SOIL ORGANIC MATTER ON THE PRAIRIES - A DWINDLING RESOURCE

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ABSTRACT

Eighteen prairie surface soils representing cultivated and uncultivated coarse-, medium-, and fine-textured soils from the Brown, Dark Brown, Thin Black and Gray soil zones were analyzed for changes in total carbon, nitrogen and potentially mineralizeable nitrogen. The results show that organic matter losses are great but loss of the potentially mineralizeable nitrogen has been even greater due to cultivation. The significance of these findings is that more and more fallow soils are having to be fertilized with nitrogen.

INTRODUCTION

When the prairie grassland was broken it was inevitable that the equilibrium level of the soil organic matter would decline to a level that could be supported by cultivation. Measurement of the changes that occurred are numerous on the Canadian and American prairies. Generally, cereal cropping during the past 70 to 80 years has resulted in a loss of about 40 to 60% of the organic matter concentration from the top 15 cm of the soil and there has been some loss from the 15-to 30-cm layer too (Campbell and Biederbeck 1980).

The total organic matter (C and N) in the soil is important from a standpoint of their effect on soil tilth, physico-chemical properties, water-holding characteristics and so on. However, with respect to the availability of the N for crop growth, it is the potentially mineralizeable or "active" N fraction of the organic matter that is of main importance. This is the fraction that gives rise to the majority of the mineral N (NH_4- and NO_3-N) in soil. Thus this is the fraction that is important from a fertility standpoint.

The objective of this study was to determine to what extent the potentially mineralizeable N (usually denoted N_o) has been depleted by cultivation in an array of Saskatchewan soils.

MATERIALS AND METHODS

The soils used in this study were described last year at these meetings (Campbell et al. 1981). We collected a coarse-, medium-, and fine-textured orthic member of the Brown, Dark Brown, Thin Black and Gray Luvisol great groups. The 0- to 15- and 15- to 30-cm segments of virgin and nearby cropland (cereal, stubble fields) were sampled, air-dried, sieved (< 2 mm) and analyzed for total C by dry combustion and for Kjeldahl N. Other samples were used to determine the potentially mineralizeable N (N_o) by the method of Stanford and Smith (1972).

RESULTS AND DISCUSSION

Organic C and N concentration and C/N ratios of virgin soils

Both organic C and N were highly correlated and thus the C/N ratios were fairly constant (about 11.0) in the top 15 cm of virgin soils (Fig. 1). Organic matter (C and N) was lowest in the Brown and Gray soils and highest in the Dark Brown and the Black soils. Organic matter in the 15- to 30-cm segment was about half that in the 0- to 15-cm depth but was distributed among the great soil groups in a manner generally similar to that in the top 15 cm.

The low C/N ratios in the Brown and Gray subsoils might be an indication that some fixed NH_4-N was extracted during the Kjeldahl N determination of these soils.

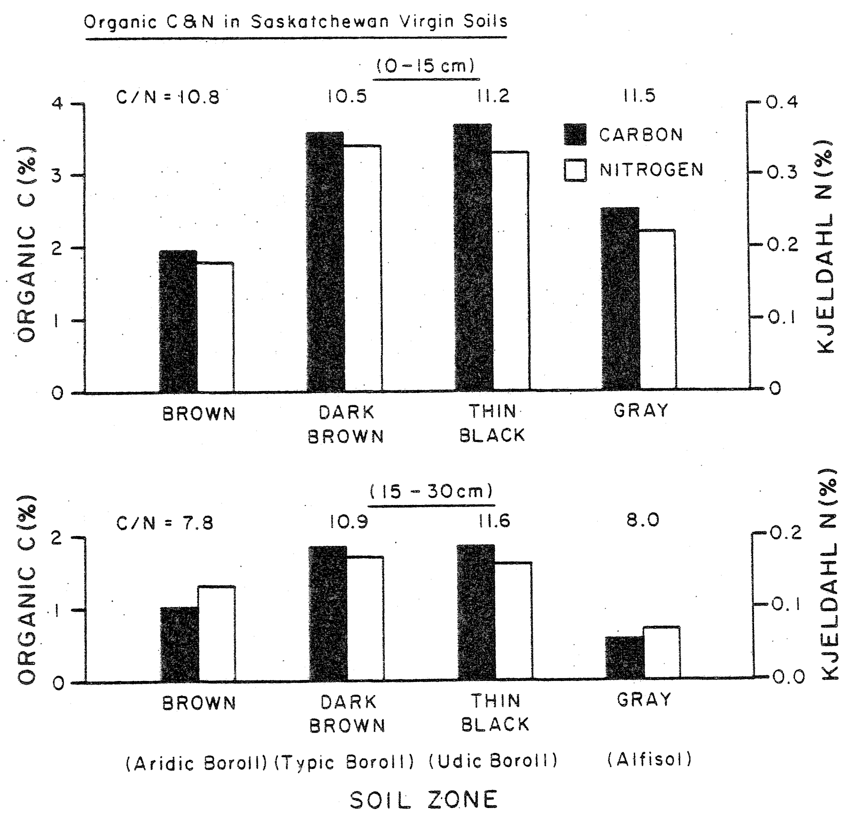

Fig. 1

Loss of organic C and N due to cropping

As reported by others (McGill et al. 1981; Voroney et al. 1981), cropping has reduced the organic C concentration in the top 15 cm by about 40 to 52% and the organic N by about 33 to 54% (Fig. 2). The magnitude of the losses increased from the Brown to Dark Brown to the Black soils and was greatest in the Gray Luvisols. Except for the Gray Luvisol, the loss of C was greater than the loss of N. In the 15- to 30-cm depth losses were only moderately less than in the top 15 cm in the Brown, Dark Brown and the Black soils but were substantially lower in the Gray Luvisol. The losses from the 15- to 30-cm depth appear relatively large. We

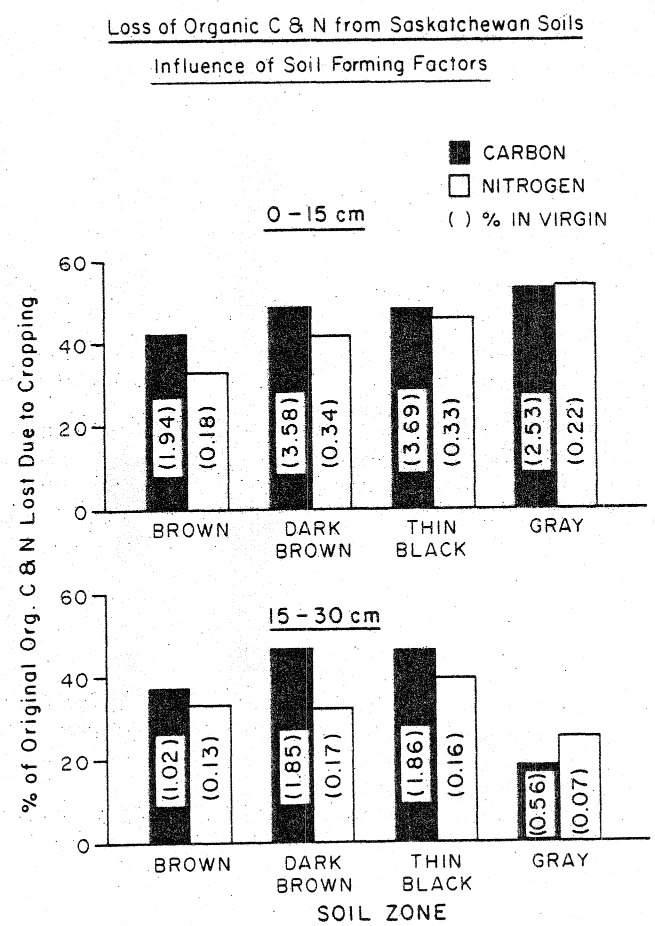

Fig. 2

do not envisage decomposition causing such large losses in this segment because the soil is usually not tilled any deeper than about 10 to 15 cm. Nor can we envisage erosion being so bad as to cause such losses in the subsoil. This leads us to wonder whether the large losses in the subsoil are partly due to our failure to consider changes in soil bulk density in these calculations. Voroney et al. (1981) have shown the importance of considering bulk density because it increased with cultivation and so the 0 to 15 cm of the virgin and cultivated soils are not equivalent segments.

As might be expected, losses of organic C and N were greatest in the coarser-textured soils (Fig. 3). This was particularly true in the 0- to 15-cm segment. Coarse-textured soils are better aerated and organic matter would therefore be expected to decompose and erode more readily in such soils.

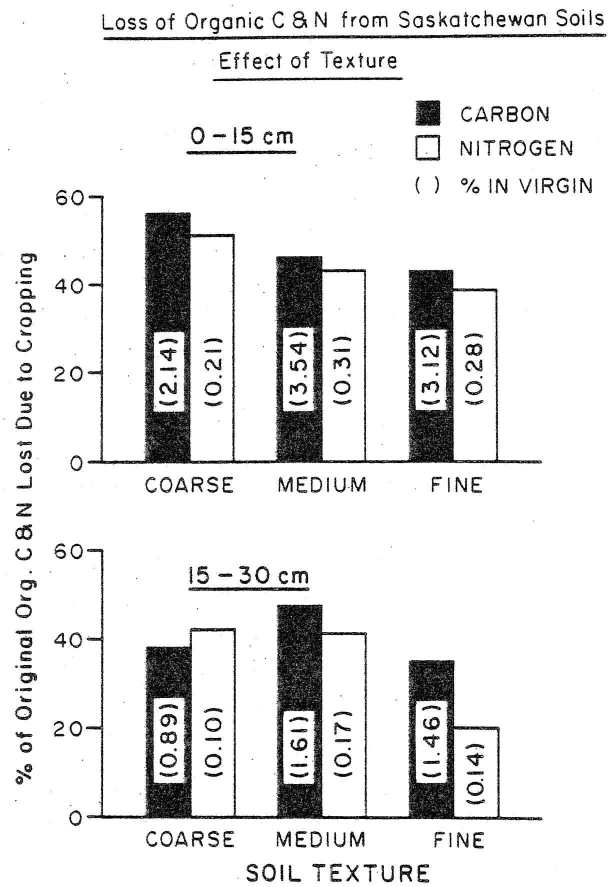

Fig. 3

Potentially mineralizeable nitrogen in virgin and cropped soils

The potentially mineralizeable N in the top 15 cm of Saskatchewan virgin soils increased from about 250 ppm (550 kg N/ha) in the Brown soils to about 330 ppm (725 kg N/ha) in the Thin Black, but there was only about 125 ppm (275 kg N/ha) in Gray Luvisols (Fig. 4). In contrast, there was no consistent difference between soil zones with respect to potentially mineralizeable N in cultivated soils; they averaged about 100 ppm (220 kg N/ha). The potentially mineralizeable N in fine-textured soils was less than in medium and coarse textured soils.

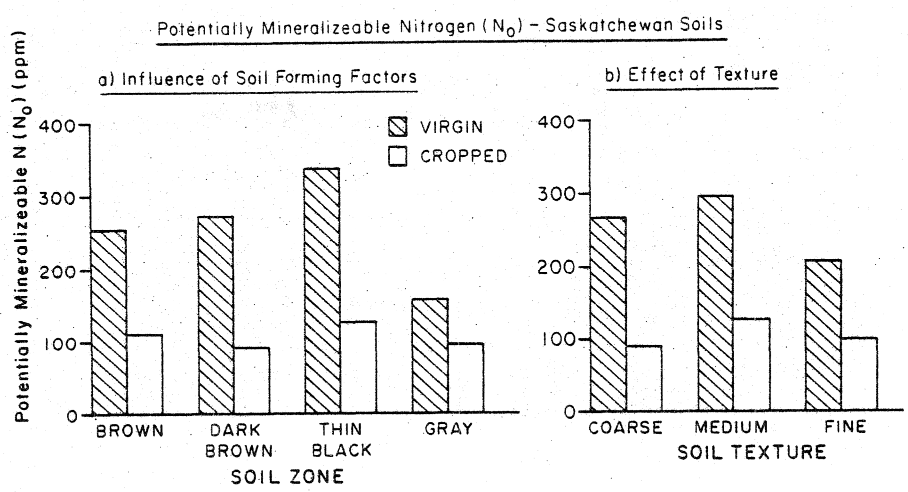

Fig. 4

Loss of potentially mineralizeable N due to cropping

Cropping has so far reduced the potentially mineralizeable N in the top 15 cm of the Dark Brown soils by 66% and the Gray Luvisol by 41% with the loss from the Brown and Thin Black soils being intermediate to these (Fig. 5). As with the total organic matter, loss of potentially mineralizeable N was greatest from the coarse-textured and least from the fine-textured soils (Fig. 5).

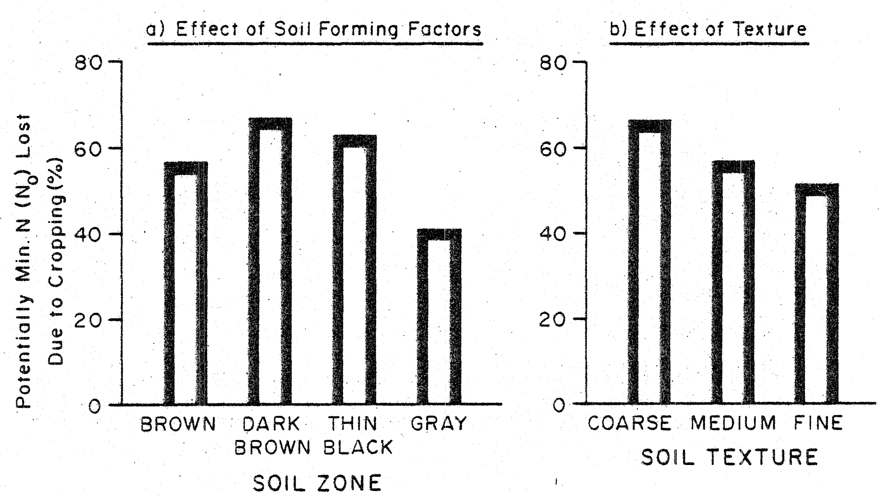

Fig. 5

Loss of total organic N compared to potentially mineralizeable N and its significance

Perhaps the most significant observation made in this study was that losses of the gross organic matter do not give the true picture regarding what has and is happening to the fertility of our soils. For example, as shown in Table 1, the losses of the potentially mineralizeable N has been much greater than losses of the gross organic N with the exception of the Gray Luvisols (the behavior of the Gray soils is a mystery to us at present). Furthermore, and even more noteworthy, is the fact that our best soils have lost more than 60% of their potentially mineralizeable N. Although it is true that these soils had a surfeit of fertility in the early years when they were broken, nonetheless we can ill afford this loss in fertility. Our results serve to corroborate the reports by Beaton (1980) that about 6 million acres of fallow land in the three Prairie Provinces are presently deficient in N and must be fertilized with N. This acreage represents 22% of all fallow land on the prairies (Table 2).

Table 1. Loss of the potentially mineralizeable N compared to loss of organic N for some Saskatchewan soils (0-15 cm)

	Loss as % of virgin	
Soil zone	Organic N	Potentially Min. N
Brown	33	56
Dark Brown	53	66
Thin Black	58	63
Gray	54	41

Table 2. Cropland in Prairie Provinces requiring fertilizer Nitrogen†

Land use pattern	Alta.	Sask.	Man.	Prairies
		Stubble		
Cultivated acreage (million acres)	10.5	4.3	6.4	21.3
% requiring N fertilizer	96	73	90	89
		Fallow		
Cultivated acreage (million acres)	3.6	1.3	1.0	5.9
% requiring N fertilizer	51	8	38	22

† Laverty et al. 1976 in Beaton 1980

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