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SOILS, TUBEWELL WATER QUALITY AND WHEAT YIELD IN DIFFERENT SECTIONS OF A CANAL IN THE WHEAT-COTTON CROPPING ZONE

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The Pir Mahal canal (C) and water courses (WC) were divided into three equal lengths i.e. head (H), middle (M) and tail (T) sections. In each section of C and WC, one wheat field was randomly selected from which wheat grain yield was recorded and composite soil samples from 0-15, 15-30, 30-60 and 60-100 cm depths were drawn. The soil texture varied from sandy loam to sandy- clay loam in the study area. On the basis of pH~, EC_e and SAR, 10,8 and 19% soils were found as salt-affected at CH, CM and CT sections, respectively. Similarly, 7, 5 and 24% sites were salt-affected at WCH, WCM and WCT, respectively. To overcome the water shortage, 31, 27 and 11 tubewells were already installed in the CT, CM and CH sections, respectively. However, tubewell count was 25, 23 and 21 in the WCH, WCM and WCT reaches, respectively. At the CH, CM and CT reaches, 82, 72 and 32% tubewells are discharging unfit water. About 48, 57 and 62% tubewells are pumping unfit water at WCH, WCM and WCT sections, respectively. The wheat yield was reasonably good (2316 to 2518 kg ha^{-1}) at all the sections of the canal and water courses. The pH«, EC_e , SAR, soil P and K concentrations were not statistically correlated with wheat yield.

Key words: tubewell water, water course, wheat yield, wheat-cotton cropping zone

INTRODUCTION

Main source of irrigation in Pakistan is the gravity flow network of surface canals which probably is the largest in the world. In this type of irrigation infrastructure, it is expected that in areas near the head-works of canals or water courses, the water delivery is much more compared to distant parts i.e. the tail sections (Anonymous, 1988). Decreased water delivery to farm areas at or near tail end is expected because of water leakage, seepage and pilferage at up-stream sections.

To overcome the shortage of canal water, tubewells have been installed in public and private sectors. In most parts of the canal commanded area (CCA), the groundwater is of poor quality (Ahmad, 1993) but farmers do pump it to supplement the canal supplies for irrigation. However, such low quality groundwater could cause soil salination/sodication and loss of crop yields. Thus under the existing irrigation set up and insufficient as well as inefficient utilization of nutrients by plants, lower crop yields seem to be a natural outcome. Hence this study was undertaken to characterize the soils and tubewell waters in different parts of the canal and water courses, and determine wheat yield, to correlate it with soil pHs, EC_e, SAR, P and K to identify yield limiting factors.

MATERIALS AND METHODS

The research work was carried out in the Pir Mahal canal command area. This canal (C) is 48 km long and has 50 water outlets to irrigate 14891 hectares of land where cotton-wheat is the dominant crop rotation. In this area, 13 soil series have been established by the Soil Survey of Pakistan. The Fluventic and Typic Camborthids occupy about 50 and 25% area, respectively. The remaining 25% soils belong to Typic Calciorthids, Halic Camborthids, Typic Halorthids, Typic Ustifluvents and Terrace Escarpments. The Pir Mahal canal was divided into three equal lengths and section towards head-works was designated as head (H) followed by middle (M) and tail (T) towards the ulterior end. From each section of the canal, 11 water courses (WC) were selected. Each marked water course was again divided into three equal lengths and the part close to canal was designated as head (H) followed by middle (M) and distant section as tail (T). In each section, a representative wheat field was randomly marked to record grain yield and to draw composite soil samples from 0-15, 15-30, 30-60 and 60-100 cm depths after wheat harvest. In each section of the canal and water courses, number of tubewells were there from which water samples were collected after running the well for half an hour. The chemical analysis of soil and water was accomplished following Page *et al*, (1982) and Klute (1986). The tubewells were found installed along the canal and water courses in whole of the area but specific locations were not considered.

At harvest, whole wheat plants were sampled to assess the concentrations of P and K following

Table 1. Soils of the Pir Mahal canal command area

A. Soil EC and SAR (mean values and standard deviation in parentheses)

Canal section	EC_e (dS/m)		SAR	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Head (n=24)	1.29 (0.87)	1.22 (0.83)	4.43 (3.79)	4.61 (3.18)
Middle(n=33)	1.35 (0.64)	1.50 (0.75)	5.93 (3.95)	6.46 (3.35)
Tail (n=33)	1.62 (0.95)	1.91 (1.27)	8.04 (6.64)	10.30 (9.86)

B. Salt-affected soils (%) considering EC_e and SAR

Canal section	Depth (cm)	Water course section			
		Head	Middle	Tail	Mean
Head	0-15	-	20	20	14
	15-30	20	-	-	7
Middle	0-15	-	-	25	8
	15-30	12	-	12	8
Tail	0-15	12	-	50	21
	15-30	-	12	38	17
Mean	0-15	4	7	32	-
	15-30	11	4	17	

Classification according to US Salinity Lab. Staff (1954).

Cottenie *et al.* (1979). To determine the impact of yield limiting factors, correlation coefficients between pH_s, EC_e, SAR, soil P and K concentrations and economic yield of wheat were computed (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The study was undertaken during the months of March to August, 1992 in the Pir Mahal canal command area. This year was relatively more wet and thus farmers claimed better crops than those during the past many years.

Soil Characteristics: Soils were dominantly sandy loam and sandy-clay loam in texture at 0-15 and 15-30 cm depths, respectively. On the basis of pH_s, EC_e and SAR values for 0-15 cm soil depth, about 14, 8 and 21% sampled fields were found salt-affected in the CH, CM and CT parts, respectively. The corresponding salt-affected soils in water course sections were 4, 7 and 32 % (Table 1). The emerging picture of soil quality clearly showed more soil problems for crop yields in the CT and WCT sections and the farmers thus had to provide more inputs to get the yields comparable to farmers in CH and WCH sections. In general, the EC_e and SAR at the above given soil depths in CH, CM, CT, WCH, WCM and WCT sections were lower than the respective critical values of 4 dS m! and 13.2, respectively. However, the values of. these parameters progressively increased towards the tail sections of both the C and WC. The pH_s, EC_e and SAR were consistently lower for the upper 30 cm soil layer compared to those at 30-60 or 60-100 cm depths.

Tubewell Water Quality: The chemical analysis of groundwateris shown in Table 2. On average, nearly 82, 72 and 32 % tubewells are pumping water of unsuitable quality at CH, CM and CT sections, respectively (Table 3). The percentage of unfit water was about 48, 57 and 62% in the corresponding sections of water courses. The water quality pattern at canal sections appears to be the result of hydro-geological formation (Ahmad, 1993), while that in water course sections seems to have been improved in WCH parts through seepage from the canal. Because of higher percentage of unfit groundwater quality at CH and WCT (Table 3), the occurrence of more salt-affected fields in these sections (Table 1) seems a natural consequence.

The farmers there generally use tubewell water mixed with canal water or as alternate irrigations or alternating both these water sources crop-wise. Thus the problems of salinity/sodicity were so far manageable and also not wide spread in this arid region of.the CCA. But if left unattended, these will pose a serious threat after a few years.

Wheat Grain Yield: The wheat grain yield was the highest from the CH section followed by CT and CM sections. The same was true of the water course sections (Table 4). The yield appears satisfactory and mean ranged from 2300 to 2500 kg ha-t. The

Table 2. Tubewell water quality of Pir Mahal Canal command area

Section	Tubewells (No.)	EC (dS/m)	SAR	RSC (me/L)
Canal (mean values and standard deviation in parentheses)				
Head	11	1.84 (0.73)	8.91 (3.92)	5.27 (3.76)
Middle	27	0.91 (0.17)	3.63 (0.81)	2.80 (0.66)
Tail	31	0.83 (0.25)	3.55 (1.46)	1.87 (0.90)
Water course (mean values)				
Head	25	0.90	3.95	1.94
Middle	23	1.09	4.96	3.26
Tail	21	0.94	3.83	2.55

Table 3. Tubewells pumping unfit water in Pir Mahal canal command area

Canal section	Water course section			Total	Unfit (%)
	Head	Middle	Tail		
Head	4/6*	4/4	1/1	9/11	81.82
Middle	5/8	5/6	8/11	18/25	72.00
Tail	3/11	3/11	4/9	10/31	32.26
Total	12/25	12/21	13/21	37/67	-
Unfit (%)	48.00	57.14	61.90	-	-

* Number of tube wells discharging unfit water/total number of tube wells in a seetion.

Table 4. Wheat grain yield in Pir Mahal canal command area

Canal section	Grain yield of wheat	
	Mean (kg/ha)	Mean (% of total dry matter)
Head (n=24)	2518 (608)*	34.26 (4.4)*
Middle (n=33)	2316 (601)	31.99 (3.2)
Tail (n=33)	2399 (750)	32.89 (3.4)

* Values of SD in parentheses.

Table 5. Correlation coefficients between soil properties and wheat grain yield in Pir Mahal canal command area

Soil property	Head	Middle	Tail
A. Canal			
pHs	0.3820	0.2932	-0.2407
EG_e	0.0161	0.1284	-0.5366
SAR	0.1064	-0.0160	-0.4127
Soil P	0.1101	0.6123	0.4299
Soil K	0.2433	-0.6120	-0.6050
B. Water course			
pHs	-0.2776	0.0463	0.0110
EG"	-0.5656	-0.1932	-0.1932
SAR	-0.6400	0.3562	-0.3255
Soil P	-0.6874	-0.3101	0.6489
Soil K	0.4840	-0.6213	0.6465

All the values of correlation coefficients are statistically similar at 5 % level.

wheat yield reflects better agronomic management by the tail farmers. One of such practices followed by the tail farmers was to leave part of their land uncultivated and diverting more and better agricultural inputs to the remaining farm fields resulting in better crops. Similar were the findings of Willardson (1992) from farmers, interviews in the Fourth Drainage Project Area, Faisalabad. However, the cost: benefit ratio was higher in the CT and WCT than that in the CH and WCH sections. This aspect, however, needs in depth studies.

Plant Nutrition: The concentrations of soil P and K, and N, P and K in whole wheat plants were found higher than their respective critical levels (data not presented), although according to farmers, none of them applied N, P and K fertilizers at recommended rates. Perhaps due to adequate nutrient assimilation by plants, the correlation coefficients (Table 5) between wheat grain yield and pHs, ECe, SAR, soil P or K concentrations remained statistically similar both in the water course as well as canal sections.

Conclusions: It may be stated that tubewell water quality is the index of soil quality i.e. more the number of hazardous quality water tubewells, higher the proportion of salt-affected fields in a region. The seepage from canals does help improve the groundwater quality and such tubewell sites should be given preference. The tail-end farmers have to provide better agronomic management of crop and soil for effective use of water resources for sustainable crop production.

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