Soybean Row Spacing and Planting Rate Effects on Litter Decomposition

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Introduction and Objectives

Cover crops have been rapidly adopted in Delaware, with cereal rye being a popular option for soybean production. The benefits of a rye mulch is weed suppression and soil moisture conservation, but may also cause increased pest presence and disrupt the release of nitrogen (N) to cash crops. While soybeans may not be as affected by the N cycle as corn, the mineralization and release of N in rye may also provide supplemental N to the plant mid-season. These fields may also include corn fodder from the previous cropping year, which will continue to breakdown through the soybean growing season, providing some carbon the soil surface. What is not currently known is now soybean populations and row spacing may affect the decomposition of residues on the soil surface. Earlier canopy may preserve soil moisture, allowing for increased residue decomposition, or may increase evapotranspiration reducing overall soil moisture. This study will take the first steps in measuring decomposition of residues under soybean planting densities.

Methods

Soybeans were planted at the Carvel Research and Education Center in Georgetown, DE on 05/25/23 into plots 10’ wide by 60’ long. The field contained a rye cover crop that had been terminated two weeks prior using glyphosate. Soybeans were planted at five densities (80, 100, 120, 140, 160 thousand seeds per acre) and two row spacings (15 and 30 inch) and irrigated throughout the season. Soil temperature and moisture sensors were installed in 120 and 180 seeding rate plots at both 15 and 30” in June 2023.

Additional rye biomass was collected after termination from outside the plot boundaries and corn fodder was collected from fields at the research center. Biomass was separated into decomposition bags for each plot (30 rye and 30 corn fodder), weighed, and placed back into the planted plots in the center of a row. Three subsamples of each were dried and saved to determine the initial carbon (C), N, and moisture content of the biomass. At the end of the season decomposition bags were collected from the plots, dried, weighed, and analyzed for C, N, and the biomass loss. Yields were collected with a plot combine in the late fall.

Data were analyzed in SAS as a randomized complete block design structured by a factorial including biomass loss, changes in C and N, and yield using Proc Glimmix. Yield and other factors were also correlated using Proc Corr.

Results and Discussion

Plot Yields

Similar to previous studies on row spacing at population at UD, planting at rates between 90 to 180,000 seeds per acre produced no yield differences. Modern soybean varieties have adapted to lower populations for full season beans, and traditional rates can be lowered. At each population planted, 15" rows had greater yields (6.9 bu), for an average of 68.7 vs 61.8 bushels per acre for 15 and 30" rows, respectively.

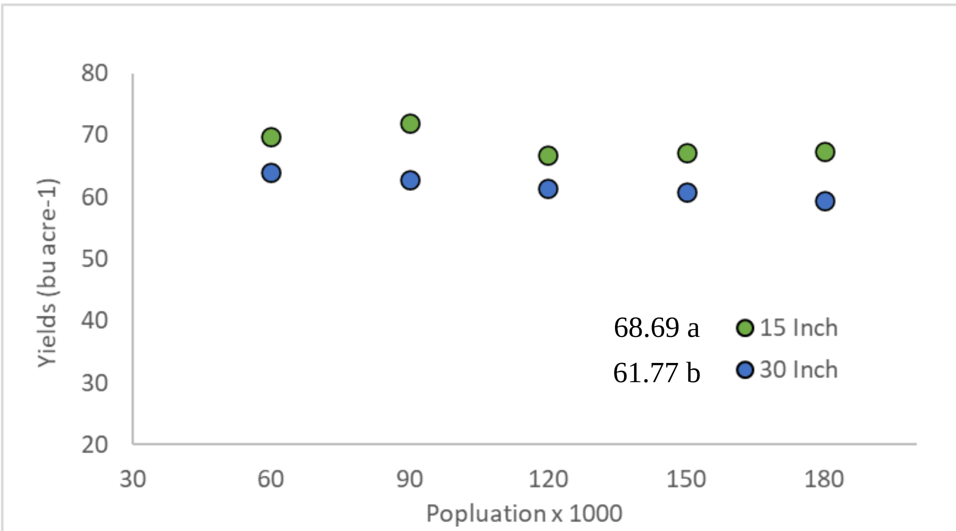

Figure 1: Yields across population and row spacing treatments from the litter bag study at the Carvel Research and Education Center in 2022. Yields were significantly different at p = 0.0001.

Overall Biomass Loss (% Weight Loss) for Rye and Corn Biomass

Both rye and corn fodder had opposite breakdown rates of expectations, with more open canopies producing greater biomass loss (Figure 2). There were no interactions between population and row spacing for either fodder type, but there were differences between factors affecting rye and corn. The rye biomass losses ranged from 60 to 80%, with the greatest loss occurring under a planting population of 60,000 seeds/acre and the lowest under 180,000 seeds/acre (Figure 2). Corn, however, had no differences with population, but had greater breakdown (42%) within 30 inch rows than 15 inch (32%). This could potentially be explained by irrigated conditions, where adequate moisture and sunlight increased breakdown. Either way it supports that residue breakdown can vary under canopies, but does not follow the initial observations from the 2021 growing season. Further examination under varying conditions will be necessary to influence breakdown of residues and incorporation of carbon into the soil.

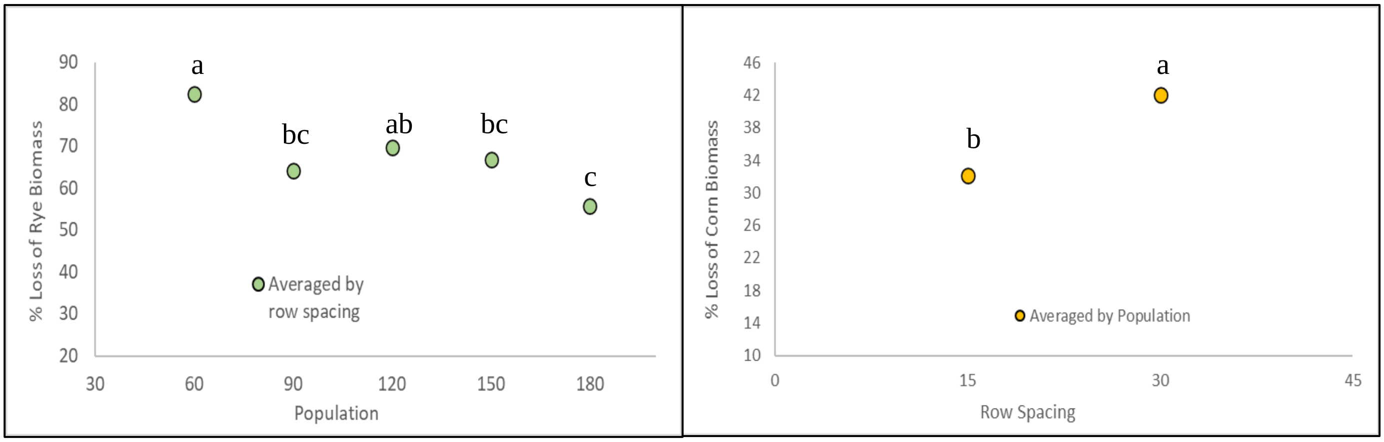

Figure 2: a) Loss in rye biomass (%) by population (averaged across row spacings) b) loss in corn biomass (%) row spacing (averaged by population). Differences are significant at p = 0.0399 and p =0.0182.

The Carbon and Nitrogen Content of the Rye and Corn Residues

There were no differences in final residue characteristics (C, N, or C:N ratio) or their changes over the season (Table 1). For the initial samples, only six subsamples were sent off, while the final samples were from thirty plots (30 rye, 30 corn decomposition bags). There is a large range in values (min to max) for all final fodder characteristics, which may represent differences in breakdown in the field, or the difficulty in getting similar C and N contents in each bag. Particularly with corn fodder, which has leaves and stalks with variable C and N contents, making it difficult to get consistent results. However, there were differences in breakdown by soybean management (Figure 2), so the differences may average out across the plots. There were also no differences by soybean treatment.

On average, the C:N ratio of the materials dropped for rye (52.7 to 21.3) and corn (65.9 to 27.93), meaning significant loss in mass occurred as carbon converting to CO_2 through microbial respiration. This is supported by the overall mass loss observed in open canopies (Figure 2).

Table 1: The Nitrogen (N), carbon (C), and C:N ratio of corn and rye decomposition bags.

Residue Characteristic	Initial Mean	Final Mean	Final Min	Final Max
Rye N%	0.88	1.11	0.26	1.60
Rye C%	46.36	23.97	4.58	40.05
Rye C:N	52.7	21.30	15.8	26.70
Corn N%	0.70	0.66	0.37	1.06
Corn C%	45.49	18.98	7.73	33.65
Corn C:N	65.9	27.93	21.20	41.50

Soil Temperatures by Soybean Planting Management

Soil moisture and temperature sensors (Figure 3) were installed in both 15" and 30" row spacings in selected population (120 and 180k seeds) plots at the beginning of June, approximately two weeks after planting when the soybeans had fully emerged. For the lower population (120k), 30" rows were slightly warmer for daytime highs in June (Figure 3a). For 120k seeding rates, the appearance of canopy closure for 15" rows is apparent after the second week in July, where the difference between day and night temperatures becomes smaller, which doesn't occur for 30" rows until August.

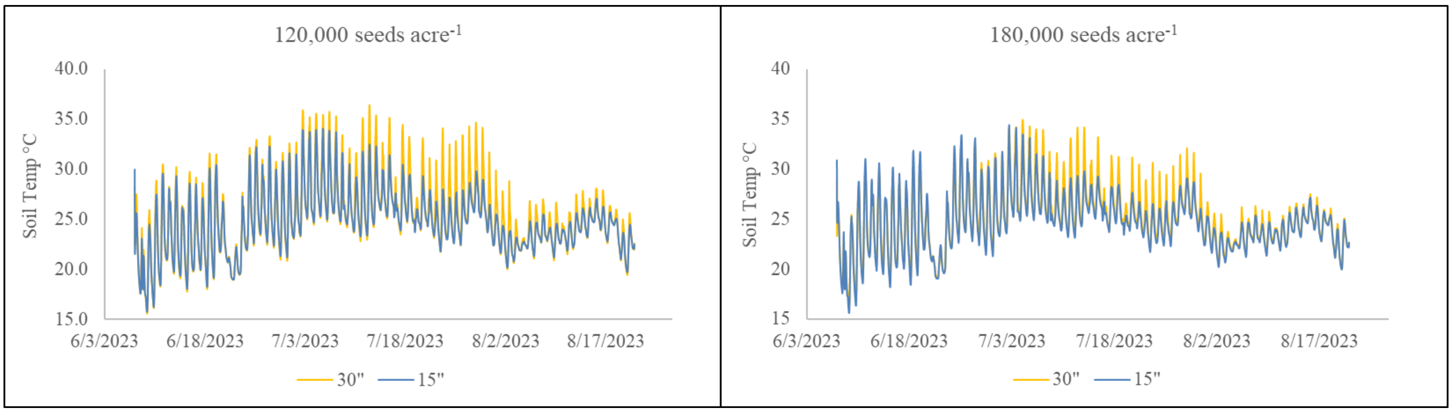

Figure 3: Soil temperatures within 15" (blue) and 30" (yellow) rows for plots planted in a) 120,000 seeds per acre and b) 180,000 seeds per acre.

For the 180k seeding rate (Figure 3b), the higher temperatures for 30" rows don't appear as different than 15", still not having full canopy closure until August. The 15" rows also appear a little more stable in early July when planted at 180k seeding rates but have similar patterns to the 120k seeding rates at this stage.

Based on both graphs, if there are differences by population and row spacing, it occurs during the month of July. The breakdown of corn may be influenced by the conditions that occur in July, at least when soybeans are planted late May. Both June and August have similar temperature profiles, although the lower seeding rate has warmer highs in August which may have influenced rye breakdown, which was affected by population (Figure 2). A more intense bag sampling across the season would probably elucidate when mass loss is occurring.

Relationships Between Biomass, NDVI and Yield

Yields had no positive correlations with rye or corn residue characteristics, but yields increased as corn decomposition decreased (Table 2). This would match observations of higher yields under 15" row spacings, but lower corn decomposition, or mass loss. Although rye shifted by populations and not row spacing, lower final C:N and greater change in C:N was associated with higher yields, regardless of population or row spacing. All of the above correlations were weaker (<0.50). Although different planting management affected rye and corn decomposition, they had a moderate correlation (0.55) with mass loss. So similar factors overall may have affected breakdown of residues.

Table 2: Correlations (positive or negative relationships) of selected corn and rye variables to changes in C, N, and C:N.

Variable	Correlations with Other Variables (p = 0.1)
Yield	Corn Decomposition (-0.41), Rye Final C:N (-0.31), Change in Rye C:N (0.31)
Rye Mass Loss	Corn Mass Loss (0.55)
Corn Mass Loss	Rye Mass Loss (0.55), Final Corn N% (0.38), Final Corn C % (0.51), Final Corn C:N (0.60), Change in Corn C:N (-0.60), Change in Corn N % (-0.38), Change in Corn C % (-0.51)
Rye Final C:N	Final Rye N% (0.37), Final Rye C% (0.63), Change in Rye C:N (-0.37), Change in Rye N% (-0.37), Change in Rye C (-0.63)
Corn Final C:N	Corn Mass Loss (0.60), Final Corn N% (0.60), Final Corn C% (0.81), Change in Corn C:N (-0.99)

The decomposition of corn (mass loss) had several positive relationships, including with the final corn %C and N as well as the final corn C:N ratio (Table 2). This means that when more mass was lost, the C, N and C:N remained higher in those materials. For rye and corn C:N ratios, both higher final %C and %N resulted in higher C:N ratios, and greater change in C, N, or C:N resulted in lower C:N values.

Summary and Conclusions

As noted for Delaware in other recent studies, populations can be dropped below 120,000 seeds per acre for full season beans without a yield penalty, while 15” rows provide at least a 7-bushel increase. Although we hypothesized that greater canopy coverage would lead to ideal conditions for residue decomposition, we found the opposite results. Lower populations increased rye breakdown while wider rows increased corn breakdown. Based on soil temperatures, the major differences in planting management appears to occur in July, at least when soybeans are planted in late May. So weather during this period may also explain differences between plots, which were all irrigated.

While no differences were observed in rye or corn fodder %N or %C by planting management, there were relationships with yield and other residue characteristics. Breakdown of residues increases in plots with higher yields, so there is a underlying mechanism that supports both yield and residue decomposition. This include for Rye C:N ratios, which were lower in higher yielding plots, although the relationship was weaker. Additionally, there was a moderately strong relationship between corn and rye residue decomposition, indicating that there was some similarity if processed that induced breakdown. This project should be expanded to dryland conditions, and residue may need to be pre-ground to produce consistent (but not field approximate) results.