Soybean Row Spacing and Planting Rate Effects on Litter Decomposition

Jarrod O. Miller
University of Delaware Extension
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Introduction and Objectives

Cover crops, particularly cereal rye, have been widely adopted in Delaware soybean production due to their benefits in weed suppression and soil moisture conservation. However, rye mulch may also influence pest dynamics and affect nitrogen (N) availability to cash crops. While soybeans are less dependent on N fertilization than corn, the mineralization of N from decomposing rye could provide a mid-season nutrient boost. Additionally, corn fodder from the previous cropping season may persist on the soil surface, contributing carbon as it decomposes throughout the growing season.

Currently, it is unclear how soybean population density and row spacing influence residue decomposition on the soil surface. An earlier canopy closure may help retain soil moisture, potentially accelerating decomposition, whereas increased evapotranspiration could reduce soil moisture and slow down the process. This study aims to take the first steps in evaluating how soybean planting densities affect residue decomposition dynamics.

Methods

The study was conducted at the Carvel Research and Education Center in Georgetown, DE, where soybeans were planted on May 21, 2024. Experimental plots measured 10 feet wide by 60 feet long, with a rye cover crop that had been terminated two weeks prior using glyphosate. Soybeans were planted at five seeding rates (80, 100, 120, 140, and 160 thousand seeds per acre) and two row spacings (15-inch and 30-inch), with irrigation provided throughout the season. Soil temperature and moisture sensors were installed in plots with seeding rates of 120,000 and 180,000 seeds per acre at both row spacings in June 2023. An additional field without irrigation was added offsite, with the same population and row spacing treatments.

Additional rye biomass was collected from outside the plot boundaries after termination, and corn fodder was gathered from other research center fields. The biomass was separated into decomposition bags (30 rye and 30 corn fodder per plot), weighed, and placed back into the planted plots at the center of a row. Three subsamples from each biomass type were dried and analyzed to determine initial carbon (C), N, and moisture content. At the end of the season, decomposition bags were retrieved, dried, reweighed, and analyzed for biomass loss as well as final C and N content.

Soybean yield was harvested in late fall using a plot combine. Data were analyzed in SAS using a randomized complete block design with a factorial structure. Biomass loss, C and N changes, and yield were analyzed using PROC GLIMMIX, while yield correlations with other factors were assessed using PROC CORR.

Results and Discussion

Plot Yields

For full-season soybean, neither row spacing, nor population significantly influenced yield under irrigated or rainfed conditions. In irrigated fields, soybean yields averaged 59.6 bu/acre for 15-inch rows and 56.4 bu/acre for 30-inch rows, with no statistical difference between the two. Similarly, in rainfed conditions, yields were 44.6 bu/acre for 15-inch rows and 43.5 bu/acre for 30-inch rows, again showing no significant difference. This is the first year of the study where row spacing had no effect on yield, whereas in previous years, 15-inch rows provided a yield advantage.

Population also had no effect on soybean yield in either irrigated or rainfed environments. Across all seeding rates, irrigated yields remained between 55.3 and 60 bu/acre, while rainfed yields ranged from 37.9 to 47.4 bu/acre, with no statistical differences detected.

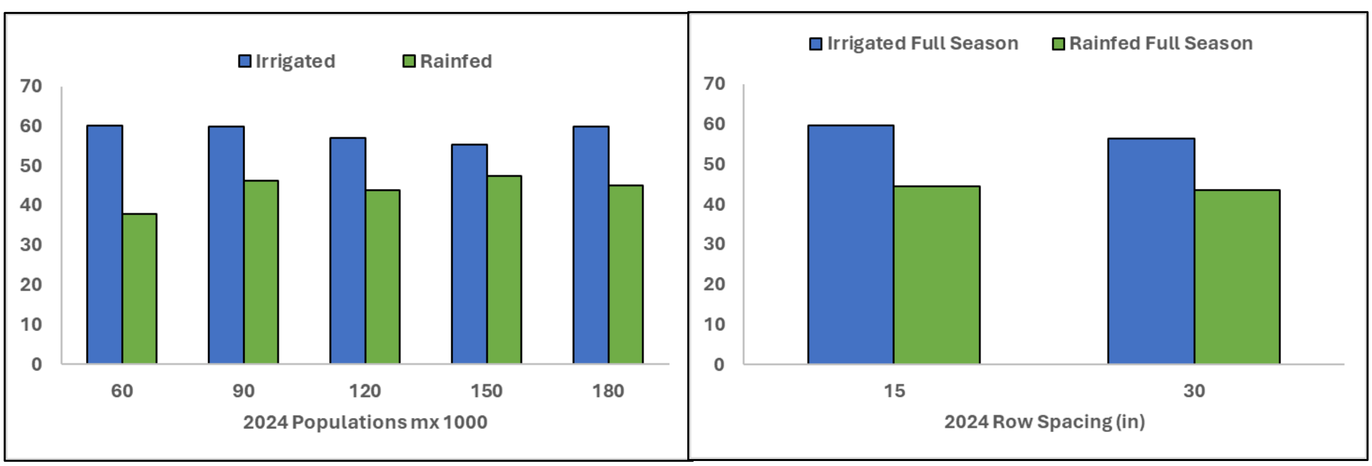

Figure 1: Yields across population and row spacing treatments from the litter bag study at the Carvel Research and Education Center in 2022. Yields were significantly different at p = 0.0001.

Overall Biomass Loss (% Weight Loss) for Rye Biomass

Rye residue decomposition (as percent weight loss) varied slightly by soybean population, though differences were not statistically significant under either irrigated ($p = 0.1051$) or rainfed ($p = 0.2021$) conditions. Under irrigation, the greatest weight loss occurred at 60 thousand seeds per acre (71%), while the lowest was observed at 90 thousand seeds per acre (51%), with other populations falling between these values. In rainfed conditions, residue loss ranged from 51% to 59%, with no clear pattern across populations. While these trends suggest potential interactions between plant density and residue breakdown, further research is needed to determine whether population meaningfully influences decomposition over time.

Rye residue decomposition was influenced by row spacing under irrigated conditions but not in rainfed fields. Under irrigation, 15-inch rows lost 66% of their initial weight, compared to 56% in 30-inch rows, with a statistically significant difference ($p = 0.0508$). This suggests that narrower row spacing may have enhanced decomposition, possibly due to improved soil moisture retention or microclimate effects. In contrast, rainfed plots showed no significant difference in weight loss, with 53% in 15-inch rows and 56% in 30-inch rows ($p = 0.1325$), indicating that without supplemental irrigation, row spacing had less impact on residue breakdown.

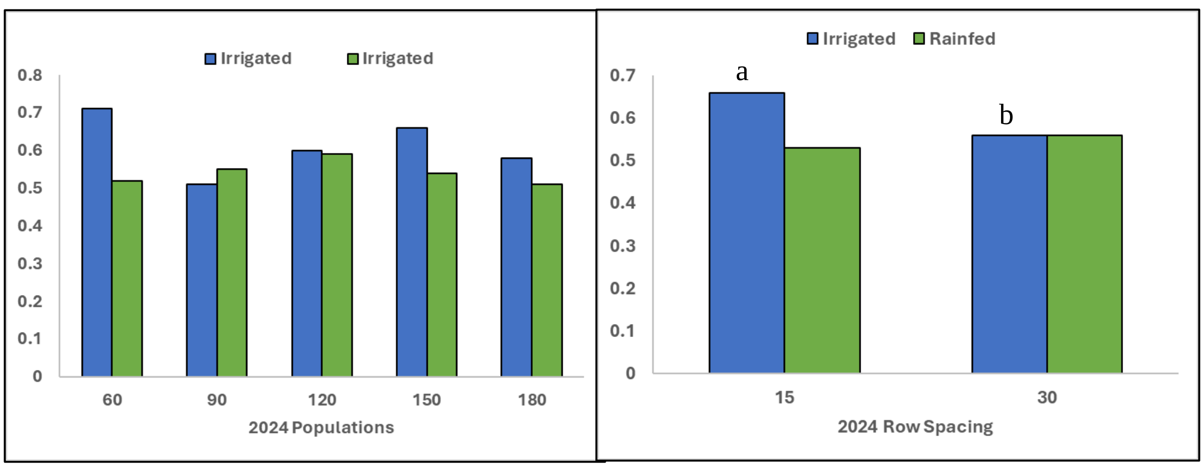

Figure 2: a) Loss in rye biomass (%) by population (averaged across row spacings) and b) row spacing averaged across populations.

Overall Biomass Loss (% Weight Loss) for Corn Biomass

Corn residue decomposition showed differences in weight loss between populations, particularly under rainfed conditions, where there was a significant effect ($p = 0.0214$). In rainfed fields, weight loss ranged from 45% to 52%, with the highest decomposition observed at 180, 120, and 150 thousand seeds per acre populations, which were significantly different from the lower populations of 60 and 90 thousand seeds per acre (26-33%). In irrigated fields, there were no significant differences in residue decomposition across populations ($p = 0.89$). The differences in corn residue decomposition across populations may be linked to canopy development. Higher populations tend to result in denser canopies, which could enhance soil moisture retention and create more favorable microclimatic conditions for microbial activity, promoting faster decomposition. This is particularly evident under rainfed conditions. In irrigated fields the absence of significant differences suggests that water availability may have lessened the impact of population on decomposition.

Corn residue decomposition showed a significant difference in rainfed conditions based on row spacing (p = 0.0373), but no significant effect in irrigated conditions (p = 0.76). In rainfed fields, 15-inch rows resulted in 46% weight loss, while 30-inch rows had a slightly higher loss of 49%. Although there was a trend toward increased decomposition in 30-inch rows, the difference was not statistically significant. In irrigated fields, there was no significant difference between row spacings, with both 15-inch and 30-inch rows showing similar residue breakdown (around 30%). This suggests that under irrigated conditions, row spacing had little impact on corn residue decomposition, but under rainfed conditions, there may have been a slight effect, though not significant.

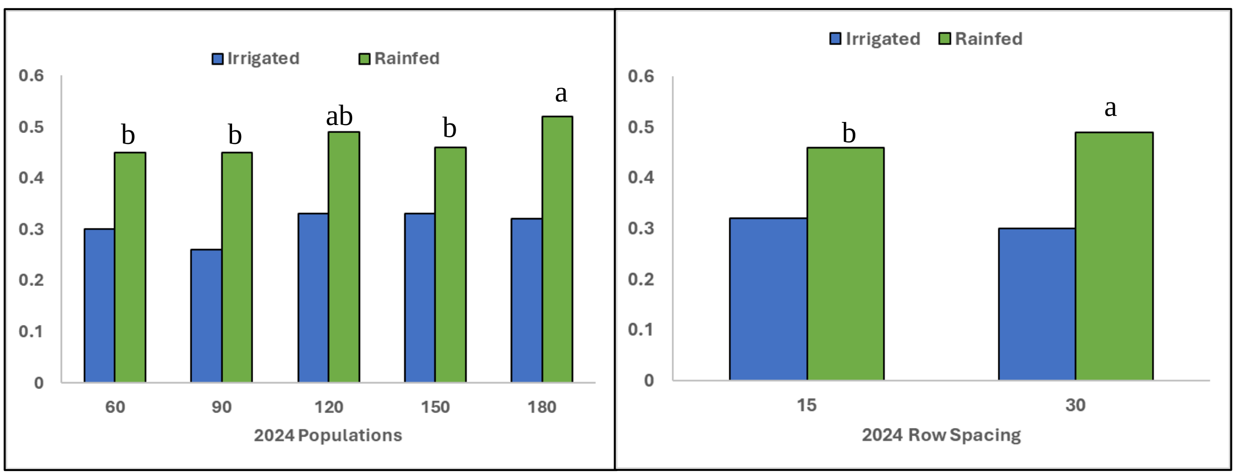

Figure 3: a) Loss in corn biomass (%) by population (averaged across row spacings) and b) row spacing averaged across populations.

In rainfed conditions, it was unexpected to see 30-inch rows result in slightly higher residue decomposition compared to 15-inch rows, especially since 30-inch rows typically create a less dense canopy. A denser canopy in 15-inch rows would normally promote more shading and moisture retention at the soil surface, which should enhance microbial activity and accelerate decomposition. However, these results suggest that other factors, such as soil moisture distribution or temperature fluctuations, may have had a greater influence on residue breakdown than row spacing alone. Notably, the highest decomposition in 30-inch rows was observed at the 180 and 120 thousand seed populations, further suggesting that population density may be influencing decomposition in ways not immediately tied to canopy density. The lack of a significant difference further emphasizes the complexity of these interactions, indicating that environmental variables beyond canopy density likely played a more significant role in the decomposition process.

The Carbon and Nitrogen Content of the Rye and Corn Residues

The C:N ratio of rye residues showed no significant differences across populations in either irrigated or rainfed conditions (p = 0.2221 and p = 0.91, respectively). The ratios ranged from 25.6 to 31.3 in irrigated fields and from 31.0 to 32.3 in rainfed fields, with no clear trend across population densities. These results suggest that population density did not significantly affect the C:N ratio of rye residues, indicating that other factors, such as environmental conditions or the inherent characteristics of the rye biomass, may have been more influential in determining the C:N ratio.

For row-spacing, the C:N ratio of rye residues showed a significant difference in irrigated conditions (p = 0.0251), but not in rainfed conditions (p = 0.72). In irrigated fields, 15-inch rows had a lower C:N ratio (26.4) compared to 30-inch rows (30.3), suggesting that row spacing may influence the C:N ratio when irrigation is available. This could be due to differences in canopy density, moisture retention, and microbial activity under irrigation. In rainfed fields, however, both row spacings showed similar C:N ratios (31.1 to 31.5), and no significant effect was observed. These results highlight that row spacing appears to influence the C:N ratio, causing greater decomposition in 15” rows.

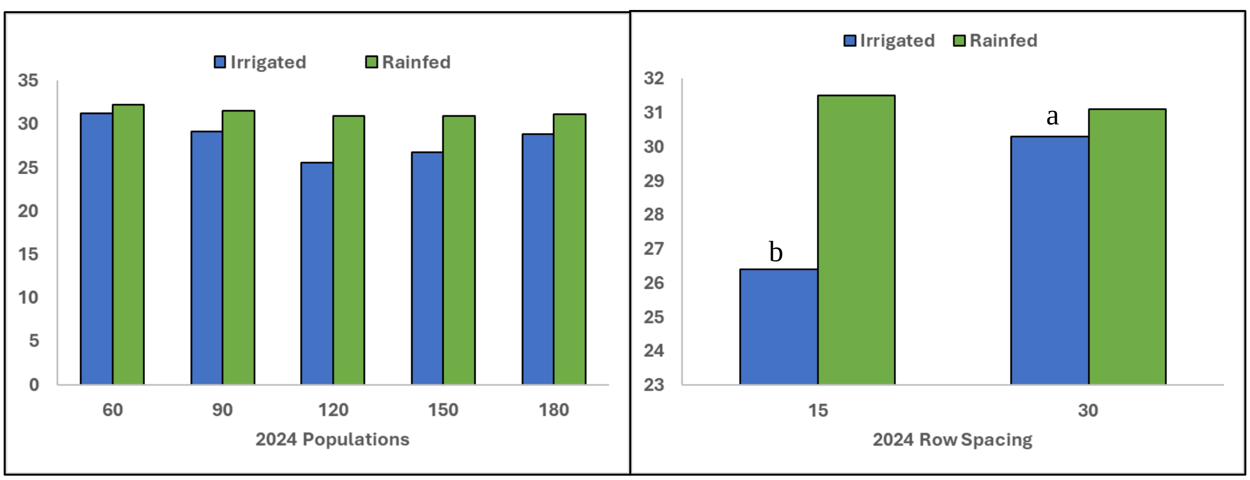

Figure 4: a) Final rye C:N by populations (a) and row spacing (b) in irrigated and rainfed fields.

The C:N ratio of corn residues also did not show significant differences across populations in either irrigated or rainfed conditions (p = 0.4912 and p = 0.89, respectively). In irrigated fields, the C:N ratios ranged from 35.1 to 42.9, while in rainfed fields, the ratios ranged from 40.8 to 44.8. These results suggest that population density had little effect on the C:N ratio of corn residues in both irrigated and rainfed conditions, implying that factors other than population density, such as environmental conditions or residue quality, may be more influential in determining the C:N ratio of corn residues.

For row spacing, the C:N ratio of corn residues showed a significant difference in irrigated conditions (p = 0.0771) but not in rainfed conditions (p = 0.6). In irrigated fields, 15-inch rows had a lower C:N ratio (36) compared to 30-inch rows (42.1), suggesting that row spacing may influence the C:N ratio under irrigation, similar to rye. In rainfed fields, however, no significant difference was observed, with both row spacings showing similar C:N ratios (41.9 to 43.5). These results indicate that row spacing may affect the C:N ratio in irrigated fields but has little impact in rainfed conditions, where other environmental factors are likely more influential.

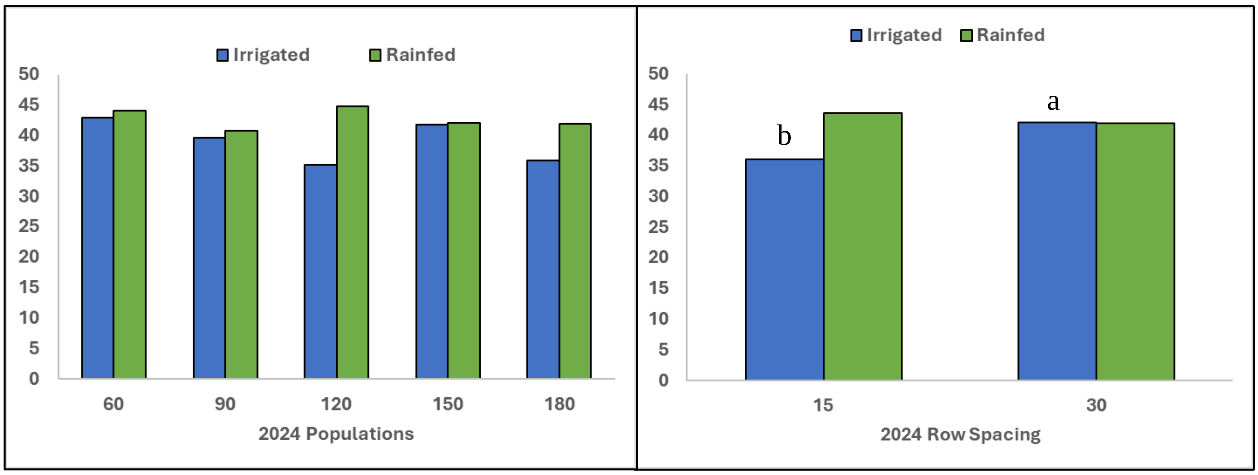

Figure 5: a) Final rye C:N by populations (a) and row spacing (b) in irrigated and rainfed fields.

Rye residues started at a C:N of 62, while corn residues had a lower initial C:N ratio of 48, and we would expect rye to end with a higher C:N. However, over the course of the growing season, rye residues exhibited a significant reduction in C:N ratio (reaching 25.6 to 31.3 in irrigated fields), indicating active microbial breakdown. In contrast, corn residues maintained higher C:N ratios (ranging from 35.1 to 42.9 in irrigated fields), which aligns with the expectation that corn residues would decompose more slowly.

The biomass loss trends also support this pattern. Rye residues, with their higher initial C:N ratio, showed greater biomass loss, particularly in irrigated fields. For instance, 15-inch rows of rye had the highest biomass loss (0.66), which suggests that the microbial decomposition of rye was facilitated by the lower C:N ratio over time, allowing for faster breakdown. In contrast, corn residues, with their relatively higher C:N ratio, experienced slower decomposition, as indicated by more consistent biomass loss across row spacings and populations. The slower breakdown of corn residues is consistent with their higher C:N ratio, which indicates a more recalcitrant form of carbon that is harder for microbes to decompose.

Summary and Conclusions

This study explored the effects of row spacing, population density, and residue type on yield, biomass loss, and C:N ratios in irrigated and rainfed soybean fields. Soybean yields were not significantly influenced by either row spacing or population density in both conditions, marking a shift from previous years where narrower row spacing had provided a yield advantage.

For biomass loss, rye and corn residues showed different decomposition patterns. Rye residue decomposition was more influenced by population under irrigated conditions, with denser canopy leading to greater breakdown. Corn residue decomposition was impacted by row spacing, with 30” rows under rainfed conditions, causing greater loss, but mostly at higher populations.

The C:N ratios of both rye and corn residues were generally unaffected by population density. However, irrigated row spacing had a significant impact on rye C:N ratios in irrigated fields, with narrower rows resulting in a lower ratio, suggesting faster decomposition. While rye residues, with their higher initial C:N ratio, decomposed more quickly, corn residues maintained a higher ratio throughout, indicating slower breakdown. These results highlight the complex interactions between environmental conditions, row spacing, and population density in influencing residue decomposition and nutrient cycling.