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Influence of Conjunctive Use of Canal and Sodic Water on Performance of Crops in Rice Based Cropping System

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Abstract: A field experiment was conducted at Agricultural College and Research Institute, Trichy, Tamil Nadu during 1999-2002 to find out the effect of conjunctive use of canal water and sodic water in rice based cropping systems on the growth and yield of crops. The initial soil pH, EC and ESP were 7.8, 0.13 dSm^{-1} and 15.8, respectively. The canal water with pH 7.5, EC 0.5 d Sm^{-1}, SAR 1.2 and RSC 1.2 mel^{-1} and alkali water with pH 8.4, EC 1.9 dSm^{-1}, SAR 16.5 and RSC 11.8 mel^{-1} were used in the experiment. The experiment was laid out in plots of 8 x 6 m size replicated thrice in a strip plot design. Four irrigation treatments viz., continuous use of alkali water, canal water alone, conjunctive use of canal and sodic water in 1:1 and 1:2 ratio for rice were fitted in the main plot. The sub plot treatment consisted of four rice based cropping systems viz., rice - fallow, rice - green gram, rice - sunflower and rice - cotton. The treatments were imposed to rice crop and the follow up crops were irrigated with available alkali water. The results revealed that the conjunctive use of canal water for rice and alkali water for green gram recorded the highest rice grain equivalent yield and BC ratio followed by conjunctive use of 1:1 ratio of canal and sodic water for rice and alkali water for green gram. Continuous use of alkali water for rice and follow up crops resulted in yield decline of 18 – 35% of rice and 35 – 50% of follow up crops. Further this resulted in an increase in soil ESP from initial 15.8 to a range of 39 - 42 depending on the cropping system. Greengram after rice with alkali water irrigation was agronomically efficient and economically viable without deteriorating soil health.

Key words: *Alkali water, conjunctive use, cyclic mode, SAR, ESP, RSC, cropping system.*

INTRODUCTION

India has been endowed by nature with considerable amount of surface and ground water resources which are unevenly distributed in both time and space. The groundwater system has remained the major source of irrigation and it is treated as dependable source of water supply for assured crop production. Hence, its use for agriculture in conjunction with canal water remains inevitable. The survey work indicates that marginal and poor quality ground waters constitute a greater part of ground water resources. The extent of poor quality water range from 32 to 84 %[7]. Further in brackish water areas, the average extent of sodic and saline waters are approximately 37 to 43 % respectively [9].

Abrol and Bhumbla [1] proposed that water with less than 2.5 mel^{-1} RSC should be considered safe for irrigation of field crops. Later, several reports appeared where irrigation water upto 10 RSC and SAR < 10 were used successfully for raising semi tolerant crops keeping the land fallow during monsoon for leaching[5]. Field experiments at Kanpur showed a reduction in yield of wheat, paddy, mustard and sorghum when they were continuously irrigated with sodic water. Pulses were also sensitive to the use of alkali waters and showed decline in yields at RSC of 5 - 10 mel^{-1}.

In low land rice based cropping systems, whenever water is limited, only one rice crop can be raised with the available canal water. However, with the available alkali groundwater, there exists a possibility of raising one more crop after rice with proper selection of crops for sodicity tolerance. With the conjunctive use of canal and sodic water, the effects of the resultant sodicity build up can be minimized. With these points in view, in order to utilize the available underground alkali water, an experiment was conducted to find out the effect of underground alkali water on the performance of crops in rice based cropping systems.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural College and Research Institute, Trichy, Tamil Nadu during 1999-2002 to find out the effect of conjunctive use of canal water and sodic water in rice based cropping systems on the growth and yield of crops. The initial soil pH, EC and ESP were 7.8, 0.13 dSm^{-1} and 15.8, respectively. The canal water with pH 7.5, EC 0.5 d Sm^{-1},

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SAR 1.2 and RSC 1.2 me l^{-1} and alkali water with pH 8.4, EC 1.9 dSm^{-1}, SAR 16.5 and RSC 11.8 me l^{-1} were used in the experiment. The experiment was laid out in plots of 8m x 6m size replicated thrice in a strip plot design. Four treatments with different irrigations viz., continuous use of alkali water, canal water alone, conjunctive use of canal and sodic water in 1:1 and 1:2 ratio for rice were fitted in the main plot. The sub plot treatment consisted of four rice based cropping systems viz., rice - fallow, rice - green gram, rice - sunflower and rice - cotton. The irrigation treatments were imposed to rice crop and the follow up crops were irrigated with available alkali water. The rice crop (var. TRY- I) was transplanted during September - October and the follow up crops viz., green gram (var. Pusa bold), sunflower (var. CO 4) and cotton (LRA 5166) were sown during March - April. All the crops were raised by following the recommended fertilizer dose and cultural practices.

The rainfall received was 683, 372 and 456 mm, respectively for the three years during the rice crop period and 282, 149 and 176 mm, respectively during the follow up crop period. Number of irrigations with alkali water varied from 10 - 23 for rice crop based treatments and 4-7 for follow up crops. Grain yield of rice and the yield of other crops were recorded at harvest. Rice equivalent yield was calculated by equating the cost of the produce obtained in that system to that of rice. BC ratio was computed considering the current market price of inputs and resources. Soil samples were collected after the harvest of each crop keeping an interval of 0.15 m down to 0.3 m and 0.3 m interval down to 0.9 m. The soil samples were processed and analyzed for pH (1:2 saturation extract), electrical conductivity and ESP following standard procedures.

RESULTS AND DISCUSSIONS

Rice grain yield: Grain yield of both rice and follow up crops was pooled over years and presented in Table 1 and 2. Irrigation treatments had significant influence on rice grain yield. Irrigation with canal water for rice and sodic water for follow up crops recorded significantly higher yield (5.22 t ha^{-1}) over other irrigation treatments. Irrigating with alkali water to rice either alone or in conjunction with canal water reduced the rice yield. Moreover, higher rice yields were recorded when the plots were kept as fallow following rice rather than growing crops irrigated with alkali water. However, it was comparable with rice-greengram cropping system resulting in comparable grain yield of rice. Continuous irrigation of alkali water to rice as well as follow up crops resulted in yield reduction of 36%. Decline in yield of

Table 1: Effect of conjunctive use of canal and alkali water on rice grain yield (kg ha^{-1}).

Irrigation Mode during		Crops following rice				
Rice	Follow up crops	Fallow	Greengram	Sunflower	Cotton	Mean
AW	AW	4100	3985	3906	3707	3924
CW	AW	5750	5417	5033	4705	5226
1CW:1AW	AW	4601	4247	4194	3930	4243
1CW:2AW	AW	4328	4211	4054	3830	4106
Mean		4695	4465	4297	4043	
		M	**S**	**M at S**	**S at M**	
SEd		86.65	57.50	113.4	142.1	
CD		211.1	118.9	237.8	293.8	

AW: Alkali Water cw: Canal Water

Table 2: Effect of conjunctive use of canal and alkali water on rice equivalent yield (kg ha^{-1}).

Irrigation Treatments		Crops following rice			
Rice	Follow up crops	Green gram	Sunflower	Cotton	Mean
AW	AW	1716 (429*)	513 (308)	1503 (451)	1244
CW	AW	3860 (965)	711 (427)	2793 (838)	2445
1CW1AW	AW	2904 (726)	648 (389)	1993 (598)	1848
1CW:2AW	AW	2628 (657)	587 (352)	1877 (563)	1697
Mean		2777	615	2042	

*Actual yield of follow up crops

Table 3: Effect of conjunctive use of canal and alkali water on B: C ratio.

Irrigation Treatments		Crops following rice			
Rice	Follow up crop	Fallow	Green gram	Sunflower	Cotton
AW	AW	1.96	2.03	1.58	1.78
CW	AW	2.43	2.69	2.15	2.14
1CW:1AW	AW	2.33	2.49	1.94	2.04
1CW:2AW	AW	2.27	2.31	1.80	1.89

Table 4: Effect of conjunctive use of canal and alkali water on soil pH after three years.

Irrigation treatments		Crops following rice				
Rice	Follow up crops	Fallow	Green gram	Sunflower	Cotton	Mean
AW	AW	9.12	9.23	9.33	9.42	9.28
CW	AW	8.07	8.40	8.51	8.62	8.40
1CW:1AW	AW	8.70	8.75	8.83	8.85	8.78
1CW:2AW	AW	8.96	9.08	9.22	9.25	9.13
Mean		8.72	8.87	8.97	9.03	
		M	S	M at S	S at M	
SEd		0.03	0.02	0.05	0.04	
CD		0.08	0.05	0.11	0.09	

crops receiving alkali waters on long term were mainly due to increased pH, ESP and decreasing infiltration rate[4]. With respect to the yield of follow up crops, the highest green gram grain yield (965 kg ha^{-1}) and rice equivalent yield (3860 kg ha^{-1}) were recorded with conjunctive use canal water for rice and alkali water for green gram. Fifty five per cent yield reduction in green gram was observed when all the corps in the system i.e. rice as well as green gram were continuously irrigated with alkali water. Chauhan *et al*[3] also observed sodicity induced accumulation of salts with the use of poor quality water and there by yield reductions in the long term experiments.

Rice equivalent yield: On a system basis, rice - green gram cropping system recorded the highest rice equivalent yield of 7.47 t ha^{-1} followed by 6.09 t ha^{-1} by rice - cotton cropping system. This is significantly superior over rice -sunflower cropping system as well as rice alone indicating the possibility for intensification using alkali water. Considering the sodicity building in terms of ESP, it is minimal in case of rice green gram cropping system. Considering effect of irrigation treatments on the systems, conjunctive use of alkali water to rice and alkali water to greengram recorded the highest rice equivalent yield of 9.28 t ha^{-1}. When the alkali water was used in cyclic mode with canal water, yield of both the crops were maintained at par with canal water[8].

BC ratio: To compare the economics of the system, B: C ratio was worked out and presented in Table.3. Among various treatments, irrigating rice with canal water and green gram with alkali water in a rice-summer crop cropping system recorded higher B: C ratio of 2.69 indicating the economic feasibility of raising greengram after rice with the available underground alkali water.

Soil parameters: Soil samples were analyzed for pH and EC and the values are given in Table 4 & 5. At the end of the three years of experimentation, continuous irrigation with alkali water resulted in increasing the pH with a maximum value of 9.28. Conjunctive use of canal water for rice and alkali water for follow up crops resulted in lower pH of 8.25. However, increase in pH was noticed whenever alkali water was used either in 1:1 or 1:2 ratio for rice. Among the cropping systems, keeping the land fallow after rice resulted in lower pH of 8.72 followed by rice-green gram cropping system. Higher pH of 9.03 was recorded in rice – cotton cropping system since it involved more number of alkali irrigation. Manchanda *et al*.,[6] in a study on the long term effect of sodic water on soil deterioration also reported increase in pH and ESP of soil irrigated with water having high residual sodium carbonate level.

Single crop of rice recorded the lowest pH with canal irrigation with a value of 8.07. Conjunctive use of canal water for rice and alkali water for green gram recorded

Table 5: Effect of conjunctive use of canal and alkali water on soil EC (dSm^{-1}) after three years.

Irrigation treatments		Crops following rice				
Rice	Follow up crops	Fallow	Greengram	Sunflower	Cotton	Mean
AW	AW	0.36	0.39	0.45	0.84	0.51
CW	AW	0.12	0.14	0.15	0.16	0.14
1CW:1AW	AW	0.17	0.19	0.20	0.20	0.19
1CW:2AW	AW	0.24	0.25	0.28	0.31	0.27
Mean		0.22	0.24	0.27	0.38	
	M	S	M at S	S at M		
SEd	0.03	0.02	0.05	0.04		
CD	0.07	0.05	0.11	0.09		

Table 6: Effect of conjunctive use of canal and sodic water on soil ESP at different depth after three years.

Irrigation Mode during			Crops following rice				
Rice	Following crop	Depth (cm)	Fallow	Green gram	Sunflower	Cotton	Mean
AW	AW	0-15	31.63	38.11	39.40	39.66	37.2
		15-30	32.59	39.31	40.62	41.55	38.5
		30-60	28.50	28.60	27.50	29.20	28.5
		60-90	30.62	30.59	30.36	30.79	30.6
CW	AW	0-15	12.89	13.88	15.27	15.43	14.4
		15-30	14.37	15.72	15.87	15.91	15.5
		30-60	27.41	27.32	27.30	27.40	27.4
		60-90	31.16	30.30	31.37	30.32	30.8
1CW:1AW	AW	0-15	19.63	21.67	23.99	24.78	22.5
		15-30	23.11	24.74	26.36	26.96	25.3
		30-60	27.00	27.50	28.10	28.60	27.8
		60-90	29.80	30.10	30.20	30.10	30.1
1CW:2AW	AW	0-15	19.63	21.67	23.99	24.78	22.5
		15-30	23.11	24.74	26.36	26.96	25.3
		30-60	27.00	27.50	28.10	28.60	27.8
		60-90	29.80	30.10	30.20	30.10	30.1
0-15 cm		M	S	M at S	S at M		
SEd		0.39	0.74	1.34	1.48		
CD		0.95	1.53	2.81	3.08		

slightly higher pH of 8.40, indicating the possibility of raising greengram after rice utilizing the available underground alkali water.

Continuous irrigation with alkali water increased the EC of soil. However, all the treatments recorded EC below the critical limit of 2 dS m^{-1}. Changes in soil properties (0 - 0.15 m) at the end of three years of experimentation are presented in Table.6. In general, sodicity buildup, as indicated by significant increase in ESP, occurred as a result of irrigations to rice as well as the follow up crops with alkali water. With continuous irrigation with alkali water to all the crops in the system, mean soil ESP at (0-0.15 m) increased from initial 15.8 to 21.61, 25.30, 30.93, 34.00, 34, 85 and 37.20, respectively after each crop during 1999-2002. However, irrigation with canal water for rice and alkali water for follow up

crops resulted in lesser sodicity build up with an ESP of 14.4, especially rice-green gram cropping system recording the lowest value of 13.88 resulting in higher sustainable yields. However, conjunctive use of canal and alkali water for rice in 1:1 and 1:2 ratio and irrigating follow up crops with alkali water increased the surface ESP to 22.5 and 29.3 respectively, thereby resulting in certain yield loss.

The soil ESP (0 - 15 cm) was the least (31.6) when the land was left fallow after rice as compared to follow up crops. The ESP increased to 38.1, 39.4 and 39.6 when greengram, sunflower and cotton were grown as follow up crops, respectively under continuous irrigation with alkali water for all the crops. However, the increase is ESP was insignificant when conjunctive use of canal water for rice and alkali water for follow up crops was followed. Analysis of profile soil samples revealed that effect of alkali water in increasing ESP was more pronounced in soil surface layers of 0-15 and 15-30 cm only. Under monsoonal climate major build up of salts at only surface layers even after long term use of alkali waters and higher ESP was observed by Bajwa and Josan[2] in rice-wheat system because of increased use of sodic water.

Conclusion: The results revealed that the conjunctive use of canal water for rice and alkali water for green gram recorded the highest rice grain equivalent yield and BC ratio followed by conjunctive use of 1:1 ratio of canal and sodic water for rice and alkali water for green gram. Continuous use of alkali water for rice and follow up crops resulted in yield decline of 18 – 35% of rice and 35 – 50% of follow up crops. Further, this resulted in an increase in soil ESP from initial 15.8 to a range of 39 - 42 depending on the cropping system.

From the results of the experiments, it is concluded that the conjunctive use of canal water for rice and alkali water for green gram can be recommended wherever canal water is available for one season and underground water is alkali in nature. When there is limited water supply in canal, conjunctive use of 1:1 ratio of canal and sodic water can be practiced for rice with moderate sodicity build up of soil which can be managed with the application of suitable amendments.

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