AGRONOMIC MANIPULATION IN SALINE SODIC SOILS FOR ECONOMIC BIOLOGICAL YIELDS

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ABSTRACT

A large area of land is gradually turning barren due to soil sickness with sodicity. The present study on the impact of agronomic manipulation in these soils at Barwaha (Nimar, M. P.) is indicative of not only reducing the dominance of Na but also affecting the fall in ECe and ESP values, thereby restoring the productivity appreciably. Rotating crops in definite sequence resulted in the decline of salt concentration, favourable crop growth and higher biological yields besides increased crop intensity. Cropping rice–wheat followed by dhaincha (*Sesbania aculeata*) as green manure was most remunerative. Monetary returns accrued either by rice–barely or rice–berseem were far less due to poor emergence of *rabi* crops under Barwaha agro-climatic conditions.

INTRODUCTION

The hazard of salination and alkalinization is bound to grow parallel with the development of irrigation resources envisaged in the Sixth Five Year Plan. Out of about 7 million hectares of such land in India, 3.39 million hectares are already awaiting suitable management and reclamation of salt affected lands in Madhya Pradesh. Excess sodium accumulation on soil exchange complex and/or soluble salts in the soil profile are threatening the productivity of about 3,000 ha land of Nimar plains of Narmada trough of west M. P.[1]. In course of time, due to weathering of alkaline rich material (basalt), from alkaline earth, carbonates from higher elevation got deposited in the basin of Nimar during flooding. The high clay content coupled with high temperature resulted in the surface accumulation of salts in this region.

The effective management of such sodic soils is possible by a single or combination of either mechanical, agronomical or chemical methods[2]. Along with the use of gypsum as soil amendment, selection of suitable crop sequence, planting method and optimum plant stand are of great significance in reclaiming salt affected soils. Initial studies undertaken by few workers[3–7] confirmed the suitability of berseem, rice, dhaincha, cotton, wheat, sugarcane and sugarbeet for the alkali soils. They, however, expressed the need for determining the effectivity and economics of fitting these crops in proper crop rotation, pertaining to specific problems of the region. Practically no work is yet reported on the suitability of cropping pattern of saline-sodic soils of Nimar tract of Madhya Pradesh. It is with this intention that the field experiments were carried out at Barwaha, Madhya Pradesh.

MATERIALS AND METHODS

Field trials were conducted at the Research Farm of Salt Affected Soil Project, Barwaha, M.P. during 1982–83 and 1983–84 in *kharif* and *rabi* seasons to determine the effectivity and economics of cropping pattern in the management of saline-sodic vertisols of the region. The experiment included four crop rotations *viz.* rice–wheat; rice–berseem; rice–barley and rice–wheat–*dhaincha* as green manuring. These four treatments were randomly distributed in six replications in randomised block design with plot size 7 m × 5 m. The varieties included were CSR 4 in paddy, WH 157 in wheat, tetraploid in berseem and local in barley. The crops were raised from July to October in *kharif* and November to March in *rabi* seasons in two years. The experiment was conducted at the same site since 1970 when the fields were treated with gypsum @ 50% GR initially. From 1970–71 to 1971–72 four crop rotations (CR I to CR IV) included rice–wheat, cotton–berseem, maize–wheat and sorghum–wheat. Similar sets of cropping sequence continued from 1972–73 to 1981–82, except the last one which was changed to rice–berseem. Later from 1982–83 maize–wheat was replaced by rice–barley and cotton berseem by rice–wheat–*dhaincha*. In the present study, paddy seedlings were first raised in the nursery and transplanted thereafter into the main field, whereas other crops were sown directly. Rice, wheat and barley received fertilizers @ 120 N + 80 P_2O_5 + 40 K_2O kg/ha, while berseem @ 20 N + 80 P_2O_5 + 40 K_2O kg/ha as urea, superphosphate and muriate of potash, respectively. Timely irrigation and drainage were provided as and when necessary. Soil samples were collected from each plot for estimating the chemical properties at the initial stage and after the harvest of crops. Wheat equivalent (W. E.) was calculated for purpose of yield comparison on statistical parameters using following formula and converting the yield of either berseem or barley to the yield of wheat on the basis of prevailing market prices: W. E. = $(Yb \times Pb)/Wp$, where Yb was the yield of berseem or barley and Pb was their price per quintal and Wp was the price of wheat per quintal.

RESULTS AND DISCUSSION

Effectivity of cropping pattern: The data on chemical analysis of soil samples done at the initial stage are presented in table 1 and 2. It is quite evident that the soil of the experimental area was saline-sodic in nature with pH varying from 7.9 to 8.1 in 1982–83 and 1983–84. The ECe and ESP values of soil complex at the initial stage oscillated between 4.4 to 5.2 and 3.7 to 3.8 mmhos/cm at 25°C and 31.1 to 33.0 and 28.7 to 31.7 in the two years, respectively. The dominance of cation sodium and anion chloride was quite apparent. The perusal of data recorded after harvest of rice revealed declinement in salt concentration. The fall in ECe values was associated with the decreasing values of soluble and exchangeable sodium. It is in conformity with the earlier findings which reveals the removal of soil exchangeable sodium caused by mobilization of the native insoluble $CaCO_3$ as a result of increased hydrolysis and liberation of CO_2 by the plant roots[8]. This eventually led to the fall in SAR of sodium solution. The concentration of chlorides and sulphates also exhibited a decreasing trend in thø saturated extract. The observed fall in the values of ECe and ESP in the surface soil may be attributed to the removal of salt through percolation of water to deeper layers facilitated by paddy roots. The soil analysis after the harvest of wheat crop exhibited practically no differences in the ECe, SAR and ESP values indicating thereby the continued effect of preceding crop of rice on the soil properties. None of the four crop rotations included in the studies showed substantial distinction among themselves in influencing the chemical properties of soil at this stage.

Impact on the biological yield: It is evident from table 1 that the maximum yield of paddy (35.84 q/ha and 37.71 q/ha) in *kharif* and that of wheat (25.71 q/ha and 28.01 q/ha) in *rabi* during 1982–83 and 1983–84 respectively were recorded in rice–wheat–*dhaincha* (CR IV) crop rotation. Although, paddy showed

Table 1 *Chemical properties of soil at initial stage, after harvest of paddy and wheat crops in 1982–83*

			Saturation extract analysis							
			Cations me/l			Anions me/l				
Crop rotations	pH	mmhos/ cm at 25°C	Ca	Mg	Na	HCO_3	Cl	SO_4	SAR	ESP
i) *Initial stage*										
Rice–wheat	8.1	4.4	7.0	4.3	38.3	5.3	27.0	19.5	16.3	33.0
Rice–berseem	7.9	4.7	7.8	4.5	35.2	5.6	25.8	16.6	14.3	31.8
Rice–wheat–DHC	7.9	4.9	8.3	3.9	38.6	5.5	28.2	18.2	15.6	32.4
Rice–barley	8.0	5.2	7.4	4.8	40.4	5.1	28.2	18.7	16.6	31.1
ii) *After harvest of paddy*										
Rice–wheat	8.0	3.8	8.0	4.0	26.1	5.2	18.2	15.3	10.6	30 6
Rice–berseem	7.9	3.9	8.5	4 9	27.0	5.2	20.2	15.0	10.4	28.0
Rice–wheat–DHC	7.9	4.0	8.5	4 8	28.8	5.1	22.0	13.9	11.2	29.0
Rice–barley	7.9	4.1	8 0	5.0	28.0	4.8	22.0	14.2	11.0	27.9
iii) *After harvest of wheat*										
Rice–wheat	8.1	3.8	8.1	4.4	26.2	5.1	20.1	13.4	10.5	31.7
Rice–berseem	8 1	3.7	8.1	4 4	25.5	5.0	20.8	13.4	11.1	30 2
Rice–wheat–DHC	8.0	3.8	8.2	4.3	26 0	5.1	20.5	12.6	10.4	29.3
Rice–barley	7.9	3.7	8.1	4.3	24.5	5.1	20.3	11.5	9.8	28 7

DHC–Dhaincha as green manure crop.

Table 2 *Chemical properties of soil at initial stage, after harvest of paddy and wheat crops in 1983–84*

			Saturation extract analysis							
			Cations me/l			Anions me/l				
Crop rotations	pH	ECe mmhos/cm at 25°C	Ca	Mg	Na	HCO_3	Cl	SO_4	SAR	ESP
i) *Initial stage*										
Rice–wheat	8.1	3.8	8.0	4 4	26.2	5.1	20 1	13.4	10.5	31.7
Rice–berseem	8 1	3.7	8.1	4.4	25.5	5.0	20.8	13.4	11.1	30.2
Rice–wheat–DHC	8.0	3.8	8 2	4.3	26.0	5.1	20.5	12.6	10.4	29.3
Rice–barley	7.9	3.7	8.1	4.3	24.5	5.1	20.3	11.5	9.8	28.7
ii) *After harvest of paddy*										
Rice–wheat	8 2	3.6	8.4	4.7	23.1	5.0	18 5	12.8	9.0	28.8
Rice–berseem	8.1	3.5	8.1	4.1	21.7	5.1	18.6	10.7	8.6	30.2
Rice–wheat–DHC	8.0	3.1	8.1	4.9	18 1	5.0	16.1	10.1	7.1	28.7
Rice–barley	8.2	3.1	8.4	4.8	16.4	4.9	16.6	10.2	6.4	29.6
iii) *After harvest of wheat*										
Rice-wheat	8.2	3.0	8.5	4.7	17.0	4.6	15.5	10.3	6 6	26.7
Rice–berseem	8.0	2.9	8.5	5.1	15.6	4.1	14.2	10.6	6.0	27.7
Rice–wheat–DHC	8.0	3.0	8.7	4.7	16.2	4 9	13.7	11.2	6.3	25.4
Rice–barley	8.0	3.1	8.6	4 7	17.7	4.8	15.1	10.6	6.9	26.4

DHC–Dhaincha as green manure crop.

record production in both the years under CR IV the differences between CR I were significant only in 1983–84 but not in the first year. As expected green manuring with *dhaincha* in 1982–83 exhibited beneficial effects on the yield of succeeding crop in 1983–84, though lofty yields of rice and wheat already recorded in the first year of study subduced this influence considerably. Such high yields of paddy (35.84 q/ha) and of wheat (25.71 q/ha) registered in CR IV in the very first year may be attributed to the accumulated residual effect of berseem grown on the same field for about a decade (since 1972–73 to 1981–82) under cotton–berseem cropping sequence. Incidentally, this is reconfirmed by the fact that inspite of vast variation of about 8.5 q/ha paddy yields between CR I and CR IV in 1982–83 the differences failed to be substantial on the statistical parameters. Noted fluctuation in the yields may be due to the observed variability within the blocks or more specifically to the errors occurring due to uncontrollable adephic and extraneous factors.

W. E. estimated for the purpose of yield comparisons, on the basis of market values of the rabi crops revealed a significant difference between cropping sequences in both the years. Although differences in W. E. values between treatments were conspicuous, none of the two *rabi* crops included in the rice–berseem (CR II) or rice–barley (CR III) rotation produced enough fodder or grain yields to reach to the level of significance with wheat (in CR I or CR IV) in either years. Unusual low yields of berseem or barley noted in the sodic soils of Barwaha (Nimar) may be ascribed to the sudden rise in atmospheric temperatures[1] commonly observed during December. This perhaps affected the plant stand adversely. In view of the agro-climatic conditions existing at Barwaha, it will be worth while to take up field studies on early plantation with higher seed rate of barley and berseem.

Economics of cropping pattern

Data presented in table 3 reveal that out of four crop rotations, sequencing wheat after rice followed by *dhaincha* as green manure, was most profitable and gave the highest mean net returns (Rs. 5,845/ha) followed by rice–wheat (Rs. 4732/ha). This was perhaps due to the improved macro and micro environment in the soil due to turning down of green

Table 3 *Mean yield, wheat equivalent and economic returns as influenced by different crop rotations (1982–82 & 1983–84)*

Crop rotations		Crop yield (q/ha) 1982–83	1983–84	Mean	Mean gross income (Rs/ha)	Mean net returns (Rs/ha)	Cost benefit ratio
CR I	Rice	27.36	34.04	30.70	3837	2037	
	Wheat	21.75	26.20	23.97	4195	2695	
					(8032)	(4732)	1:1.4
CR II	Rice	29.17	33.00	31.08	3885	2085	
	Berseem	98.62	69.12	83.87	1667	677	
	W. E.	11.27	7.90	9.58	(5562)	(2762)	1:1.0
CR III	Rice	29.24	28.42	28.83	3604	1804	
	Barley	19.17	15.81	17.49	2623	1423	
	W. E.	16.43	13.60	15.01	(6227)	(3227)	1:1.1
CR IV	Rice	35.84	37.71	36.78	4597	2797	
	Wheat	25.71	28.01	26.86	4700	3050	
					(9297)	(5847)	1:1.7

Statistical values for crop yields	1982–83 S. E. μ	1982–83 CD 5%	1983–84 S. E. μ	1983–84 CD 5%
Paddy	2.29	N. S.	1.72	N. S.
	0.79	2.17	1.30	3.91

Figure in parenthesis indicate the total values of *kharif* and *rabi* crops.

	Paddy	Wheat	Berseem	Barley	Dhaincha
Cost of cultivation (Rs/ha)	1800	1500	1000	1200	150
Market rates of commodity (Rs/q)	125	175	20	150	–

manure crop of *dhaincha* which favoured soil bulk density and permeability of the plough layer, thereby contributing to increased wheat yields. Similar observations were recorded by other workers[6,7,9] who recommended the utility of green manuring in reducing the sodicity and increasing the financial returns.

The studies also brought out clearly that the additional cost involved in taking the green manure crop and incorporating into the soil was more than compensated by the higher yields of wheat obtained consistantly in both the years of studies. The cost-benefit ratio in rice–wheat–*dhaincha* remained highest and was estimated to be 1:1.7 (table 3).

It is further observed that the monetary returns accrued by the other two crop rotations *viz* rice–barley (Rs. 3227/ha) and rice–berseem (Rs. 2762/ha) were far less than either rice–wheat–*dhaincha* or rice–wheat. This may possibly be due to poor emergence resulting in inadequate crop stand of barley and extremely low fodder yield of berseem. Reasons for poor stands are presented in the earlier discussion.

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