# Tillage System Effect on Vertical Phosphorus Stratification and Phosphorus Uptake of Winter Wheat, Winter Pea, and Spring Pea

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**Introduction**

The increasing adoption and use of no-till (NT) dryland cropping systems in Montana has resulted in uniquely different patterns of soil phosphorus (P) distribution compared to conventionally tilled (CT) systems (Grant and Bailey 1994; Lupwayi et al. 2006; Selles et al. 1999). Consequently, P availability, and hence, P fertilizer needs, may be different in NT than in CT systems, yet no studies have been conducted on this issue in Montana. Therefore, the objectives of this study were to 1) determine the difference in vertical P distribution between NT and CT systems, as well as in the transition period from one tillage system to the other, and 2) determine if P uptake, and hence P availability and fertilizer need, is different between tillage systems.

**Methods**

This project was conducted on an existing small plot study designed to assess the effects of tillage, nitrogen (N), and previous crop on soil fertility and yield at the Central Ag. Research Center. The soil texture was clay loam. Four treatments included >30 yr CT (CTCT), NT since 1996 (NTNT), CT converted to NT in 2005 (CTNT) and NT converted to CT in 2005 (NTCT). Nitrogen fertilizer (46-0-0) was broadcast at 0, 40, 80, and 120 lb N/ac. The layout was a randomized complete block design with 4 replicates, and each plot was 25 x 15 ft. Since 1996, tillage was completed with a 15 ft. IHC cultivator with 16 sweeps. Tillage was performed once a year in the fall or spring depending on whether a winter or spring crop was planted. CT plots were leveled using a cultivator with a harrow attached. Since 1996, the site had been under a continuous rotation of small grains and oilseeds. Phosphorus fertilizer (either MAP or TSP) was applied with the seed in all years of the study at 0.75 to 1.0 in. deep. Although 4 crop rotations were being evaluated in the existing system (fallow, spring wheat, pea, and pea forage, each followed by winter wheat), only the fallow treatment was soil sampled for P distribution in this study. Soil cores (1.0 in. diam.) were collected from the 0-12 in. depth at 5 locations within each plot prior to winter wheat seeding (August 22 to September 1, 2005). These five cores were collected from each fallow plot that was to be applied with 80 lb N/ac within each tillage treatment. Each core was segmented into 1.2 in. increments and each of the respective five sub-samples was composited for each depth increment.

In September 2005, all plots were seeded with winter wheat ("Yellowstone") using a ConservaPak no-till air drill equipped with hoe-type openers at 12 in. row spacing. Phosphorus fertilizer (0-45-0) was applied at 22.5 lb $P_2O_5$/ac with the seed. At harvest in 2006, one winter wheat plant bundle sample was collected from each plot where soil samples had been collected in 2005. Wheat was threshed and dry biomass of grain and straw subsamples were weighed and analyzed for P. In order to investigate the effect of tillage on P uptake by peas, both winter pea (Common Austrian) and spring pea (Majoret) were seeded in Pea-Winter Wheat rotation plots with no P fertilizer on 25 October 2006 and 25 April 2007, respectively, and harvested on June 19, 2007 and July 25, 2007, respectively.

**Results**

*Olsen P Distribution*

The Olsen P levels were 4 to 5 fold higher in the upper 1.2 in. than below 6 in. for all tillage systems (Fig. 1), likely because P had been banded near the 1.0 in. depth. The Olsen P concentration in 10-yr NT was more stratified than in long-term CT, based on concentration differences between the 0-1.2 in. and the 1.2-2.4 in. layers. There were essentially no differences between

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long-term CT and the transitional years (NTCT, CTNT). In addition, there were no significant differences in average Olsen P concentrations averaged over 0 to 6 in. among tillage treatments (P=0.05). The results suggest that vertical P stratification patterns were only somewhat altered by tillage. The general lack of differences in Olsen P concentrations and stratification is likely because sweep tillage moves soil horizontally more than vertically, and there was only one tillage pass per year. Because roots tend to grow towards areas containing high nutrient levels, the high degree of stratification in all tillage systems may favor root growth near the surface, a disadvantage in dry years.

*P Uptake*

Aboveground P uptake by winter wheat was not significantly different between tillage treatments when the optimum N rate of 80 lb/ac was applied (Fig. 2). P uptake in winter pea forage and spring pea grain were also not significantly different among tillage treatments (data not shown). This suggests that P fertilizer rates do not need to be adjusted based on tillage system.

**Fertilizer Facts**

- Available phosphorus levels are somewhat more stratified in no-till than tilled systems.
- Phosphorus fertilizer rates apparently do not need to be adjusted based on tillage system.
- Phosphorus fertilizer should be placed with the seed, or below the seed, especially in reduced till systems to promote deep root growth.

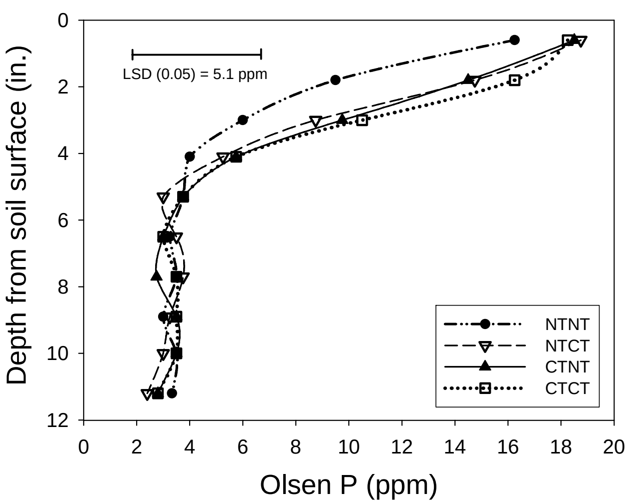


Figure 1. Distribution of Olsen P concentrations for each tillage treatment in the upper 12 inches (August 22 – September 1, 2005 sampling). LSD = least significant difference.

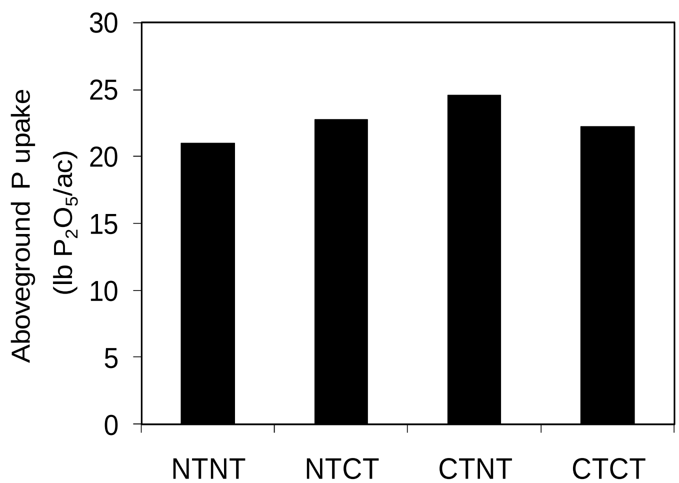


Figure 2. Winter wheat aboveground P uptake for each tillage system fertilized with 80 lb N/ac and 22.5 lb $P_2O_5$/ac. There were no significant differences in P uptake among tillage systems.

**References**

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