Stubble Burning and Tillage Effects on Soil Organic C, Total N and Aggregation in Northeastern Saskatchewan

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BACKGROUND

- Sustainable crop production is a function of soil quality, which is linked to organic matter. Crop residues are a source of soil organic matter and plant nutrients.
- Zero-tillage (ZT) with standing stubble conserves soil, enhances organic matter and water in soil, and generally increases crop production.
- In the Parkland region of western Canada, large quantities of straw are produced, which if left on soil surface sometimes cause management problem in seeding and depress crop yield due to poor establishment and N immobilization.
- In these areas, producers often burn straw in the field to facilitate the seeding operation, and reduce crop disease and weed populations.
- Burning of straw can cause a considerable loss of crop residues, and organic C, N, S and other nutrients by volatilization to the atmosphere.
- Burning also causes soil desiccation, makes soil harder and less friable, reduces the potential for snow trapping or conservation, and increases water runoff and potential for soil erosion.
- Long-term continuous use of this practice can result in considerable reduction in soil organic C and N and cause detrimental effects on some soil properties, and loss of productivity.
- Therefore, the impact of this practice on crop yield and soil properties must be assessed.

OBJECTIVE

- The objective of this study was to determine the effects of tillage and crop residue burning on soil total organic C (TOC) and N (TN), light fraction organic matter (LFOM), C (LFC), and N (LFN) and aggregation on a Gray Luvisol (Boralf) in northeastern Saskatchewan.

MATERIALS AND METHODS

- Field experiments were established in 1999 at Star City and Birch Hills in fields that were frequently cropped to canola and cereals.
- Both sites had been managed under zero tillage for at least the previous 5 years.
- The experiments (one for canola and one for barley) was 2 x 2 factorial in a randomized complete block design (RCBD) with six replications established under a 2 year rotation of canola and barley. Factors were ZT – zero tillage, CT – conventional tillage, B – residue burnt, NB – residue not burnt.
- Soil samples were collected in the spring of 2005 from 0-5, 5-10 and 10-15 cm depths by taking 8 2.4 cm diameter cores per plot.
- The finely-ground soil samples were analyzed for total organic C (TOC) and N (TN), light fraction organic matter (LFOM), C (LFC), and N (LFN).
- In the spring of 2005, soil samples for dry aggregates were collected from 0-5 cm depth at two inter-row locations in each plot using a rectangular trough (15 cm x 17.5 cm) with minimal disturbance.
- The air-dried soil samples were shaken, using an automatic rotary sieve shaker, at 12 cycles per minute, through a nest of sieves having rectangular holes with equivalent diameter of 38, 12.7, 6.4, 2.0, 0.83, and 0.42 mm, and a pan underneath. Aggregate fraction retained on each sieve was expressed as a percentage of total dry soil mass. The results were expressed as percent aggregate size distribution as well as mean weight diameter (mm).

SUMMARY OF RESULTS

Soil Organic C and N

Figures 1, 2, 3, 4 and 5

- After five crop seasons, mass of TOC and TN in the 0-15 cm soil tended to be greater, whereas mass of LFOM, LFOC and LFN was significantly greater in NB compared to B treatments in all soil layers studied at both sites.
- Compared to B, the NB treatment had greater TOC by 9.6%, TN by 9.6%, LFOM by 15.2%, LFOC by 21.5%, and LFN by 15.7% in the 0-15 cm soil at Birch Hills.
- The corresponding values for TOC, TN, LFOM, LFOC and LFN at Star City site were 2.6%, 1.2%, 15.2%, 25.5% and 19.3%, respectively.
- The decline of soil C and N with B suggests that the practice of burning for convenience in seeding in the long run may result in soil degradation.
- ZT treatment had greater TOC, TN, LFOM, LFOC and LFN in soil than the CT treatment regardless of burning treatment.
- Compared to CT, the ZT treatment had greater TOC by 16.2%, TN by 15.7%, LFOM by 31.9%, LFOC by 44.1%, and LFN by 43.5% in the 0-15 cm soil at Birch Hills.
- The corresponding values for TOC, TN, LFOM, LFOC and LFN at Star City site were 12.7%, 14.6%, 3.3%, 5.3% and 3.1%, respectively.
- The mass of TOC, TN, LFOM, LFOC and LFN in soil was highest in the ZT-NB treatment, and lowest in the CT-B treatment.

SUMMARY OF RESULTS

Soil Aggregation

Figures 6, 7, 8, 9, 10 and 11

- Straw burning had little effect but tillage had significant effect on aggregation at both sites.
- Dry aggregates <0.83 mm are considered wind-erodible fraction. At the end of 5 years the proportion of wind-erodible aggregates was significantly greater in the surface soil of CT compared to ZT treatment.

- On the other hand, the proportion of larger aggregates (>6.4 mm) was usually greater under ZT compared to CT. The ZT systems had lower percentage of finer aggregates and higher percentage of larger aggregates than CT under both NB and B.
- Tillage x straw burning interaction was not significant, but the combination of ZT with NB resulted in the lowest proportion of finer aggregates (30.2% at Birch Hills and 14.9% at Star City) and greatest proportion of larger aggregates (51.7% at Birch Hills and 42.9% at Star City), whereas CT-B combination resulted in the greatest proportion of finer aggregates (43.1% at Birch Hills and 26.7% at Star City) and lowest proportion of large aggregates (33.8% at Birch Hills and 37.8% at Star City). This indicates that ZT-NB has lower potential for soil erosion than CT-B.
- The beneficial influence of ZT was also reflected in mean weight diameter (MWD) of aggregates at the Birch Hills site, which was larger with ZT (15.1) compared with CT (9.2). The MWD was generally larger for ZT (15.79 or 14.46 mm) than CT (9.10 or 9.34 mm) under both NB and B treatments. The MWD tended to be greater with NB than B.
- The aggregation data indicated much greater impact of tillage on soil aggregation than straw management.
- The results indicate a better seed-bed soil structural condition and lowest potential for soil erosion by wind where tillage is omitted and crop residues are retained on the soil.

CONCLUSIONS

- Returning crop residue to the soil rather than burning usually had a beneficial impact on the soil quality parameters, but the differences between treatments for soil quality parameters measured were of greater magnitude between tillage treatments (ZT vs CT) than between burning treatments (B vs NB).
- Overall, returning crop residues along with ZT improved and burning in combination with CT deteriorated soil properties.

ACKNOWLEDGEMENTS

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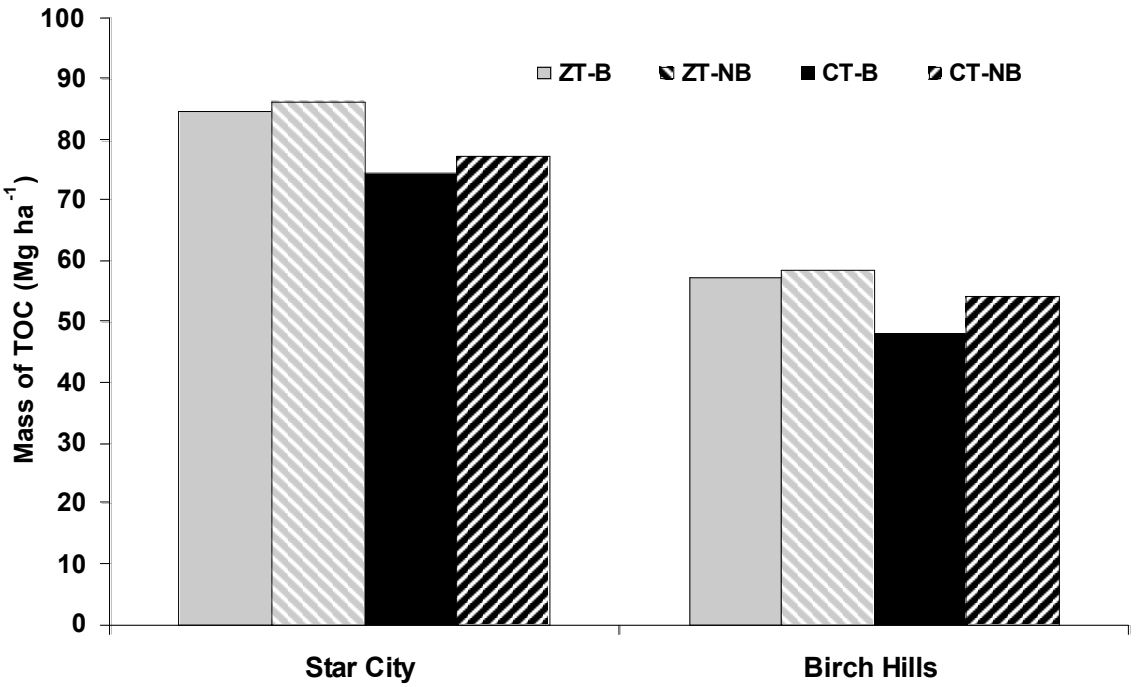


Figure 1. Effect of tillage and burning of residue on mass of total organic C (TOC) in 0-15 cm of soil.

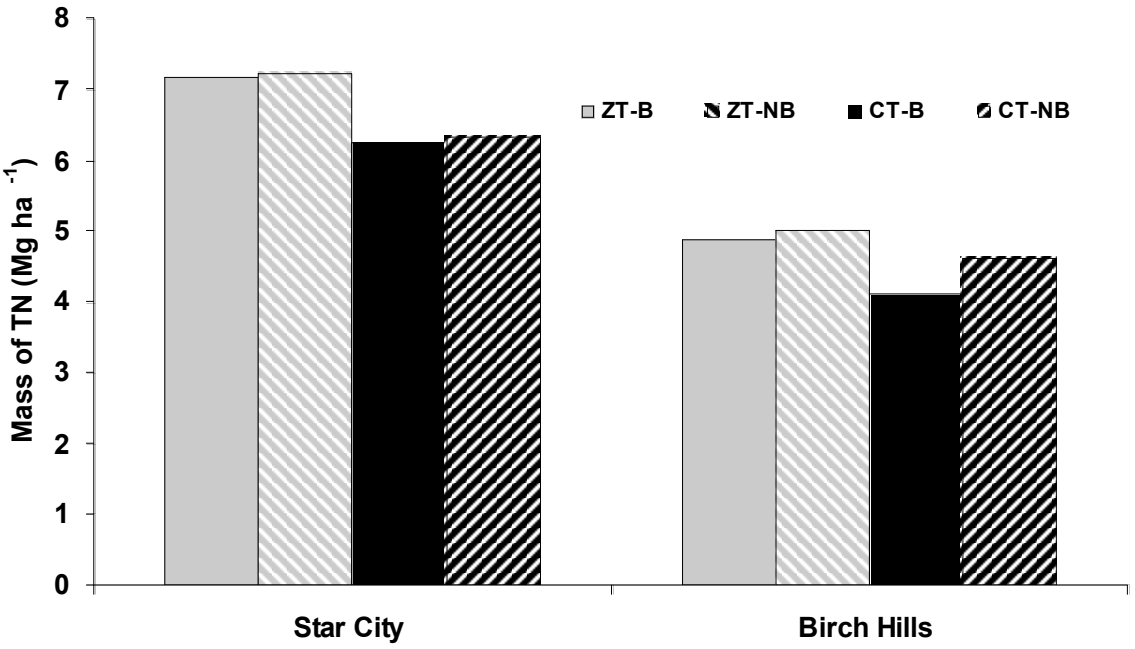


Figure 2. Effect of tillage and burning of residue on mass of total N (TN) in 0-15 cm of soil.

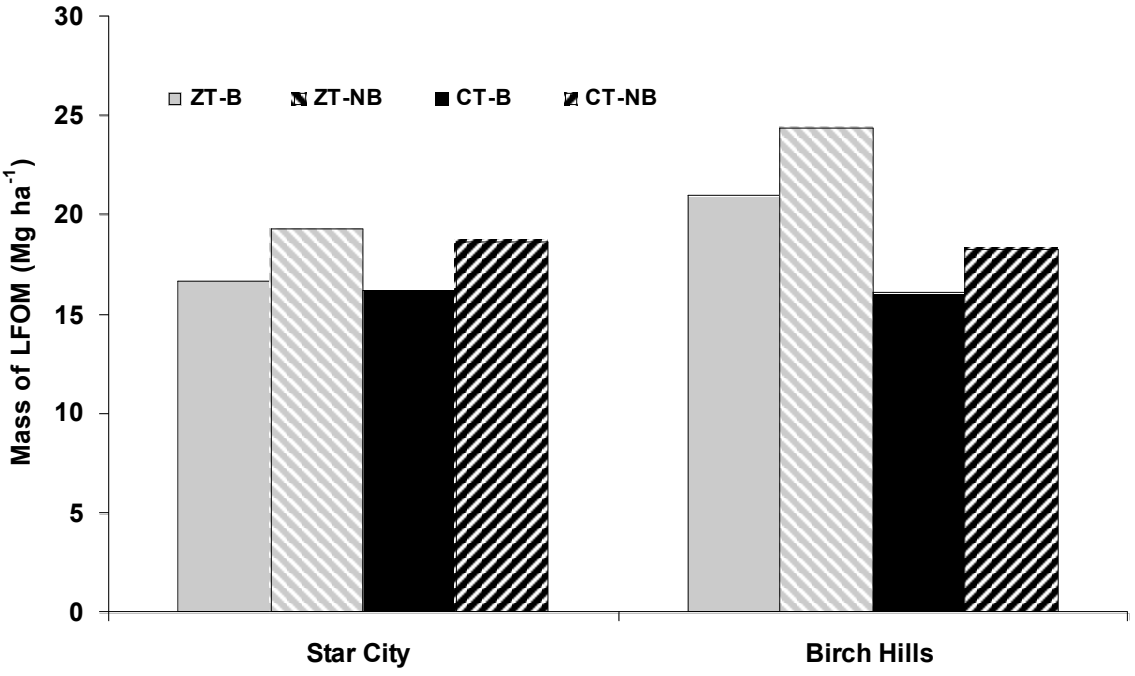


Figure 3. Effect of tillage and burning of residue on mass of light fraction organic matter (LFOM) in 0-15 cm of soil.

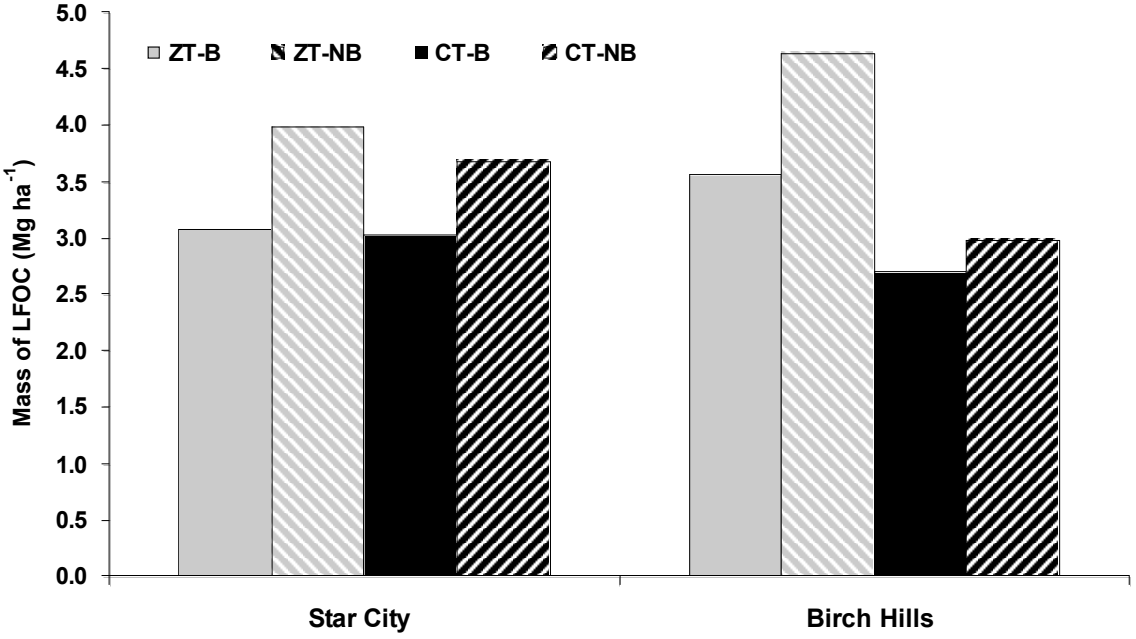


Figure 4. Effect of tillage and burning of residue on mass of light fraction organic C (LFOC) in 0-15 cm of soil.

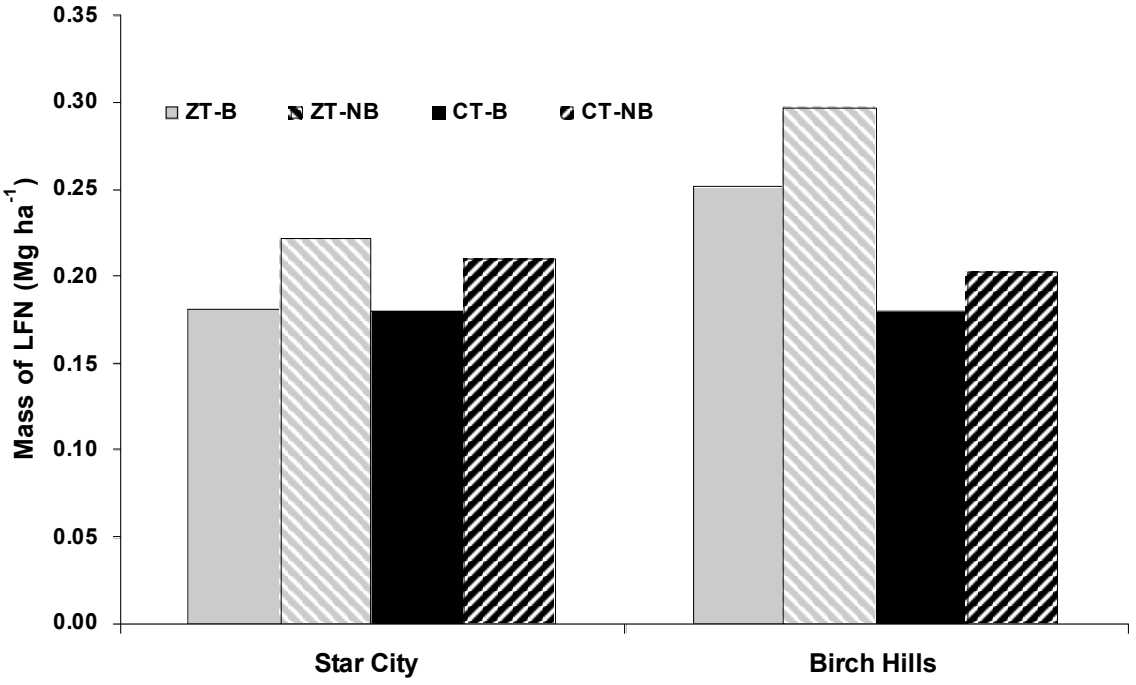
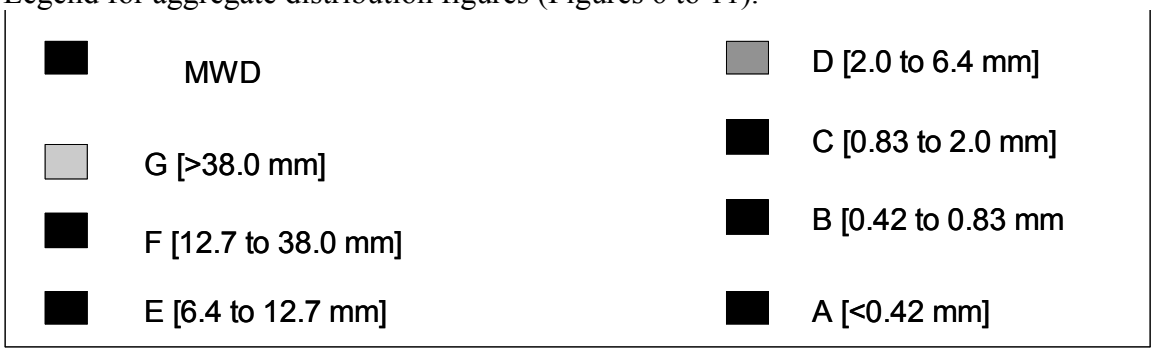


Figure 5. Effect of tillage and burning of residue on mass of light fraction organic N (LFN) in 0-15 cm of soil.

Legend for aggregate distribution figures (Figures 6 to 11).



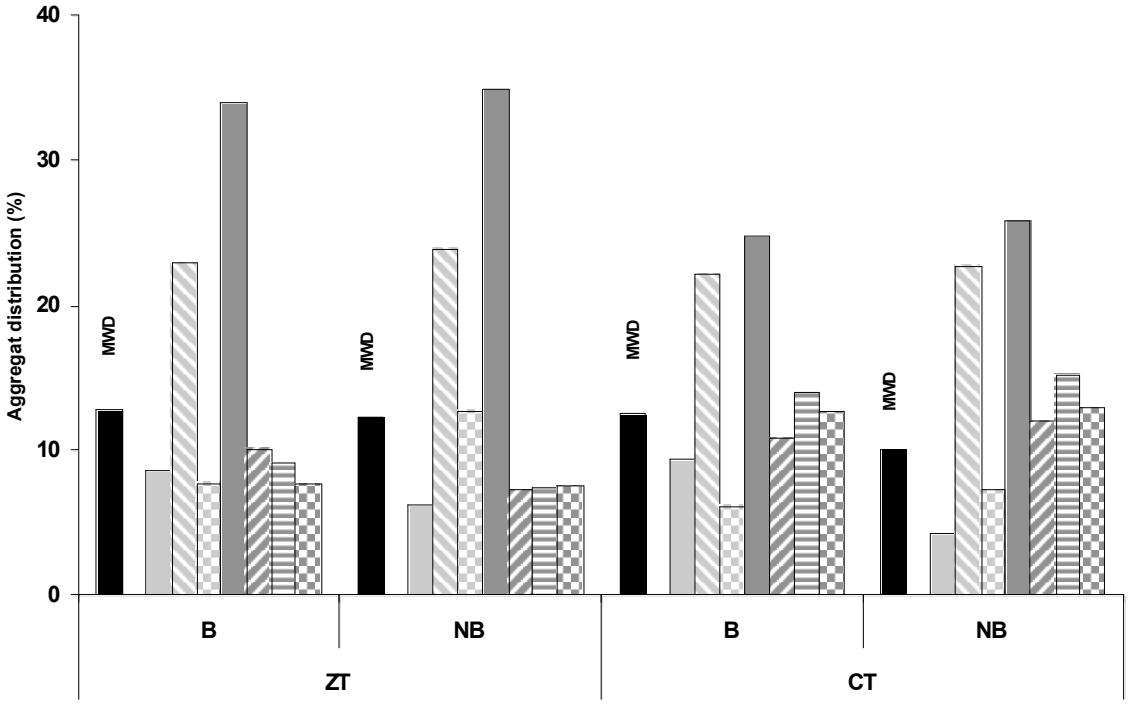


Figure 6. Effect of tillage [CT] and zero tillage [ZT] with burning straw [B] and not burning straw [NB] on soil aggregate distribution as a percentage of the total fractions at Star City Saskatchewan in 2005.

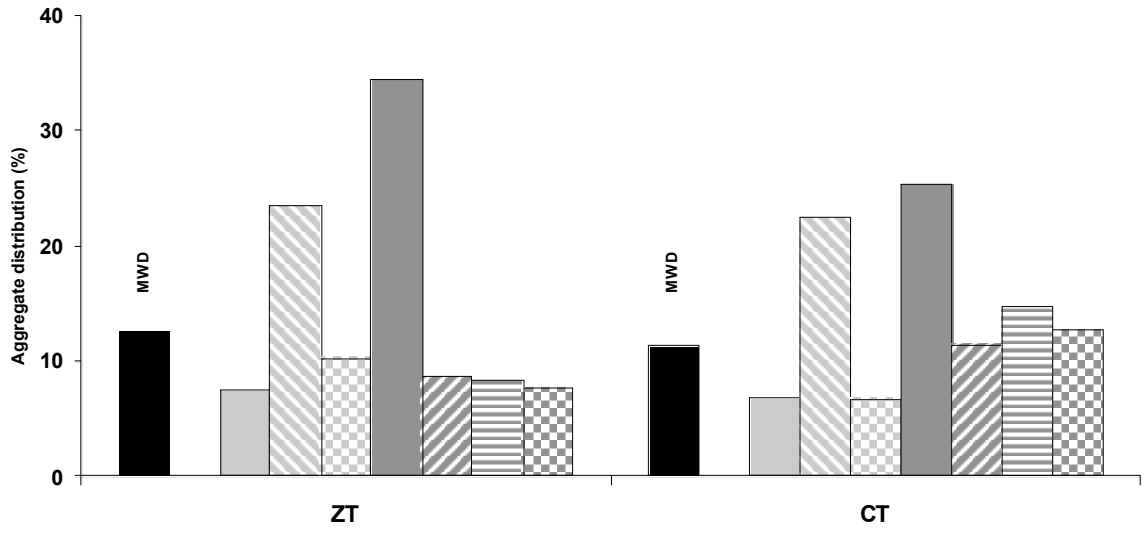


Figure 7. Effect of tillage [CT] and zero tillage [ZT] on soil aggregate distribution as a percentage of the total fractions at Star City Saskatchewan in 2005.

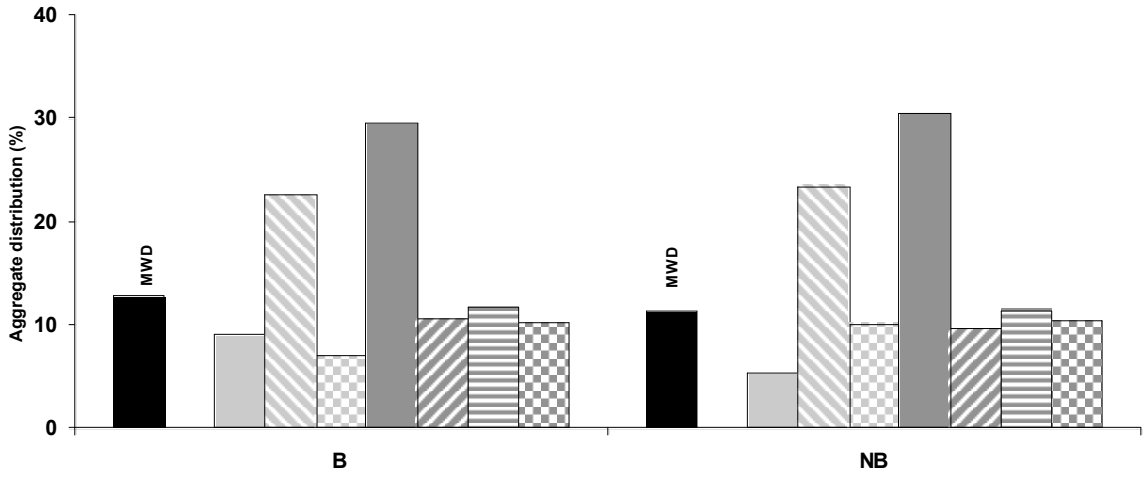


Figure 8. Effect of burning straw [B] and not burning straw [NB] on soil aggregate distribution as a percentage of the total fractions at Star City Saskatchewan in 2005.

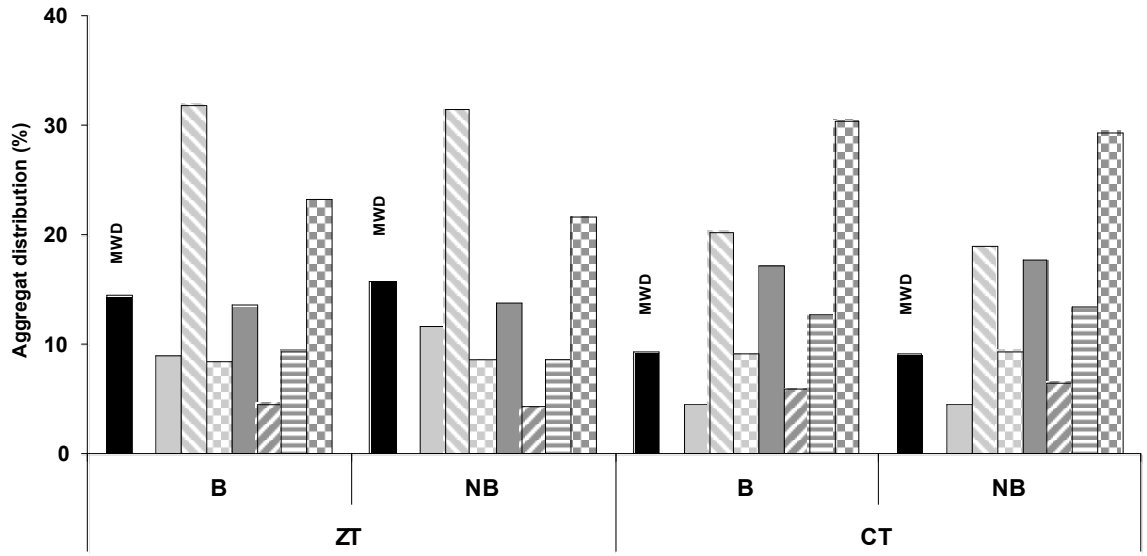


Figure 9. Effect of tillage [CT] and zero tillage [ZT] with burning straw [B] and not burning straw [NB] on soil aggregate distribution as a percentage of the total fractions at Birch Hills Saskatchewan in 2005.

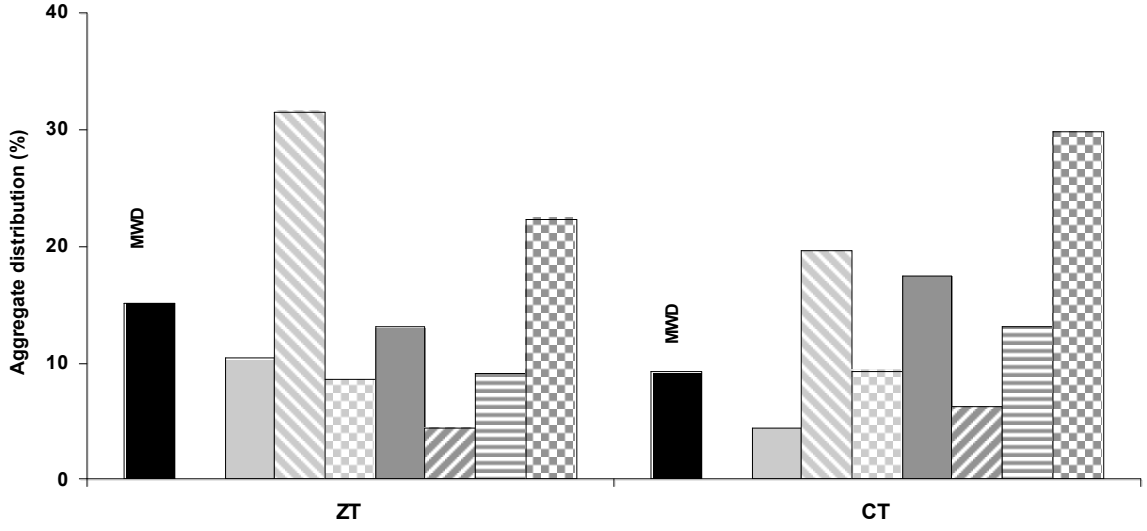


Figure 10. Effect of tillage [CT] and zero tillage [ZT] on soil aggregate distribution as a percentage of the total fractions at Birch Hills Saskatchewan in 2005.

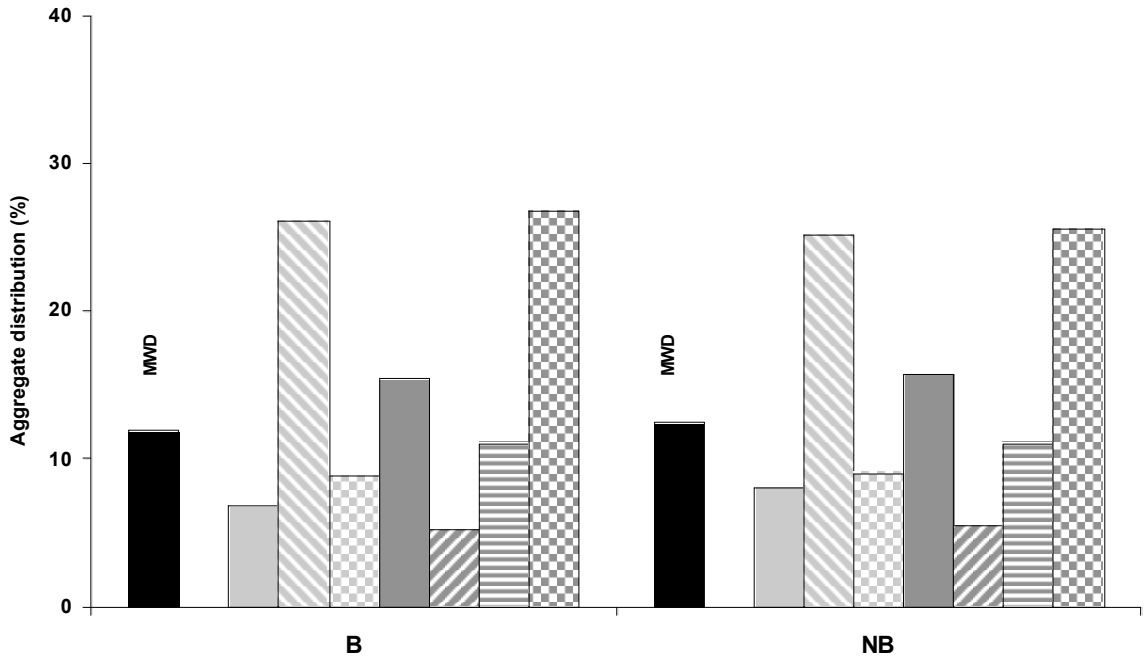


Figure 11. Effect of burning straw [B] and not burning straw [NB] on soil aggregate distribution as a percentage of the total fractions at Birch Hills Saskatchewan in 2005.