

# **Subsoiling an Irrigated and Dryland Brown Chernozem: Effects on Soil Density, Moisture, Yield and Economic Return**

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## **Abstract**

There has been a renewed interest in subsoiling among agricultural producers in Saskatchewan, looking to improve soil water management and crop yield. Subsoiling in this study was performed using a Paraplow (Howard Rotavator). Evaluating the tillage effects of subsoiling, looking at changes to bulk density and moisture, and crop yield. Paraplowing reduced bulk density and its effects persisting over multiple field seasons. The changes to the soil physical properties also had an affect on crop production, observing variations in grain yield in the dryland cropping system, but no measureable effect in irrigated systems. It is important to also consider if the operation is economical. Without a multi-year yield benefit it is difficult recover the costs of the operation.

## **Introduction**

Paraplowing is a form of non-inversion subsoiling sought after by producers for its effectiveness at loosening soil structure without compromising the soil conservation practices that are already employed on the farm. 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. Creating a soil environment with fewer limitations for plant growth. This study aims to evaluate a subsoiling using a Paraplow, a bent leg subsoiler producer by Howard Rotovator. Observing how it modifies the soil structure by looking at soil bulk density, moisture content, and crop response to determine if there economic benefit to subsoiling in Saskatchewan.



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

## **Materials and Methods**

A study area is located near Birsay, SK. Two sites were established on quarter section outfitted with centre pivot irrigation system (SE-18-24-7-W3). One site located within the outside span of the irrigation system and the other within a dryland corner on the quarter section. This contrasts the effectiveness of paraplowing between the two water management systems. Each site was set up in a randomized complete block design with two treatments replicated six times. Subsoiling took place in the Spring 2011 using a 6-leg paraplow pulled with an 180hp New Holland tractor.

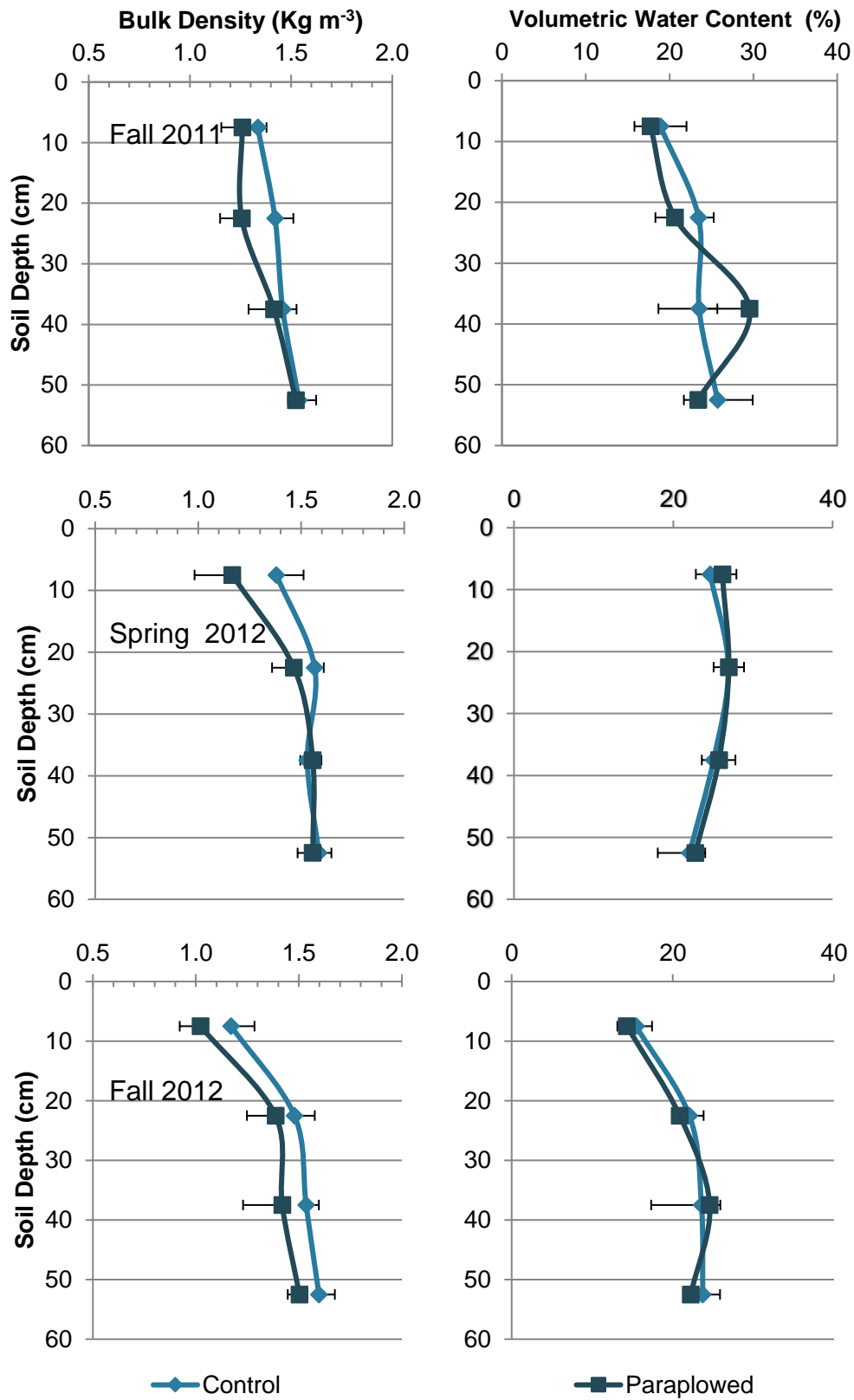
Initial background measurements were taken in the Spring 2011 before paraplowing. Treatment effects were then measured the following fall, and every spring and fall thereafter. Soil Samples were then collected for a determination of bulk density and volumetric water content. Samples were extracted using a truck mounted punch then segmented into four separate sections: 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm. Bulk density was then calculated for each of the segments using their specific volume, weight, and water content, determined in the lab. For the crop measurements, Three sq m plant samples were collected from each plot. The samples were then dried, threshed, cleaned, and the grain weighted to get a determination of crop yield.

## **Results and Discussion**

### *Bulk Density & Volumetric Water Content*

Bulk Densities were reduced initially from the tillage operation at both the dryland and irrigated sites, with the tillage effect eroding over time. Bulk densities were significantly reduced in the 15-30 cm soil segment and to a lesser extent in the 0-15 cm soil segment ( $p \leq 0.1$ )(Figure 2). The 0-15 cm measurements are high variable due to surface dynamics and environmental exposure, which mask some of the effects from the paraplow. The bulk density measurements remained significantly different from the control up until the fall 2012, when there was no significant effect observed at the Dryland site (Figure 2). A significant effect was observed at only the 15-30 cm measurement in irrigated site. This may suggest that the tillage effect may persist longer under irrigated conditions as the soil endures fewer wet-dry cycles throughout the season compared to a dryland cropping system. Provided that the soil is not completely saturated for an extended period as was observed in a previous study.

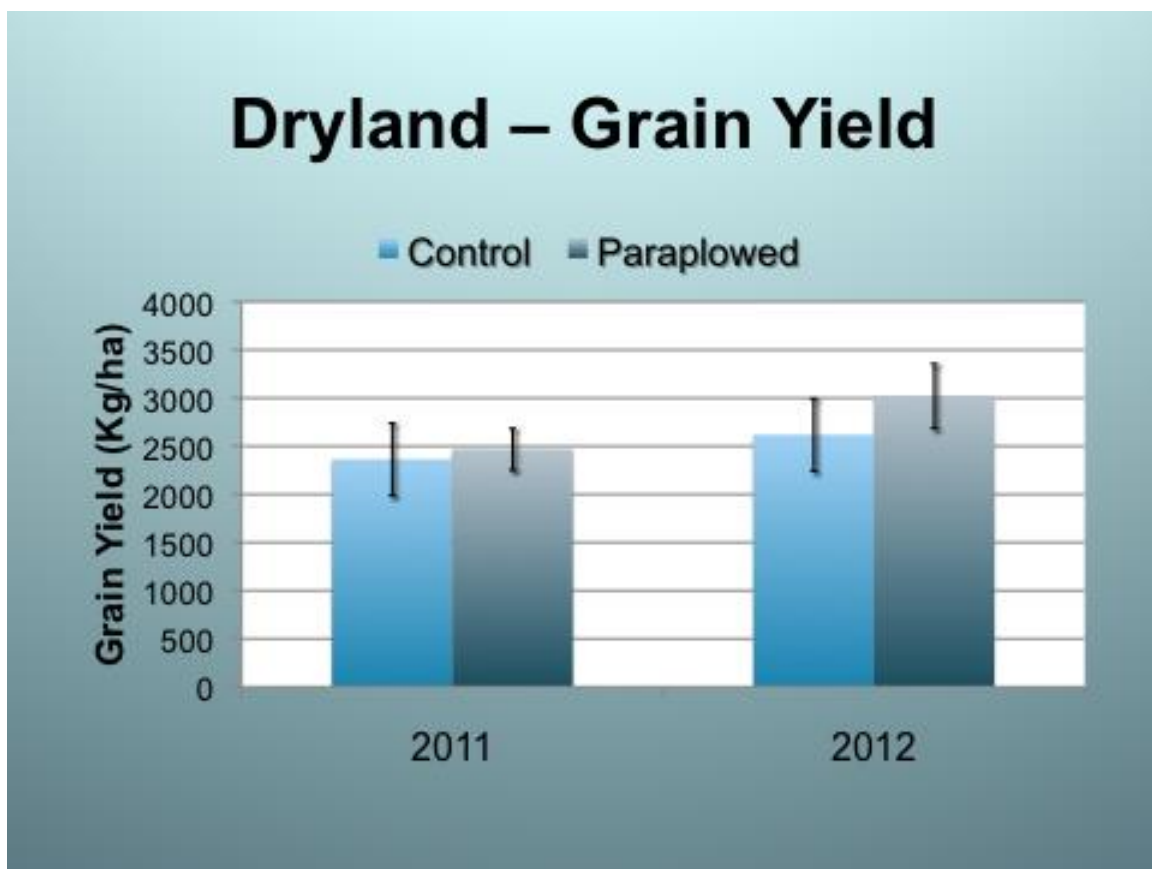
Little difference was observed in the moisture contents between treatments and the control (Figure 2). Differences in moisture content were observed between seasons and sites. With the soils being more saturated in the spring due to the moisture addition from snow melt. The irrigated site had higher moisture content throughout the profile compared to the dryland site (Not shown).



**Figure 2.** Summary of Soil Density and Moisture at the Dryland site (Error Bars = SD)

### *Crop Yield*

Soil loosening and soil structure do not directly influence crop yield but can effect plant rooting and affect the plants ability to effectively access water and nutrient from the soil (Arkin & Taylor, 1981). Because there is not a direct link between soil loosening and crop yield, variable effects on crop yield were observed. Flax was grown on the sites in 2011 and Hard Red Spring Wheat was sewn in 2012. Soil Loosening had the greatest impact on the crop yield at the dryland site (Figure 3.). With a significant yield increase observed in yield measurements in both years of the study. Little or no yield effect was observed at the irrigated site (not shown). This suggests that soil structure has little effect on crop yield when soil water is adequate for crop growth.



**Figure 3.** Summary of grain yield at the dryland site (2011- Flax, 2012 – CWRS)

## *Economic Analysis*

The cost to subsoil is highly variable due to the various sizes and power ranges of implements. Subsoiling implements range in working widths from 1 to 10 m in width, and have power requirements ranging from 40 to 500 hp. A rough estimation of the cost is \$50 per acre, but to understand the real cost it would have to be calculated for the individual operation taking into account equipment size, horsepower requirements as well as intended annual acreage. The cost of tillage will determine the breakeven cost when estimating an economic return.

When calculating the economic return you must consider: crop type, yield, and price. Your net return will vary depending on these factors. Varying crop types have different responses to subsoiling. Generally crops with course roots such as tuber and legumes crops are the more sensitive to compaction and have the greatest potential for a yield response from subsoiling (Arkin & Taylor, 1981). While crops with fine root systems are affected to a lesser extent by compaction and have a lower potential yield benefit (Arkin & Taylor, 1981). The value of the crop is also important. Crops of higher value will require a lower yield benefit to be profitable compared to a lower value crop. Ideally, when timing your subsoil tillage operation, plan to do it prior to a high value, course-rooted crop for the maximum benefit.

Crop price and yield are the most important factors to calculate the economic return from subsoiling. When grain prices are high, any investment that enhances crop yield will pay high dividends. It becomes easier to payoff the high initial cost of subsoiling, but other investments such as more fertilizer or fungicide application may achieve the same goal at lower cost. When grain prices are low, it becomes more difficult to pay of the initial cost subsoiling. Requiring a higher yield response or multi year response to achieve an economic return. Looking at the tillage and cropping system used in this study there was no economic benefit to paraplowing irrigated land and it required two cropping years to payoff the subsoil tillage on the dryland.

## **Conclusion**

Soil loosening can impact crop yield. The physical changes to the soil applied by the paraplow had little affect on crop yield when soil structure is not limiting and water is readily available. Like in an irrigated cropping system. Wet-dry soil cycling seems to have an effect on the persistence of the tillage effect. Subsoiling my not be economical in all cases, carefully consideration should of all options should be employed before engaging subsoiling activities, with the greatest potential for a return in compacted soils.

## References

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