Wheat Cover Crop Management Impact Lingers after Corn Harvest in a Corn-Soybean Rotation

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Introduction

- According to the US Department for Agriculture, National Agricultural Statistical Service (USDA-NASS), Illinois is the largest producer of soybean (*Glycine max*) and the second largest producer of corn (*Zea mays*) in the US. The corn-soybean cropping rotation system is very popularly in the state.
- Studies done in Southern Illinois have shown nitrate-N leaching to be high after cash crop harvest, even higher following soybean harvest (Thilakarathne et al., unpublished data).
- Winter cereal cover crops (WCCC) are recommended as the best in-field management practice by the Illinois Nutrient Loss Reduction Strategy (INLRS) to minimize nutrient loss to Illinois water and the Gulf of Mexico (Sadeghpour et al., 2021).
- Winter cereal cover crops including wheat (*Triticum aestivum* L.) are often terminated 3-4 weeks prior to planting corn (early April). Delaying termination increases N uptake and decreases N leaching potential but could immobilize N during corn growing season due to increased C:N ratio of wheat (Adeyemi et al., 2020).
- While effect of late termination of wheat as a WCCC on the following corn production is well documented in literature, the possible lasting effect of the practice beyond corn in a cash crop-cover crop rotation cropping system is still very limited (Fig. 1A-B).

Experimental Design and Treatments

- Experimental design was a randomized complete block design with split plot arrangements and four replicates in 2020 and 2021.
- The Main plots were wheat CC treatments [(I) fallow (no-cover crop control) and (II) late termination], and the subplots were N treatments including (I) 0 (no-N control), (II) 224, and (III) 330 kg N ha^{-1}.

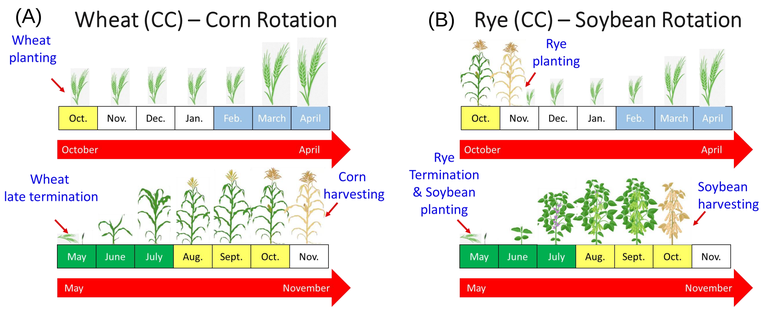

Figure 1. Schematic of wheat-corn rotation (A), and winter rye-soybean rotation (B) during a full wheat-corn-winter rye-soybean cropping system in Southern Illinois.

Acknowledgements

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Materials and Methods

- Wheat (var. AgriMAXX 446) was planted on October 8th and 14th of 2019 and 2020 respectively at 4.75 million plant ha^{-1}. Wheat was top-dressed with 34 kg N ha^{-1}. Wheat cover crop was terminated at corn planting time.

Table 1. Winter wheat shoot and root biomass, N, lignin, C:N and lignin:N ratio in 2020 and 2021.

Year	Biomass (DM) (Mg ha^{-1})		N (g kg^{-1})		Lignin (g kg^{-1})		C:N		Lignin:N	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
2020	6.81	1.21	7.46	5.91	37.95	63.69	57.36	72.16	5.10	10.52
2021	6.39	0.92	11.82	6.13	30.71	54.46	37.74	70.02	2.62	8.91

- Plots were 10m long and 3.3m wide. A no-till drill was used to plant corn (Dekalb "DKC64-35RIB") at 79,000 seeds ha^{-1} on 12 May 2020 and 2021.
- The two N fertilizer treatments (224 and 330 kg N ha^{-1}) were side dressed at V4-V5 stages of corn, on 18 June and 16 June of 2020 and 2021 respectively, in the form of liquid urea ammonium nitrate (28-0-0).
- Cereal rye (*Secale cereale*) was planted in all the treatment plots after corn harvest on 10 November 2020 and 27 October 2021 and terminated on 12 May 2021 and 16 May 2022.
- Soybean was planted on treatment plots after termination of cereal rye on May 16, 2021, and May 21, 2022. The soybean was harvested on October 13th and 6th in 2021 and 2022 respectively to complete the cropping rotation system.

Results and Discussion

Corn Phase

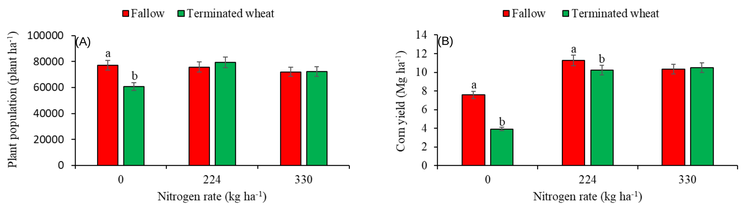

Figure 2. Corn plant population (A) and corn grain yield (B) in fallow (no cover crop control) and terminated wheat plots averaged over two years (2020 and 2021) as influenced by N application rates (0, 224 and 330 kg N ha^{-1}).

- Corn population was influenced by N rate and cover crop × N rate (Figure 2A).
- Corn population was higher in the fallow at the 0N treatment; N fertilization resulted in similar corn population between fallow and wheat cover crop treatment emphasizing the need for N to promote corn stand.
- Corn grain yield was influenced by cover crop × N rate (Figure 2B).
- Corn grain yield was lower in wheat cover crop than the fallow treatment in 0N and 224 kg N ha^{-1} indicating that soil N immobilization effect led to yield penalty in terminated wheat plot.
- Corn grain yields were similar at 330 kg N ha^{-1}.
- Our results indicate a challenge in avoiding yield penalty in corn following a wheat cover crop at optimum N rate.

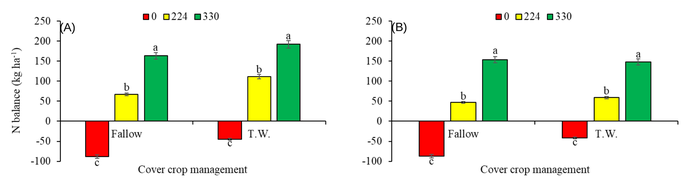

Figure 3. N balance for 2020 (A) and 2021 (B) in (no cover crop control) and terminated wheat (T.W.) plots as influenced by Nitrogen application rate; 0, 224 and 330 kg N ha^{-1}.

- N balance was influenced by year, cover crop, N rate, and their interactions (Figure 3A-B).
- N balance in the fallow plots were lower than the terminated wheat in all N rate treatments indicating higher N concentration in corn grain and higher N uptake in fallow plots than wheat terminated plots.
- This indicates that wheat cover crop captures residual N but removes less N during the corn season.

Results and Discussion

Rye Phase

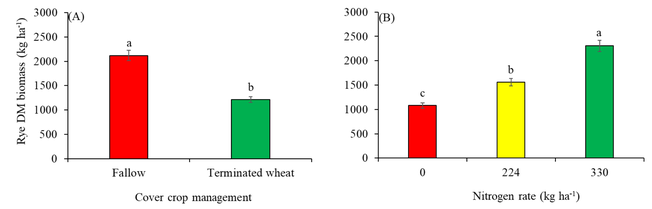

Figure 4. Rye dry matter (DM) biomass as influenced by terminated wheat compared to the no-cover crop control (fallow) (A), and rye DM biomass as influenced by N rates compared to the no N control (B).

- Rye (DM) biomass was influenced by wheat cover crop (Figure 4A) and N rate (Figure 4B).
- Lower rye biomass in wheat terminated plots indicates not only did wheat decrease corn grain yield but also its effect continued into a rye growing phase reflecting soil N immobilization.
- Increase the N rate in the corn phase resulted in higher end of season residual soil N (data not shown) which reflected on higher rye DM biomass following corn. This indicates a need for planting a winter cereal back-to-back to capture N that remains following corn harvest to decrease nitrate-N leaching losses

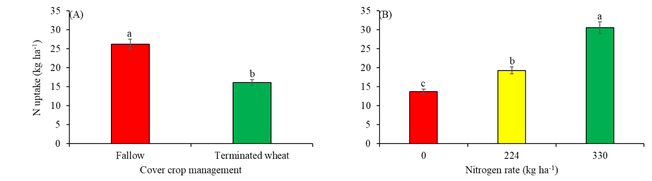

Figure 5. Rye N uptake as influenced by terminated wheat compared to the no cover crop control (fallow) (A), and rye N uptake as influenced by N rates compared to the no N control (B).

- Rye N uptake was influenced by wheat cover crop (Figure 5A) indicating wheat termination decreased rye N uptake compared to the fallow treatment due to potentially less available N and lower rye biomass.
- Rye N uptake was also influenced by N rate (Figure 5B) suggesting higher N rates during corn lead to residual N that could be captured by a cover crop like rye to avoid N losses.

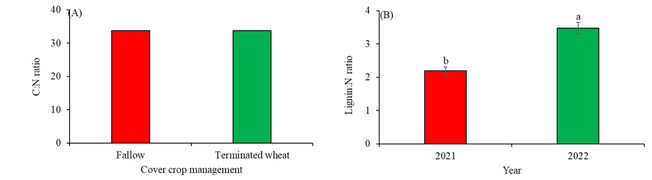

Figure 6. Rye C:N ratio as affected by cover crop treatments (A), and rye lignin:N ratio as influenced by year (B).

- Rye C:N ratio similar between fallow and the wheat terminated treatment indicating rye decomposition potentially remain similar in the soybean phase (Fig. 6A).
- Higher lignin:N ratio in 2020 than in 2021 indicate a potentially slower rye decomposition in that year that could influence soybean production (Fig. 6B).

Soybean Phase

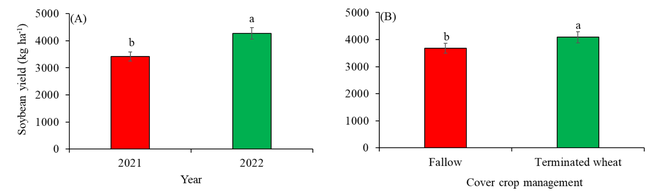

Figure 7. Soybean yield as influenced by year (A) and cover crop treatments (B).

- Soybean yield was influenced by year indicating better growth of soybean in 2022 than 2021. This is further explained by the lower C:N of the wheat cover crop in 2021 compared to 2020 (Table. 1).
- Soybean yield was higher in terminated wheat than fallow suggesting a need for economic assessment into yield loss during corn phase vs. yield gain in soybean phase by late termination of wheat.

Conclusion and Future Research

- Wheat cover crop planted prior to corn, and terminated at corn planting can help take up residual N.
- Wheat cover crop can immobilize soil N during the corn phase and its effect lingers on into the next rye phase but provides some benefit to the soybean in rotation.
- Future research should assess the long-term economic and soil health benefit of winter cereal cover crops in a cash crop – cover crop cropping rotation system.

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