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EFFECT OF ALKALI WATER/ CANAL WATER ON YIELD AND YIELD ATTRIBUTES OF POTATO IN SEMI-ARID REGION OF UTTAR PRADESH

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ABSTRACT

A field experiment was conducted to study the effect of quality of irrigation water on yield of potato (Solanum tuberosum) during 2003-04 to 2008-09 at Bichpuri Agra. The results revealed that the tuber yield of potato was highest with canal water (28.6 t ha^{-1}) and lowest with alkali water (4.4 t ha^{-1}).The irrigation mode of canal and alkali water also differed significantly with all canal water treatments. Amongst the different canal: alkali water mode, highest yield was recorded in 2 year CW: 1year AW with 78% relative yield. The mode 1year CW: 2year AW, 1year AW: 2year CW and blending (1CW:2AW) produced significantly lower yield compared with 2yearCW:1yearAW treatment. However, the former blending was superior to all the alternate modes except 2year CW: 1year AW. The relative yields of different canal/alkali irrigation modes were 66% in 1year CW: 2 year AW, 54% 2 year AW: 1year CW, 78% in 2 year CW: 1year AW, 60% in 1year AW: 2 year CW, 48% in AWp: CWs, 58% in blending (1CW:2AW) and 83% in blending (2CW:1AW) when compared with all canal irrigated treatment. The water use and water use efficiency was higher in CW treatment and lowest in all AW treatments. The A grade potato tuber was produced in all CW irrigated treatment and C grade in all AW irrigated treatments. The keeping quality of potato tuber (% weight loss) was maximum in AW (52.4%) treatment and lowest in all CW treatments (30.6%).

Keywords: Alkali water, Canal water, yield, potato

INTRODUCTION

Degradation of soils with the use of alkali ground water constitutes a major threat to irrigated agriculture in semi-arid parts especially south Asia (Minhas and Bajwa 2001; Qadir and Oster 2004). High incidence (30-50%) of these waters is found in semiarid parts (annual rainfall 500-700mm), which are the most intensively cultivated areas in the Indo-Gangetic plains. Irrigation with alkali waters results in a rise in soil alkalinity and sodicity thus adversely affecting the soil physical behaviour in terms of crusting, hard-setting and low intake rates. This not only decreases the crop yields but also limits the choice of crops that can be grown on these soils (Minhas and Gupta 1992; Ayers and Westcot 1985; Minhas 1996; Oster and jayawardene 1998). Specialized soil-crop-irrigation management practices, which help to maintain the sodicity in the root zone within permissible limits, are therefore advocated for sustained irrigation with alkali waters. In addition to the appropriate selection of crops and improvement in water management, application of amendments is required to maintain soil structure/permeability and thus sustain irrigation with alkali waters. Therefore, an investigation was carried out to study the effect of alkali water / canal water on potato.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Raja Balwant Singh College of Agriculture, Bichpuri, Agra, Uttar Pradesh ($27^0$2' N and $77^0$9' E). The climate at the site is semi-arid with average rainfall of 650mm, about 80% of which is received during July-September. The soil at the site was a well-drained (water level below 12 m) sandy loam soil with an electrical conductivity of saturation paste extract (ECe) of 2.7 d Sm^{-1}, pH of the saturation paste (pHs) of 7.9, exchangeable sodium percentage (ESP) of 5.3, organic matter content of 2.9 g kg^{-1} soil and clay content of 14%. Treatments consisted of combinations of irrigation with an alkali water (AW, Ecaw 3.6 d Sm^{-1}, residual sodium carbonate (RSC) 15.8 me L^{-1}, sodium adsorption ratio (SAR) 12.4) and a good quality canal water (CW, Eccw 1.1 d Sm^{-1}, RSC nil, SAR 1.8) applied either alone, as blends or in cyclic (i.e. alternate) application both irrigation-wise and crop-wise. The treatments were:

(1) All irrigations either with canal water or alkali water

(i) All irrigations with canal water (CW) (ii) all irrigations with alkali water (AW)

(2) Cyclic application of canal and alkali water either irrigation wise or crop wise

(iii) Annual cycle, 1 year CW and 2 and 3 year AW (Cyc- 1YCW:2YAW)

(iv) Annual cycle, 1 & 2 year AW and 3 year CW (Cyc- 2YAW:1YCW)
(v) Annual cycle, 1 and 2 year CW and 3 year AW (Cyc- 2YCW:1YAW)
(vi) Annual cycle, 1 year AW and 2 and 3 year CW (Cyc- 1YAW:2YCW)
(vii) Crop cycle, AW to potato and CW to sunflower (Cyc- AWp: CWs)

(3) Irrigation with blends of CW and AW
(viii) Blending in the ratio of 2:1 (2CW:1AW)
(ix) Blending in the ratio of 1:2 (1 CW: 2AW).

The experiment was conducted for 6 years but one annual cycle was completed in 3years and next cycle was tiring in next 3 years. Treatments were imposed in a randomized block design with four replications. The plot size was 20 m^2 (5 m x 4 m) and to control lateral fluxes of salt and water, each plot was lined with polyethylene sheet down to a depth of 0.9 m. Alkali water was synthesized by dissolving the required quantities of sodium bicarbonate in canal water. Local agronomic practices in terms of inter/intra-row spacing, seed rates, fertilizers, irrigation schedules and other cultural practices were followed for each crop. Potato (cv.Kufri-3797) was planted during the end of October and harvested during the end of February. The open pan evaporation, rainfall and irrigation water applied was recorded (Table 1).The tuber yield was recorded grade wise i.e. A grade (<60 gm), B grade (40 gm) and C grade (> 40 gm) in all treatments. The keeping quality of potato tuber in the form of weight loss (%) was recorded. Soil samples were collected (0.9 m) at planting and harvest of the crop and soil water storage (SWS) was determined thermo-gravi-meterically. The quantity of water used (WU) was calculated as difference in soil storage during the season (SWS) plus irrigation (IW) and rainfall (RW). The water use efficiency (WUE, kg/ha-cm) was then calculated as the ratio of yield (kg ha^{-1}) to WU (cm).

Table 1: Rainfall (mm), US Open pan evaporation (OPE, mm), irrigation water applied (mm) to potato crop

Crop	Parameters	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	Mean
Potato	OPE	229	257	285	232	245	266	252
	Rainfall	25.8	10.3	NIL	87.1	1.3	NIL	31.1
	Irrigation	250	250	300	300	300	300	283

RESULTS AND DISCUSSION

Crop performance

Irrigation with alkali water (AW) significantly reduced the average yields over a period of six years of potato (85%), though the reductions in yields were comparatively lower in the first year (71%), than subsequent years (Table 2). The significant reduction in crop yields can be ascribed to bicarbonate toxicity and build up of alkalinity and sodicity in soils leading to structural deterioration and poor permeability problems. These factors ultimately result in nutritional imbalances (Qadir and Oster 2004). The restricted movement of water in soils irrigated with alkali water may also result in the retention of salts in surface layers, which simultaneously induces salinity stresses affecting crop growth (Minhas *et al.* 2003 and Chauhan et al, 2007). The salinity (2.9-4.9 d Sm^{-1}) during the crop growth period, though not high, was beyond the threshold values reported for the crops under consideration (Maas and Grattan 1999).

Table 2: Effect of modes of irrigation with alkali and canal water on tuber yield (t ha^{-1}) of potato

Mode of irrigation	Yield (t/ha) during the year							
	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	Mean	RY%
All canal water(CW)	24.5	28.2	25.9	31.2	25.7	36.3	28.6	100
All alkali water (AW)	7.1	4.3	3.4	2.6	2.3	6.6	4.4	15
Cyclic (1YCW:2YAW)	23.1	17.9	16.6	23.6	15.9	17.3	19.1	66
Cyclic (2YAW:1YCW)	18.8	10.8	18.4	13.7	8.4	20.8	15.5	54
Cyclic (2YCW:1YAW)	19.7	24.1	20.9	24.9	23.4	22.9	22.4	78
Cyclic (1YAW:2YCW)	9.3	16.8	18.9	13.7	14.1	21.1	17.3	60
Cyclic (AWp:CWs)	11.4	13.5	15.9	12.7	9.9	19.6	13.8	48
Blending (2CW:1AW)	21.0	22.4	21.7	23.9	21.3	31.8	23.7	83
Blending (1CW:2AW)	13.8	15.3	17.2	16.6	12.8	24.4	16.7	58
LSD(p=0.05)	1.8	2.1	1.7	2.1	2.3	1.9	-	

The yields of potato crop improved under the various combinations of canal water (CW) and alkali water (AW) usage compared with alkali water alone. The crop tended to perform better with yearly water use compared to blending. When averaged over the 6-years, the relative yield (RY) of potato were 66, 54, 78, 60 and 48% under the cyclic 1YCW:2YAW, 2YAW:1YCW, 2YCW:1YAW, 1YAW:2CW and AWp: CWs treatments, respectively while the RY was 83 and 58% for waters blended in the ratio 2CW:1AW and 1CW:2AW, respectively. It can be concluded that the combined use of alkali and good quality canal waters can maintain the soil sodium saturation at relatively low levels depending upon the proportion of the two waters. Amongst the various treatment options, the cyclic use should be preferred especially when canal waters are utilized for initial irrigations since it would have both operational and performance advantages over the blending of the water supplies. The use of AW should be avoided during the initial stages of crop growth.

Quality of produce

The effect of sodicity build up in the soil profile due to combined use of alkali and canal water under different treatments were evaluated in terms of quality of potato tuber . The quality of potato was measured in terms of the tuber grade (A>60g, B 40-60g and C < 40g) and keeping quality (percentage weight loss in storage) (Table 3).In general, it was observed that the lower grade tubers (C grade) increased with decline in yield under different treatments, (Chauhan, 2008). Storage quality also deteriorated with AW irrigation (e.g. the potatoes shriveled with two-third-weight loss on storage for 90 days under AW treatments where as the weight loss was just about two-fifth under CW).

Table 3: Effect of various treatments on quality parameters and water use and water use efficiency (Av. 6 years)

Mode of water use	Tuber yield grade wise (t ha^{-1})			Weight loss (%)	Water use (cm)	Water use efficiency (kg/ha-cm)
	'A' >60 g	'B' 40 g	'C' <40 g			
All canal water(CW)	13.1	8.8	6.8	30.6	30.8	944.5
All alkali water (AW)	0.47	1.47	2.41	52.4	28.9	161.7
Cyclic (1YCW:2YAW)	7.52	6.31	5.27	33.9	30.1	650.3
Cyclic (2YAW:1YCW)	4.54	5.35	5.27	37.5	30.2	527.5
Cyclic (2YCW:1YAW)	9.37	7.73	5.54	37.2	29.6	775.7
Cyclic (1YAW:2YCW)	6.25	5.02	6.05	39.5	29.3	604.8
Cyclic (AWp:CWs)	4.79	4.64	4.41	39.1	30.2	472.5
Blending (2CW:1AW)	10.07	7.41	6.23	37.6	29.7	815.9
Blending (1CW:2AW)	5.49	5.19	6.01	40.3	29.4	572.7
LSD(p=0.05)	0.47	0.25	0.23	0.9	-	-

The water use efficiency (WUE) was declined with reduced yields and sodicity development under various treatments (Table 3). For different treatments of CW and AW, WUE was estimated between 944 and162 kg/ha-cm. The highest WUE was estimated for all CW whereas the lowest for AW treatments. Among different modes of combined use of alkali and canal waters, WUE was estimated highest in blending of canal and alkali waters in ratio of 2CW:1AW (816 kg/ha- cm) in potato crop.

Table 4: Soil analysis (0-30 cm depth) in different irrigation modes (Av. 6 years)

Treatments	At sowing				At harvest			
	ECe	SAR	pH	ESP	ECe	SAR	pH	ESP
All canal water(CW)	2.7	2.9	7.5	9.2	3.4	3.3	7.7	9.9
All alkali water (AW)	4.2	15.6	8.5	24.1	4.6	17.7	8.8	26.8
Cyclic (1YCW:2YAW)	3.4	6.7	8.1	13.8	3.6	9.2	8.2	14.3
Cyclic (2YAW:1YCW)	3.5	9.8	8.2	16.3	3.7	10.9	8.4	18.5
Cyclic (2YCW:1YAW)	3.3	4.8	8.1	13.2	3.4	6.2	8.3	14.7
Cyclic (1YAW:2YCW)	3.8	8.4	8.3	14.2	4.2	8.8	8.4	15.9
Cyclic (AWp:CWs)	3.2	6.8	8.2	14.9	3.5	8.8	8.4	15.8
Blending (2CW:1AW)	3.3	5.5	8.2	14.1	3.4	6.0	8.4	14.9
Blending (1CW:2AW)	3.3	7.0	8.3	16.8	3.5	7.5	8.5	18.2

Change in soil properties

The salt build up in the surface soil layer (0-0.30 cm), where most dense crop roots are confined and has high potential for clay dispersion, surface crusting thus low infiltration rate, was most influenced by irrigation water quality (Table 4). The effects of various modes of irrigation on the properties, though monitored up to 90 cm in the effective root zone depth, is limited to agriculturally important soil layer. Continuous irrigation with alkali water (AW) significantly increased salt built up in soil profile as compared to continuous use of canal water (CW). The average values of pH, ECe, SARe and ESP at the harvest of potato crop ranged between 7.7 and 8.8, 3.4 and 4.6 d Sm^{-1}, 3.3 and 17.7 and 9.9 and 26.8, respectively.

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