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Soil suitability of reclaimed salt affected soil for wheat

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Abstract

Using parametric and limitation approaches, productivity of reclaimed alkali and saline soils was evaluated for wheat. Properties like drainage, texture/structure, nature of clay, exchange capacity, organic matter, calcium carbonate, sodium saturation and soluble salts were used to evaluate productivity. Original alkali soils have low productivity index of 19, whereas saline soils have lower productivity index of 15. On reclamation, alkali soils achieved high productivity index of 62 producing 57 q ha^{-1} wheat grains as against less than 1 q ha^{-1} when unreclaimed. In case of artificially drained saline soils the productivity index of 43 was achieved which increased the wheat grain yield from less than 1 q ha^{-1} to 51 q ha^{-1}. It is observed that reclaimed alkali soils with the Bt-horizon are highly productive and light textured, artificially drained saline soils having cambic B-horizon are moderately productive for wheat crop.

Additional keywords: Productivity indices.

Introduction

Flood irrigation and monsoonic climate with alternate dry and wet cycles subject the soils of north-west Indian plain to develop waterlogging and salinity. In the three states of Haryana, Punjab and Uttar Pradesh an area of 2.2, 5.2, and 12.9 lakh ha, respectively have been reported as saline and alkali by Singh (1992) and Sharma and Bhargava (1994). Wheat is widely grown in this region and moreover it is one of the important crops recommended in the reclamation cycle of alkali and saline soils. Sharma (1987) computed the potential productivity of saline and alkali soils as excellent but reported that their productivity was low when they are unreclaimed. The reclamation process improves the soil properties to a great extent. Thus there is a need for an evaluation and determination of soil suitability in terms of crop performance in reclaimed alkali and saline soils for wheat production.

Materials and methods

Six pedons consisting, two alkali, two saline and one each from reclaimed alkali and saline, representing major salt-affected soils from Haryana, were studied for morphological, physical and chemical characteristics. Productivity of soils was evaluated using the parametric (Riquier *et al.* 1970) and limitation approaches (FAO 1976; Sys 1981). The properties like drainage, texture/structure, sodium saturation and soluble salts were used to evaluate the productivity of soil for wheat. For the purpose, the data on wheat yield obtained through the CSSRI reclamation experiments at Karnal and Sampla were used.

Rating of the soil and site parameters for wheat was computed as suggested by Riquier *et al* (1970), Sys (1981, 1986) and Sehgal (1986) and expressed in terms of degree of limitations from 0 to 4. Each parameter was assigned a suitable rating. The productivity index was worked out and related with yields to validate these ratings.

Results and discussion

Limitations of alkali soils

The surface horizon with the highest pH, ESP, high content of sodium carbonate and bicarbonate and platy structure is the most limiting horizon in alkali soils. Higher content of carbonate concretions render these soils deficient in calcium and magnesium. In their original state alkali soils have very poor productivity index of 19 (Table 2). In alkali soils, medium textured sandy loam epipedons grade to relatively heavy textured sandy clay loam and silty clay loam endopedons with presence of clay skins indicating development of clay enriched B (argillic) horizon. On reclamation the alkali soils improved in the root zone (Table 1). A decrease in the soil toxicity characteristics was noticed in pHs from 10.4 to 8.3; ECe (dS m^{-1}) from 102.3 to 1.1; ESP from 90.0 to 10.0; $CaCO_3$ percentage from 5.4 to 3.7 and bulk density (Mg m^{-3}) from 1.7 to 1.4. Due to continuous cropping soil organic matter increased from 0.24 to 0.51 per cent. Less dense soil fabric and lowered water table (due to more withdrawal) improved soil infiltration and percolation. Sandy loam and sandy clay loam textures provide excellent moisture storage characteristics and the illitic mineralogy (Sharma, 1989) impart favourable soil physical characteristics and soil workability over a wide range of moisture content (Baver 1962). These medium textured, well aerated soils favour unrestricted development of roots and hence high productivity index of 62 (Table 2). The yield of wheat in these soils on amelioration was 57 q ha^{-1} (Singh 1985) which compare well in productivity with any non-alkali soil.

Table 1. Characteristics of original and reclaimed alkali and saline soils.

Soil pedon	Drain-age	Texture			Lime g kg^{-1}	CEC cmol (p+) kg^{-1}		O.M g kg^{-1}	ECe dS m^{-1}		ESP	Hori-zons
		D1	D2	D3		D1	D2		D1	D2	D1	
Karnal alkali (O)	Imper-fect	sl (12.4)	scl (27.0)	Sl (11.9)	5.4	7.0	13.0	0.2	102.3	3.4	90	Bt
Sampla saline (O)	Poor	ls (9.5)	sl (13.4)	sl (16.5)	1.9	4.7	4.0	0.3	62.3	13.0	23	Bw
Karnal alkali (R)	Mod. Well	sl (12.0)	scl (27.6)	sl (13.8)	3.7	8.5	13.5	0.5	1.1	1.2	10	Bt
Sampla saline (R)	Mod.	ls (8.0)	sl (14.0)	sl (17.5)	2.2	3.9	4.0	0.5	1.0	2.5	7	Bw

D1 = Soil depth, 0-20 cm; D2 = 20-100 cm; D3=100-150 cm; O = original alkali/saline soil; R=reclaimed alkali/saline soil. Mod=moderately; Bt=argillic horizon; Bw=cambic horizon
Figures in parenthesis indicate clay percentage.

Limitations of saline soils

The saline soils are characterised by shallow water table depth, high salt content and lighter soil texture. Reduced soil depth, increased osmotic pressure of soil solution and low base saturation leads to soil deterioration to the extent that saline soils were found to have very poor productivity index of 15 (Table 2).

Saline soils have light texture (loamy sand) in the epipedons and medium texture (sandy loam) in the endopedons. The B-horizon meets the requirements of cambic horizon (Table 1). In a drainage experiment at Sampla, in Rohtak, Rao *et al*. (1987) installed underground drainage at 1.70 m depth to artificially drain the saline soils. After three years soil ECe decreased from 62.0 to 1.3 dS m^{-1} and organic matter percentage increased from 0.35 to 0.52. Simultaneously water table was also lowered to create aerobic conditions in the root zone. After reclamation, these soils developed easy workability, greater stability and higher bearing capacity. These soils with high available moisture, increased soil depth and due to lowering of watertable resulted in better crop growth (Table 1). After draining excess salts, saline soils have a productivity index of 43 (Table 2) and produced wheat yield at the rate of 51 q ha^{-1} (Singh 1992).

Table 2. Evaluation of soil type for wheat according to soil site characteristics

Soil Pedon	Drainage	Texture	Lime (g kg^{-1})	CEC cmol (p+) kg^{-1} (Bt-hor.)	Org. M. (g kg^{-1}) (Ap– horizons)	Profile development	ECe (dS m^{-1})	ESP	Productivity indices	Yield (q ha^{-1})
Karnal alkali (O)	2 (80)	2 (80)	1(95)	1(90)	3(70)	2(80)	3(80)	3 (80)	19	<1.0
Sampla saline (O)	3 (50)	2 (80)	2(90)	3(70)	2(80)	0(100)	3(80)	1 (90)	15	<1.0
Karnal alkali (R)	1 (95)	1 (95)	1(95)	1(90)	1(90)	1(90)	0(100)	0 (100)	62	57.0
Sampla saline (R)	1 (90)	2 (80)	1(95)	1(90)	0(100)	0(100)	0(100)	0 (100)	43	51.0

O = Original alkali/saline soil; R = Reclaimed alkali/saline soil. Figures in parenthesis indicate the rating.

Conclusions

It may be concluded that medium textured, well drained, deep reclaimed alkali soils having argillic horizon and productivity index of 62 are best suited for wheat. On the other hand light textured, artificially drained saline soils having cambic horizon and productivity index of 43 are moderately suited for wheat production.

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