Effects of Paratilling on Soil Bulk Density and Infiltration

B. Ewen[1], J. Schoenau[1], M. Grevers[1], and G. Weiterman[2]

[1]Department of Soil Science, University of Saskatchewan, Saskatoon, SK S7N 5A8
[2]Irrigation Branch, Saskatchewan Ministry of Agriculture, 401 Saskatchewan Ave W, Outlook, SK SOL 2N0

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Abstract

Paratilling is a form of non-inversion deep tillage sought after by producers for its effectiveness at loosening soil structure without compromising the soil conservation practices that are already employed on the farm. An experiment was set up to evaluate the tillage effects of paratilling. Looking at changes to the soil physical properties, bulk density and infiltration, and crop yield. Initially, paraplowing reduced bulk density and soil strength but with over time these effects were eroded. At the Vertisolic site the effects were lost before the end of the first growing season, which may be a result of natural processes and the unusually wet spring. Infiltration increased as a result of paratilling. Soil loosening did not increase yield suggesting that soil structure is not limiting plant growth at these sites. Paratilling is only feasible if a yield response is observed.

Introduction

Soil structure can be a limitation to crop production in irrigated cropping systems (Grevers and de Jong, 1992). Soil structure has implications on water infiltration, storage, and runoff from the soil surface. Modifying the soil structure by mechanical means can be effective in loosening soil structure providing at soil environment that is more conducive for plant growth. This study aims to evaluate a Paraplow, a bent leg subsoiler producer by Howard Rotovator. Observing how it modifies the soil structure by looking at soil bulk density and infiltration and determine if there is any subsequence benefit to plant growth by looking at crop yield.

Figure 1. Non-inversion subsoil tillage implement called a Paraplow in operation

Materials and Methods

A study area was selected around Birsay, SK. Two sites were established on quarter sections outfitted with centre pivot irrigation systems (SE-18-24-7-W3 & SE-26-24-8-W3). Each site was representative of a different soil types to determine if the natural processes within the soil will have an impact on the effectiveness and persistence of the tillage operation, examining Chernozemic and Vertisolic soils. Each site was set up in a randomized complete block design with six treatments replicated four times. The treatments were set up to evaluate seasonality of the tillage operation, spring and fall. As well as look at different tillage depths and implement configuration (Figure 2). Paraplowing took place on November 18, 2009 using 220hp Caterpillar tractor and a 6-leg paraplow and again in the spring on April 27, 2010 using an 180hp New Holland tractor with the same paraplow. The use of different tractors is assumed to have no impact on the comparison of the spring and fall treatments. The fields were then managed according to the farmer's current crop rotation and management scheme. Monitoring of the soil physical properties began in the spring following paratilling.

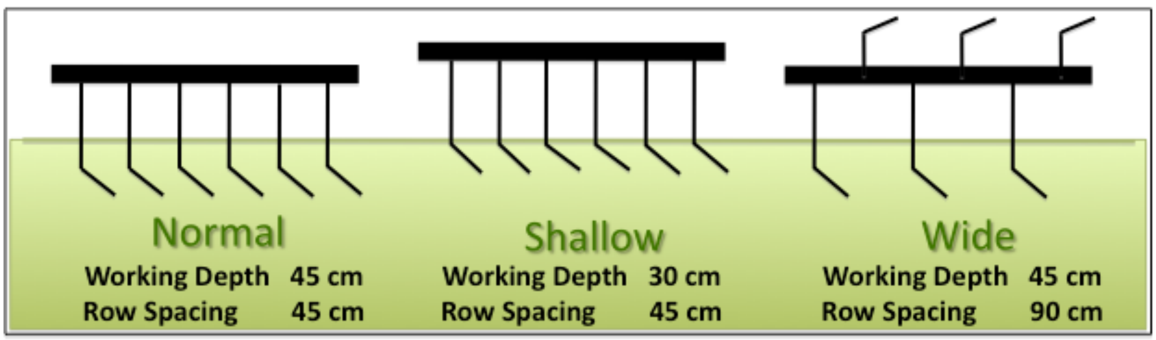

Figure 2. Summary of paratill treatments

Penetration resistance was the first measurement taken using a penetrograph (Eijkelkamp Agrisearch Equiptment, The Netherlands). Penetration resistance gives an indication of soil strength. Each plot was probed six times, with half of the measurements taken in the furrow and half of the measurements directly between the furrows. The resistance curves plotted on the scorecard of penetrograph were then averaged to come up mean values for each plot. Following the penetrograph measurements soil samples were then taken. Soil Samples were then collected for a determination of bulk density and water content. Samples were extracted using a truck mounted punch then segmented into five separate sections: 0-15 cm, 15-30 cm, 30-45 cm, 45-60 cm, and 60-90 cm. Bulk density were then calculated for each of the segments using there specific volume, weight, and water content, determined in the lab. Soil sampling was then repeated consecutively every spring and fall to determine bulk density until no residual tillage effect was observed. In the second last week of July 2010, field-saturated hydraulic conductivity (K_{fs}) measurements were completed using a double ring infiltrometer. A simplified falling-head technique was used following the procedure outlined by Bagarello et al. (2004). In the fall crop samples were taken in conjunction with the time of swathing. Three sq m samples were collected from each plot. The samples were then dried, threshed, cleaned, and the grained weighted to get a determination of crop yield.

Results and Discussion

Penetration resistance is a rapid measurement of soil strength effective in identifying the impact of a tillage operation and or compacted layers within the soil. Looking at the control (Figure 3) there is no evidence of compaction in these soils. The chernozem had greater soil strength at depth compared to the vertisol (Figure 3). This is best explained by soil texture. Clay content decreases penetration resistance while sand and silt content increase penetration resistance (Kumar, 2006). The normal treatments were the most successful at loosening the soil and the spring treatment was slightly more effective than the fall operation. A result of sampling shortly after the spring paratilling occurred. Penetration resistance should be closely linked with bulk density.

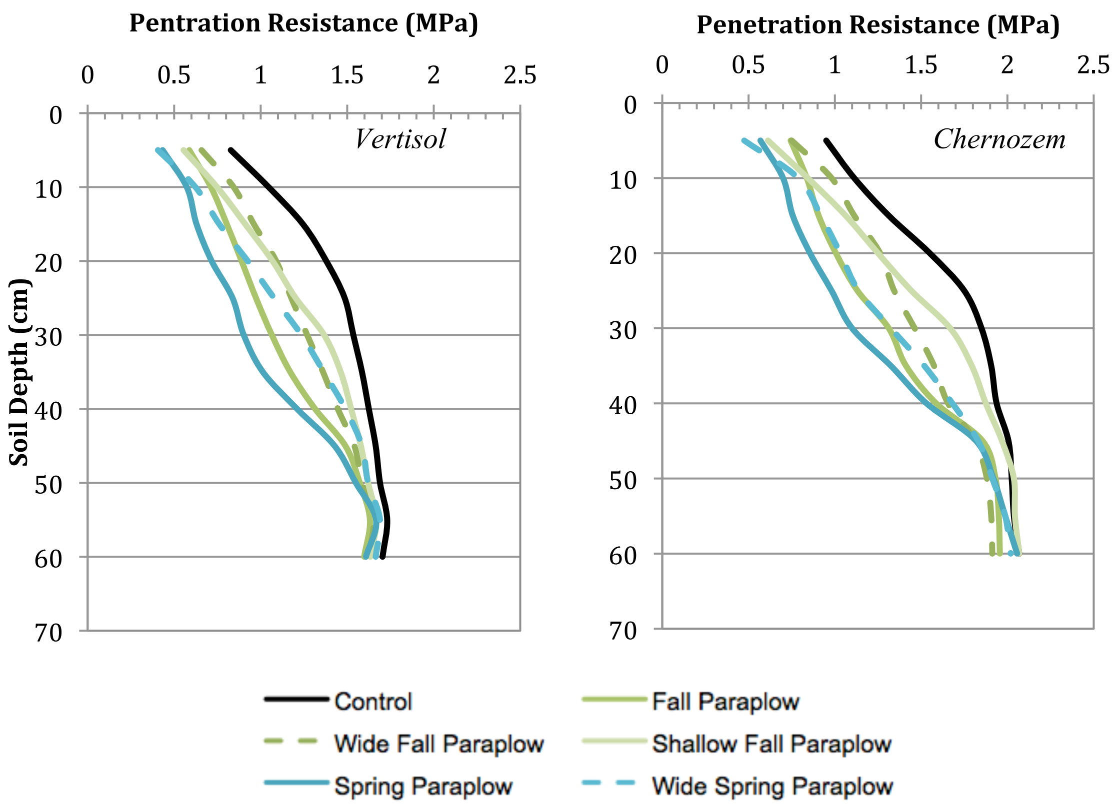

Figure 3. Penetration resistance measurements at sites taken in Spring 2010

Increased bulk density was observed in the tillage zone immediately after paratilling (Figure 4). However, at the Vertisolic site, the tillage effect was short lived. Bulk density sampling in the spring revealed some settling had occurred in the fall paraplow treatments relative to the spring treatments a result of freeze thaw cycling and clay swelling from the initial intake of water from snow melt. This effect was relatively small and not at level that is significant. Unfortunately no soil samples were collected from the chernozemic site in the spring due to unusually wet field conditions.

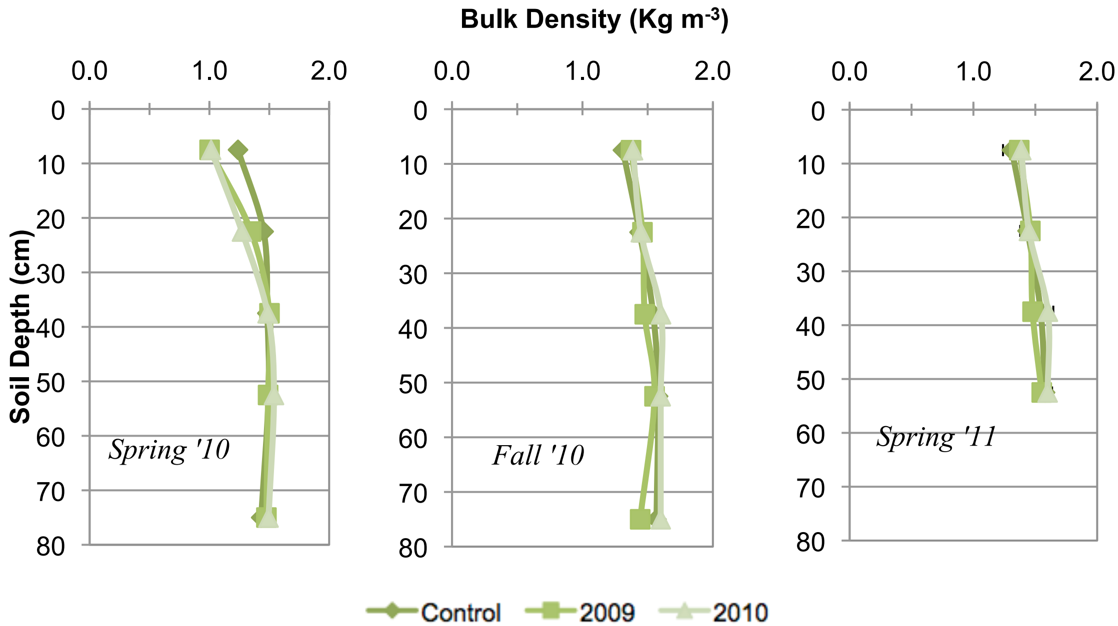

Figure 4. Bulk densities observed at Vertisolic site

The fall sampling showed that much of the soil loosening benefit had been lost in vertisolic treatment. This suggests the tillage effects from paratilling may not persist throughout an entire growing season in soils with high clay content. This could also be a result of the excessively wet soils and a longer lasting effect may be observed under more typical conditions. The chernozem showed some evidence that the loosening effects lasted the full growing season (not shown).

Infiltration measurements showed similar results to the bulk density measurements. Paraplowing did cause sufficient fracturing of soil structure to have an effect on the porosity of the soil. An increase in total porosity means an increase in the macroporosity (Grevers and de Jong, 1992). Macropores are responsible for drainage in the soil that effect K_{fs}, as observed in the study (Figure 5). At the chernozemic site, both normal paraplow treatments showed an increase in K_{fs} of two orders of magnitude, over the control. The degradation of the tillage effect was evident in the vertisol where the fall treatments were not significantly different from the control. A high degree of variability was observed in the shallow treatment, which may have been a result of an uneven seedbed left from subsoil tillage. The uneven seedbed was not observed in the other treatments.

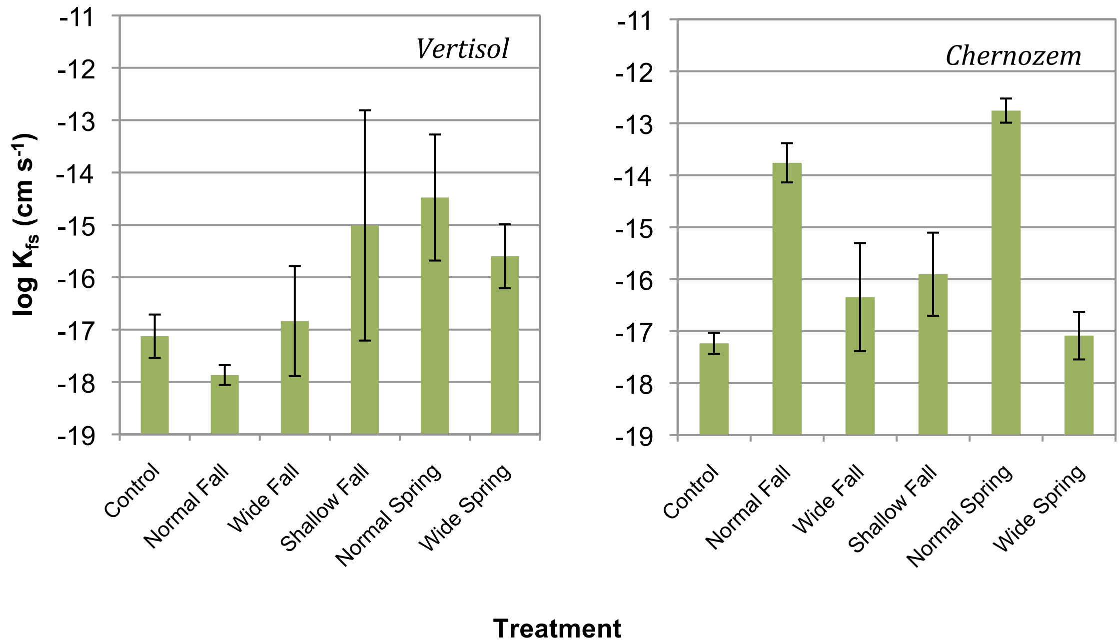

Figure 5. Field saturated hydraulic conductivity (K_{fs}) at the Chernozem and Vertisol observed July 2010

In the 2010 growing season, little yield benefit was observed from paraplowing. Hybrid Canola was grown on vertisolic site and Hard Red Spring Wheat was grown on the chernozem. Most of the paraplow treatments out-yielded the control by not at a significant level. The exception would be the shallow treatment that yielded the lowest at both sites and be explained by the poor seedbed conditions. In 2011, crop samples were taken only from the control and normal paraplowed treatments and again no yield benefit was observed.

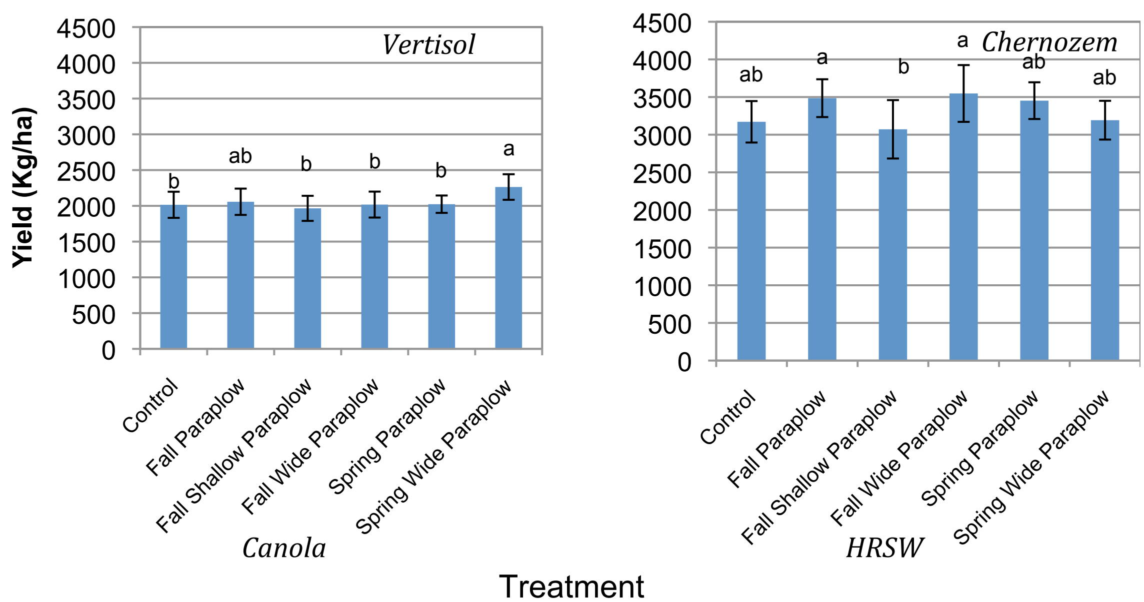

Figure 6. Crop Yield at sites in 2010

Conclusion

Subsoil loosening by paratill, increased porosity and infiltration, and decreased soil strength. All soil physical properties that could potentially impact plant growth. However, the changes to the soil physical properties had little effect on crop yield in year one and two. It is possible that the effects from paratilling were diminished by the unusually wet conditions in the spring of 2010, or that the soil structure was not limiting crop growth at these sites. Due to the high costs of this intensive tillage operation, it is not feasible to engage in this type of operation without realizing a yield benefit. Under drier conditions or in soils with a distinct compacted layer a yield benefit may be observed.

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