# 25 years' tillage effects on wheat production in a continuous cropping system

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Heat stress occurs often in wheat on the Canadian Prairies especially during grain growth (from anthesis to maturity), which has a markedly negative impact on yield (McCaig 1997). Under no-till management (NT), surface residue and stubble act as insulation and impede the exchange rate of thermal energy between the soil and the atmosphere, and the superior soil moisture of NT compared to conventional tillage (CT) can buffer the extremes in daily soil temperatures. It is, therefore, possible that the cooling effect of NT could alleviate the root heat stress of wheat.

Under a continuous wheat cropping system on a Thin Black Chernozemic clay loam in central Alberta, Wang et al (2007) found that the near-surface soil temperature of NT was lower than that of CT throughout the growing season, which reduced the risk of root heat stress and benefited grain yield and biomass.

The objective of this study was to investigate whether a similar effect of NT is present in southwestern Saskatchewan.

## Materials and Methods

A long-term tillage study was initiated in 1981 at SPARC near Swift Current, Saskatchewan. There were two crop rotations: continuous wheat (CT and NT) and fallow-wheat rotation (CT, minimum tillage and NT).

Soil moisture and available $NO_3$-N for the 0-0.15, 0.15-0.30, 0.30-0.60, 0.60-0.90 and 0.90-1.20 m depths were measured every spring before seeding. Soil temperatures were measured in 2004 at 0.075 m in each continuous wheat treatment.

Heat stress index (HSI) was calculated according to the method of Bristow and Abrecht (1991):

$$HSI = \sum (Ti - Tc)$$

where *Ti* is soil temperature at time *i* (the hour of the day) and *Tc* is the critical temperature (20°C, Wardlaw et al. 2002).

## Results and Discussion

### Tillage effects on soil available N, moisture and temperature

Over the 25 years spring soil available NO3-N in 0-0.6 m depth rarely differed significantly between CT and NT. Both treatments averaged 25 kg $ha^{-1}$.

Although spring soil moisture in the 1.2 m profile did not differ significantly in most of the years, in 22 of the 25 years the NT treatment had higher moisture at 0–0.15 m than CT and half of them were significant (Fig. 1). The 2-5 mm more water in NT than in CT is unlikely to be enough for increasing yield considerably, but it might be able to buffer the flux of heat into soil.

Figure 2 showed that in 2004 the CT treatment started to have higher HSI at 0.075 m than NT from the mid of ear development stage at 45 days after seeding (DAS), and was significantly higher since the beginning of grain filling (68 DAS).

### Tillage effects on wheat production

In the first five years of this study (1982-1986) the NT treatment had lower or equal grain yield compared to CT. From then on (1987-2006), NT outyielded CT in most of the years although often not significant (Fig. 3). The mean yields over 25 years were 2029 and 2063 kg $ha^{-1}$ for CT and NT, respectively. Similar to grain yield, in the first five years non-grain dray matter of NT was lower than or equal to that of CT (Fig. 4). Then, NT produced more straw than CT in most of the years (85%) and most of them (71%) were significant at $P<0.10$. On average of the 25 years, NT produced 215 kg $ha^{-1}$ more straw than CT. Regarding the total biomass, on average, NT outyielded CT by 250 kg $ha^{-1}$.

### Conclusion

Over 25 years, no-till wheat under a continuous cropping system on a Swinton loam soil in southern Saskatchewan tended to produce more grain and straw than conventional tillage. This is similar to findings at the site located in central Alberta (Wang et al. 2007). It could be associated with increased pre-seeding near-surface soil moisture and reduced near-surface soil temperature under NT, which resulted in the alleviation of root heat. The benefit of NT to straw yield over grain yield is possibly related to the fact that wheat has the ability to increase the remobilization of reserved assimilates in stems and other non-grain organs to the grain under water stress and heat stress conditions.

## References

Bristow, K. L. and Abrecht, D. G. 1991. Daily temperature extremes as an indicator of high temperature stress. Aust. J. Soil Res. 29: 377–385.

McCaig, T. N. 1997. Temperature and precipitation effects on durum wheat grown in southern Saskatchewan for fifty years. Can J. Plant Sci. 77: 215–223.

Wang, H., R. Lemke, T. Goddard, C. Sprout. 2007. Tillage and root heat stress in wheat in Central Alberta. Can. J. Soil Sci. 87: 3-10.

Wardlaw, I. F., Blumenthal, C., Larroque, O. and Wrigley, C. W. 2002. Contrasting effects of chronic heat stress and heat shock on kernel weight and flour quality in wheat. Funct. Plant Biol. 29: 25–34.

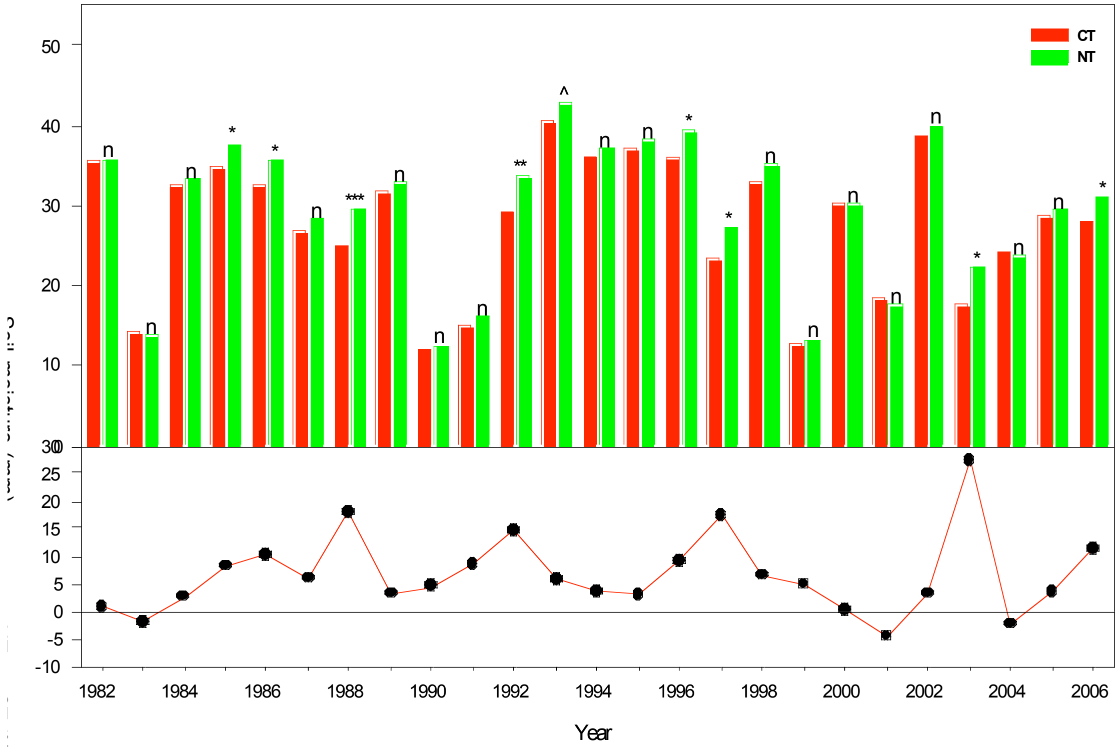

Fig. 1. Tillage effect on spring soil water content at 0-0.15 m. *** *P*<0.001, *P*<0.01,** *P*<0.01, * *P*<0.05, ^ *P*<0.10, n non-significant at *P*<0.10.

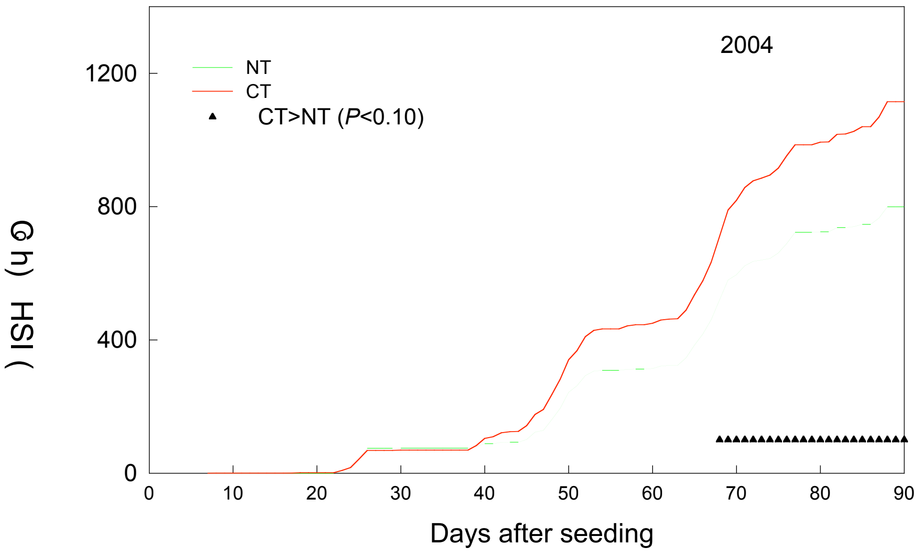

Fig. 2. Tillage effect on root heat stress index (HSI).

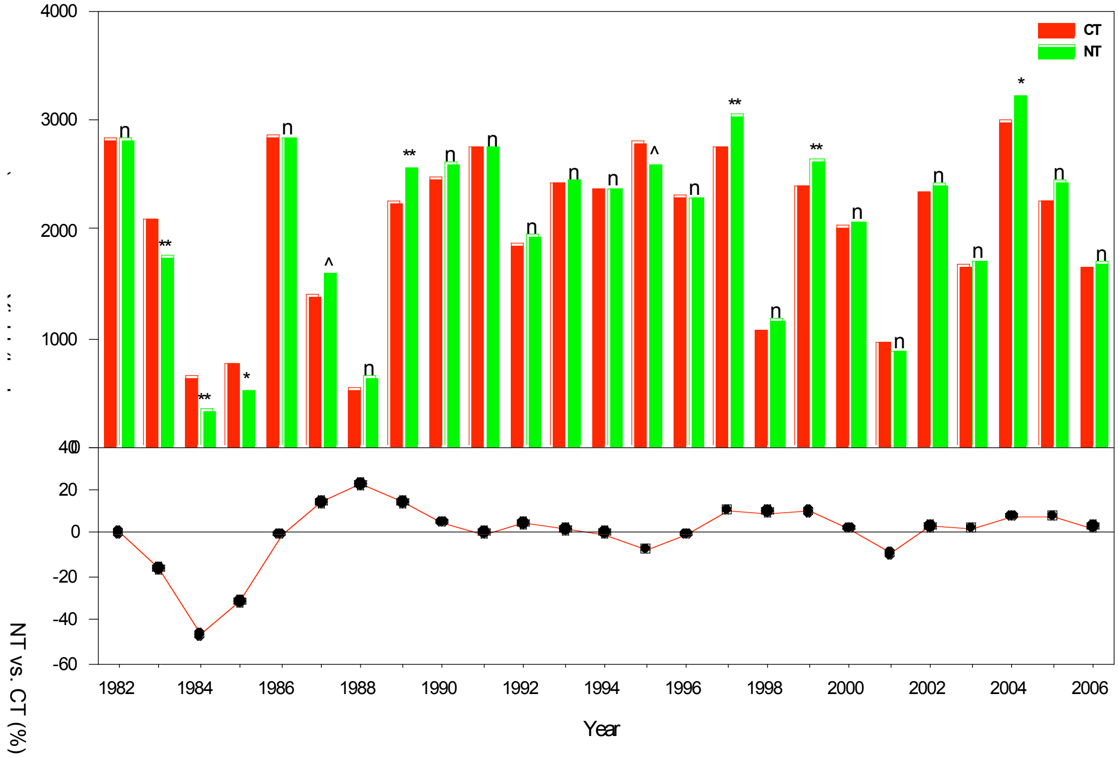

Fig. 3. Tillage effect on grain yield. ** $P<0.01$, * $P<0.05$, ^ $P<0.10$, n non-significant at $P<0.10$.

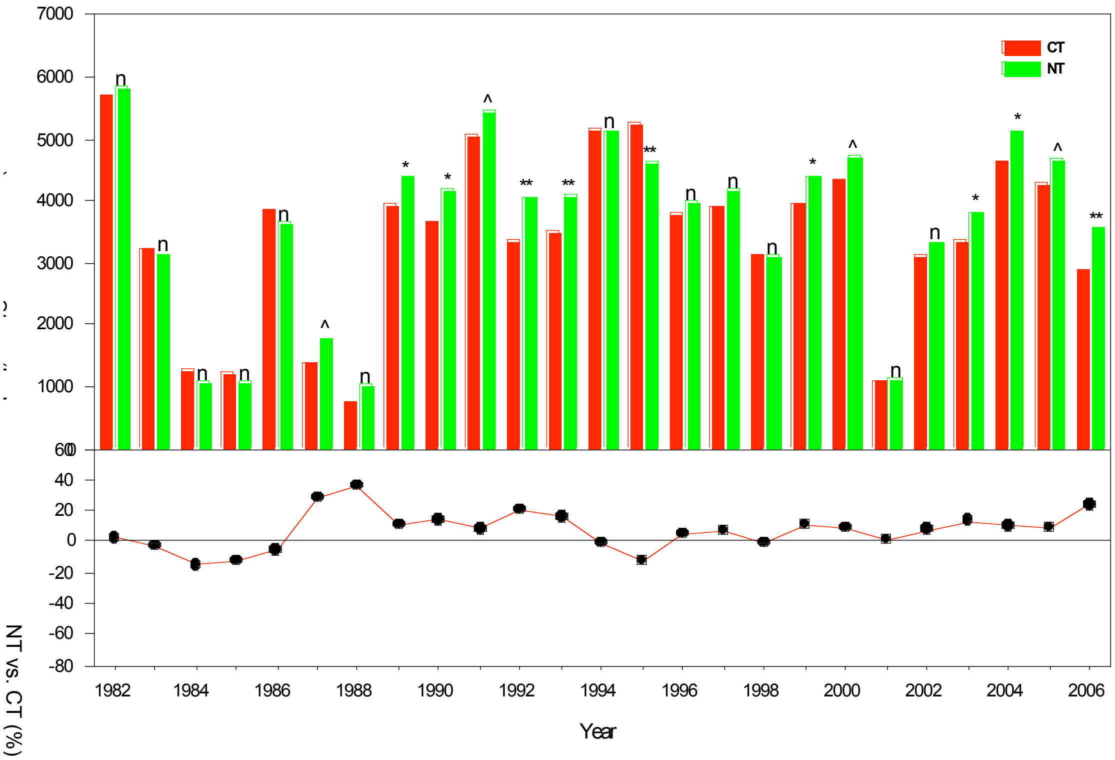

Fig. 4. Tillage effect on non-grain biomass. ** *P*<0.01, * *P*<0.05, ^ *P*<0.10, n non-significant at *P*<0.10.