Received: 27 January 2026 | Accepted: 29 April 2026

DOI: 10.1002/agj2.70438

Agronomy Journal

ORIGINAL ARTICLE

Agronomy, Soils, and Environmental Quality

Baseline row cleaners were adequate for high-speed soybean planting into rye residue

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Assigned to Associate Editor Arun Jani.

Funding information
Mississippi Soybean Promotion Board, Grant/Award Numbers: 44-2023, 44-2024, 45-2025; Hatch, Grant/Award Number: MIS-182110

Abstract

Double cropping and cover cropping systems require efficient planting into crop residue. However, planting into residue can compromise seed placement and seed–soil contact, affecting crop establishment and yield. Row cleaners (RCs) address these challenges, but their efficacy depends on RC type, attachment configurations, residue quantity and management, and planting speed. This study evaluated the field performance of different row cleaner configurations (RCC) at various planting speeds into rye (*Secale cereale* L.) residue. Field trials were conducted during two seasons (2023/2024 and 2024/2025) at Brooksville, MS. Eight RCC (baseline Martin-Till 1345 narrow RC and seven combinations with side treader wheels, wheel weights, and coulters) and two planting speeds (7.7 and 15.5 km h^{-1}) were evaluated in a 2 × 8 factorial as a randomized complete block design with four replications on plots 500 m long. Soybean (*Glycine max* [L.] Merr.) was planted at 345,800 seeds ha^{-1} into 7753 and 5002 kg ha^{-1} rye residue in the 2023/2024 and 2024/2025 seasons, respectively. Response variables included surface and subsurface residue quantity, plant stand, spacing uniformity, and grain yield. Results showed season-to-season variation in treatment effects. In 2023/2024, higher planting speed significantly reduced plant stand and spacing uniformity but did not affect other variables. In 2024/2025, planting speed had no significant effects. Configuration or speed × configuration interactions did not influence any measured variable in either season. These findings indicate that baseline RCC systems are adequate for planting into residue regardless of speed, such that additional attachments may not provide measurable benefits.

Abbreviations: RC, row cleaner; RCC, row cleaner configurations; ST, side treader wheels; WW, wheel weights.

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Plain Language Summary

Farmers who double crop or grow cover crops often need to plant soybean into residue. This residue can impede planting equipment and prevent seed–soil contact, which affects crop growth. Row cleaners are planter attachments that sweep residue away from the seed row. This study tested whether adding extra attachments to row cleaners would improve planting performance when planting at fast speeds into heavy rye residue. We tested eight row cleaner configurations at two planting speeds (7.7 and 15.5 km h^{-1}) over two growing seasons in Mississippi, measuring residue removal, plant establishment, and yield. The basic row cleaner worked just as well as with extra attachments. Faster planting reduced spacing uniformity in one season but not the other, and yield was unaffected. Farmers can plant at higher speeds into residue without additional equipment costs, saving time during narrow planting windows, without sacrificing soybean yield.

1 | INTRODUCTION

Double cropping and cover cropping are commonly adopted in the southeastern United States because they enhance profitability and provide soil ecosystem services (Blanco-Canqui & Ruis, 2020; Sanford, 1982). However, these systems typically result in late planting of second crops. Planting soybean (*Glycine max* (L.) Merr.) late (after April 20) in Mississippi results in a 26.7 kg ha^{-1} per day yield loss (Bateman et al., 2020), so planting quickly after double cropping or cover cropping is critical to optimize yield. Indeed, a double-cropped wheat (*Triticum aestivum* L.)–soybean system will not be able to plant soybean until early June, at the earliest. This results in significant yield losses due to shortened season length and increased environmental stress (Heatherly & Elmore, 2004). High-speed planting systems offer an opportunity to limit yield loss due to late planting, but high-speed planting into high-residue systems is likely to produce challenges for crop establishment.

Crop residue on soil surface can block furrow openers, affecting furrow opening and closing, as well as the consistency of seed placement (depth and spacing), and potentially compromising seed–soil contact (Aikins et al., 2017). Impaired seed–soil contact can result in poor germination, seedling emergence, crop establishment, and yield. Various row cleaners (RCs) and attachments have been developed for planters to manage residue and mitigate poor seed–soil contact. RCs cut and remove residue in the seed-row to improve seed placement and maintain adequate seed depth and seed–soil contact.

Previous studies (Brandelero et al., 2015; Dadi & Raoufat, 2012; Fallahi & Raoufat, 2008; Gürsoy, 2014; Kaspar & Erbach, 1998; Kornecki et al., 2009; Raoufat & Matbooei, 2007; Sanavi & Raoufat, 2006; Yang et al., 2016) evaluated the performance of no-till planters with different RC attachments and configurations when planting into residue. They reported that the efficacy of RCs was influenced by type, configuration, and planter speed. Evaluating the effects of three RC types on corn (*Zea mays* L.) and soybean stand establishment and yield, Kaspar and Erbach (1998) reported that staggered-disc RCs and powered horizontal disc RCs more effectively moved residue from the seed furrow than an offset-double coulter. Staggered-disc and powered horizontal disc RCs also increased corn and soybean final population and emergence rate but did not affect yield. Comparing the performance of active and inactive types of RCs, Yang et al. (2016) reported that active RCs performed better under higher residue conditions.

Fallahi and Raoufat (2008) evaluated the effect of three planter attachment configurations (plain rolling coulter, RC, and a combination of RCs followed by a plain rolling coulter) and tillage systems on the emergence rate and placement uniformity of corn in wheat residue. They reported that while both RCs alone and RCs followed by the plain rolling coulter improved emergence rates under all tillage systems, RC alone was more effective than the combination. RCs alone and RCs followed by a coulter were the best planter configuration for seed spacing indices compared to a plain coulter alone. Sanavi and Raoufat (2006) reported similar results when comparing the performance of four configurations (double disc furrow opener preceded by an RC, chisel furrow opener preceded by an RC, winged chisel furrow opener preceded by an RC, and winged chisel furrow opener without RC) when planting into two residue levels. The winged chisel furrow opener preceded by an RC removes more residue and improved seed placement uniformity, emergence rate index, and quality of feed than the other three configurations. Dadi and Raoufat (2012) evaluated the performance of six configurations of row unit attachments (chisel, winged chisel, and double disc proceeded by RC with and without treader) on a no-till planter in two residue management systems. They reported that the treader attachment improved the RC performance and had a higher corn

emergence rate and quality of feed than the RC alone. Brandelero et al. (2015), evaluating RCs with treaders compared to a disc coulter, also concluded that the former removed residue from the planting path at approximately twice the rate of the latter.

Planting speed has also been shown to influence RC performance and seed placement. Evaluating the performance of a conventional corn planter equipped with RCs at three speeds (4, 7, and 10 km h^{-1}) and three residue levels, Raoufat and Matbooei (2007) reported the highest residue-clearing capacity at 10 km h^{-1}. Better indices of plant establishment and seed placement uniformity (depth and spacing) were obtained at a speed of 7 km h^{-1}. A similar result was reported by Yang et al. (2016) when evaluating the performance of a newly designed active RC at three speeds (4, 6, and 8 km h^{-1}) and two residue levels. The RC achieved maximum cleaning capacity at 8 km h^{-1} speed. Better seed distribution and seeding depth uniformity were obtained at 6 km h^{-1}. A planting speed of 6.5 km h^{-1} resulted in a higher residue removal and quality of feed index (the number of plant spacings that were within a range of 0.5–1.5 times the target plant spacing) than the 5 km h^{-1} speed (Gürsoy, 2014).

Despite this body of research, important knowledge gaps remain. First, previous studies examined relatively modest speeds (4–10 km h^{-1}), while advanced planting technologies allow planting speeds above 17.7 km h^{-1} that can maximize area planted during narrow planting windows (Olomitutu et al., 2024, 2025). Second, most studies evaluated limited RC configurations, typically comparing few options. The evaluation of different RC configurations at higher planting speeds under high biomass systems will allow cover crop and double crop producers access to high-speed planting technologies.

The objective of this study was to evaluate eight RC configurations (RC alone and various combinations with treader wheels, wheel weights (WW), and coulters) at two actual planting speeds (7.7 and 15.5 km h^{-1}) for soybean planting into high biomass rye residue. We hypothesized that (1) configurations combining multiple attachments would remove more residue and improve stand establishment compared to an RC alone, (2) higher planting speed would increase residue removal but may compromise seed placement uniformity, and (3) the interaction between configuration and speed would influence optimal RC selection.

Core Ideas

- Adding side treader wheels, wheel weights, or coulters to row cleaners did not improve any measured variable.
- Doubling planting speed (7.7–15.5 km h^{-1}) did not affect residue removal from the seed row.
- Higher planting speed reduced soybean stand consistency in one of two seasons, but yield was unaffected in either season.

2 | MATERIALS AND METHODS

2.1 | Research site

Field experiments were conducted during 2023/2024 and 2024/2025 growing seasons at the Mississippi Agricultural and Forestry Experiment Station Black Belt Branch Experiment Station, Brooksville, MS (33°15′23″ N, 88°32′44″ W; 82 m elevation). The soil is an Okolona silty clay (fine, smectitic, thermic Aquic Hapluderts) with 23.9% sand, 36.3% clay, 39.8% silt (i.e., clay loam), and bulk density of 1.32 g cm^{-3}. Data on selected weather indices, including precipitation and temperature, are provided in Table 1. Sites were rainfed. The second season was wetter compared to the first. Precipitation from April to July 2025 totaled 726 mm compared to 318 mm during the same period in 2024, resulting in a 2-month delay in soybean planting during the second season.

2.2 | Tillage and rye management

Tillage practices differed between seasons. In 2023/2024, fields were disked and hipped (raised rows/ridges/seedbeds) in winter before rye planting. In 2024/2025, fields were disked, cultivated with a field cultivator, and left flat (without raised rows/ridges/seedbeds). Elbon rye was broadcast-seeded in November at 67 kg ha^{-1} (2023) and 107 kg ha^{-1} (2024). Rye seed was incorporated by reforming beds in 2023, but was not in 2024, hence the higher seeding rate that year. Nitrogen (46-0-0 granular urea) was applied at 56 kg N ha^{-1} in mid-February via aerial application. Rye was terminated in late April with glyphosate (Roundup PowerMAX) at 2.92 L ha^{-1} 4 weeks before planned soybean planting. Rye was not rolled or otherwise managed prior to planting. Rye residue was left standing, or lodged as the case may be, in order to provide the most challenging planting environment that could be created (Figure 1). The rationale for this was that if we can successfully plant into such harsh conditions, we could be confident that results are applicable across a wide range of residue conditions.

2.3 | Experimental design and plot management

The experimental design was a 2 × 8 factorial in a randomized complete block design with four replications. Two actual planting speeds: 7.7 and 15.5 km h^{-1} (obtained from the monitor), and eight RC configurations: the baseline Martin-Till 1345 narrow RC (which included razor wheels but not a coulter), RC + side treader wheels (ST), RC + WW, RC +

TABLE 1 Weather conditions at each trial site during the 2023/2024 and 2024/2025 cropping season in Brooksville, MS.

2023/2024					2024/2025				
Year	Month	Max. temp. (˚C)	Min. temp. (˚C)	Precipitation (mm)	Year	Month	Max. temp. (˚C)	Min. temp. (˚C)	Precipitation (mm)
2023	November	19.39	7.02	26.92	2024	November	22.44	11.11	117.35
2023	December	16.06	3.75	72.90	2024	December	15.14	4.18	94.23
2024	January	10.99	−0.07	192.79	2025	January	10.79	−0.99	102.36
2024	February	18.83	5.52	93.73	2025	February	17.52	4.86	110.74
2024	March	20.79	8.98	198.63	2025	March	21.99	8.53	129.54
2024	April	25.13	12.69	94.74	2025	April	26.69	14.31	204.72
2024	May	31.02	19.07	49.53	2025	May	28.10	17.46	209.3
2024	June	33.85	20.78	49.78	2025	June	32.98	21.04	248.67
2024	July	34.43	22.51	124.21	2025	July	35.50	23.06	63.25
2024	August	35.39	20.9	52.32	2025	August	33.96	20.75	21.34
2024	September	30.54	18.96	182.63	2025	September	34.30	18.33	8.13
2024	October	28.98	12.28	10.67	2025	October	26.01	12.69	4.32
					2025	November	17.87	4.97	97.79

Abbreviations: Max. temp., maximum temperature; min. temp., minimum temperature.



FIGURE 1 Soybean planting operation into 7753 kg ha^{-1} (dry matter basis) standing and lodged rye residue at Brooksville, MS, in 2024.

coulter (C), RC + ST + WW, RC + ST + C, RC + SW + C, and RC + ST + WW + C (Figure 2). Plots were 4.1 m × 500 m long. Plots were planted as a "strip trial," that is, a single planter pass for each treatment. Weeds, fertility, and pests were controlled using standard agronomic practices for the region.

2.4 | Planter description and soybean planting

A John Deere 6R130 tractor with 130 horsepower was used to operate an eight-row precision planter (John Deere toolbar with MaxEmerge 2 row units retrofitted with AgLeader SureSpeed and SureForce) during soybean planting. The planter had stack-fold capability that allowed four-row planting. The planter was fitted with Martin-Till 1345 narrow RCs with razor wheels. The planter was also equipped with double disc openers, gauge wheels, and rubber "V" closing wheels. The target seeding depth was 3–5 cm set with rows 0.97 m apart.

In 2023/2024, planting was conducted into 7753 kg ha^{-1} (dry matter basis) standing/lodged rye residue on May 24, 2024. In 2024/2025, rye biomass was 6156 kg ha^{-1} (dry matter basis) at termination. However, due to wet field conditions resulting from consistent rainfall, soybean planting was delayed till July 29, 2025. By this time, biomass



FIGURE 2 Row cleaner configurations used during planting into rye residue. (A) 1345 razor wheels narrow row cleaner, (B) wave coulter, (C) side treader wheel, and (D) wheel weight.

decomposition had begun, and weeds had established. Consequently, Roundup PowerMAX at 3.51 L ha^{-1} was applied 10 days prior to planting to control weeds. Planting was then conducted into 5002 kg ha^{-1} (dry matter basis) standing residue.

Soybean variety Revere 4606XFS was planted at 318,136 pure live seeds ha^{-1} (345,800 seeds ha^{-1} at 92% germination), verified by warm germination testing. Seeding rates were calibrated at the lowest target planting speed (8.05 km h^{-1}) and were not adjusted for the 16.1 km h^{-1} target planting speed. Vacuum settings were configured according to the planter manual at 4.23 kPa (17 in. H_2O) for 8.05 km h^{-1} and 6.23 kPa (25 in. H_2O) for 16.1 km h^{-1}. Tractor test runs were performed to determine the appropriate tractor gear and engine speed needed to achieve target planting speeds during field operations. Actual ground speed at planting were 7.7 and 15.5 km h^{-1}.

2.5 | Data collection

Rye biomass was quantified by randomly collecting, drying, and weighing surface residue (0.25 m^2 square sampling frame with 0.5 m length edges) from 15 locations across field before soybean planting. Immediately after planting, surface and subsurface residues were determined using the method described by Kaspar and Erbach (1998) but briefly described here. A cylinder with 0.15 m diameter and 0.15 m height was used to sample undisturbed soil from the row zone immediately after planting to measure residues on the surface and in the upper 0.06 m of the soil for subsurface residue (Figure 3). Two subsamples were collected in each border row of every plot. Surface residues from the row area were removed by hand and dried at 105˚C for 24 h. They were weighed to estimate surface residue biomass after planting. Subsurface residue was determined by cutting off the upper 0.06 m of soil core. Residues were separated from the soil using water and a sieve, dried at 105˚C for 24 h, and weighed.

Following the protocol for evaluating planter performance described by Olomitutu et al. (2024), plant population and spacing data were collected from two randomly selected 5-m row segments located centrally within each plot after emergence was deemed complete. A measuring tape was used to measure the distance between plants. Plant spacing was then calculated as the mean of the measured spacings. Plant spacing variability was estimated as the standard deviation of the measured spacing. Grain yield was determined from the middle of the plots where the actual ground speeds were constant. Harvest was conducted in the two middle rows, 350 m length, after acceleration and deceleration portions of the plots were removed. The yield was adjusted to 13% moisture content following the procedure described by Mulvaney and Devkota (2020).

2.6 | Data analysis

Data were analyzed separately by year due to differences in planting dates, residue quantity, and weather. A two-factor analysis of variance was computed for all measured parameters using a mixed model approach. The model was fitted using the lmerTest package (Kuznetsova et al., 2017) in R version 4.3.2 statistical software (R Core Team, 2023). Planter speed, row cleaner configurations, and their interactions were considered fixed effects, whereas replication was regarded as a random effect. Model assumptions of normality and homogeneity of variance were verified by visual inspection of residual plots and the Shapiro–Wilk test. Least square means were computed for fixed effects using the emmeans package (Lenth, 2023). Treatment differences for measured parameters were considered significant at $p < 0.05$ (Least Significant Difference).

3 | RESULTS AND DISCUSSION

3.1 | Residue removal performance

Planting speed, row cleaner configuration, and their interaction did not significantly affect surface or subsurface residue quantity after planting across both years (Table 2). The similar residue clearing performance suggests that the row cleaner configurations evaluated maintain residue



FIGURE 3 Surface and subsurface residue sampling procedure immediately after planting. (A) cylinder (0.15 m diameter × 0.15 m height) and snips/pruning shears used for sampling, (B) collection of surface residue from the row zone, (C) subsurface residue removal to 0.06-m depth, and (D and E) Bagged surface and subsurface residue samples, respectively.

management efficiency even at doubled planting speeds (7.7–15.5 km h^{-1}).

The absence of significant speed and row cleaner configuration effects on residue clearing contradicts findings from several previous studies. Raoufat and Matbooei (2007) reported that residue-clearing capacity increased with speed up to 10 km h^{-1}, while Yang et al. (2016) found maximum cleaning at 8 km h^{-1}. Kaspar and Erbach (1998) found that staggered-disc and powered row cleaner configurations significantly outperformed offset-double coulters. Dadi and Raoufat (2012) reported substantial performance improvements when adding treader wheels to RCs. The contradiction with previous studies may be explained by the fact that the baseline Martin-Till 1345 RC may have been sufficiently effective and that additional attachments provided no measurable improvement under the conditions tested. Modern RC designs represent substantial technological advancement over the systems evaluated in earlier studies. The razor wheel design, optimized geometry, floating capability, and improved materials may have created a performance ceiling that additional attachments could not exceed within the range of conditions encountered.

3.2 | Stand establishment

Treatment effects on stand establishment differed between the two growing seasons (Table 2). In the 2023/2024 season, planting speed significantly affected plant stand, plant spacing, and spacing variability. In the 2024/2025 season, planting speed had no significant effect on any measured variable. Row cleaner configuration and speed × configuration interactions did not significantly affect any measured variable during either season.

In 2023/2024, higher planting speeds led to reduced plant populations, greater spacing between plants, and less uniform spacing (Figure 4). This relationship between planting speed and plant establishment has been extensively documented across multiple crops, including peanut (*Arachis hypogaea*) (Chhinnan et al., 1975), cotton (*Gossypium* spp.) (Moody et al., 2003), corn (Badua et al., 2021; Liu et al., 2004; Miller et al., 2012; Nielsen, 1995; Quanwei et al., 2017; Staggenborg et al., 2004), and soybean (Bortoli et al., 2021; Brandelero et al., 2015; Kovács & Casteel, 2023). These studies consistently show that faster planting speeds affect planting quality. Reduced planting quality at high speeds has been attributed to numerous factors that affect planter performance in the field. They include ground speed, field conditions, seed plate peripheral speed, meter configuration, seed tube wear, seeding rate, vertical vibration, seed hopper level and design, and seed movement within the furrow (Badua et al., 2021; Chhinnan et al., 1975; Kocher et al., 2011; Liu et al., 2004; Moody et al., 2003; Quanwei et al., 2017; Staggenborg et al., 2004; Virk et al., 2019; Yazgi & Degirmencioglu, 2007; Zhai et al., 2020).

The absence of speed effects in 2024/2025 season should not be interpreted as contradicting these fundamental limitations but rather highlight the importance of environmental

TABLE 2 Rye surface and subsurface residue after planting, soybean plant stand, plant spacing, plant spacing variability, and yield response to planting speed and row cleaner configuration during the 2023/2024 and 2024/2025 cropping seasons.

Factors	*df*	Surface residue	Subsurface residue	Plant stand	Plant spacing	Spacing variability	Yield
2023/2024		Pr > *F*					
Speed	1	0.4727	0.2786	0.02156	0.01064	0.02628	0.6169
Row cleaner configuration	7	0.9538	0.9296	0.79698	0.73785	0.75537	0.1592
Speed × row cleaner configuration	7	0.6605	0.7138	0.92856	0.95842	0.94325	0.1090
		Means					
Speed		kg m^{-2}	kg m^{-2}	Plants ha^{-1}	cm	cm	kg ha^{-1}
7.7 km h^{-1}		0.388	0.366	271,964	3.82	2.77	1862
15.5 km h^{-1}		0.433	0.437	254,416	4.12	3.12	1893
SE		0.044	0.049	2512	0.079	0.19	86
Row cleaner configuration							
Row cleaner (RC)		0.454	0.509	260,050	4.01	2.97	1,863
RC + coulter (C)		0.404	0.362	260,309	3.98	3.17	1,726
RC + wheel weights (WW)		0.505	0.358	274,036	3.89	2.68	1,808
RC + side treader wheels (ST)		0.386	0.365	270,669	3.87	2.82	1,842
RC + C + WW		0.356	0.424	261,604	3.87	2.84	2,084
RC + TR + C		0.366	0.398	269,633	3.88	2.95	1,941
RC + TR + WW		0.384	0.360	258,496	4.07	2.98	1,961
RC + TR + WW + C		0.428	0.439	250,725	4.22	3.14	1,792
SE		0.088	0.092	10,423	0.158	0.263	113
2024/2025		Pr > *F*					
Speed	1	0.9888	0.0707	0.3787	0.4421	0.3447	0.2967
Row cleaner configuration	7	0.5286	0.073	0.792	0.8182	0.8888	0.164
Speed × row cleaner configuration	7	0.9351	0.5579	0.9881	0.9773	0.99965	0.8107
		Means					
Speed		kg m^{-2}	kg m^{-2}	Plants ha^{-1}	cm	cm	kg ha^{-1}
7.7 km h^{-1}		0.085	0.167	282,856	3.70	2.32	631
15.5 km h^{-1}		0.085	0.143	278,971	3.75	2.41	594
SE		0.011	0.009	4030	0.055	0.061	55.6
Row cleaner configuration							
Row cleaner (RC)		0.047	0.163	278,837	3.74	2.33	735
RC + coulter (C)		0.066	0.103	285,347	3.66	2.28	666
RC + wheel weights (WW)		0.086	0.145	273,691	3.82	2.52	632
RC + side treader wheels (ST)		0.096	0.159	280,132	3.73	2.4	563
RC + C + WW		0.111	0.196	276,713	3.79	2.35	555
RC + TR + C		0.085	0.154	285,778	3.66	2.41	599
RC + TR + WW		0.096	0.144	281,030	3.72	2.33	561
RC + TR + WW + C		0.092	0.173	285,778	3.66	2.30	591
SE		0.022	0.019	6581	0.094	0.129	70.2

Abbreviation: SE, standard error.

conditions in determining planter performance. Several factors may have contributed to the consistent performance across speeds in 2024/2025 season. First, the flat field surface in 2024/2025 contrasted with the raised beds used in 2023/2024. Flat ground provides a smoother planting surface, potentially reducing planter component vibration and minimizing seed meter disruption. Second, the decomposed residue in 2024/2025 presented less physical interference to the planter compared to 2023/2024. Fresh, fibrous rye residue can cause transient blockages that disrupt seed flow

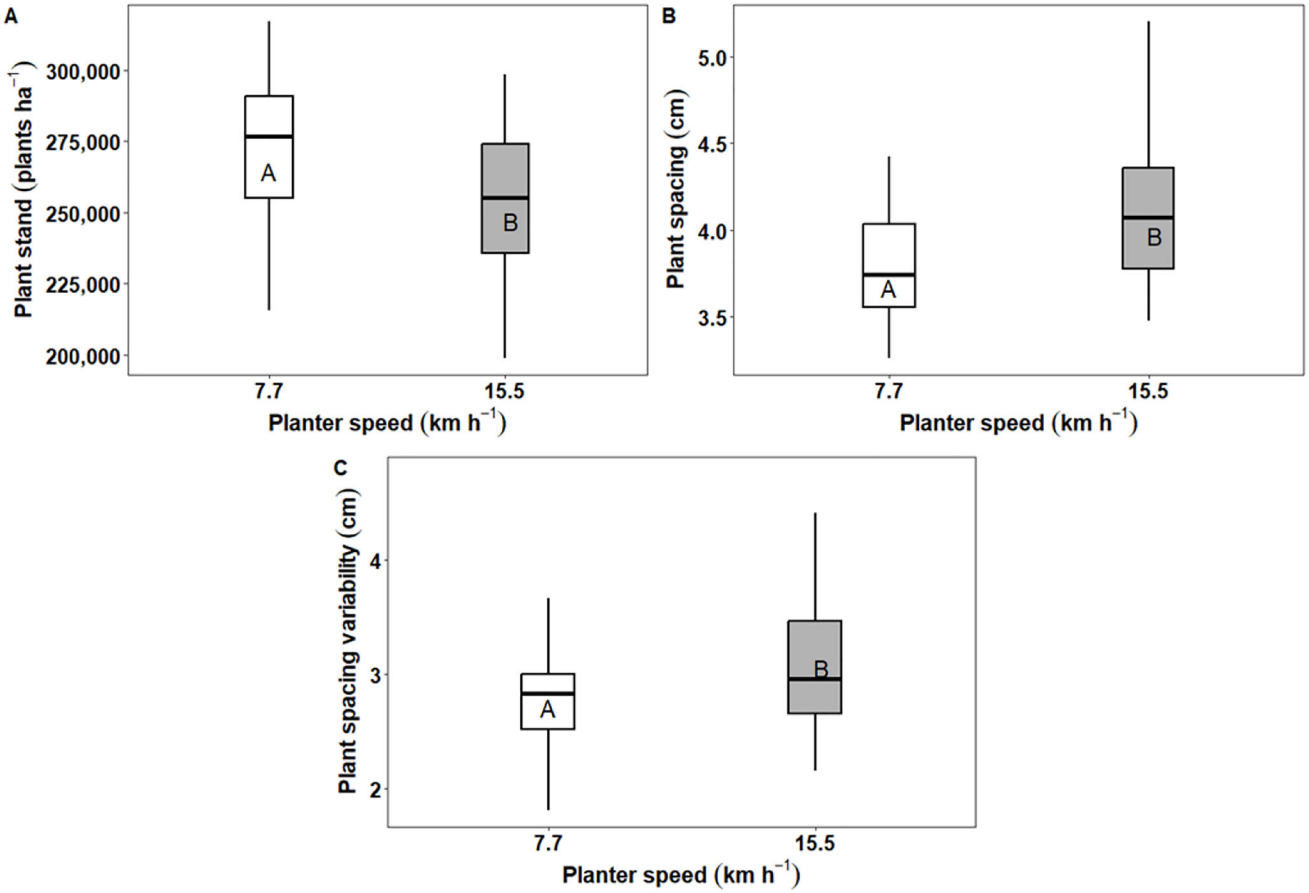


FIGURE 4 (A) Plant stand, (B) spacing, and (C) spacing variability (spacing standard deviation) of soybean planted into 7753 kg ha^{-1} rye residue during the 2023/2024 cropping season. Means with different letters indicate significant differences in response at $p < 0.05$ (Least Significant Difference).

(effects that may be exacerbated at higher speeds), whereas partially decomposed residue in 2024/2025 posed minimal obstruction.

3.3 | Yield performance

Yield was not affected by planting speed, row cleaner configuration, or their interaction during either season (Table 2). However, as expected, soybean yield was low due to late planting. Planting was delayed in this study to increase rye biomass production and, during the second season, due to substantial rainfall in the spring. The delay mimicked a traditional soybean double cropping system in Mississippi.

The absence of yield differences in this study despite significant plant stand variation in 2023/2024 demonstrates soybean's phenotypic plasticity. Soybean exhibits strong compensatory growth when plant populations vary within a moderate range, until plant populations fall below approximately 196,000 plant ha^{-1} (Carver, 2018). In this study, no plant population was below 196,000 plant ha^{-1} in response to speed or row cleaner configuration. This is consistent with previous research showing that soybean yield is generally insensitive to plant population variation within moderate ranges (Cox et al., 2010; De Bruin & Pedersen, 2008). However, yield results should not be interpreted to mean that planting speed and stand uniformity are unimportant. Yield is only one component of crop production success. Irregular spacing can increase harvest losses due to lodging. Variable stands can complicate weed management by creating uneven canopy closure. However, in double-cropping systems, time savings from higher planting speeds may be more economically valuable than marginal improvements in stand uniformity, particularly when yield is maintained.

4 | CONCLUSION

This 2-year study evaluated eight row cleaner configurations at two planting speeds for soybean establishment in terminated high-biomass rye residue. Treatment effects were highly dependent on year-specific environmental conditions. In 2023/2024 with timely planting into higher biomass

residue, higher planting speed significantly reduced plant stand and spacing uniformity but did not affect yield. In 2024/2025, with delayed planting into decomposed residue, planting speed had no significant effects. Row cleaner configuration did not significantly influence any measured variable in either year. These results indicate that baseline RC systems may be adequate for planting into residue at high speeds, and that additional attachments may not provide measurable benefits. Higher planting speeds can compromise stand uniformity under some conditions but may be acceptable when time is limited and final populations remain adequate. From a practical standpoint, this result suggests that farmers have flexibility in choosing planting speeds and row cleaner configurations within the tested ranges without compromising field performance.

AUTHOR CONTRIBUTIONS

Oluwaseyi E. Olomitutu: Conceptualization; data curation; formal analysis; investigation; methodology; writing—original draft. **Jagman Dhillon**: Conceptualization; funding acquisition; project administration; supervision; writing—review and editing. **J. Wes Lowe**: Conceptualization; project administration; supervision; writing—review and editing. **Corey J. Bryant**: Conceptualization; project administration; supervision; writing—review and editing. **Erick J. Larson**: Conceptualization; project administration; supervision; writing—review and editing. **Jialin Zhang**: Conceptualization; project administration; supervision; writing—review and editing. **John Wallace**: Conceptualization; data curation; project administration; supervision; writing—review and editing. **Grant Shavers**: Data curation; investigation. **Tucker Hilyer**: Data curation; investigation. **Oluwafemi Oyedele**: Data curation; investigation. **Michael J. Mulvaney**: Conceptualization; funding acquisition; methodology; project administration; supervision; writing—review and editing.

ACKNOWLEDGMENTS

This work was funded by the Mississippi Soybean Promotion Board project numbers 44-2023, 44-2024, and 45-2025 and by Hatch project number MIS-182110.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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How to cite this article: Olomitutu, O. E., Dhillon, J., Lowe, J. W., Bryant, C. J., Larson, E. J., Zhang, J., Wallace, J., Shavers, G., Hilyer, T., Oyedele, O., & Mulvaney, M. J. (2026). Baseline row cleaners were adequate for high-speed soybean planting into rye residue. *Agronomy Journal*, *118*, e70438. https://doi.org/10.1002/agj2.70438