***Triticum Aestivum;*** **Canal water; Groundwater; Irrigation; Quality; Scheduling; Soil; Pakistan.**

INTRODUCTION

About one third of land area in the world has arid and semiarid climate. The situation is worse in Pakistan where two third of its land area account for this specific climate classification with low precipitation and high temperature. The

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agriculture sector, being mainstay of the country, enjoys the major share of available fresh water resources and is ever more demanding. Pakistan is blessed with good quality surface water sources from the Indus River and its tributaries where irrigated agriculture is mainly confined to the plains of these rivers. The country is enduring water crisis in many agricultural regions due to changing climate, unsustainable exploitation of available fresh water resources and poor management of water supplies. High seasonality and inter-annual variability of rainfall along with substantial variations in canal water supplies leads farmers to rely heavily on groundwater which in many cases is not fit for irrigation. In spite of environmental and health concerns associated with it, the application of groundwater with marginal/hazardous quality for enhancing agriculture land development is continued and even increasing with time.

Salinity and sodicity problems find its root both in land and water. Globally, there are over 4,000,000 km^2 of land affected to some degree by salinity (1). Around 950 million hectares of land are salt-affected in arid and semi-arid regions of the world. The salt accumulation threatens the productivity of irrigated lands. In South Asia, annual economic loss is estimated at US$1,500 million due to salinization (2). The total annual cost of crop losses from salinity in Pakistan has been estimated 15-55 billion rupees (Rs.) per year. This is in addition to Rs. 15 billion estimated to have been lost from land that has been rendered unproductive. This makes the costs of salinity in Pakistan equivalent to 0.6 percent of gross domestic production in 2004 (3,6).

Saline-sodic soils are widely spread in the Indus plains making the cultivated lands less or unproductive. According to latest estimates, about 21percent of the irrigated land in Pakistan is affected by varying levels and types of salinity. On the other hand, many water scarce areas have aquifers of marginal quality, such as those that contain saline and/or alkali (~sodic) waters (15). The problem of land degradation is pronounced in places where saline groundwater is applied for irrigation (16). As a matter of fact, the native groundwater in the Indus basin is also saline due to its marine origin and more than 60% groundwater used for irrigation has a water quality far inferior to canal water (4). Application of such low quality water alone or in conjunction with canal water complicates the problem of soil degradation (9) reported that principal manifestation of irrigated agricultural lands of Pakistan is salinization of soil due to inadequate leaching of salts contained in the soil. The problems of soil salinity/sodicity are common under the climatic characteristics as prevailing in Pakistan. The major factors contributing to aggravation of the situation are *inter alia* poor soil drainage, insufficient eater, inefficient irrigation methods and improper use of poor quality groundwater.

The fixed-rotation irrigation (traditional *Warabandi* (TWB)) is a customary method of applying water to the agricultural fields in Pakistan. In this method, irrigation water is applied with fixed time allocations based on the size of landholdings of individual water users within a watercourse command area. The system does not precisely cater the crop water requirements and leads to over or under irrigation applications which may spoil the soil, decrease water use efficiency and hamper the crop production. In contrast to fixed-rotation, scientific scheduling involves determining when to irrigate the crop and requires the selection of a management-allowed depletion (MAD). This is management determined allowed soil moisture depletion prior to irrigation. The importance of scientific scheduling is greater in water-scarce areas, the regions endowed with plentiful irrigation water can also benefit from scheduling by reducing the cost of production, energy, and wastage of water (10).

The present study was an attempt to develop uncultivated and salt affected land for agriculture under wheat crop. This site-specific study is believed to make it a valuable contribution to the much-needed local-level understanding on the problems in using irrigation water with varying quality and making choice between different irrigation scheduling approaches under semi-arid environments.

MATERIALS AND METHODS

Experimental Site

This study was conducted in Sargodha, Pakistan during the year 2011. The experiments were conducted in Sargodha, Pakistan (latitude 31^{o} 46’ N, longitude 72^{o} 25’ E and altitude 164m above mean sea level). The experiment was laid on 0.4 hectare (1 acre) barren land loam soil (29% sand, 44% silt and 27% silt contents), lying uncultivated for the last three decades. Wheat (cv. *Pasban 90* local variety) was directly seeded in the experimental site on 11th December and harvested on 18th May. This site was divided into 12 field plots. The soil was identified as saline-sodic (5) with initial ECe 7.65-10.35dS/m, pH_s 9.0-9.1 and SAR 69.5-103.7 at 0 to 90cm depths.

The local climate is normally considered semi-arid with an average annual rainfall of 200 mm, concentrated in the monsoon season of July-September.

In this region, wheat usually takes 140–170 days to mature and suits the prevailing climate in *Rabi* season (October–April). .

Irrigation treatments

The experimental field plots, each measuring 21.34 m x 13.72 m (70 x 45 ft.) in dimension, were properly leveled, ploughed and planked. A main watercourse and 2 sub-watercourses were provided to supply irrigation water to the field plots. The ridges of watercourses were compacted to check irrigation water leakage.

Total in all four irrigations (including a pre-sowing irrigation) were applied to all field plots during the entire cropping period. Out of total 12 field plots, six were irrigated under TWB system and remaining six were irrigated under 75 percent MAD based irrigation scheduling system. Fig. 1 presents the timing and volume of irrigations applied to the field plots in combination with rainfall occurrence during the cropping period.

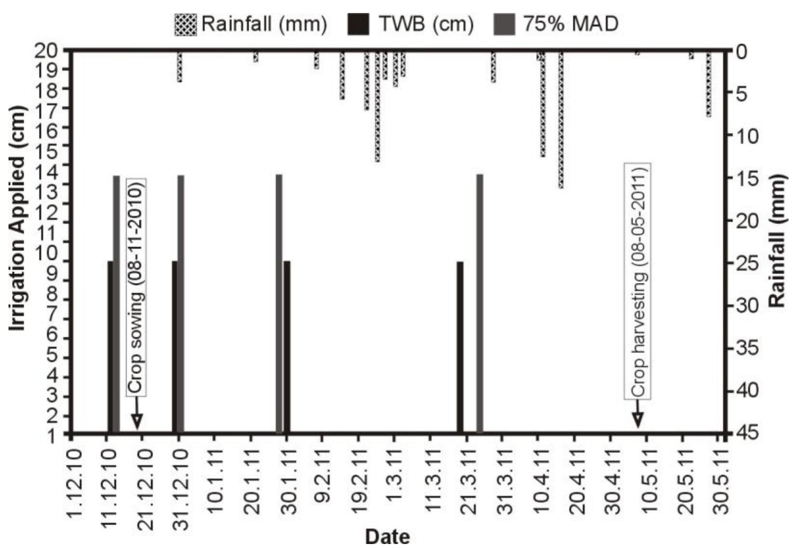

Fig. 1. Timing of irrigation and rainfall during the cropping period

Six irrigation treatments, each replicated in two field plots, were applied during the field experiments. All six irrigation treatments combined two variables i.e. (i) source of irrigation (canal water, brackish groundwater and mixed in 50:50 proportions) and (ii) irrigation scheduling (TWB and 75% MAD). The description of irrigation treatments is shown in Table 1.

Table 1. Description of different irrigation treatments applied during the experiment.

S. No.	Irrigation treatments	Treatments applied to field plots	Description of irrigation treatments
1	T_1	1 & 2	All irrigations with canal water under TWB system
2	T_2	3 & 4	All irrigations with canal water under 75% MAD based irrigation scheduling system
3	T_3	5 & 6	All irrigations with canal and groundwater (50:50) under TWB system
4	T_4	7 & 8	All irrigations with canal and groundwater (50:50) under 75% MAD based irrigation scheduling system
5	T_5	9 & 10	All irrigations with groundwater under TWB system
6	T_6	11 & 12	All irrigations with groundwater under 75% MAD based irrigation scheduling system

Soil sampling

Total 192 soil samples were collected during four crop growth stages over the entire copping (Fig. 2). The samples were collected from each plot at four depth intervals viz. 0-15cm, 16-30cm, 31-60cm and 61 to 90cm from the ground surface. All the samples were analyzed for soil physical characteristics (bulk density, percentage of sand, silt and clay and textural class of the soil), volumetric moisture contents (field capacity, permanent wilting point and total available moisture contents), and chemical properties (pH, electrical conductivity and sodium adsorption ratio).

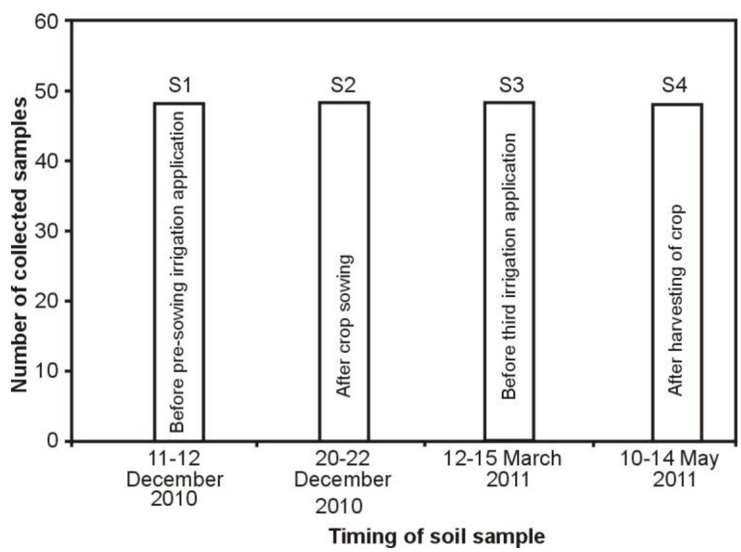

Fig. 2. Soil sampling methodology

Yield estimation

The wheat crop was grown in all 12 field plots. The cultural operations and/or inputs except the irrigation were identical for all field plots (Table 2.) Wheat crop was harvested on plot basis, threshed and weighed separately to estimate yield.

Table 2. Cultural input and operations carried out at the experimental site.

Operation	Activity	Details
Seed bed preparation	No. of ploughing	6
	No of planking	4
Wheat Crop	Variety	Pasban 90 (local variety)
	Sowing date	18-12-2010
	Harvesting date	08-05-2011
	Seed rate	150 (kg/ha)
Irrigation application	TWB scheduling	Traditional *Warabandi*
	No. of irrigations applied	4 irrigations (including one pre-sowing irrigation)
	Time allocated by the government for *Warabandi*	18 min/acre
	Depth of each irrigation	8.89 cm
	75% MAD based irrigation scheduling	Management Allowed Depletion
	No. of irrigations	4 irrigations (including one pre-sowing irrigation)
	Depth of each irrigation	13.36 cm
	Rainfall	75.7 mm
Fertilizer application	Di-Ammonium Phosphate (DAP)	50 kg/ha
	Single Super phosphate (SSP)	100 kg/ha
	Urea	100 kg/ha

Pre-experiment characteristics of soil and irrigation

Field capacity (θ_{FC}) was approximated in the field after applying irrigation to the field plots and observing temporal variation of soil moisture contents at different depths (Fig 3).

The permanent wilting point (θ_{PW}) of 10 percent was adopted from Jensen *et al.* (8) for loam soil to calculate the required irrigation depth. Summary of physical characteristics of the soil shown in Table 3.

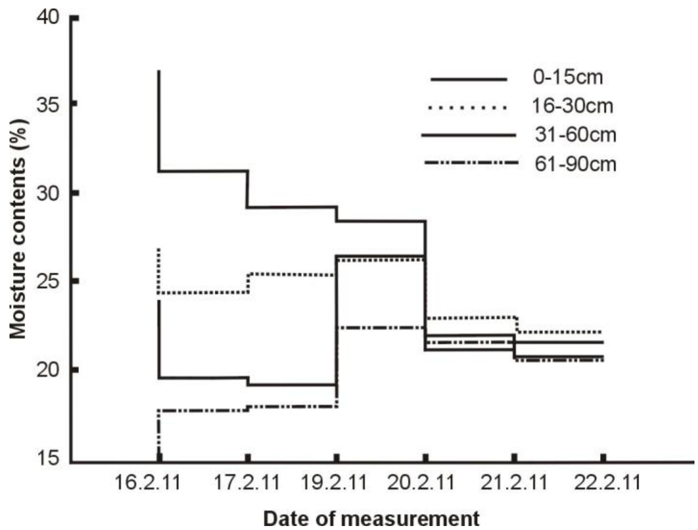

Fig. 3. Variation of soil moisture contents in the study area.

Table 3. Summary of various soil characteristics in determination of MAD based irrigation scheduling.

S.No.	Parameters	Values
1	Root zone depth (cm)	90
2	Bulk density of soil (g/ cm^3)	1.65
3	Field capacity of soil (%)	22
4	Permanent wilting Point (%)	10
5	Available water content (AWC) (%)	12
6	AWB at 75% MAD (AWC × 0.75) (%)	9
7	Irrigation at75% MAD (3-6) (%)	13
8	Depth of water required (cm)	13.36

The water samples from both the sources (canal and groundwater) were analyzed for the parameters of EC, concentration of calcium + magnesium ions (Ca^{2+}+Mg^{2+}), sodium ions (Na^{+}), Bi-Carbonates (HCO^{3-}), SAR and residual sodium carbonate (RSC). The result of chemical analysis of water samples is shown in Table 4 which shows that canal water is fit for irrigation but the groundwater is marginally fit (based on EC and RSC values) according to the fitness criteria for irrigation water proposed by Malik *et al.* (11) (Table 5).

Table 4. Chemical characteristics of irrigation water.

Source of irrigation	EC (µS/cm)	(Ca^{2+}+Mg^{2+}) (meq/L)	(Na^{+}) (meq/L)	(HCO_3^-) (meq/L)	(SAR)	(RSC) (meq/L)
Groundwater	1005	5.3	3.37	7.8	2.0	2.5
Canal water	244	2.3	0.14	2.2	0.14	0.1

Table 5. Fitness criteria of irrigation water.

Parameter	Fit	Marginally Fit	Unfit
EC (µS/cm)	0-1000	1000-1250	> 1250
SAR	0-6	6-10	> 10
RSC (meq/L)	1-1.25	1.25-2.50	> 2.50

Statistical analysis

The data collected for soil chemical properties were statistically analyzed using Microsoft EXCEL software wherein treatment differences were evaluated by using least significant difference (LSD) test (15). The efficiency of different treatments in reclaiming the soil salinity and sodicity is compared as cumulative distribution functions.

RESULTS AND DISCUSSION

Soil ECe and SAR as affected by various treatments

Prior to the field experiment, average ECe in dS/m (and SAR) of the experimental plots was 7.65 (69.5), 12.65 (103.7), 11.8 (107.2) and 10.35 (94.1) at soil depths of 0-15, 16-30, 31-60 and 61-90 cm, respectively. Table 6 shows a summary of ECe and SAR of soil in response to the irrigation treatments. The table reports ECe and SAR averaged over four crop growing stages i.e. S1 to S4 (as explained in Fig. 2) However, the statistical tests takes into account individual ECe and SAR values at each growth stage. In our field experiment the null hypothesis is that the irrigation treatments are totally ineffective in reducing ECe and SAR from the respective initial values. To test this hypothesis P-test statistics were used. Table 6 shows that in the top soil layers (0-30 cm) P values are significantly small suggesting that the null hypothesis is untrue. This explains that in the top soil layers irrigation treatments have been effective. In deeper soil layers (31-90 cm), high P values are reported as non-significant (Table 6). These values suggest that in deeper soil layers, irrigation treatments have not been much effective in reducing ECe and SAR (i.e. the null hypothesis is true).

Least significant difference (LSD) in contrast to P-statistics which applies only to the grouped data was used to compare means of different irrigation treatments that have an equal number of replications. A closer look of Table 6 shows that on the basis of LSD test it is not easy to decide which treatment performed better than other in reclaiming the soil. In the top most layer (0-15 cm), it is obvious that T_1 and T_2 performed significantly better than the other treatments. However, for the rest of soil layers no clear trend exists. The reduced ECe and SAR levels as a result of T_1 and T_2 are very close to each other indicating their comparable performance. However, LSD results support that T_2 can be ranked as the best option at least for the top soil layer. Interestingly, all six irrigation treatments tended to decrease SAR of soil from initial levels. This is due to the fact that in all treatments, SAR of either canal or groundwater was within the admissible limits (Tables 4 and 5).

Table 6. Effect of irrigation treatments on soil quality.

Soil profile	Treatments	[1]ECe (dS/m)	[1]SAR	Soil profile	Treatments	[1]ECe (dS/m)	SAR
0-15 cm	T_1	4.92^{b}	29.83^{ab}	31-60 cm	T_1	13.20^{bc}	60.84^{b}
	T_2	4.91^{b}	30.49^{ab}		T_2	11.08^{c}	59.69^{b}
	T_3	6.73^{ab}	35.82^{a}		T_3	14.74^{ab}	61.90^{b}
	T_4	6.13^{b}	33.24^{a}		T_4	12.47^{bc}	65.66^{ab}
	T_5	8.41^{a}	34.77^{b}		T_5	16.41^{ab}	60.52^{b}
	T_6	6.26^{b}	32.79^{b}		T_6	18.15^{a}	74.98^{a}
	P(<0.05)	*	*		P(<0.05)	NS	NS
16-30 cm	T_1	9.95^{a}	56.43^{bc}	61-90 cm	T_1	14.83^{a}	65.20^{ab}
	T_2	8.18^{ab}	54.49^{c}		T_2	14.06^{a}	64.21^{a}
	T_3	11.94^{d}	59.65^{ab}		T_3	14.20^{a}	66.08^{ab}
	T_4	9.34^{cd}	58.00^{abc}		T_4	14.99^{a}	66.13^{b}
	T_5	14.43^{bc}	59.76^{ab}		T_5	15.75^{a}	64.78^{b}
	T_6	13.23^{abc}	61.03^{a}		T_6	15.68^{a}	68.13^{b}
	P(<0.05)	*	*		P(<0.05)	NS	NS

*Stands for significant at P<0.05 level; NS, stands for non-significance at P>0.05 level, [1] Average of four ECe values at four crop growth stages S1 to S4, Any two means having a common letter are not significantly different at 5% level based on LSD test

A common concept about deficit irrigation (i.e. MAD based scheduling) is that applying less water than the crop requirement can enhance salt accumulation in the soil and apparently reduce the crop yields. The results presented (Table 6) do not support this argument. The results show that in most of the cases, irrigation treatments employing 75% MAD (i.e. T_2, T_4 and T_6) remained slightly more efficient in reclaiming soil salinity and sodicity than those treatments employing TWB (i.e.T_1, T_3 and T_5). This is chiefly because of the fact that within the study area much less water is supplied under TWB than the crop water requirements. The comparison of irrigation depths applied under TWB and 75% MAD irrigation systems (Fig. 1) clearly shows that during present study period even less water was supplied under traditional *warabandi* system than 75% MAD. In addition to this, under *warabandi* system the water is not supplied when it is most needed by the crop rather it is supplied based on fixed turns. Prathapar *et al.* (12) also present similar argument based on their soil water and solute transport model results for a dominant soil series in the Punjab, Pakistan. They tried to evaluate consequences of deficit irrigation in semi-arid areas with shallow water table and report that deficit irrigation (20% less water) can minimize water requirements without affecting soil salinity and crop transpiration. This indicates that in case of deficit irrigation, there exists some scope for increasing the cropping intensity with existing water supplies. Farmers in general tend to apply more water to their fields. This practice often results in yield reduction due to waterlogging.

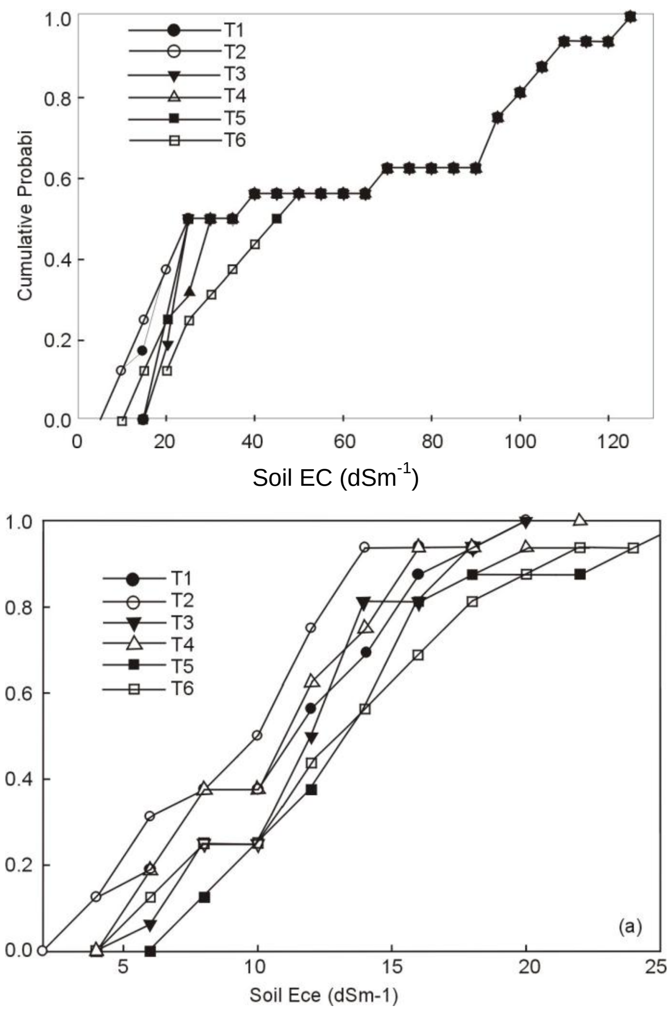

Fig. 4. Cumulative distribution function plots in response to various treatments a) for soil electrical conductivity, and b) for sodium adsorption ratio. Bold lines represent the most efficient treatment.

Fig. 4(a) reveals that the distribution lines of treatment T_2 and T_1 distinctly twitter out from the remaining treatments for lowered ECe. Both of these treatments use canal water as the only irrigation source (Table 1). These results support the conclusion that opting canal water as irrigation source and 75% MAD as the irrigation scheduling scheme can offer an opportunity to efficiently minimize the soil salinity. Fig. 4(b) shows that within the cumulative probability range of 0 to 0.5, the distribution line of T_2 (shown with bold line) distinctly moves towards lower SAR values while T_6 protruded out for higher SAR values. For higher cumulative probabilities ranging from 0.5 to 1.0, all treatments behaved almost identically as all the lines are superposed in this region. This can be explained with the fact that during S2 (stage referring to time after crop plantation) all six treatments could bring very similar changes across the field plots from their respective initial values due to unknown reasons.

Wheat yield as affected by various treatments

The comparison of land productivity (i.e. average yields per unit of land) obtained by applying different irrigation treatments Table 7. A decreasing trend in the average crop yield can be seen by varying the source of irrigation from canal water to groundwater. The results show that average crop yield was highest (1215 kg/ha) where only canal water was applied to irrigate the field plots.

Table 7. Response of crop yield to the irrigation treatments.

Source of irrigation	Irrigation treatment	Treatments applied to field plots	Yield (kg/ha)	Average yield for a treatment (kg/ha)	Average yield for an irrigation source (kg/ha)
Q1 (Canal water)	T_1 (TWB)	1	1383	1166 (-7.80%)*	1215
		2	948		
	T_2 (75% MAD)	3	1502	1265	
		4	1028		
Q2 Canal water + Groundwater (50:50)	T_3 (TWB)	5	553	613 (-51.54%)	711 (-41.48%)**
		6	672		
	T_4 (75 % MAD)	7	790	810 (-35.97%)	
		8	830		
Q3 Groundwater	T_5 (TWB)	9	514	435 (-65.61%)	465 (-61.73%)
		10	356		
	T_6 (75 % MAD)	11	553	494 (-60.95%)	
		12	435		

*Average yield reduction as compared to highest yield for treatment T_2, **Average yield reduction as compared with the highest yield for Q1

The yield reduced by 41percent of the highest figure when mixed canal and groundwater was applied and it was reduced by 62 percent when switched to groundwater only. Besides the water quality of irrigation source, irrigation scheduling has also played important role in yield variations. Higher average yield is obtained from the plots where 75% MAD irrigation scheduling was adopted than those where TWB method was applied.

The present results corroborate the findings of a similar field experimental study by Darwish *et al.* (7) conducted in semi-arid region of northeastern Bekaa-Lebanon. In their study area typical crop rotation is fruit/vegetable followed by barely or wheat. They have observed that not only agricultural practices including the crop rotation and fertilization but also water quality and irrigation management affected the salinity build-up and yield. They conclude that in dry land agriculture, the most critical element is water management and its quality.

CONCLUSIONS AND RECOMMENDATIONS

The specific results of the field trials suggest that irrigation treatments with canal water as the only source of irrigation tends to reclaim the saline-sodic soil, especially in the top layer (0-15), from their respective initial ECe and SAR levels. The land productivity is sensitive to the source of irrigation i.e. canal or groundwater. The highest land productivity was observed in case good quality canal water was applied for irrigation and it was profoundly reduced with change in irrigation source and quality.

Overall, field plots under deficit irrigation treatments (i.e. 75% MAD) yielded higher than those where traditional *warabandi* irrigation scheduling was adopted. The study suggest that to cultivate barren saline lands under semi-arid conditions MAD based irrigation scheduling system is more efficient than traditional time based rotational irrigation system. With limited water supplies, MAD based irrigation scheduling can allow farmers to increase the cropping intensities without jeopardizing salt buildup and compromising reduced yields.

This field trial was implemented as an initial effort to investigate the response of a small piece of land which remained uncultivated for more than a decade. Although, only one site was considered for field experimentation over one crop season, the short term effects of irrigation treatments on soil and land productivity are explorative in nature. For extended investigations, however, it is recommended that the optimum percentage of MAD are evaluated using more crops to allow cumulative effects over seasons.

REFERENCES

1. Anon. 2006. Food and Agricultural Organization of the United Nations. Terra STAT database, http : // www. fao. Org / ag /agl / agll / terrastat/
2. Anon. 1994. Land Degradation in South Asia: Its Severity Causes and Effects upon the People. World Soil Resources Report 78, FAO, Rome.
3. Anon. World Bank. 2006. Pakistan Strategic Country Environmental Assessment, Volume II. World Bank: Washington, DC.
4. Ashraf, M. and M.M. Saeed. 2006. Effect of improved cultural practices on crop yield and soil salinity under relatively saline groundwater applications. Irrigation and Drainage Systems. 20(1):111–124.
5. Brady, N.C. 2002. The Nature and Properties of Soils. New York: Macmillan Inc.
6. Corbishley, J. and D. Pearce, 2007. Growing trees on salt-affected land. ACIAR Impact Assessment Series Report No. 51, Australian Centre for International Agricultural Research (ACIAR): Canberra.
7. Darwish, T., T. Ataullah, M. El Moujabber and N. Khatib. 2005. Salinity evolution and crop response to secondary soil salinity in two agro-climatic zones in Lebanon. Agriculture Water Management. 78:152-164.
8. Jensen, M.E., R.D. Burman and R.G. Allen. 1990. Evapotranspiration and Irrigation Water Requirements. ASCE Manual No. 70, American Society of Civil Engineers, New York.
9. Kahlown, M.A., M.H. Chang, M. Ashraf and M.S. Hassan. 2003. Salt affected soils and their reclamation. Research Report No. 4, Pakistan Council of Research in Water Resources, Islamabad.
10. Laghari, K.Q., B.K. Lashari and H.M. Memon. 2008. Perceptive research on wheat evapotranspiration in Pakistan. Irrig. Drain. 57(5):571–584.
11. Malik, D.M., M.A. Khan and T.A. Chaudhry. 1984. Analysis Manual for Soils, Plants and Waters. Soil Fertility Survey and Soil Testing Institute, Lahore. Department of Agriculture, Punjab.
12. Prathapar, S.A. and A.S. Qureshi. 1999. Modelling the Effects of deficit irrigation on soil salinity, depth to water table and transpiration in semi-arid zones with Monsoonal rains. Int. J. of Water Resources Dev. 15(1-2):141-159.
13. Qadir, M., B.R. Sharma, A. Bruggeman, R. Choukr-allah and F. Karajeh. 2007. Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. Agri. Water Manage. 87(1):2-22.

14. Qureshi, A.S., P.G. Mccornick, M. Qadir and Z. Aslam. 2008. Managing salinity and waterlogging in the Indus Basin of Pakistan. Agri. Water Manage. 95(1):1–10.
15. Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics. New York: McGraw Hill Co. Inc.

Received: October 25, 2014 Accepted: April 27, 2016

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Muhammad Yar	**:**	**Collected field data**