# The Effect of Traditional Versus Innovative Farming Systems on Soil Structure

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A good soil structure is critical for root growth, water infiltration etc. In many parts of the world soil structure problems are common with much time and effort spent improving the soil (e.g. green manuring and subsoiling). Major soil problems facing Saskatchewan farmers are more related to soil moisture, fertility, salinity, and erosion.

Saskatchewan farmers have noted changes in soil structure after breaking the soil following a legume crop. The results of a survey held by the Soil Science Department, U of S in 1980, indicated that our farmers found their soils to be mellower and easier to till as a direct effect of legumes in the rotation. Legumes differ from cereals in that they are taprooted while the cereals have fibrous roots. The root biomass production is also substantially higher for the legumes (Voroney, 1982). The absence of tillage from the time the legume is underseeded to when it is harvested could result in additional changes in soil structure.

Another question Saskatchewan farmers are asking is whether fields under zero tillage will become compacted with time. Tillage in general has the effect of loosening the soil, improve aeration, and reduce soil aggregate size. It may also lead to plow pan formation and disrupting continuous soil pores (Russell, 1973; Bauer et al., 1972; Pidgeon and Soane, 1978; Hadas et al., 1978).

## Innovative Systems

Soil structures under the following conditions were analyzed:

(A) Crop rotations where legumes have been part of the rotation on a regular basis for at least 15 years, were compared with rotations which did not include legumes for at least 15 years.

(B) Fields under zero tillage for 3 or more years were compared with fields under conventional tillage.

## Results and Discussion

### (A) Inclusion of legumes as a regular part of the rotation

Soil physical properties showed no consistent pattern (Table I). At Scott the soil bulk densities were higher for the surface horizon under the legume treatment. However, for the other sites differences were negligible or even reversed. Aeration porosities showed no trend between the treatments. Hydraulic conductivities were greater for the legume treatment in one case only, Indian Head.

Soil strength measurements are shown in Table II. The B horizons of the legume treatment had lower strength than that of the cereal treatment. This was further emphasized by the draught measurements (Table III) which showed significantly lower draught values for the legume treatment.

### (B) Zero tillage versus conventional tillage

Results from soil physical properties (Table IV) were inconsistent. Bulk densities tended to be somewhat greater under zero tillage except for the Elrose site. The results from the soil aeration and hydraulic conductivity measurements indicated no clear trend amongst treatments.

Soil strength was somewhat greater for the B horizon under conventional tillage which could possibly be explained by a plow pan phenomena (Table V).

Significant differences did appear in the aggregate size distribution results (Table IV). The aggregates under zero tillage were larger especially in the A horizon.

## Conclusions

The structure of the soil was not very much affected by the inclusion of legumes as a regular part of the rotation. Some loosening of the B horizon was apparent due to legumes.

After three years of zero tillage, the soil structure did not show major signs of deterioration. However, soil aggregates were larger under zero tillage. Larger aggregates are less aerobic than smaller ones. This could result in greater denitrification rates. Other factors that result from larger soil aggregates are slower organic matter decomposition and less erodibility of soils in general.

References:

Baver, L. D., W. H. Gardner and W. R. Gardner. 1972. Soil Physics. 4th edit. John Wiley & Sons Inc. NY.

Hadas, H., D. Wolf and A. Meirson. 1978. Tillage Implements - Soil Structure Relationship and Their Effects on Crop Stands. Soil Sci. Soc. Am. J. 42:632-637.

Pidgeon, J. D. and B. D. Soane. 1977. Effects of tillage and direct drilling on soil properties during the growing season in a long-term barley mono-culture system. J. Agric. Sci., Camb. 88:431-442.

Pidgeon, J. D. and B. D. Soane. 1978. Soil Structure and Strength Relations Following Tillage, Zero-Tillage and Wheel Traffic in Scotland. In "Modification of Soil Structure" Ed. Emerson, W.W.; Bond, R. D., and Dexter, A. R. pp. 371-378. John Wiley and Sons Chichester.

Russell, E. W. 1973. Soil Conditions and Plant Growth. 10th Ed. Longman, N.Y.

Voroney, Paul. 1982. Private Communication, Saskatchewan Institute of Pedology. Univ. of Sask.

TABLE I.



| SITE | HORIZON | B.D. GM/CM (GM/CM3) | | A.P. (%) | | K* ($10^{-3}$ CM/SEC) | |
|---|---|---|---|---|---|---|---|
| | | L | C | L | C | L | C |
| SCOTT (LOAM) | A | 1.19 | 1.09 | 11.1 | 9.6 | 0.5 | 0.5 |
| | B | 1.23 | 1.28 | 9.6 | 10.4 | 0.3 | 0.2 |
| LOON LAKE (LOAM) | A | 1.46 | 1.42 | 7.1 | 5.6 | 0.1 | 0.1 |
| | B | 1.64 | 1.69 | 8.5 | 6.0 | 0.2 | 0.1 |
| INDIAN HEAD (CLAY) | A | 1.06 | 1.06 | 6.5 | 5.3 | 0.2 | 0 |
| | B | 1.21 | 1.19 | 3.1 | 2.8 | 0.1 | 0 |
| MOOSOMIN (LOAM) | A | 1.03 | 1.10 | 16.2 | 16.7 | 0.9 | 2.4 |
| | B | 1.35 | 1.31 | 14.2 | 14.0 | 1.0 | 1.0 |
| SCOTSGUARD (LOAM) | A | 1.27 | 1.30 | 9.6 | 10.8 | 0.9 | 0.5 |
| | B | 1.40 | 1.36 | 10.7 | 10.9 | 0.4 | 0.5 |
| MELFORT (HEAVY CLAY) | A | 0.88 | 0.90 | 15.5 | 16.1 | 2.5 | 2.8 |
| | B | 1.26 | 1.26 | 9.9 | 9.6 | 0.2 | 0.4 |

SOIL PHYSICAL PROPERTIES OF SOILS HAVING LEGUMES AS A PART OF THEIR REGULAR ROTATION AND THOSE HAVING CEREALS ONLY.

* A.P. = AERATION POROSITY AT 40 CM TENSION

** K = SATURATED HYDRAULIC CONDUCTIVITY

TABLE II.

| Site | Horizon | Penetrometer Resistance | | Shear Vane Resistance | |
|---|---|---|---|---|---|
| | | ---------- $KG/CM^2$ ---------- | | | |
| | | L | C | L | C |
| Scott (Loam) | A | 0 | 0 | 0 | 0 |
| | B | 2.4 | 4.6 | 2.9 | 7.3 |
| Loon Lake (Loam) | A | 0.5 | 0.6 | 0.9 | 1.3 |
| | B | 21.2 | 25.6 | 9.0 | 9.0 |
| Indian Head (Clay) | A | 0 | 0 | 0 | 0 |
| | B | 4.2 | 3.4 | 2.2 | 2.5 |
| Moosomin (Loam) | A | 0 | 0 | 0 | 0 |
| | B | 2.9 | 2.5 | 3.3 | 2.8 |
| Scotsguard (Loam) | A | 0 | 0 | 0 | 0 |
| | B | 3.7 | 4.0 | 6.8 | 5.9 |

Soil strength measurements of fields having legumes a part of their regular rotation and those having cereals only.

TABLE III.

| SITE | LEGUME | CEREAL | L.S.D. 0.05 |
|---|---|---|---|
| | (NEWTONS) | | |
| SCOTT | 618 | 957 | 175 |
| LOON LAKE | 428 | 768 | 125 |
| INDIAN HEAD | 1130 | 1016 | N.S. |

DRAUGHT MEASUREMENTS OF SOILS HAVING LEGUMES AS A PART OF THEIR ROTATION AND THOSE HAVING CEREALS ONLY (DRAUGHT WAS MEASURED TO A DEPTH OF 15 CM).

TABLE IV.

| SITE | HORIZON | B.D. (GM/CM$^3$) | | A.P.* (%) | | K** ($10^{-3}$ CM/SEC) | |
|---|---|---|---|---|---|---|---|
| | | O-T | C-T | O-T | C-T | O-T | C-T |
| LEIPZIG | A | 1.13 | 1.10 | 5.5 | 7.5 | 0.3 | 0.8 |
| (CLAY LOAM) | B | 1.26 | 1.23 | 6.4 | 8.8 | 0.6 | 0.7 |
| ELROSE | A | 1.12 | 1.24 | 11.8 | 8.9 | 1.5 | 1.5 |
| (CLAY LOAM) | B | 1.13 | 1.35 | 9.2 | 4.5 | 0.9 | 0.6 |
| MELFORT | A | 1.04 | 1.07 | 13.2 | 11.7 | 3.0 | 1.3 |
| (H. CLAY) | B | 1.08 | 1.06 | 9.8 | 9.8 | 0.7 | 1.8 |
| DRINKWATER | A | 0.91 | 0.95 | 22.3 | 20.1 | 0.6 | 2.2 |
| (H. CLAY) | B | 1.04 | 0.96 | 17.1 | 19.2 | 0.6 | 0.6 |
| CUPAR | A | 1.15 | 1.01 | 12.0 | 16.6 | 2.8 | 3.6 |
| (CLAY) | B | 1.17 | 1.12 | 11.2 | 12.3 | 1.9 | 1.8 |

SOIL PHYSICAL PROPERTIES OF SOILS UNDER ZERO TILLAGE (O-T) AND THOSE UNDER CONVENTIONAL TILLAGE (C-T).

* A.P. = AERATION POROSITY AT 40 CM TENSION

** K = SATURATED HYDRAULIC CONDUCTIVITY

TABLE V.

| Site | Horizon | Penetrometer Resistance | | Shear Vane Resistance | |
|---|---|---|---|---|---|
| | | ----------- $KG/CM^2$ | ----------- | | |
| | | O-T | C-T | O-T | C-T |
| Leipzig (clay loam) | A | 0.4 | 0.4 | 1.2 | 1.3 |
| | B | 4.0 | 4.8 | 3.9 | 5.0 |
| Elrose (clay loam) | A | 0 | 0 | 0 | 0 |
| | B | 3.2 | 4.0 | 8.7 | 9.2 |
| Melfort (H. clay) | A | 0 | 0 | 0.1 | 0 |
| | B | 3.9 | 4.2 | 7.1 | 8.4 |
| Drinkwater (H. clay) | A | 0 | 0 | 0 | 0 |
| | B | 2.0 | 1.3 | 4.5 | 2.5 |
| Cupar (clay) | A | 0.7 | 0.3 | 0 | 0 |
| | B | 2.7 | 2.8 | 3.7 | 3.0 |

Soil strength measurements of fields under zero tillage (O-T) and conventional tillage (C-T).

TABLE VI.

| Site | Horizon | Zero Tillage | Conv. Tillage |
|---|---|---|---|
| | | ------------ mm | ------------ |
| Beaufield (clay) | A | 6.237 | 3.411 |
| | B | 16.212 | 11.929 |
| Drinkwater (h. clay) | A | 9.602 | 5.635 |
| | B | 13.888 | 11.984 |
| Elrose (clay loam) | A | 6.389 | 3.457 |
| | B | 10.628 | 11.804 |
| Melfort (h. clay) | A | 11.149 | 8.137 |
| | B | 10.998 | 12.506 |
| Leipzig (clay loam) | A | 3.671 | 4.127 |
| | B | 9.559 | 10.133 |

Average aggregate size of soils under zero tillage and conventional tillage.