Influence of Time and Method of Terminating Alfalfa Stands on Soil N Supply, Crop Yield, N Uptake and Greenhouse Gas Emissions

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BACKGROUND

- In the Parkland region, alfalfa is often grown (for forage or seed production) in rotation with annual crops.
- In a rotation, alfalfa reduces fertilizer N input for the succeeding crops, while also improving seed yield/protein content.
- It also helps to prevent soil erosion, and improve soil structure and organic matter.
- This is particularly important in Gray Luvisol soils (inherently low in organic matter, and have surface crusting problem).
- After about 3 years, alfalfa cannot maintain its original productivity, and is terminated primarily by tillage (often 5-7 cultivations).
- However, termination of stands by tillage exposes soil to erosion by wind and water, causes loss of soil moisture and productivity, and can also lead to soil crusting, resulting in poor crop emergence.
- This can also result in release of substantial amounts of nitrate-N from mineralization of soil organic N (subjected to leaching and denitrification), CO_2 and N_2O (greenhouse gases) emissions into the atmosphere.
- Recently, herbicides have been identified that control alfalfa effectively. Therefore, termination without tillage (NT) can be used as a feasible alternative to tillage for stand termination.
- Research was conducted to determine if no-till (herbicide) method of alfalfa stand termination can improve synchronization between N release from alfalfa residues and its

uptake by succeeding annual crops. This could increase crop recovery of N and reduce N losses by leaching and denitrification.

OBJECTIVE

- To compare the influence of time and method of terminating alfalfa stands on seed yield, quality, N uptake and N fertilizer requirements for wheat (*Triticum aestivum* L.) and canola (*Brassica napus* L.), soil N supply, aggregation and organic C and N, and nitrous oxide (N2O) emissions on a Gray Luvisol soil.

MATERIALS AND METHODS

- Stand termination treatments were initiated on 7-yr old alfalfa stand in the summer of 2003 near Star City, Saskatchewan on a Gray Luvisol (Boralf) soil with loam texture, 3.1% organic matter and 6.6 pH.
- Mean growing season precipitation (GSP - May-August) is about 240 mm for this area. GSP at AAFC Melfort Research Farm was 290 mm in 2004, 372 mm in 2005 and 220 mm in 2006.
- The 36 treatments in 4 replications in a RCBD were 3 x 3 x 4 factorial combinations of 3 methods of termination (herbicide (NT), tillage, and herbicide + tillage), 3 times of termination (after first cut, after second cut and spring) and 4 rates of N (0, 40, 80 and 120 kg N ha^{-1}). Herbicides used were Lontrel + 2,4-D and Glyphosate + 2,4-D.
- Blanket applications (30 kg P, 42 kg K and 17 kg S ha^{-1}) of fertilizers broadcast in all plots prior to tillage and sowing in every spring. N fertilizer (urea) was side-banded 2.5 cm away and 2.5 cm below seed rows at sowing.
- The plots were seeded to annual crops in a rotation of wheat (*Triticum aestivum* L. cv. CPS 500PR) in 2004, canola (*Brassica napus* L. cv. Invigor 2573 - hybrid) in 2005 and wheat (cv. HRSW AC Barrie) in 2006. Seed rate was 108 kg ha^{-1} for wheat and 9 kg ha^{-1} for canola.
- Only the data collected on soil mineral N, seed yield, protein and oil concentration, total N uptake and recovery of applied N, and nitrous oxide (N_2O) gas emissions from early spring to late autumn in different years will be reported in this poster.

SUMMARY OF RESULTS

First Growing Season (2004) After Termination

– Wheat –

- Soil nitrate-N was higher in tilled/herbicide + tilled plots than in herbicide plots in autumn 2003 and in spring 2004, and decreased with delay in termination.
- Maximum seed yield and N uptake was produced from termination in spring in herbicide, and from termination after cut 1 in tillage/herbicide + tillage treatments.
- Delay in stand termination with tillage or herbicide + tillage decreased seed yield and N uptake, but the negative influence was much larger at 0 and 40 kg N ha^{-1} than at 80 and 120 kg N ha^{-1} rates.
- Spring was the best time for stand termination using herbicide, but herbicide method produced lower yield and N uptake than tillage or herbicide + tillage, particularly with termination after cut 1 and cut 2.
- The differences in seed yield and N uptake produced with different termination methods were relatively greater at lower than at higher N rates, and with earlier than later stand termination time.
- There was usually no significant increase in seed yield above 80 kg N ha^{-1} (except with herbicide in spring where it continued to increase up to 120 kg N ha^{-1} rate).
- Protein concentration increased, but recovery of applied N in seed decreased with increasing N rate.
- Protein concentration was highest with herbicide method and lowest with spring termination. The differences between termination times were much greater for herbicide method than other termination methods.
- Recovery of applied N in seed for tillage or herbicide + tillage methods was in the order of spring > cut 2 > cut 1 at all N rates. For herbicide only method, it was cut 1 > spring > cut 2 for 40 kg N ha^{-1} rate, and was spring > cut 1 > cut 2 for the 80 and 120 kg N ha^{-1} rates.
- Mean cumulative N_2O loss during 2004 ranged from 220 to 420 g N ha^{-1}. There were negligible N_2O emissions during the snow melt period likely due to dry conditions in previous autumn and limited snow cover in winter.
- The N_2O loss tended to be lower with termination after cut 1 than the other termination times.

- N_2O emissions from tillage termination were significantly higher than termination by herbicide.

SUMMARY OF RESULTS

Second Growing Season (2005) After Termination

– Canola –

- In spring 2005, soil nitrate-N was usually higher in herbicide than tillage or herbicide + tillage treatments. There was little or no effect of termination time on soil nitrate-N.
- Seed yield, protein concentration and N uptake increased, but oil concentration decreased with increasing rate of N application.
- There was no significant effect of termination time or method on seed yield, but in the zero-N treatment seed yield, protein concentration and N uptake tended to be higher and oil concentration tended to be lower with herbicide than tillage or herbicide + tillage methods.
- Oil concentration in seed increased, but protein concentration and N uptake in seed decreased with delay in termination. Oil concentration in seed was higher with tillage or herbicide + tillage termination methods, but the opposite was true for protein concentration and N uptake in seed.
- Recovery of applied N in seed for herbicide method was in the order of cut 1 > cut 2 > spring termination time at the 40 and 120 kg N ha^{-1} rates. There was no consistent trend for tillage or herbicide + tillage termination methods .
- Mean cumulative N_2O loss during 2005 ranged from 330 and 730 g N ha^{-1}. N_2O emissions during the snow melt period were substantially higher (representing 16 to 55% of the cumulative seasonal totals).
- The N_2O loss tended to decline with delay in termination. In the second year, N_2O emissions from tillage termination were lower than termination by herbicide. This is consistent with tillage producing a greater flush of microbial activity and nitrate release in the first year that diminished by the second year.

SUMMARY OF RESULTS

Third Growing Season (2006) After Termination

– Wheat –

- Seed yield increased with increasing N rate.
- There was no significant effect of termination time or method on seed yield, but in the zero-N treatment seed yield tended to be lower with herbicide method than tillage or herbicide + tillage method.

CONCLUSIONS

- Overall, the results suggested that in the first crop year after alfalfa stand termination, N fertilization can be used to compensate for the decline in yield due to the delay in alfalfa stand termination, especially when herbicide method is used.
- The effect of termination performed in summer 2003 or in spring 2004 diminished substantially in the second cropping season, and diminished almost completely in the third cropping season.
- There was delayed release of mineral N in untilled soils, so herbicide (no-till) termination may reduce the potential for nitrate N loss to the environment if there is potential for large releases of nitrate. This is evidenced by reduction in N_2O emissions in the termination year or in the first crop year after termination.
- The preliminary results suggest that termination timing and method have limited influence on cumulative N_2O emission at this study site.

ACKNOWLEDGEMENTS

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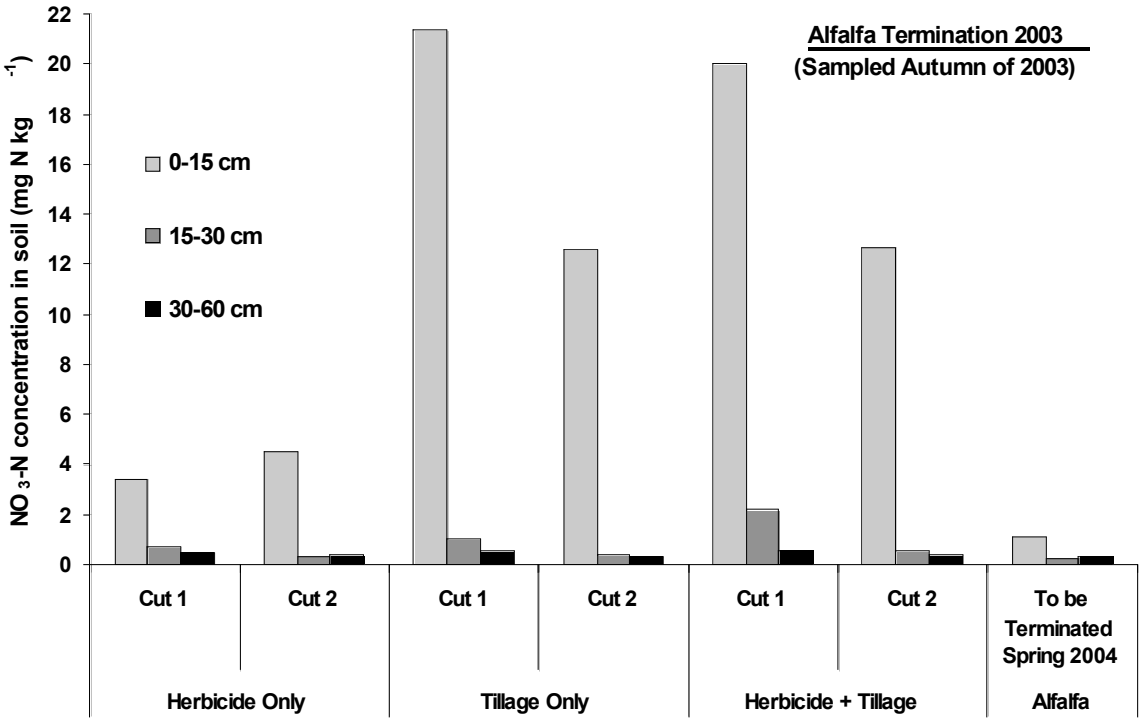

Figure 1. Nitrate-N concentration in soil in the zero-N treatment for 3 termination methods and 3 termination times in autumn 2003 (termination of alfalfa stands was done in summer of 2003 or in spring 2004) at Star City Saskatchewan.

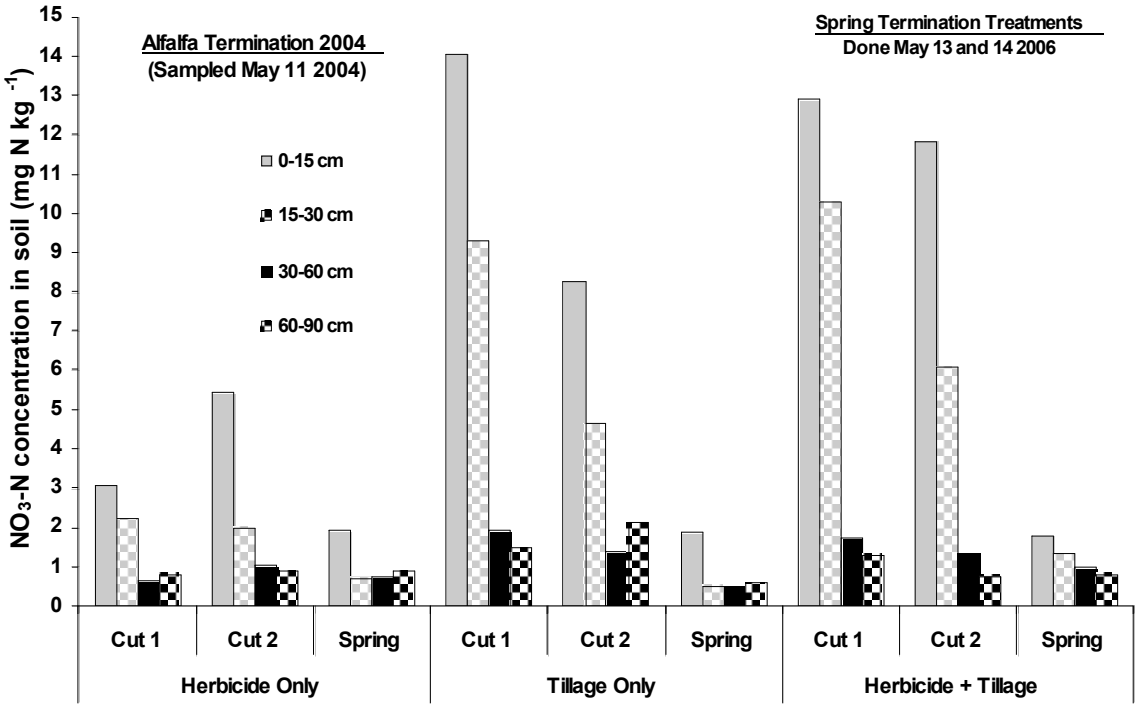

Figure 2. Nitrate-N concentration in soil in the zero-N treatment for 3 termination methods and 3 termination times in spring 2004 (termination of alfalfa stands was done in summer of 2003 or in spring 2004) at Star City Saskatchewan.

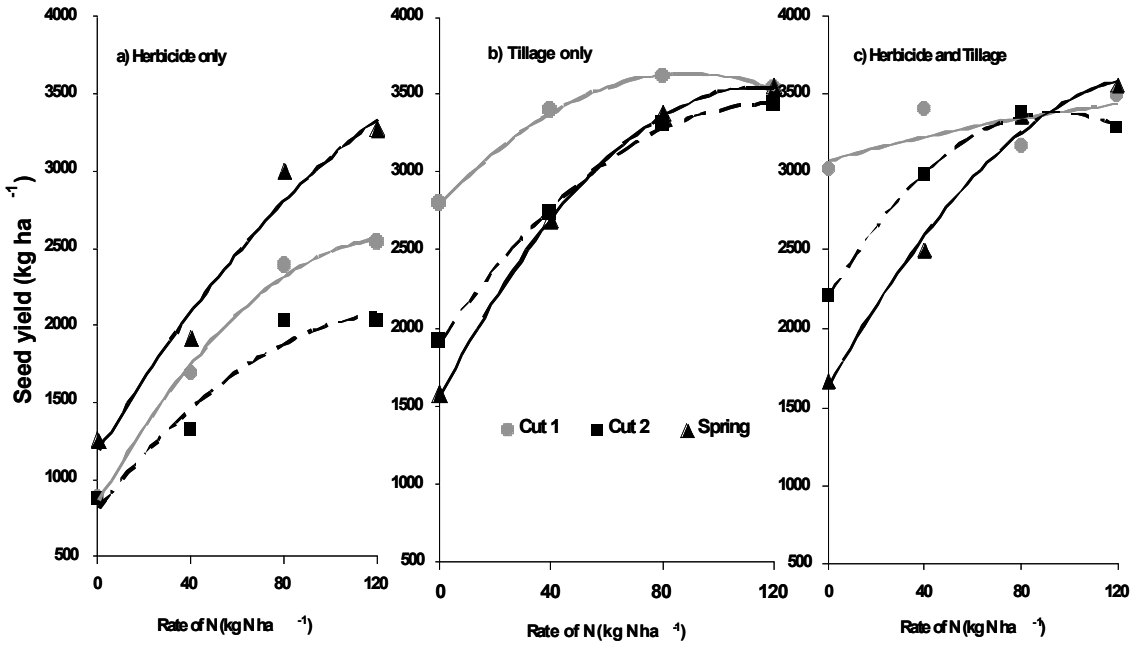

Figure 3. Seed yield of CPS wheat for termination method x termination time x rate of N in 2004 at Star City Saskatchewan.

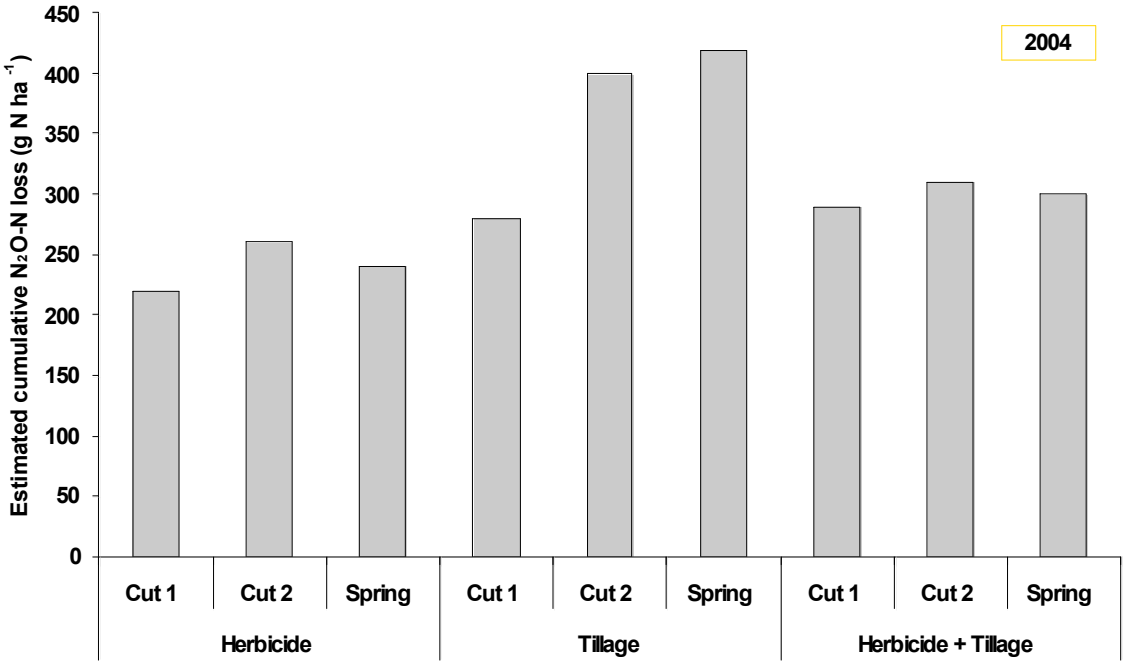

Figure 4. Estimated cumulative N_2O-N emissions in the zero-N treatment for 3 termination methods and 3 termination times in 2004 at Star City Saskatchewan.

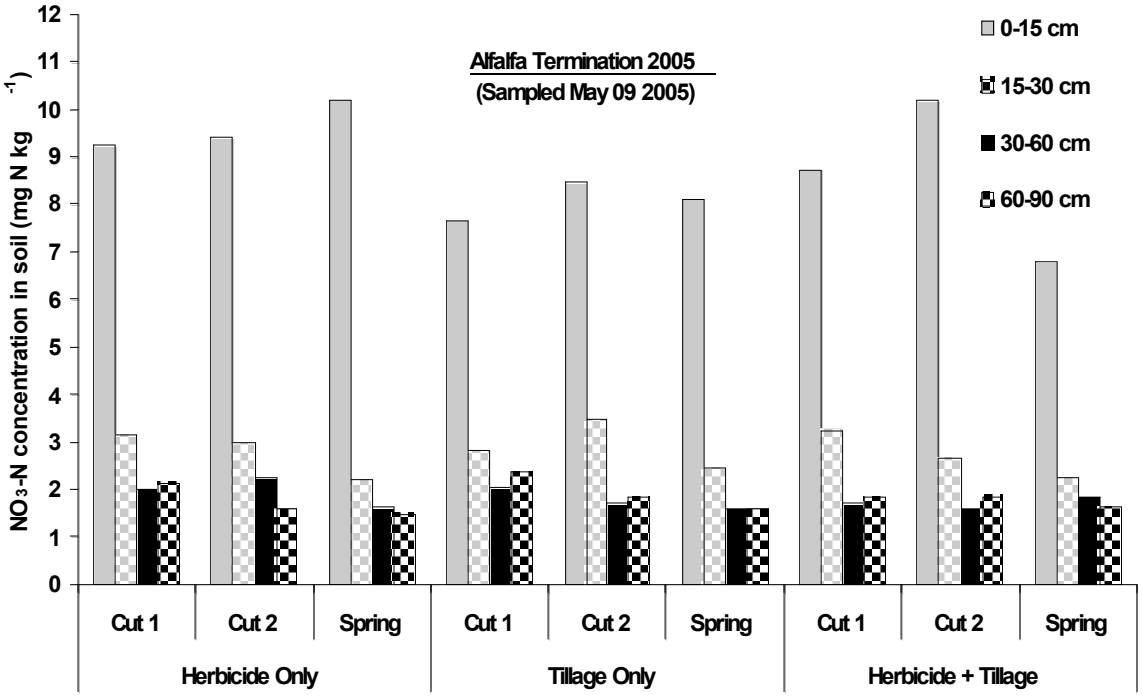

Figure 5. Nitrate-N concentration in soil in the zero-N treatment for 3 termination methods and 3 termination times in spring 2005 (termination of alfalfa was done in summer of 2003 or in spring 2004) at Star City Saskatchewan.

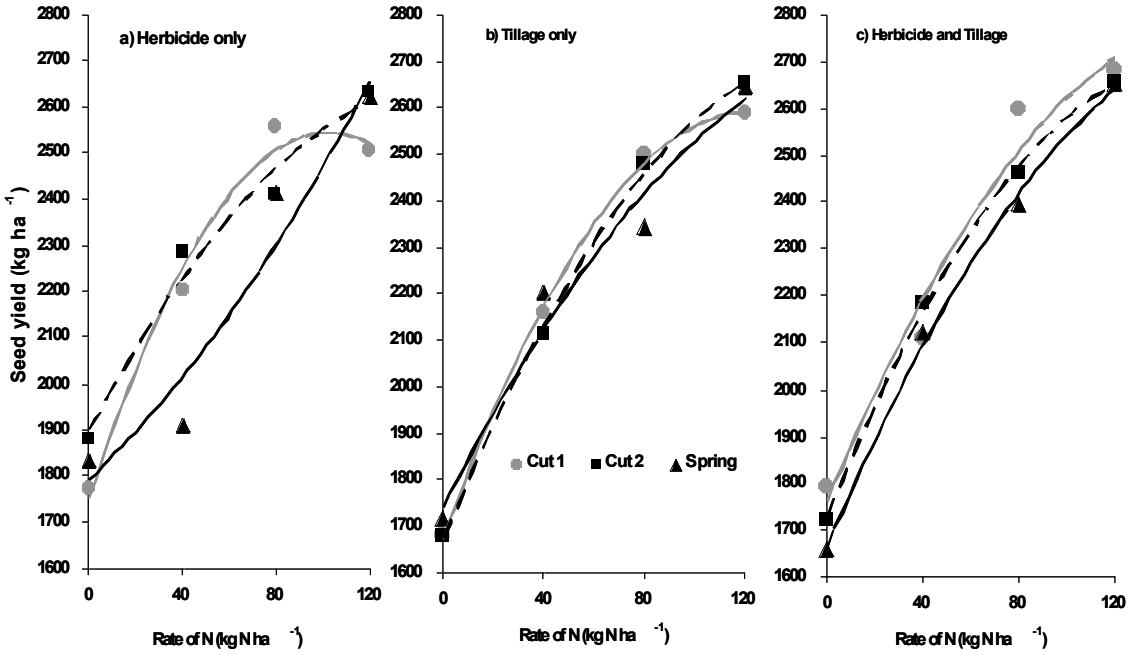

Figure 6. Seed yield of hybrid canola seed for termination method x termination time x rate of N in 2005 at Star City Saskatchewan.

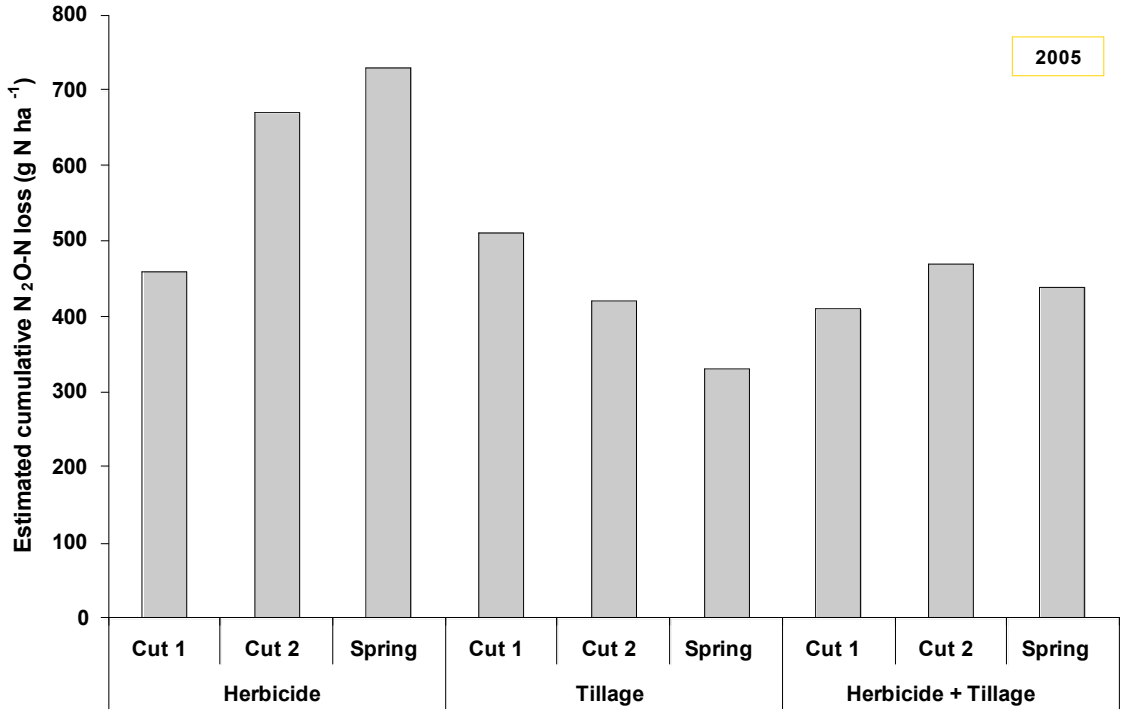

Figure 7. Estimated cumulative N_2O-N emissions in the zero-N treatment for 3 termination methods and 3 termination times in 2005 at Star City Saskatchewan.

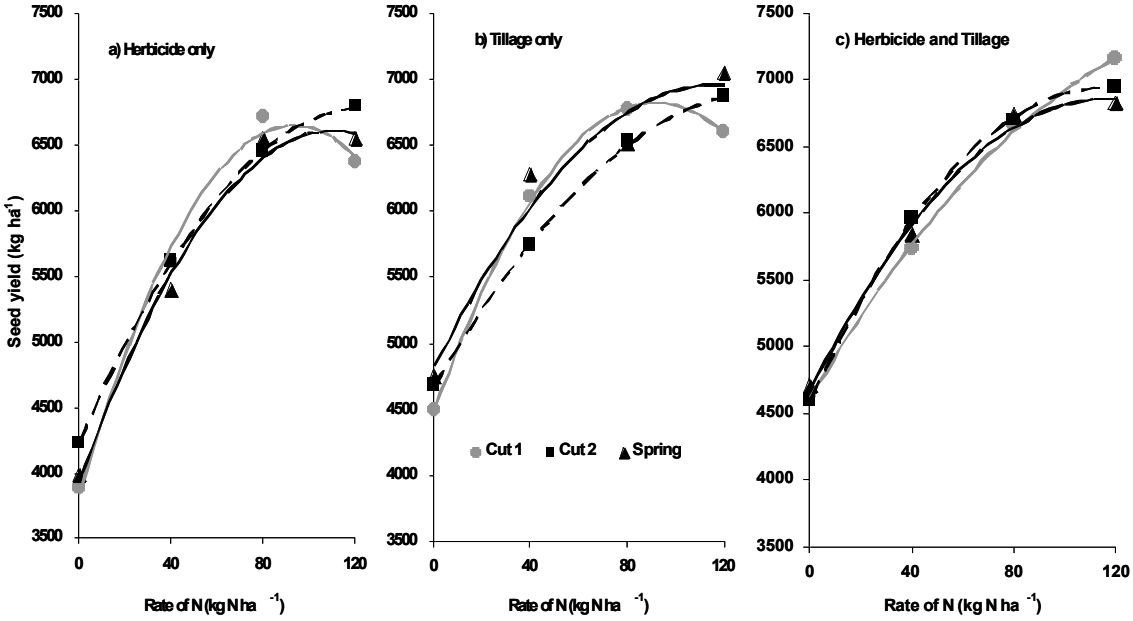

Figure 8. Seed yield of HRS wheat seed for termination method x termination time x rate of N in 2006 at Star City Saskatchewan.