The UofMN/MSR&PC Drainage and Tillage Research Site: Enhancing Soybean Production with Residue Management and Cover Crops

A final report to the Minnesota Soybean Research and Promotion Council

May 30 2024

Seth Naeve and Anibal Cerrudo

About this report:

This report shall serve at the final report to the Research Action Team of the MSR&PC for the 2023 funded project with the above title. The MSR&PC has graciously funded soybean research at the UofMN/MSR&PC Drainage and Tillage Research Site since 2012. As of 1 May 2024, research at this site has begun to evolve toward providing real-world research data about common production practices including, but not limited to, tillage, drainage and residue management on soil carbon and soil health with potential impacts on carbon markets and Carbon Index (CI) scores. Much of the systems and treatments employed at the site will remain the same, but the work will focus on evaluating claims of management-based impacts on monetizable factors such as carbon sequestration and CI scores.

Therefore, this report will both provide a final report for the 2023 research project and a partial summary of some of the highest-level research findings at this site over the past three years. We will not present data from management effects on soil properties, treatment effects on soybean establishment, nor will we discuss treatment effects on grain quality here. We will not highlight effects on corn yields, but we will discuss soybean yield affects here. Additional detailed reports will be forthcoming that both describe the previous three years' findings in detail but will also cover high-level findings from the previous twelve years. Master's student Carlos Sanchez is currently wrapping up his thesis, from this work we will create more thorough reports for the MSR&PC over the next six months.

Summary:

While soybean is thought of as a highly competitive and resilient crop, early-season growth and development is critical to maximizing yields. Early planting is important, but it is early spring vigor and growth rates that determine yield potential. In other words, planting dates have little effect on soybean yields, but emergence dates and early season vigor do. Rainfall patterns have shifted significantly, making very heavy rainfall events more frequent, thus making drainage, tillage, and residue/cover crop research critical.

This research utilized a wide range of contemporary crop management scenarios to examine many aspects of temperature, water, and nutrient availability, and their effects on early-planted soybean. We utilized the existing Drainage x Tillage research site near Wells, Minnesota to investigate the effects of residues on early-planted soybean. We also carefully examined the three-way interactions between residue quantity and quality, tillage, and drainage.

By including residue removal and cover crop treatments, we investigated the effects of residue level on all aspects of both early-season and season-long soybean growth. This represents a first-of-a-kind experiment to evaluate effects of drainage, tillage, and residue on soil temperatures, moisture, and nutrient availability at the seed and in the rhizosphere from planting through harvest (detailed results are forthcoming).

Results:

Weather: The growth seasons from 2021 to 2023 were characterized by unique weather and climatic conditions and precipitation patterns. Importantly, each of these three years exhibited abnormally dry periods at some time during the crop cycle. This unusually dry period perfectly overlapped with this three-year project and had direct and important impact on the results described here.

Soybean yields: Across the three years, grain yield for soybeans showed significant statistical differences between drained and undrained soil conditions (Table 1). However, the actual disparity in soybean grain yield between Drained (72.6 bu/ac) and Undrained (70.3 bu/ac) conditions was relatively minor, amounting to only a 3.1% difference. The lack of a greater increase in soybean yield due to drainage is potentially attributable to the influence of abnormal environmental conditions experienced throughout the term of this work, particularly variations in precipitation.

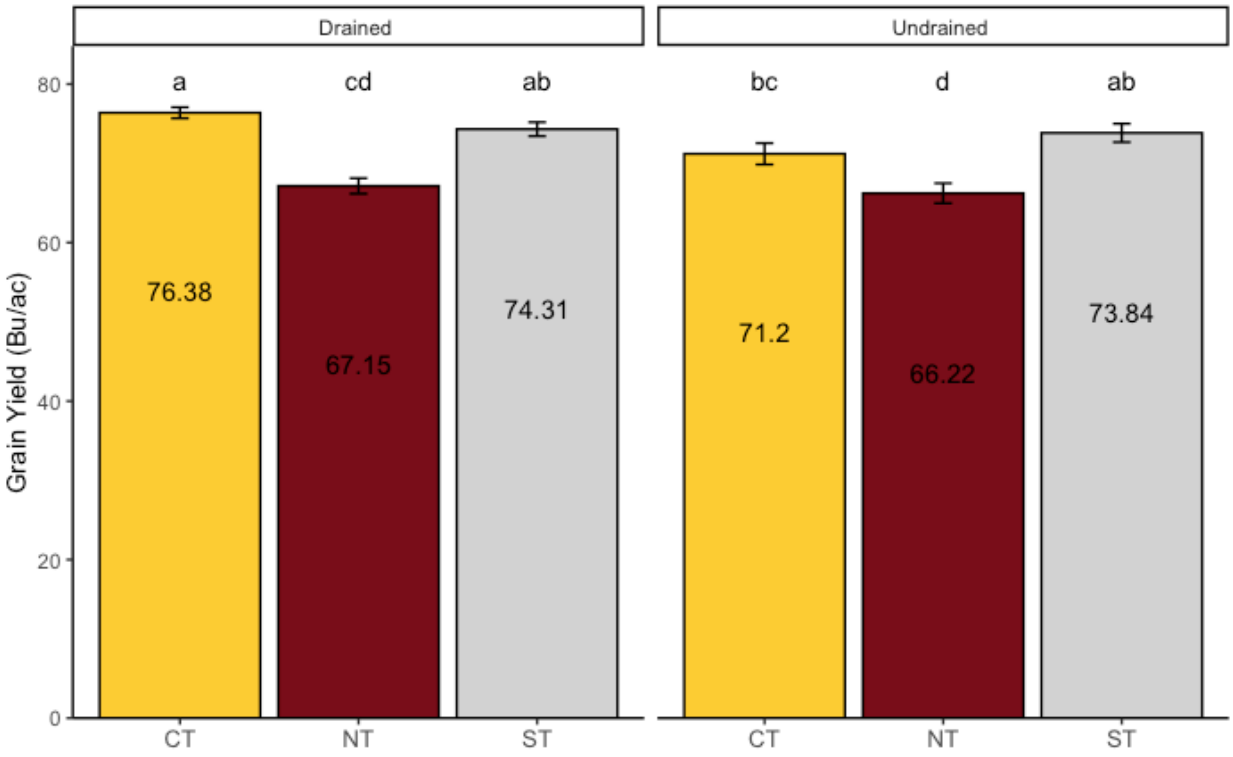
Among soybean yields from tillage treatments, averaged across other main effects and years, Strip Till (ST) and Conventional Till (CT) produced ~8% more grain when compared to No Till (NT). When examining the practice of corn stalk residue management implemented in this study, it was found that across all other treatments, the removal of corn residue increased soybean yields by as much as 2.5 bu/ac, which is equivalent to an increase of 3.6% relative to no residue removal. This increase in yield is partially attributed to a relatively early emergence of the seed.

Table 1.

Management variable		**Soybean Yield (bu/ac)**	
Drainage (D)	Drained	72.6	a
	Undrained	70.3	b
Tillage (T)	CT	73.9	a
	ST	74.2	a
	NT	66.8	b
Residue (C)	No-Residue	72.7	a
	Residue	70.2	b

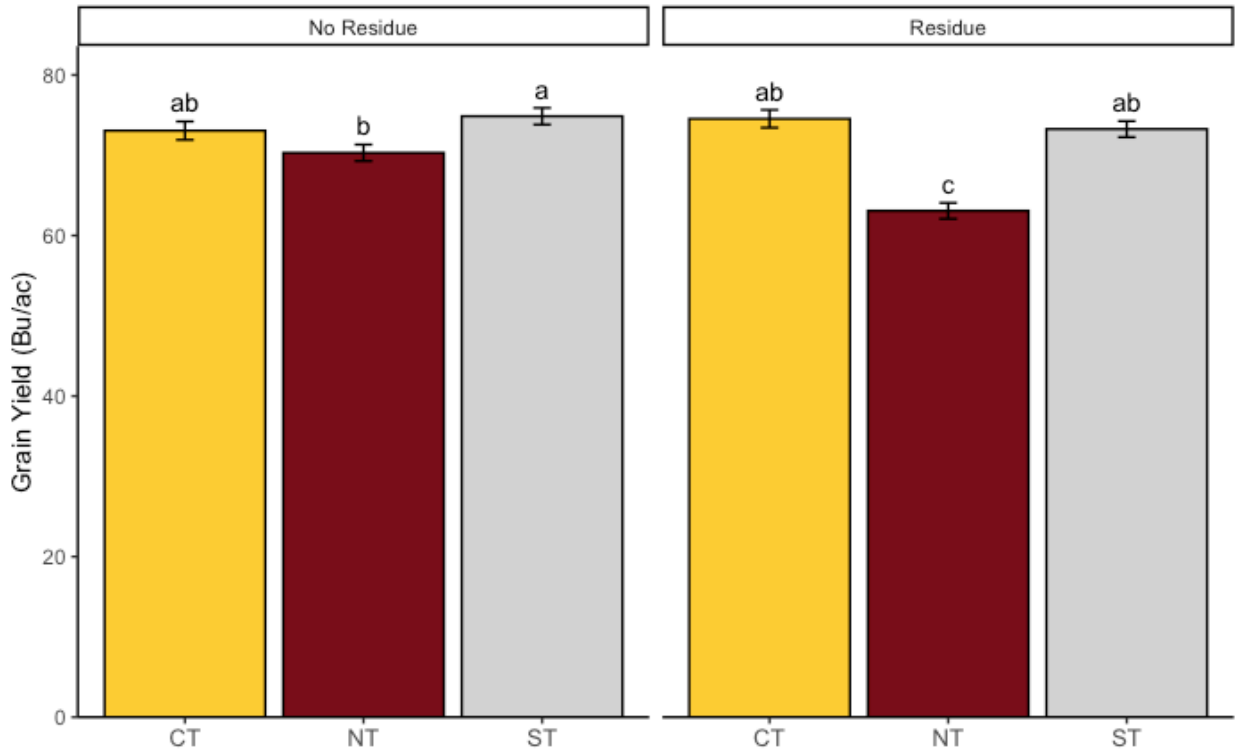
The interaction of drainage × tillage significantly influenced soybean grain yield. Under Undrained conditions, both CT and ST resulted in similar grain yields (71.4 vs. 74.1 bu/ac). Similarly, in Drained soil conditions, CT and ST produced comparable yields (76.6 vs. 74.5 bu/ac) (Figure 1). However, treatments involving no-till (NT) resulted in an average 8.1% reduction in yield, which is a significant decline. Significant interactions were a result of very small shifts in yields between CT and ST between drained and undrained where CT yielded slightly more under drained conditions while ST yielded slightly more under undrained conditions. Also, NT yielded similarly across drainage conditions, but CT and ST yields increased on drained soils.

Figure 1



There was also a significant tillage x residue removal interaction (Figure 2). This interaction shows up in the analysis because NT yields are much reduced relative to ST or CT in instances without residue removed. Where cornstalks were removed in the prior fall, NT yielded less numerically, but statistically similarly to the two tillage treatments.

Figure 2

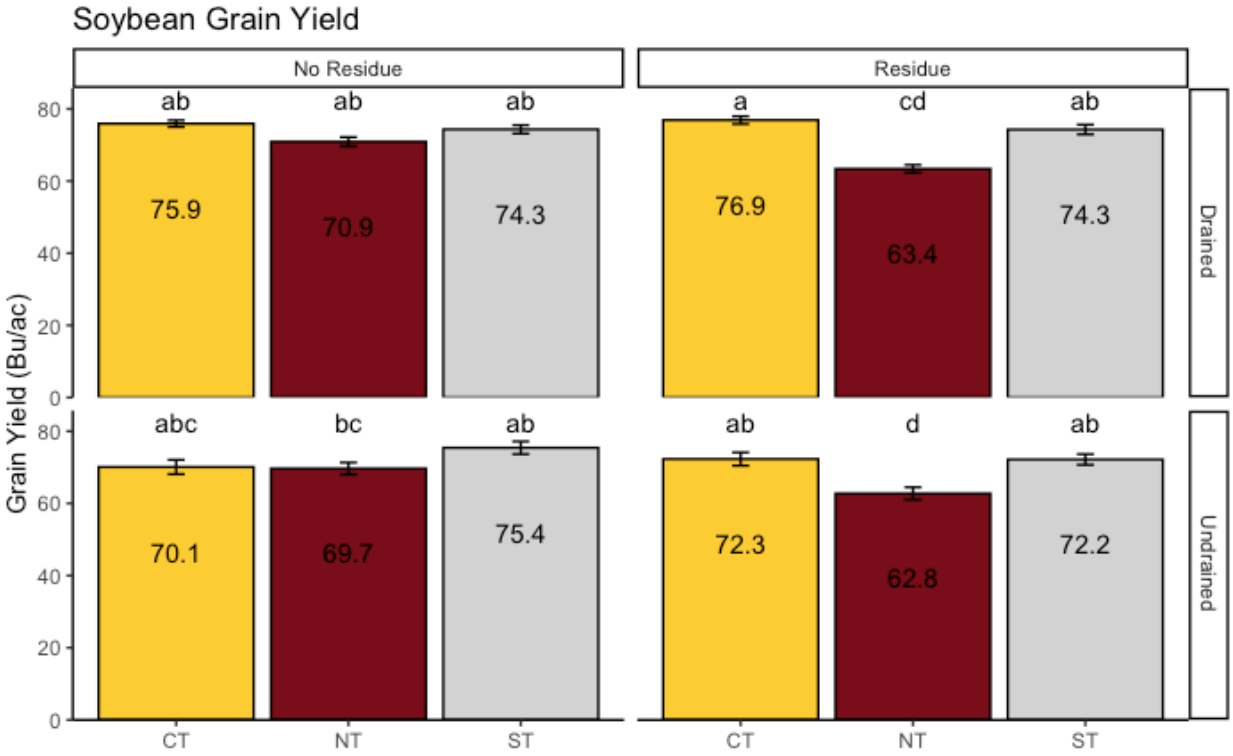


A good summary for the yield results from this work can be seen clearly in the three-way interaction among drainage × tillage × residue treatments in Figure 3. Statistically, this three-way interaction was not found to be significant, but the corresponding figure provides a convenient overview of the large yield effects of the primary (main effect) drivers such as tillage and the smaller interactive effects of drainage and residue management that were provided in figures 1 and 2.

Beginning with the largest single effect, tillage, one can easily see that yields were significantly penalized by NT. In these three (dry) years the yield penalty was only slightly different across drained and undrained conditions. Residue on the other hand played a much larger role in moderating the effects of NT on soybean yields. When soybeans were planted following the removal of residue (to simulate the common practice of baling corn stalks in the fall), yield reductions were much smaller. In fact, while there was a numerical decrease in yields (of 3.6 bu/ac), yields were not significantly lower in NT than ST or CT following residue removal. In contrast, soybean yields decreased by 11.0 bu/ac when comparing NT with ST and CT with residue. This no till penalty equates to a 15% yield hit under residue but only 5% following baled stalks. To describe the residue effects with other words, residue had no effect on the following soybean yield as long as the plots received either ST of CT.

When comparing ST and CT, it is very difficult to identify any hints of yield differences between these practices in these three years. These yielded similarly under both well drained and poorly drained soils as well as across residue vs no residue treatments.

Figure 3



Conclusions:

This long-term project has offered a very wide breadth of important research findings over the years, but this annual report could not do justice to the volume of work and findings. Therefore, we are presenting only soybean yields for the previous three years here. Stay tuned for detailed research reports coming out over the next six months that include soil and plant growth measures as well as corn yields analogous to those presented here.

This report also outlines yield results from the unusually dry years of, 2021, 2022, and 2023. While the timing of drought varied by year, late season drought certainly reduced yields at this site in each of the years. Every single result provided here must be interpreted through the lense of the unusually dry conditions that predominated during this period. However, it should not be forgotten that each year did haver periods of rainy weather, and these periods too varied by year.

Despite conducting this work in droughty years, artificial drainage did increase yields by 2.3 bu/ac relative to undrained soils. No till produced soybean yields that were more than 7 bu/ac lower than strip till or conventional till. The two latter tillage systems did not differ in yield. Removing corn residue in the fall increased soybean yields; however, this yield increase came almost entirely from differential effects on soybean yields under no till. Conventional till and strip till yields were not affected by residue removal.

<u>Key findings in 2021-2023:</u>

- Artificial drainage increased soybean yields even in dry years
- Strip till yielded nearly identically to conventional till in every scenario
- No till produced much lower yields that strip or conventional till
- Yield reductions from no till can be ameliorated (or nearly so) by removing cornstalks in the fall