Everyone wants something for nothing:
Is there any hope for cover crops or double cropping in Minnesota?

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Seth Naeve and Anibal Cerrudo

Summary:
This study investigates the feasibility and economic viability of cover crops and double cropping in Minnesota, focusing on optimizing soybean yield. Conducted at the St. Paul Campus, UMN, the research compared conventional soybean cropping with cover crop systems and double cropping systems following winter barley and wheat. Results showed significant yield losses primarily due to planting delays, with cover crops and double cropping leading to average soybean yield reductions of 20 bu/ac and up to 60 bu/ac, respectively. Despite these losses, double cropping offers the benefit of an additional cereal grain harvest. Further research under rainfed conditions and collaborations with farmers are essential to adapt these practices to real-world farming, aiming toward sustainable intensification of cropping systems.

Introduction:
In the quest for sustainable agricultural intensification, increasing production per unit of land without compromising future capacities is crucial. This can be achieved by boosting the yield of a single crop or by intensifying crop sequences. Soybean, known for its yield plasticity, has been identified as a key crop for system intensification. Cover cropping, offering multiple benefits, is one promising practice. However, for these solutions to be widely adopted, they must be economically viable. Thus, double cropping presents another potential alternative for Minnesota farms. Yet, comprehensive data to evaluate the benefits or costs of these practices remain limited, establishing a challenge in objectively assessing their impact.

This project aimed to refocus on the primary cash crop—soybean—to identify the best cultural practices that maximize yield under each cropping system and compare them against the traditional sole soybean crop. We assessed best management practices for soybean following cover crops and for soybean in double cropping systems after winter barley and wheat, which are feasible alternatives for local systems. Contrasting maturity ratings and inter-row spacing configurations were tested for each cropping system. The goal was to establish objective comparisons to determine the gains and losses in soybean production from these cropping systems. Specifically, we wanted to answer: Which maturity rate and inter-row spacing maximize soybean yield for each cropping system? and then - Under best management practices, what are the costs and benefits of each system compared with the conventional soybean sole crop cropping system?

Methodology:
We conducted a controlled field experiment at the St. Paul Campus, UMN. Crops were grown in the absence of water, nutrients, or biological stress. Winter wheat was planted the previous fall and was used to simulate the various cover or double crops. Wheat was desiccated prior to planting each of the soybean systems. Soybeans were planted under no-till conditions into remaining crop residues at each date. Planting dates for the conventional system followed local recommendations (May 10th), while for the cover crop system, soybean was planted at the end of May, linked to a cover crop biomass target of 1.6 tons per acre. For the double cropping system, planting followed the harvest dates of winter barley and winter wheat (Table 1). We evaluated short and long soybean varieties with 30-inch and 15-inch inter-row spacings.

Table 1: Assessed Cropping Systems Description

Treatment	Cropping system	Planting date	Variety	Maturity group		Inter Row spacing (in)
2	conventional	10-May	AG15XF2	short	1.5	30
3	conventional	10-May	AG26XF3	long	2.5	15
8	cover crop	31-May	AG10XF1	short	1.0	15
7	cover crop	31-May	AG15XF2	long	1.5	15
10	barley double crop	28-Jun	AG06XF3	short	0.5	30
9	barley double crop	28-Jun	AG10XF1	long	1.0	30
14	wheat double crop	14-Jul	AG01XF3	short	0.1	30
15	wheat double crop	14-Jul	AG06XF3	long	0.5	15

Results:

We estimated the impact of maturity and inter-row spacing on soybean yield across different cropping systems. Yields for the conventional system under the assessed conditions approached 100 bu/ac (Figure 1). No significant effect of inter-row spacing was observed in any cropping system ($p>0.05$). Soybean maturity group had a relatively low impact, becoming significant only in the wheat-soybean double cropping system, in which the shorter maturity presented a yield advantage (Figure 1).

Soybean yield loss following a cover crop was approximately 20 bu/ac (or an average reduction from 104 to 82 bu/ac). In our experiment, this yield loss was primarily due to the delay in planting and its impact on the capture and use of radiation. We used the generated data to calibrate and validate a simulation model, which predicted a potential yield loss of 0.4 bu/ac per day of planting delay during May (Figure 2). Soybean yield loss could be seen as a cost for this system and additionally, the cost of implementing a cover crop includes current expenses associated with integrating the cover crop into the system (seed, planting, herbicides). We utilized potential (without stress) growing conditions; however, it is important to note that the occurrence of water stress can lead to an increased impact of the cover crop on soybean yield. This extra cost could arise, for instance, if a portion of the water used by the cover crop during the spring could have been available for the soybean during critical growth stages in the absence of the cover crop. Conversely, water scarcity could create scenarios where the cover crop can enhance the soybean yield by improving water infiltration and reducing part of the evaporation from the evapotranspiration process.

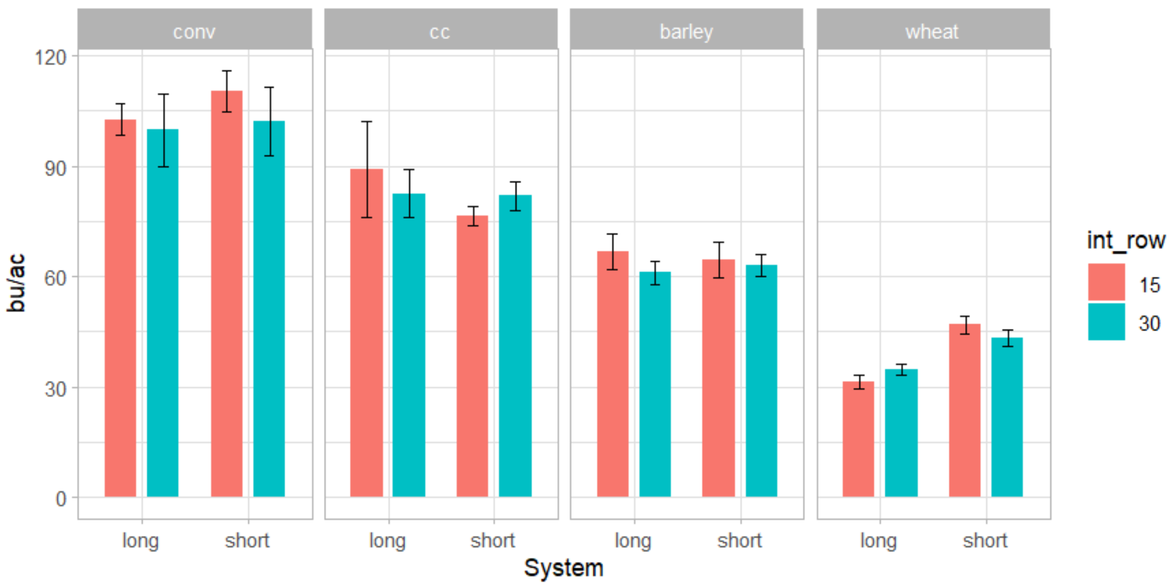

Figure 1: Soybean yield for different maturity group varieties under different inter row spacings for four different cropping systems: sole crop, cover crop, barley-soybean double crop, and wheat-soybean double crop. Experiment was conducted at St Paul Campus UMN under potential conditions during 2023.

Yield losses for double cropped soybeans after barley and wheat were approximately 40 and 60 bu/ac, respectively, higher compared with the yield depression generated by the cover crop. Field costs for double cropping are also expected to be higher than those for cover crop because of the barley or wheat cost impact that include fertilizer and harvest costs. However, the soybean component cost should be lower than sole soybean crops. The key difference comparing with the cover crop is that in the case of the double cropping, we should consider an extra benefit. This is the amount of grain produced by any of the winter crops, that under potential conditions should be above 90 bu/ac. In addition, the grain quality becomes relevant to determine the benefit, especially for barley, since its price is significantly influenced by the end use (malting barley vs feed).

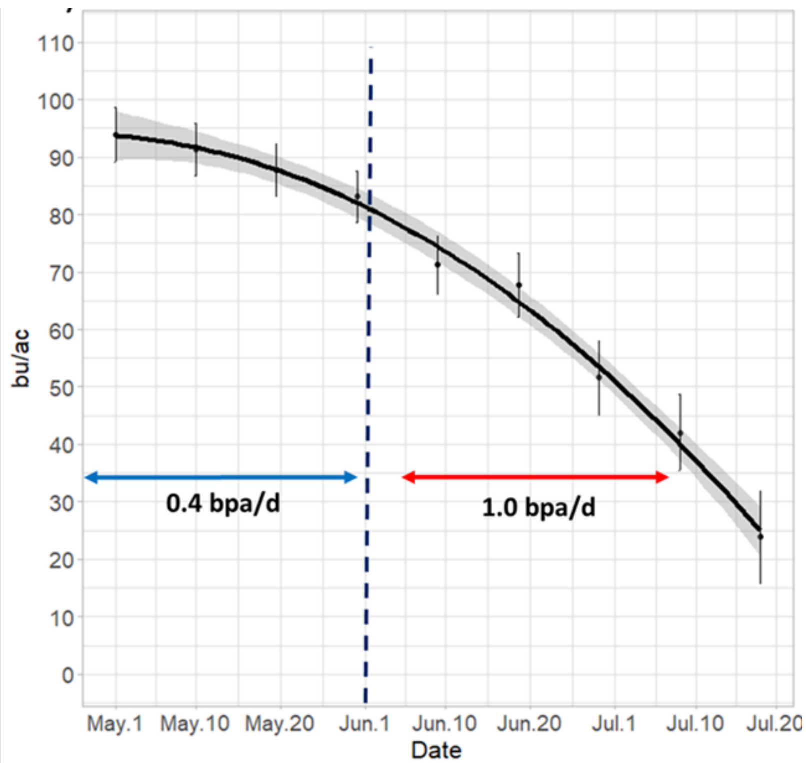

Figure 2: Potential soybean grain yield as a function of the planting date for St Paul MN. Data were simulated using a crop model (Cropgro) calibrated and validated with local data generated under this project.

Again, the main factor contributing to soybean yield depression for the double cropped soybean was the delay in the planting date (Figure 2). Yield depression becomes more pronounced with each day of planting delay after mid-June, with losses exceeding 1.0 bu/ac per day of delay. These results underscore the critical importance that the winter crop's maturity date, the dry down rate, and the interval between the winter crop harvest and the soybean planting date would have in these double cropping systems in Minnesota.

Results also indicated that the effect of the maturity group could be relevant for these double cropping systems in which the remaining growing season for the soybean after planting is very limited. Regarding the inter row spacing, our results indicated that, at least under potential growing conditions, soybean has the plasticity to cover the soil and attained to intercept all the incident radiation during the critical reproductive stages. However, it is worth noting that the vegetative plasticity of soybean is notably affected by water availability. Therefore, we can still expect a positive response to narrow rows in environments with water stress in the initial stages of the crop.

As a departing point, here we assessed these contrasting cropping systems under potential conditions, that has value for some highly productive environments and for future modeling purposes. There is now a need to evaluate these systems under rainfed field conditions in which water stress can be a yield limiting factor. Particularly, double cropping has been frequently described as a more stable cropping system compared with the sole crops, this aspect could be relevant in some more restrictive and yield-variable environments. There is a need for a greater understanding of the cropping systems interaction with different growing conditions. Accelerating the transition from controlled experiments to on-farm trials will help to accomplish this goal. The sooner we implement real-farm tests, the quicker we can gather valuable feedback on limiting factors and better understand how to adapt the system to the complexities of actual and local farming practices.

Conclusions:

While there is potential for cover crops and double cropping in Minnesota to enhance agricultural intensification, several challenges must be addressed. Our research highlighted the significant impact of planting delays on soybean yields, with both cover cropping and double cropping leading to substantial yield losses primarily due to timing issues. Despite these losses, double cropping offers another cash crop, and may offer more stable total productivity in variable environments. Further research under rainfed conditions is necessary to fully understand limiting factors. Collaboration between researchers and farmers is crucial for adapting these practices to real-farm conditions. By continuing field experiments and integrating farmers' experiences, we can develop sustainable and economically viable cropping systems tailored to Minnesota's diverse environments.