USE OF SERANI DRAINAGE EFFLUENT OF LBOD SYSTEM FOR GROWING OF LOW AND HIGH DELTA CROPS AND ITS IMPACT ON PHYSICO-CHEMICAL PROPERTIES OF SOIL

By

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ABSTRACT

Future food and fiber needs of the ever increasing population of Pakistan can only be met by bringing more area under crops without deteriorating soil and plant health. The present irrigation supplies are not sufficient to cope with the crop water requirements. The existing Indus Basin Canal System faces severe seepage losses in the way prior to reach the fields. The remedy to cater the water shortage lies in decreasing delivery losses and augmentation through the groundwater. Another alternative lies in the utilization of drainage effluent for growing salt tolerant crops, grasses and trees. It will not involve much cost compared to other irrigation water sources and secondly drainage disposal problem will be reduced. Under this objective an attempt was made to utilize saline effluent of Serani drain (LBOD system) of marginal quality for growing of low and high delta crops and its impact on physical and chemical properties of soil was also monitored. Under this experiment the crop rotation of low delta crops (Kharif-fodder-Wheat) and high delta crops (Rice-Berseem) were grown with drainage effluent and canal water was used as control treatment to determine the extent of the negative impact of the use of drainage water. A complete one crop rotation under both high and low delta crops was adopted. The water quality of Serani drain was marginal having no problem of sodicity and RSC. The drainage water applied was having an average EC_w, SAR and RSC of 2.32 (dS m^{-1}), 4.99 (mmol $L^{-1})^{1/2}$ and o (meq L^{-1}) respectively. With application of canal water, soil salinity decreased up to 12.7% and 33.3% while it increased with the application of drainage effluent up to 7.5% and 26.9% in case of low and high delta crops respectively. The increase in soil salinity depends upon the volume of drainage water irrigation applied to the crops. In case of low delta crops, 7.6% less yield of K. Fodder (Jantar) was obtained with drainage water irrigation as compared with canal water. The trend of the impact of drainage water application in case of Wheat crop was similar to Kharif fodder yield in this case reduction of 28.5% was observed with the use of drainage water. Drainage water application showed a prominent impact on reduction of wheat yield. In case of high delta crops maximum yield of Paddy crop i.e. 3307 Kg ha^{-1} was obtained with canal water irrigations while with the application of drainage water yield of about 2528 Kg ha^{-1} was obtained which is 23.6% less than the normal canal water irrigations. In case Rabi fodder (Berseem), maximum average fodder yield of 11577 Kg ha^{-1} (Three cuttings) was obtained, where all irrigations were applied with canal water where as 9.1% less yield was obtained with the exclusive use of drainage water application as compared to canal water irrigation. It was recommended that continuous and long term use of Serani drainage effluent must be avoided to control salt accumulation in soil. However, brackish water of marginal quality may be used after blending it with canal water to evade soil deterioration and loss in crop yields. Use of brackish water may be confined to low delta crops only to escape undue salt accumulation.

Key Words : Drainage Effluent, Low & High Delta crops, Physico-Chemical properties of Soil.

1. Introduction

Agriculture plays a pivotal role in the economy of Pakistan. About 67% population depends upon agriculture, account for 21.4% of the gross domestic product and employs 45% of the labour force of the country (Pakistan Economic Survey, 2011-12). It is predominantly dependent on a big irrigation network and is confronted with the problem of waterlogging and salinity. The

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supplies of canal water are not sufficient to meet the crop water requirement. To augment the inadequate supplies of good quality canal water the poor quality groundwater and waste water is being utilized for irrigation purposes. Waste water is generally used without any treatment and in many cases the industrial effluents without proper treatment are also added to the waste water.

Crop production has to be increased in order to meet the food, fiber and shelter requirements of the increasing population. The shortage of fresh water and dry spell in most of the cultivated areas compel the farmers to use poor quality groundwater for crop production. According to an estimate the availability of water in 2025 will be 104 MAF while the requirement (including drinking water) will be 135 MAF showing a shottfall of 31 MAF. (Govt. of Pakistan, 2001, Planning commission report).

According to NIAB (1997) report, salt tolerance of wheat varieties under field conditions ranged upto 12 dS m^{-1}. Cotton under green house conditions depicted tolerance upto 8 dS m^{-1}. Rice indicated EC_e tolerance upto 6.2 dS m^{-1} under field conditions and 9 dS m^{-1} under green house environment. Bodla*et al*. (1998) reported tolerance of sugarcane crop to 10 dS m^{-1} under laboratory conditions. Saline water of a high salt concentration having EC_w of 12 dS/m may be used for growing tolerant and semi-tolerant crops in coarse textured loamy sand and sandy soils under normal rainfall of more than 400 mm. But, in fine textured soils of clay and clay loam nature, waters with EC_w more than 2 dS/m would often create salinity problem (Tyagi 1998, Abdel 1997, Kandiah 1990). The saline water of EC_w more than 4 dS/m will cause salt toxicity in most of the crops in areas with annual rainfall less than 250 mm. However the poor quality water may be used on long term basis, if it is applied with alternate application of Canal water (Subhani et al. 2008)

Future food and fiber needs of the ever increasing population can only be met by bringing more area under crops without deteriorating soil and plant health. The present irrigation supplies are not sufficient to cope with the crop water requirements. The existing Indus Basin Canal System faces severe seepage losses in the way prior to reach the fields. The remedy to cater the water shortage lies in decreasing delivery losses and augmentation through the groundwater. Another alternative lies in the utilization of drainage effluent for growing salt tolerant crops, grasses and trees. It will not involve much cost compared to other irrigation water sources and secondly drainage disposal problem will be reduced. Hence, attempt was made to utilize saline effluent of LBOD and RBOD for sustaining agriculture. Under this experiment the crop rotation of low delta crops (Kharif-fodder-Wheat) and high delta crops (Rice-Berseem) were grown with drainage effluent and canal water was used as control treatment to determine the extent of the negative impact of the use of drainage water. A complete one crop rotation under both high and low delta crops was adopted.

2. Material and Methods

The study was conducted on farmer's field in the vicinity of LBOD at Serani Branch drain near village Sirani on Serani-Kudhan road. It was initiated from the season kharif 2012 and is still going on. The treatments tested were as under:

A. Irrigation Source :

(i) Canal Water (ii) Drain Water

B. Crop Rotations

Low delta crops (Kharif-fodder-Wheat) ii) High delta crops (Rice-Berseem)

Initial Physico-chemical characteristics of soil indicate that initial EC_e of soil was 5.3 (dSm^{-1}), SAR 11.04, pH 8.0 and textural class was silt loam. Details of the initial physico-chemical characteristics of soil are given in Table-1.

Table-1. Initial Physico-Chemical Characteristics of the site (0-30 cm depth)

Physico-Chemical Characteristics of soil	Value
EC_e (dS m^{-1})	5.3
SAR (mmol L^{-1})	11.04
pH	8.0
Textural Class	Silt Loam

Under this sub experiment the impact of the usage of Serani drain water was evaluated on growth of low and high delta crops. Under low delta crops, the cropping pattern of Kharif Fodder and Wheat crop was followed while under high delta crops; the cropping pattern of Rice and Berseem crops was adopted to evaluate the impact of drainage water irrigations.

The treatmental impacts on soil salinity / sodicity build up, infiltration rate of soil and crop yields under each cropping pattern was monitored separately. The average water quality of Serani drain during the different cropping seasons is detailed in Table-2.

Water quality data of Serani drain indicate that drainage effluent was saline and of marginal quality, having no problem of sodicity and RSC. The drainage water applied was having an average EC_{iw}, SAR and RSC of 2.32 (dS m^{-1}), 4.99 ($mmol_c$ L^{-1})$^{1/2}$ and 0 (meq L^{-1}) respectively.

Table-2. Water Quality of Serani Branch Drain during Different Cropping Seasons

Season	EC_w	SAR ($mmol_c$ L^{-1})	pH	RSC (meq L^{-1})
Kharif-2012	2.52	5.12	7.87	0
Rabi 2012-13	2.33	5.15	7.57	0
Kharif-2013	2.12	4.65	7.88	0
Overall Average	2.32	4.99	7.77	0

Number of irrigations applied to each crop is shown in Table-3. It is evident from the data that about 4 irrigations of canal and drainage water were applied to wheat and kharif fodder crop while irrigation applied to Rice and Berseem crops were 25 and 22 respectively in both cases of canal and drainage water application.

Table-3 Number of Irrigations Applied to each Crop

Location	Low Delta Crops		High Delta Crops	
	Wheat	Khiarif Fodder (Sorghum):	Rice	Berseem
Canal Water I_1	4	4	25	22
Drain Water I_2	4	4	25	22

Results and Discussion

3.1 Soil Salinity and Sodicity

Soil Salinity (EC_edS m^{-1})

Initially the upper most soil layer (0-30 cm) had slight salinity level. Three soil samplings have been carried out till the completion of this report to assess the impact of irrigation practices on soil salinity / sodicity build up. Soil samples were collected from 0-15, 15-30, 30-60 and 60-90 cm depths. However, to avoid too much display of the data in the text only average EC_e values of 0-30 cm soil depth are presented. The data clearly indicate that the soil salinity decreased in the treatments where we applied canal irrigation while it increased with the application of drainage effluent of Serani drain. With application of canal water soil salinity decreased upto 12.1% and 33.3% while it increased with the application of drainage effluent upto 7.5% and 26.9% in case of low and high delta crops respectively. The increase in soil salinity depends upon the volume of drainage water irrigations applied to the crops as shown in Table-4 and shown in figure-1. The Impact of different irrigation treatments under high delta crops was similar as in case of low delta crops as shown in Table-5 and shown in Figure-2.

Table-4 Effect of Different Irrigation Treatments on EC_e of Soil (0-30 cm) under Low Delta Crops.

Treatments		EC_e(dS m^{-1})		% Inc./ dec. Over Initial
		Initial Season (S_1)	Final Season (S_3)	
Canal Water	I_1	5.5	3.8	-12.7
Drainage Water	I_2	5.3	6.6	+7.5

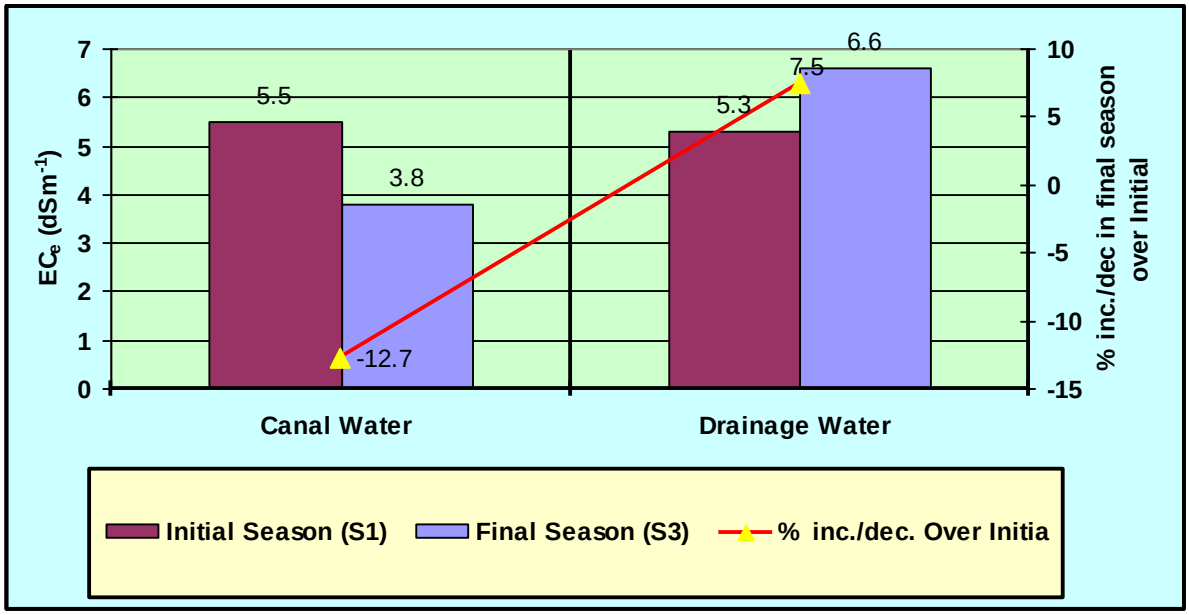


Figure-1; Effect of Different Irrigation Treatments on EC_e of Soil under Low Delta Crops.

Table-5 Effect of Different Irrigation Treatments on EC_e of Soil (0-30 cm) under High Delta Crops.

Treatments		EC_e(dS m^{-1})		% inc./dec. Over Initial
		Initial Season (S_1)	Final Season (S_3)	
Canal Water	I_1	5.7	3.8	-33.3
Drainage Water	I_2	5.2	6.6	+26.9

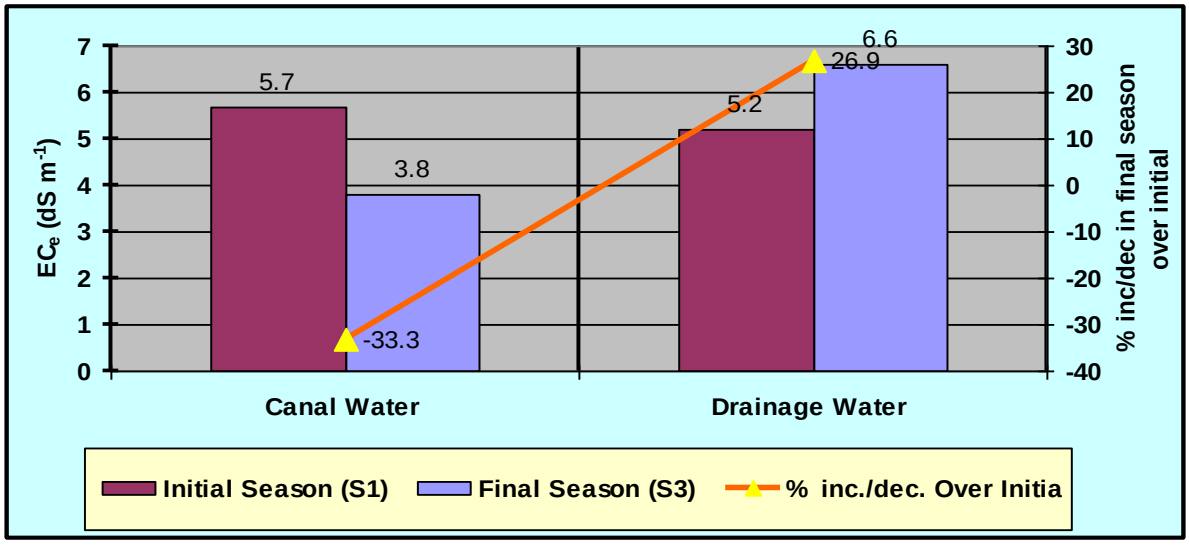


Figure-2. Effect of Different Irrigation Treatments on EC_e of Soil under High Delta Crops.

Soil Sodicity ($mmol_c\ L^{-1}$)

Initial soil sodicity was under normal limits. The sodicity of the drainage effluent applied was also under the safer limits. Both the data of soil and drainage water indicate no impact of increasing sodicity in the soil. However the regular application of canal water decreased the sodicity of soil to lower limits. Due to application of canal water, decrease in soil sodicity was 26.1% in case of low delta crops and 29.6% in case of high delta crops as shown in Tables-6 and Table-7 respectively. Due to application of drainage water there was a minor increase of about 2.5% in soil sodicity in both the cases i.e. low as well as high delta crops as shown in Figures-3 & Fogures-4 respectively.

Table-6 Effect of Different Irrigation Treatments on SAR of Soil (0-30 cm) under Low Delta Crops.

Treatments		SAR ($mmol_c\ L^{-1}$)		% inc./dec. Over Initial
		Initial Season (S_1)	Final Season (S_3)	
Canal Water	I_1	11.5	8.5	-26.1
Drainage Water	I_2	11.4	11.7	+2.6

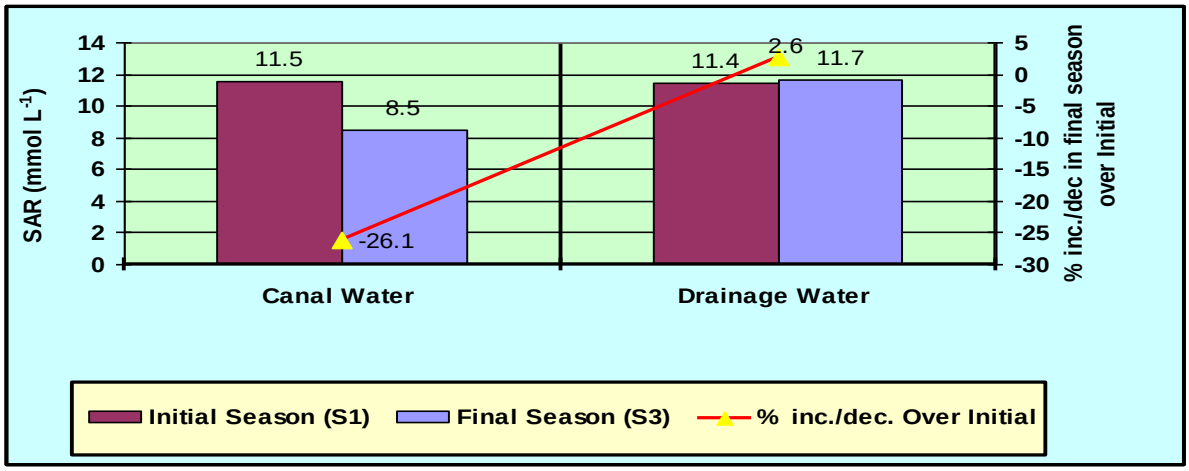


Figure-3: Impact of Different Irrigation Treatments on SAR of Soil (0-30 cm) under Low Delta Crops

Table-7 Effect of Different Irrigation Treatments on SAR of Soil (0-30 cm) under High Delta Crops.

Treatments		SAR ($mmol_c$ L^{-1})		% inc./dec. Over Initial
		Initial Season (S_1)	Final Season (S_3)	
Canal Water	I_1	12.5	8.8	-29.6
Drainage Water	I_2	11.8	12.1	+2.5

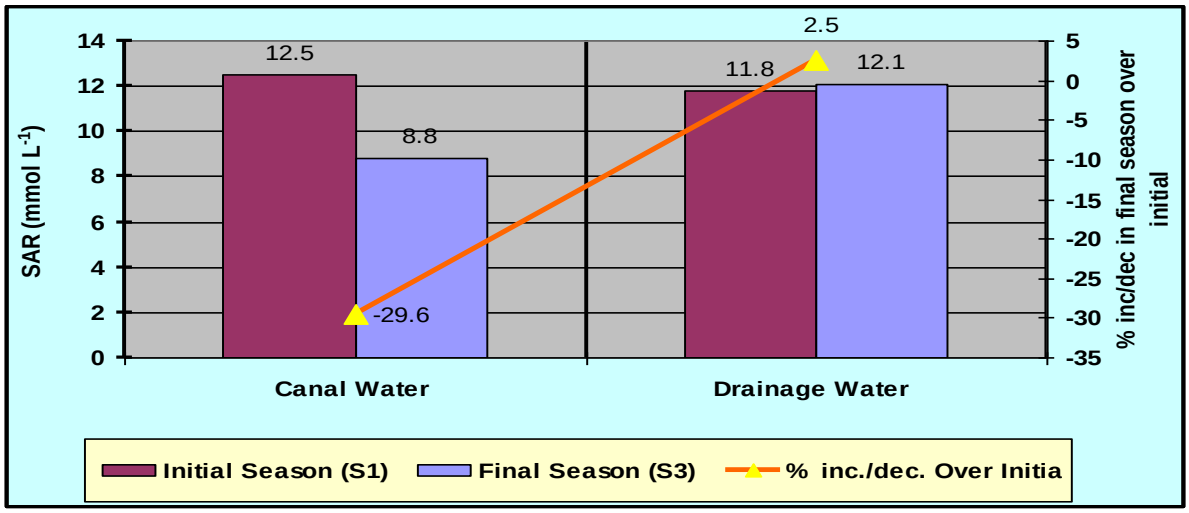


Figure-4: Impact of Different Irrigation Treatments on SAR of Soil (0-30 cm) under High Delta Crops

3.2 Infiltration Rate

Infiltration rate of soil was monitored initially and then after harvesting of each crop to evaluate the impact of different irrigation and amendments on soil permeability. Data indicate that soil infiltration increased with canal water irrigation and decreased with drainage water application. Use of drainage water decreased the penetration of water in the soil profile under all the crop rotations of low as well as high delta crops as shown in Tables-8 to Tables-9. The decrease in infiltration rate due the application of drainage water was 6.7% in case of low delta crops and 15.0% in case of high delta crops as shown in Figures-5 and Figures-6 respectively.

Table-8 Effect of Different Irrigation Treatments on Infiltration Rate of Soil under Low Delta Crops.

Treatments		Infiltration Rate (mm hr^{-1})		% inc./dec. Over Initial
		Initial Season (S_1)	Final Season (S_3)	
Canal Water	I_1	7.6	8.5	+11.8
Drainage Water	I_2	7.5	7.0	-6.7

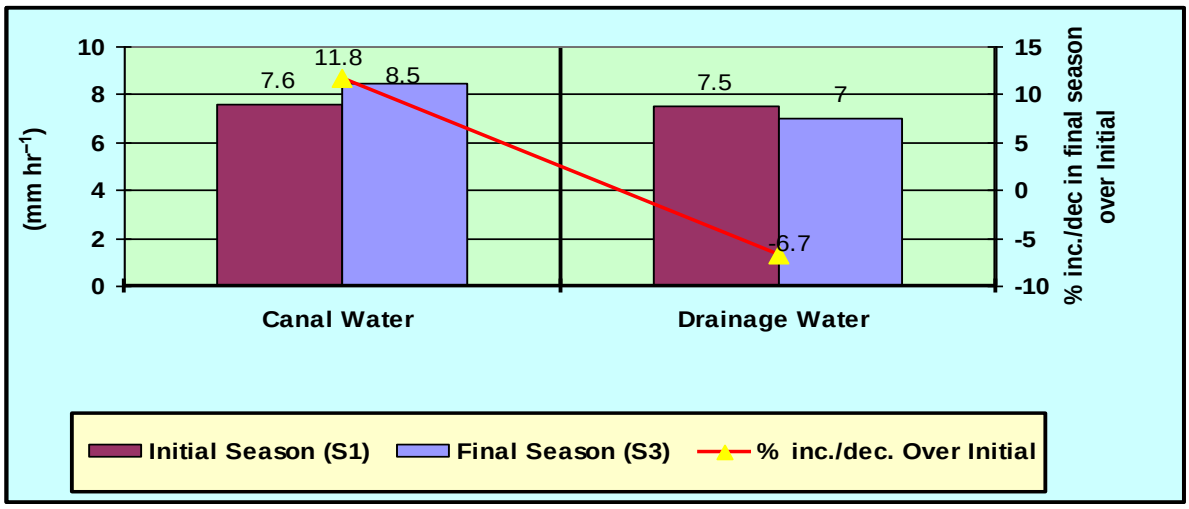


Figure-5: Effect of Different Irrigation Treatments on Infiltration Rate of Soil under Low Delta Crops.

Table-9 Effect of Different Irrigation Treatments on Infiltration Rate of Soil under High Delta Crops

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Treatments		Infiltration Rate (mm hr^{-1})		% inc./dec. Over Initial
		Initial Season (S_1)	Final Season (S_3)	
Canal Water	I_1	6.9	8.3	+20.2
Drainage Water	I_2	8.0	6.8	-15.0

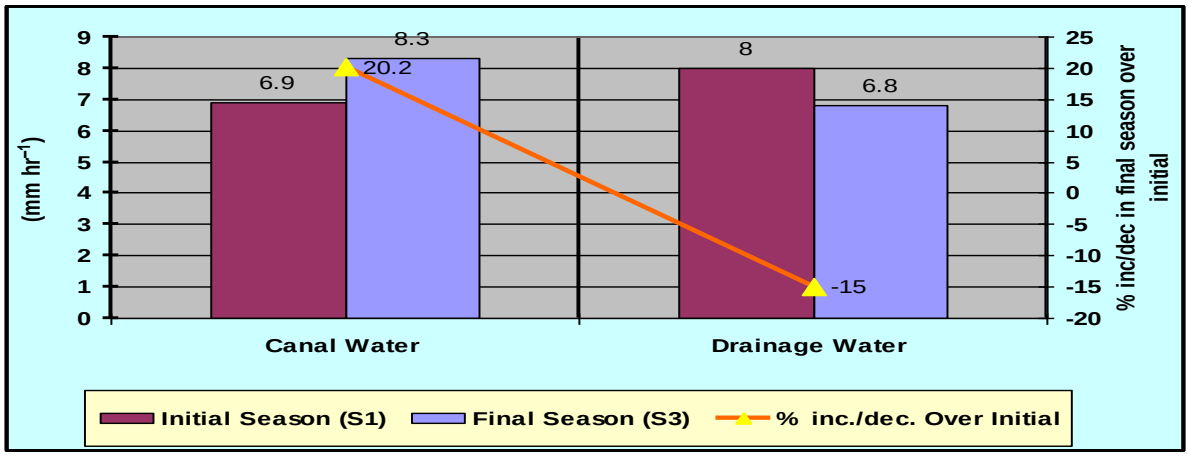


Figure-6: Effect of Different Irrigation Treatments on Infiltration Rate of Soil under High Delta Crops

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3.3 Crop Yield

(a) Low Delta Crops (Kharif Fodder (Jantar)-Wheat)

Yield of both Kharif Fodder (Jantar) and Wheat Crop was estimated on whole plot basis and subsequently converted as Kg ha^{-1} for comparison of different treatments.

Kharif Fodder (Jantar)

Data presented in Table-10 shows that maximum average fodder (Jantar) yield of 31218 Kg ha^{-1} was obtained with canal water irrigation where as 7.6% less yield i.e. of 28850 Kg ha^{-1} was obtained with drainage water irrigation. Drainage water application showed a slight impact on reducing the fodder yield as compared to canal water irrigations.

Wheat Yield

The data presented in Table-10 indicate that trend of the impact of drainage water application in case of wheat crop was similar to the previous kharif fodder yield. In this case reduction of 28.5% was observed with the use of drainage water. Drainage water application showed a prominent impact on reduction of wheat yield as shown in Figure-7.

Table-10 Impact of Different Irrigation Treatments on Yield of Low Delta Crops (Kg ha^{-1})

Treatments	Low Delta Crops			
	Kharif Fodder (Jantar)	% decrease as compared to canal water	Wheat	% decrease as compared to canal water
Canal Water	31218	0	1033	0
Drain Water	28850	-7.6	739	-28.5

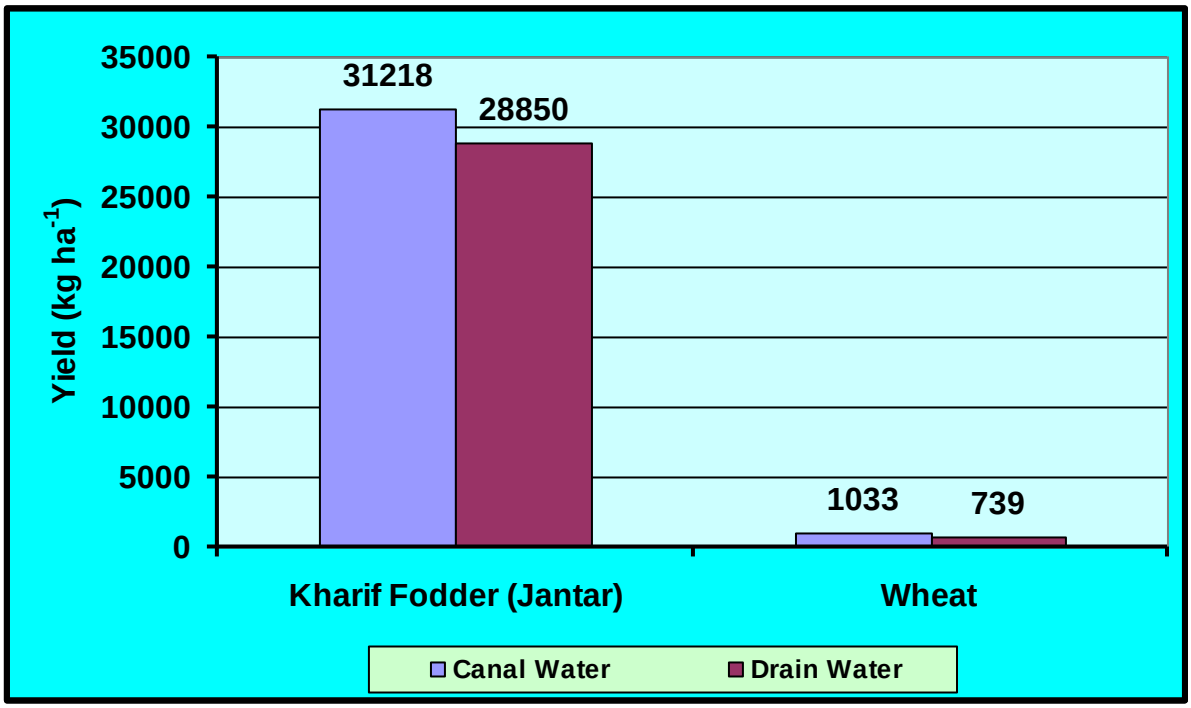


Figure-7.Impact of different irrigation treatments on yield of low delta crops.

(b) High Delta Crops (Rice-Berseem)

Paddy Yield

Yield of Paddy crop for the season Kharif-2012 is presented in Table-11. The maximum average Paddy yield of 3307 Kg ha^{-1} was obtained with canal water irrigations while with the application of drainage water yield of about 2528 Kg ha^{-1} was obtained which is 23.6% less than the normal canal water irrigations.

Berseem Fodder Yield

Yield of Rabi fodder (Berseem) for the season Rabi 2012-13 is presented in Table-11. The maximum average fodder yield of 11577 Kg ha^{-1} (Three cuttings) was obtained, where all irrigations were applied with canal water where as average yield of 10526 Kg ha^{-1} was obtained where drainage effluent was applied as depicted in Figure 8. The yield of Berseem fodder with the application of drainage water was 9.1% less than the yield obtained with canal water irrigation. Percent decrease in yield of low and high delta crops with the application of drainage water as compared to canal water is depicted in Figure-9.

Table-11 Impact of Different Irrigation Treatments on Yield of High Delta Crops (Kg ha^{-1})

Treatments	High Delta Crops			
	Rice	% decrease as compared to canal water	Berseem	% decrease as compared to canal water
Canal Water	3307	0	11577	0
Drain Water	2528	-23.6	10526	-9.1

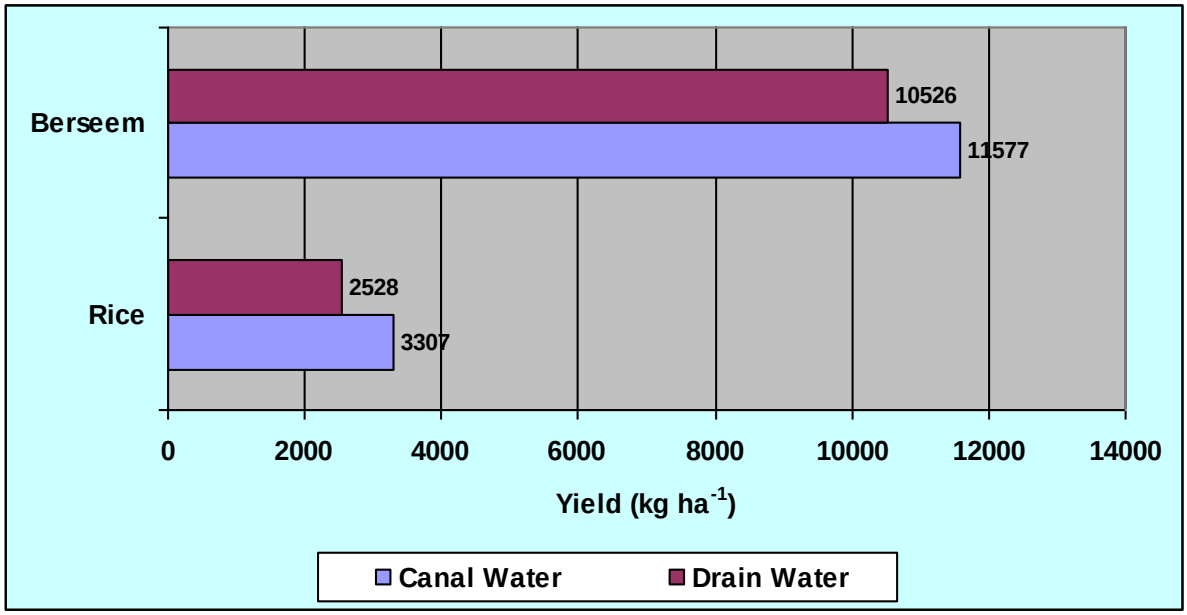


Figure-8.Impact of different irrigation treatments on yield of high delta crops.

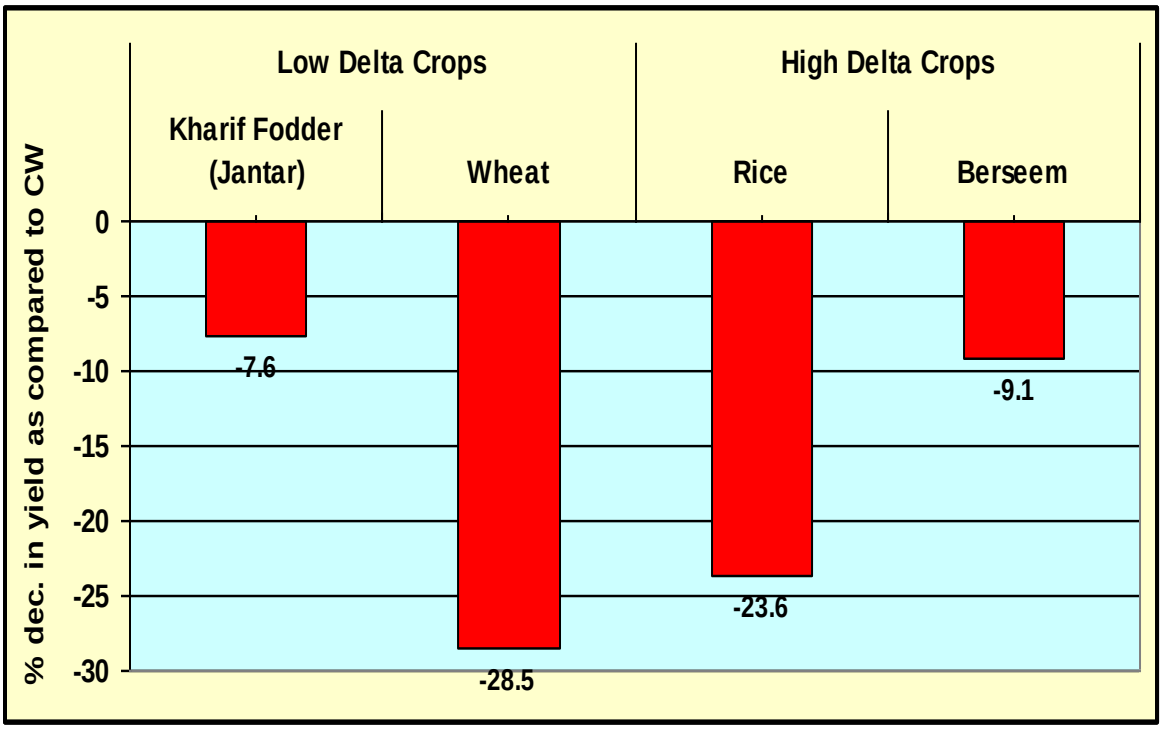


Figure-9: Percent decrease in yield of crops with the application of drainage water as compared to canal water

4. Conclusions and Recommendations

4.1 Conclusions

The water quality of Serani drain was marginal having no problem of sodicity and RSC. The drainage water applied was having an average EC_w SAR and RSC of 2.32 (dS m^{-1}), 4.99 (mmol $L^{-1})^{1/2}$ and o (meq L^{-1}) respectively.

With application of canal water soil salinity decreased up to 12.7% and 33.3% while it increased with the application of drainage effluent up to 7.5% and 26.9% in case of low and high delta crops respectively. The increase in soil salinity depends upon the volume of drainage water irrigation applied to the crops.

Due to application of drainage water there was a minor increase of about 2.5% in soil sodicity in both the cases i.e. low as well as high delta crops.

Use of drainage water decreased the penetration of water in the soil profile under all the crop rotations of low as well as high delta crops. The decrease in infiltration rate due to the application of drainage water was 6.7% in case of low delta crops and 15.0% in case of high delta crops.

In case of low delta crops, maximum average fodder (Jantar) yield of 31218 Kg ha^{-1} was obtained with canal water irrigation where as 7.6% less yield i.e. of 28850 Kg ha^{-1} was obtained with drainage water irrigation. The trend of the impact of drainage water application in case of Wheat crop was similar to Kharif fodder yield in this case reduction of 28.5% was observed with the use of drainage water. Drainage water application showed a prominent impact on reduction of wheat yield.

In case of high delta crops maximum yield of Paddy crop i.e. 3307 Kg ha^{-1} was obtained with canal water irrigations while with the application of drainage water yield of about 2528 Kg ha^{-1} was obtained which is 23.6% less than the normal canal water irrigations. In case Rabi fodder (Berseem), maximum average fodder yield of 11577 Kg ha^{-1} (Three cuttings) was obtained, where all irrigations were applied with canal water where as 9.1% less yield was obtained with the exclusive use of drainage water application as compared to canal water irrigation.

4.2 Recommendations

Continuous and long term use of Serani drainage effluent must be avoided to control salt accumulation in soil. However, brackish water of marginal quality may be used after blending it with canal water to evade soil deterioration and loss in crop yields.

Use of brackish water may be confined to low delta crops only to escape undue salt accumulation.

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