

Canadian Solonetz Soils and Their Reclamation

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Solonetzic soils are found in the Brown, Dark Brown and Black soil zones of Western Canada. Solonetz-like soils have also been found within the Gray Wooded soils area. There are from eight to twelve million hectares of solonetzic soils in Canada. The chemical and physical properties of these soils are extremely variable [4], but they have certain common characteristics; low productivity, a high sodium sulphate content, a very low infiltration rate (especially in the B horizon), poor root penetration, and a narrow moisture profile below the A horizon. The soils occur in glacial till, residual material, and post glacial water deposited material. Saline shale bedrock often occurs within three meters of the soil surface.

The solonetzic soils of Canada have been described in detail in the Canadian Journal of Soil Science. For the purposes of this paper I will restrict my remarks to a representative solonetz soil, Duagh silt loam and compare it in some regards with its field associated eluviated black soil, Malmo silt loam. Productivity, chemical and physical data pertaining to these soils are presented in Tables 1, 2, and 3, but will not be discussed in detail. I believe the Duagh soil corresponds fairly closely with European Meadow solonetz.

This particular solonetz soil, Duagh silt loam has a water table at an average depth of 1.76 meters that is known to contribute to the salt content of the surface horizons. The groundwater of the solonetz contains 154 me. of sodium per liter and has a pH of 8.8 as compared with 4 me. of sodium per liter and a pH of 7.3 in the ground water under its associated eluviated black soil. We have only recently begun to study the ground waters of other solonetzic soils in Canada.

Methods of amelioration

We are interested in two fundamental methods:

a) *Biological method*: We have found that the solonetz soils of Canada are very deficient in available nitrogen. This deficiency arises from at least two obvious factors: 1. The A horizon contains little total nitrogen per unit volume and 2. the depth of A horizon is much less than that of its associated non solonetz soil. The A horizon of Duagh silt loam releases only about 15 ppm $\text{NO}_3\text{—N}$ during four weeks incubation compared with about 50 ppm $\text{NO}_3\text{—N}$ in the A horizon of Malmo silt loam during the same incubation period. By correcting this nutritional deficiency in the field we have been able to cause

significant soil melioration (Table 4). We have summarized this work as follows: "Annual applications of ammonium nitrate (449 and 898 kg/ha) were added to bromegrass growing on a black solonetz soil. Over a five-year period the average yield per year was 1,506 kg/ha on the check plots, 4,794

Table 1
Some productive characteristics of a representative Canadian solonetz
and its field associated non solonetz soil

	Duagh silt loam solonetz	Malmo silt loam eluviated black
Yield of bromegrass (kg/ha)	900	3630
Main root mass penetration (cm)	23	50

kg/ha on the plots receiving the 150 kg rate of nitrogen and 6,779 kg/ha on the plots receiving the 300 kg rate. The nitrogen and potassium content of the bromegrass was increased from deficiency amounts on the check plots to sufficiency amounts on the fertilized plots; the sodium, aluminium and iron content of the grass was somewhat reduced. There was a significant reduction in soluble and exchangeable sodium in the A horizon of the fertilized soil as compared with the check. This, plus the greater growth of roots and the accumulation of nitrates in the subsoil of the fertilized plots suggests a greater permeability in the fertilized soil."

Some interesting work has been conducted in conjunction with this method of amelioration. We have become very interested in the effect of ammonium nitrate on the rate of water movement. We have studied various forms of nitrogen fertilizer and found that, for our soils, ammonium nitrate is a more useful nitrogen fertilizer than urea or ammonium sulphate. We are interested in the fact that the application of nitrogen fertilizer greatly stimulates the rate of uptake of potassium by the grass crop. We are interested in the possible application of this method of amelioration with irrigation on solonetz soils in the dry, brown soil zone.

Table
Some chemical properties of a representative Canadian solonetz soil

Soil	Horizon	Thickness cm	pH	om %	ECe mmhos	Saturation extract	
						Ca ²⁺	Mg ²⁺
Duagh silt loam	Ap	15	6.0	10.76	3.0	0.08	0.11
	Bnt	15	7.2	4.53	5.9	0.26	0.57
	Csk	45	7.8	1.49	15.9	0.71	1.57
	C		8.0	0.99	14.8	0.83	1.62
Malmo silt loam	Ap	20	6.1	16.09	1.1	0.18	0.14
	A ₂ +A ₃	25	6.2	4.12	1.0	0.05	0.07
	B ₂ +B ₃	30	7.6	1.72	2.4	0.10	0.35
	C	75—95	7.7	1.23	2.8	0.05	0.28

In summary, this is a profitable method that has been widely adopted in Canada, within the past few years, since we enunciated it. It holds great promise for future application in Canada.

b) *Deep plowing method*: This method is based on Soviet work, much basic information on which was generously supplied to me by the late AN-TIPOV-KARATAEV. The results of a seven year study (Table 5) conducted on Duagh silt loam have been summarized as follows: "Plowing a solonetz soil

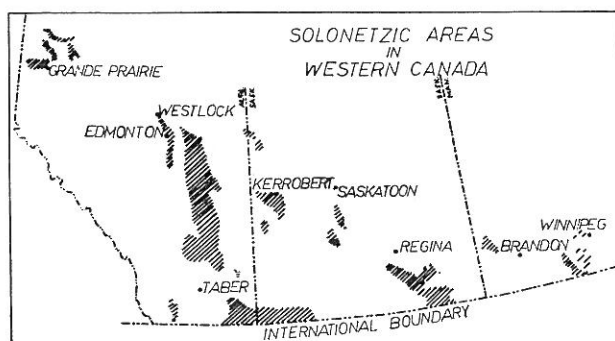


Fig. 1

to a depth of 56 cm, as compared with ordinary plowing (10 cm), greatly reduced the soluble salts, particularly sodium sulphate, throughout the 150 cm sample depth. It also reduced the percentage of exchangeable sodium. The apparent slight increase in cereal crop yields, caused by deep plowing, was not statistically significant, but the yield of an alfalfa-bromegrass crop was about doubled. There was a much denser stand of alfalfa where the soil had been deep plowed than where it had not. The depth of penetration of the main root mass was more than doubled by deep plowing. Percentages of calcium and potassium were higher and magnesium and sodium lower in the alfalfa grown on the deep plowed than on the shallow-plowed soils."

2

and 1st field associated non solonetz soil

me/100 g			Cations extractable with ammonium acetate pH 6.5 me/100 g				CaCO ₃ Equivalent me/100 g	Gypsum me/100 g
Na ⁺	K ⁺	SO ₄ ²⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺		
1.68	0.03	1.65	7.37	7.86	8.75	1.54	—	—
4.74	0.04	5.57	5.43	11.32	17.15	1.31	—	—
9.98	0.06	11.30	57.76	13.76	19.80	0.94	29.9	10.8
7.58	0.06	10.15	46.62	10.25	18.10	0.19	56.1	5.3
0.12	0.14	0.42	25.08	7.90	1.12	3.42	—	—
0.14	0.10	0.18	13.30	4.01	1.75	3.10	1.8	—
1.03	0.01	1.35	51.12	7.30	5.25	0.52	102.0	—
1.18	0.01	1.38	42.48	5.34	5.00	0.40	130.0	—

Table 3

Some physical properties of a representative Canadian solonetz soil and its field associated non solonetzic soil

Soil	Horizon	15 atm. %	1/3 atm. %	Mechanical Analyses			Hydraulic conductivity cm/hr.
				S %	Si %	Cl %	
Duagh silt loam solonetz	Ap	19.2	37.0	20	56	24	0.10
	Bnt	19.4	35.2	13	47	40	0.00
	Csk	18.0	34.4	1	51	48	0.30
Malmo silt loam non solonetz	Ap	31.2	41.2	23	54	23	5.60
	A ₂ +A ₃	18.7	30.4	38	38	24	3.81
	B ₂ +B ₃	19.0	31.4	24	39	37	2.50

We have conducted considerable greenhouse work besides a number of field studies on other solonetzic soil types. With certain soils we can obtain the crop yield increase in the greenhouse by mixing horizons without any subsequent soil leaching. In other words there seems to be a nutritional benefit derived from mixing horizons of certain soils. For other soils the main cause of crop response seems to be the increased availability of soil water, as the depletion of water pretty well relates to the increase in crop growth during the first crop year after plowing. We have not studied the role of soil air, but believe it may be worthy of attention.

Soviet workers have made considerable effort to save the A horizon during plowing. With our soils the A horizon is generally very unproductive and we are not certain as to the value of retaining it. I did not incorporate a device to retain the top soil layer in the plow we designed for our work.

In general deep plowing holds considerable promise, but the operation is presently too costly for our private farmers. We are now experimenting

Table 4

Effect of brome grass fertilized annually with 898 kg/ha of ammonium nitrate on various soil properties of Duagh silt loam

Factor measured	Check	Fertilized
Total (5 year) crop yield kg/ha	1528	33,895**
A horizon		
Depth, cm	11	11
Roots, kg/ha	6614	12,107**
Soluble sodium, me/100 g	1.24	0.75**
Exchangeable sodium me/100 g	3.84	1.85**
Exchangeable sodium (% of exch. bases)	17.34	8.92**
Soil hardness, kg/cm ²	1.45	0.66*

* Significant at the 5 per cent point.

** Significant at the 1 per cent point.

Table 5
**Selected chemical and physical data to illustrate the effect of deep
 plowing a Duagh silt loam solonetz soil**

Horizon	Depth, cm	pH	EC. mmhos	Breaking strength, kg/cm	Soluble Na	Exchangeable cations ^w				Ca:Na ratio
						Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	
						me/100 g				
<i>Check</i>										
Ap	0— 15	5.2	3.8	4	1.38	10.3	6.5	5.2	0.5	2.0
Bnt	15— 30	6.4	4.6	25	2.61	10.9	11.8	8.2	0.6	1.4
Bnts	30— 40	7.1	10.3	38	6.27	25.1	13.8	9.7	0.5	2.6
Csaca	40— 70	7.4	12.4	9	6.28	50.5	9.0	4.7	0.3	10.8
C	70—150	7.4	10.5	8	4.18	44.0	6.5	4.2	0.3	10.5
<i>Deep plowed</i>										
Ap	0— 10	5.9	1.5	9	0.38	19.6	5.9	1.2	0.6	16.3
2	10— 20	5.9	1.7	5	0.46	18.5	5.8	1.4	0.6	13.2
3 (B)	20— 38	5.8	1.7	5	0.40	18.0	6.4	1.5	0.6	12.0
4 (B)	38— 60	6.3	1.7	4	0.38	43.9	6.8	1.5	0.5	29.3
C	60—150	7.0	1.4	10	0.31	42.0	6.8	1.7	0.4	24.7

* May not be truly exchangeable in the lower horizons due to the presence of free salt.

with a modified slip-plow. The original of this was, I believe designed in the United States. With this implement we may be able to reduce the costs of soil horizon mixing to practical levels.

Remarks

In the short time that we have been studying solonetzic soils in Canada we have been able to make considerable progress. We of course, acknowledge the help we have received from workers in other countries.

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