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Tubewell Water, Soils and Wheat Yield in Different Reaches of a Canal in the Rice-Wheat Cropping Zone of Punjab

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ABSTRACT

A study was accomplished in the command area of the Mananwala Distributary during March/April 1993. This canal and each of its 33 water courses were divided into three equal lengths which were designated as head (near the head-works), middle and tail reaches. One acre of wheat crop in each section was randomly selected. From these fields, wheat grain yield and composite soil samples at 0-15, 15-30, 30-60 and 60-100 cm depths were collected. It was found that soils have pH_s, EC_e and SAR values less than 8.5, 4.0 dS m^{-1} and 13.2, respectively. The values of these soil parameters were the highest and lowest at tail and head sections of the canal, respectively. The tubewell water quality was unsuitable for irrigation to the magnitude of 100 and 88% in the tail sections of the canal and water courses, respectively. Wheat grain yield was the highest at middle section of canal followed by tail and head. The yield decreased gradually from head toward tail of the water courses. Overall, the yield was reasonably good ranging between 1800 and 2400 kg ha^{-1}. The correlation coefficients (r) between wheat grain yield and EC_e, SAR, pH_s or $CaCO_3$ showed inconsistency although it was significant for some sections.

Key Words: Canal; Wheat; Tubewell; EC_e ; SAR ; RSC

INTRODUCTION

The climate in the canal commanded area (CCA) of Pakistan is arid to semi-arid receiving annual precipitation of 200 to 500 mm. For this reason, most of the farming has to be artificially irrigated. Pakistan has about 21 mha land under cultivation and irrigated agriculture is practiced round the year on about 17 mha (78% of CCA). The irrigation system is comprised of the Indus River and its four tributaries, i.e. Jehlum, Chenab, Ravi and Satluj, three major storage reservoirs, 19 barrages/headworks, 12 link canals and 43 canal commands covering about 95,000 water course commands. The total length of the canal system is about 59,500 km. Moreover, there are 16,000 km of surface drains (Anonymous, 1991; Mirza & Ahmad, 1998). Approximately 102.82 MAF (million acre foot) of surface irrigation supplies are diverted annually into this canal system. However, only 60% of this water actually reaches the farm-gate (Anonymous, 1997). To supplement the canal supplies, Water And Power Development Authority installed > 20,000 public tubwells pumping 5.8 MAF water annually and in private sector, about 328,728 tubewells discharging 38 MAF water are in operation.

The issue recently exposed is that the loss in crop yields at tail of canal/water courses is higher compared to that at their respective middle or head sections. Mostly it is assumed that irrigation water availability at farm-gate from the gravity flow canals decreases towards tail ends {Punjab Economic Research Institute (PERI, 1988)}. Thus this shortage of canal water is being supplemented by pumping ground water which is mostly (up to 75%) hazardous in Punjab (Malik & Hassan, 1987) and could induce soil salination/sodication. Hence the present study was undertaken with the objectives to (a) characterize the soils and tubewell waters in the head, middle and tail sections of a canal and its water courses and (b) record wheat yield and correlate it with soil properties.

MATERIALS AND METHODS

For this study, Mananwala Distributary/canal (C) was selected which provides irrigation supplies to Farooqabad and Mananwala areas. It is 45 km long and has 74 water courses/moghas (WC). This canal was divided into three equal lengths and section towards headwork was designated as head (H), next middle (M) and the third towards exterior as tail (T). From each canal section, 11 water courses were marked for the studies. Each water course, like canal, was divided into three equal lengths, near to canal was head, next as middle and the last as tail.

During the months of March/April 1993, one acre of wheat crop in each section of the water courses was randomly marked. From these fields, wheat grain yield was recorded by harvesting 1 m^2 area. Then composite soil samples were drawn with soil auger at 0-15, 15-30, 30-60 and 60-100 cm depths for analyses (Page *et al.*, 1982). Tubewell water samples with which the selected wheat fields used to receive irrigation were collected and analyzed for irrigation quality {U. S. Salinity Laboratory Staff (USSLS, 1954)}. The data collected were computed for standard deviation (Chaudhry, 1984) and correlation coefficients.

RESULTS AND DISCUSSION

Soil properties exert a profound control on the crop yields. Among chemical properties, soil pH_s, EC_e, and SAR are considered the most important in this respect.

pH_s. The pH_s ranged from 7.3 to 8.5 at the upper two soil depths of the three canal sections except three sites where it was as high as 10.4 at 15-30 cm soil depths (Table I). Overall, the pH_s values were higher in the tail section of canal and were the lowest for its head section.

EC_e. All the soil samples have EC_e< 4.1 dS m^{-1}. The EC_e was the highest at CT followed by CM and CH (Table I), although for all the sections the values were much below the tolerance threshold of wheat. Ayers and Westcot (1989) reported that up to EC_e 6 dS m^{-1} wheat grain yield is not affected which is reduced to 50 % at EC_e 13-15 dS m^{-1}.

SAR of soil. The SAR values were < 13 for all the soil samples except four samples where SAR was > 15. On an average basis, SAR was the highest for CT and the lowest at CH at all the soil depths (Table I). The SAR at WCH, WCM, WCT and CM was similar (data not given).

The three soil parameters, explained above, reflect that the hazards pertaining to soil chemistry were more towards the CT section than the CM and CH. The WCT reaches have properties very similar to CM, WCH and WCM. The observed pattern of soil characteristics in canal/water course sections appears partly to have been manipulated by the higher rainfall (~ 500 mm), otherwise the number of tubewells pumping unfit water for irrigation is much more in the tail sections of both the canal and water courses. Since the tubewell waters are of hazardous quality in general (Table II), there would have been higher values of pH_s, EC_e and SAR towards the tail ends of the canal or water courses. Qayum and Malik (1985) recorded similar results.

Table I. Soil characteristics in different sections of the Mananwala Distributary

Soil property & depth (cm)	Head (n=32) Range	Head (n=32) Mean	Middle (n=32) Range	Middle (n=32) Mean	Tail (n=31) Range	Tail (n=31) Mean
pH_s 0-15	7.7- 8.4	7.8 (0.39)	7.3- 9.1	7.9 (0.44)	7.3- 9.8	8.2 (0.57)
15-30	7.2- 9.8	7.9 (0.51)	7.3- 8.8	8.0 (0.31)	7.3- 1.4	8.3 (0.59)
EC_e 0-15	0.7- 2.5	1.5 (0.51)	0.7- 2.0	1.4 (0.38)	0.7- 4.1	2.0 (0.89)
15-30	0.7- 2.1	1.3 (0.43)	0.6- 2.3	1.4 (0.39)	0.6- 4.1	2.1 (1.06)
SAR 0-15	2.5-10.9	7.4 (2.16)	2.4-13.5	7.7 (2.59)	1.8-23.8	9.2 (4.16)
15-30	2.6- 9.4	6.5 (1.85)	2.9-11.5	7.5 (2.00)	2.6-22.3	9.3 (4.09)

In mean columns, the figures in parenthesis are standard deviation. EC_e as dS m^{-1}.

Tubewell water quality. There were 59 tubewells in operation in the study area. The mean EC_e, RSC and SAR generally increased from head towards the tail of canal or water course. The data (Table II) indicate that 58, 93, and 100% tubewells are pumping hazardous water at CH, CM and CT, respectively. While these values were 82, 76 and 88% at WCH, WCM and WCT, respectively. This statistics clearly lead to opine that the problems should be more severe towards the tail reaches. This is true for CT but not for WCT and thus it has to be assumed that the observed picture is mainly because of the management factor and that seepage from canal has improved the ground water quality at head sections.

Grain yield of wheat. The ultimate objective of agriculture and its management is higher and sustainable crop yields. In the present studies, the yield ranged from 1800 to 2400 kg ha^{-1} (Table III) which seems reasonably good. However, yield was the lowest at CH where the soils were best followed by CT and CM. The yield decreased gradually from WCH towards WCT with minor differences (data not given). Since the soil, pH_s, EC_e and SAR were below the critical levels of saline/sodic soils {U. S. Salinity Laboratory Staff (USSLS, 1954)} as well as the tolerance threshold of wheat (Ayers & Westcot, 1989), the observed pattern of yield at different sections of canal and water courses is the clear response of management, like sowing time, crop variety, fertilizer rate and type, method and source of irrigation and the plant protection measures. One practice at tail sections seems more promising, as told by the farmers, that leaving some area uncultivated and providing higher agricultural inputs to the remaining fields. Similar information has been reported by Anonymous (1992). There was a positive and significant correlation between grain yield and EC_e, CH_3COONH_4 K^+ and $CaCO_3$ at head sections of canal and water courses (Table IV) whereas at CT the pH_s and $CaCO_3$ showed statistical relationships. However, EC_e, pH_s, SAR and $CaCO_3$ were non-significantly correlated with plant K and P at all the sections of canal and water courses. In general, it seems that there was no big constraint for wheat crop in the cultivated fields of the Mananwala Distributary.

CONCLUSIONS

It is concluded that rainfall do help the use of low quality irrigation waters without adverse effects on soils and crops like wheat. Since the soils were free of any salinity/sodicity in the command area of the Mananwala Distributary, the management and supervision of the tillers is the key factor for the sustainable and higher crop yield at CT than that at CH section. The farmers may pump good quality ground water by installing tubewell near to canals.

Table II. Quality of tubewell water in the command area of the Mananwala Distributary

A. Quality of tubewell waters

Water characteristic		**Head (n=23)**	**Middle (n=14)**	**Tail (n=16)**
Ec_e	Range	0.42 - 1.33	0.79 - 3.45	1.12 - 3.04
	Mean	0.89 (0.22)*	1.32 (0.67)	2.09 (0.48)
SAR	Range	1.66 - 8.37	3.54 - 12.40	5.38 - 15.80
	Mean	4.06 (1.58)	6.52 (2.20)	10.39 (2.47)
RSC	Range	1.05 - 6.70	2.80 - 8.82	1.40 - 7.70
	Mean	3.33 (1.59)	5.02 (1.59)	5.15 (1.35)

B. Class-wise distribution of tubewells

Section	**Tubewells (No.)**	**Fit (%)****	**Marginal (%)**	**Unfit (%)**
Canal				
Head	24	21	21	058
Middle	15	-	07	093
Tail	20	-	-	100
Watercourse				
Head	16	12	06	082
Middle	25	08	16	076
Tail	18	06	06	088

** Figures in parenthesis are standard deviation. ** Water quality classes are after the USSLS (1954). EC_e is as dS m^{-1} and RSC as mmol L^{-1}.*

Table III. Wheat grain yield (kg ha^{-1}) in different sections of the Mananwala Distributary

Wheat yield	**Canal section**		
	Head (n=30)	**Middle (n=32)**	**Tail (n=31)**
Range	688-3086	1310-3930	782-4404
Mean	1864	2341	2121
Standard deviation	546	535	747

Table IV. Correlation coefficients (r) between wheat grain yield and soil attributes

Soil property	Section		
	Head	Middle	Tail
Distributary sections			
pH_s	0.2650	-0.3950	-0.7015*
EC_e (dS m^{-1})	0.6908*	-0.0537	0.1397
SAR	0.5045	0.1222	0.2136
K (mg L^{-1})	0.9986*	-0.9792	-0.8838
P (mg L^{-1})	0.8390	-0.9406	-0.8240
$CaCO_3$ (%)	0.9999*	0.3592	0.9971*
Clay (%)	0.8801	-0.6286	-0.4112
Watercourse sections			
pH_s	0.1669	-0.6025	-0.5060
EC_e (dS m^{-1})	0.3305	-0.2059	0.0511
SAR	0.2576	-0.2613	0.4557
K (mg L^{-1})	-0.6177	0.9382	-0.2752
P (mg L^{-1})	0.1675	0.1141	0.1211
$CaCO_3$ (%)	0.9992*	-0.2827	-0.6922
Clay (%)	0.0520	0.8032	0.9407

* *Values are significant at p=5%, others are statistically similar.*

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