Is strip-till a useful soil management tool for Wisconsin corn and soybean production?

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IN A BEAN POD

- Strip-till reduced penetration resistance in the root zone of strip-till rows.
- Soybean seed yield was similar between the strip-till 30″ row and no-till 15″ row spacings.
- Strip-till and banded fertilizer increased corn grain yield.
- Crop rotation increased corn plant population and yield.

INTRODUCTION

Wisconsin corn and soybean growers have steadily improved grain and seed yield over the past decade; however, they are annually challenged with yield suppressing conditions such as cold, dense soils, difficult early season planting conditions, and highly erodible landscapes. To resolve these issues, many growers utilize tillage as a soil management technique. However, the combination of tillage and erodible landscapes can increase erosion (Seta et al., 1993). Current recommendations for corn and soybean production in a corn/soybean (CS) rotation in Wisconsin are to utilize no-till 30″ and 15″ row spacings, respectively. Due to a perceived yield plateau to row crop no-till soybean and corn, growers in Wisconsin have become increasingly interested in strip-till as a management tool to improve early season planting conditions while maintaining soil structure and health (Allmaras and Dowdy, 1985).

By combining strip-till with different commonly used corn and soybean management practices, the objectives were: 1) quantify the effect of strip-till, row spacing (soybean only), crop rotation (corn only), fertilizer placement, and in-furrow fungicide on corn and soybean plant population, canopy coverage, and grain or seed yield, 2) evaluate strip-till, row spacing, fertilizer placement, and in-furrow fungicide on soil temperature and penetration resistance, and 3) determine best management recommendations for strip-till use in Wisconsin corn and soybean production systems.

EXPERIMENT 1: SMALL PLOT TRIALS

MATERIALS AND METHODS

Small plot trials were conducted in Arlington, WI during the 2016, 2017, and 2018 growing seasons. The site included a corn/soybean rotation in all phases and a corn on corn sequence present since 2001. Management practices for this study consisted of twelve combinations of spring strip-till or no-till, deep banded or broadcast fertilizer, and soybean 15″ or 30″ row spacings, and in-furrow fungicide (Priaxor® at 6.0 fl oz per acre) or non-treated control. Soybean was planted at 140,000 seeds ac^{-1} into all plots in either 15″ or 30″ row spacing. For strip-till plots in soybean, 30″ row spacings were planted directly over strip-till rows whereas, the 15″ row spacings were planted with every other row planted directly over strip-till rows. To avoid planting over corn stalks from the previous year, 30″ plots were offset from the center of the previous year corn row by 15″ whereas, 15″ plots were offset by 7.5″ (Photo 1). Strip-till was applied using a four row, 30″ row spacing Remlinger unit with two Grandy fertilizer boxes which allowed for deep banded 15-38-131 lb a^{-1} NPK fertilizer application (Photo 2).

Photo 1. Offsets from previous corn row used when planting 15″ or 30″ soybean.

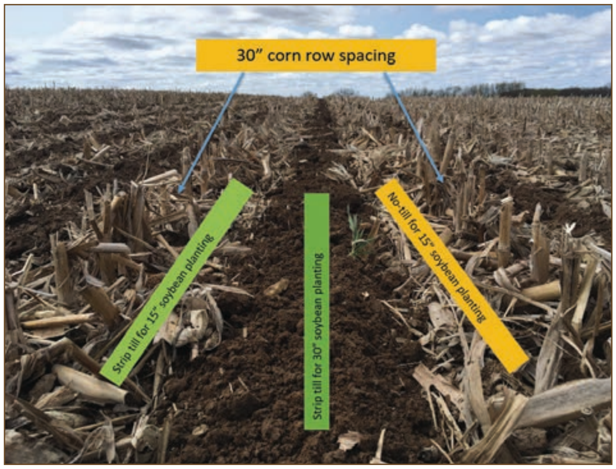


Photo 2. Remlinger strip-till unit with Gandy fertilizer box used in the small plot trial.

Photo 3. In every plot, three penetrometer measurements were collected in the in-row (I) location and three in the between-row (B) location.

The same fertilizer rate was also applied as the broadcast treatment. Nitrogen was side-dressed at 190 and 160 pounds per acre in the continuous corn and corn soybean rotation, respectively. All corn plots were planted in 30″ row spacing directly over 30″ strip-till rows or in no-till. Soil temperature and penetration resistance were collected as well as plant population, canopy coverage and yield. Soil penetration resistance was collected using a cone penetrometer in crop rows and between crop rows (Photo 3). Soybean seed yield was corrected to 13% moisture and corn grain yield was corrected to 15.5% moisture.

RESULTS AND DISCUSSION

SOIL TEMPERATURE

No differences in soil temperature were observed between strip-till and no-till plots for any date during the 2016, 2017, or 2018 growing seasons, therefore data for this measurement are not shown.

SOIL PENETRATION RESISTANCE

In soybean, the three-way interaction between tillage × row location × row spacing significantly affected soil penetration resistance (Fig. 1). Across row spacings and in the in-row location, a reduction in penetration resistance was observed in the upper 12.5-cm (Fig. 1 A, B, D). In between-row locations, there were no differences in penetration resistance by depth in 30″ row spacings, and one significant difference was observed at the 5-cm depth in 15″ row spacing (Fig. 1 C). This suggests that penetration resistance in between-row location in strip-till in 15″ row spacing was comparable to no-till. The only difference in strip-till, 15″ row spacing between in row and between row locations was observed at 10-cm depth (Fig. 1 E). Planter disturbance likely contributed to similar penetration resistance values in in-row and between-row locations in the upper 7.5-cm. Overall, penetration resistance was decreased in strip-till rows, resulting in a more favorable seedbed for soybean production.

In corn, within the corn/soybean rotation, a significant interaction between tillage × row location was observed (Fig. 2). Within no-till plots, between-row locations had greater penetration resistance than in-row locations at the 0- to 2.5-cm depths, possibly due to disturbance from planting in the upper 5-cm (Fig. 2 A). Within strip-till locations, in-row location had significantly less penetration resistance from 0- to 10-cm a reduction likely caused by the strip-till row unit (Fig. 2 B). A similar resistance difference was observed when comparing no-till and strip-till within the in-row location between 5- to 10-cm (Fig. 2 C). Again, planter disturbance in the no-till row likely decreased disturbance in the top 2.5-cm, resulting in no response. These results are in agreement with similar studies on penetration resistance in strip-till and no-till systems which also found a reduction in penetration resistance from strip-till in the upper 10-20 cm of soil (Licht and Al-Kaisi, 2005).

PLANT POPULATION

In soybean, the main effect of row spacing was significant. Plant population was 9,100 plants ac^{-1} (8.0%) greater in 30″ row spacing than in 15″ row spacing. Plants in 30″ rows likely benefited more from intra-plant assistance during emergence due to their reduced intra-row spacing.

In corn, crop rotation and fertilizer were found to be significant factors (Table 1). Banded fertilizer had 900 plants ac^{-1} (2.5%) greater plant population than surface applied fertilizer (Table 1). CS rotated corn had 1,300 plants ac^{-1} (3.8%) greater plant population than continuously planted corn (Table 1). Few studies have included the

Key for Figures 1 and 2

NT = no-till, ST = strip-till, I = in-row, B = between-row

Stars denote that there was a significant difference in moisture content between the interactions being compared. The standard errors represent the standard error of the mean.

* Significant at 0.05 level

** Significant at 0.01 level

***Significant at 0.001 level

FIGURE 1. Soil penetration resistance by depth in soybean between:

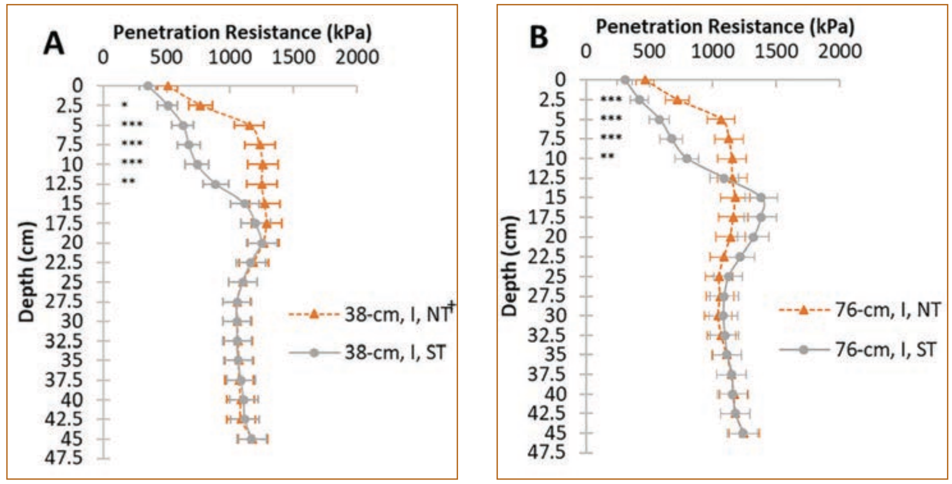
A_NT and ST for I, 15″ row spacing (38 cm)

B_NT and ST for I, 30″ row spacing (76 cm)

C_NT and ST for B, 15″ row spacing (38 cm)

D_B and I locations for ST, 30″ row spacing (76 cm)

E_B and I locations for ST, 15″ row spacing (38 cm)



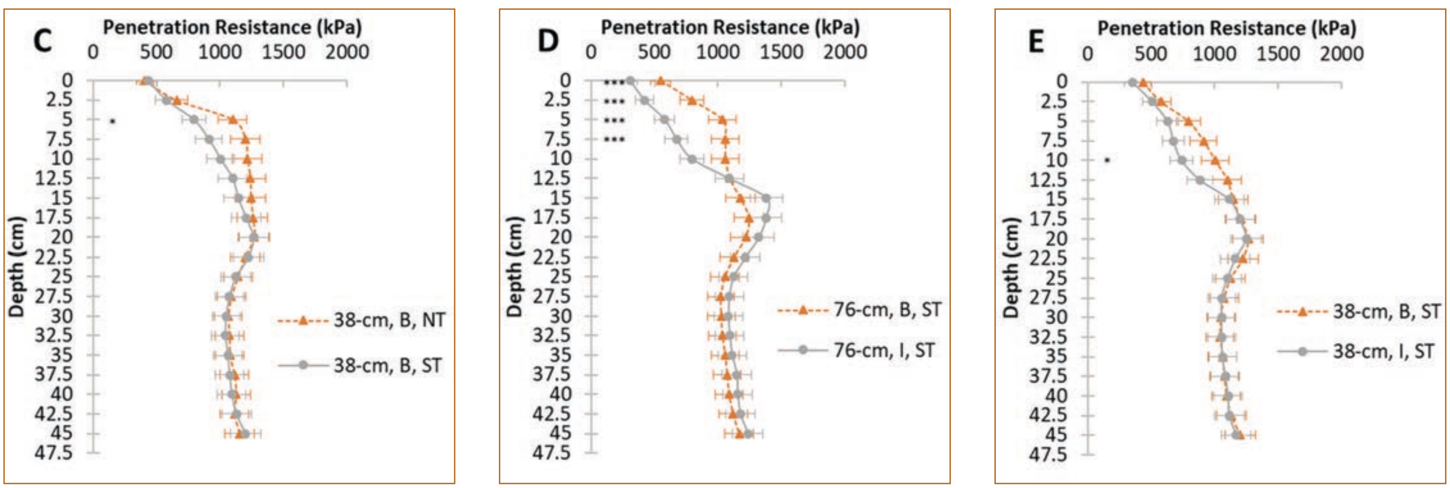


FIGURE 2. Soil penetration resistance by depth in corn between:

A_I and B for NT

B_I and B for ST

C_NT and ST for I locations

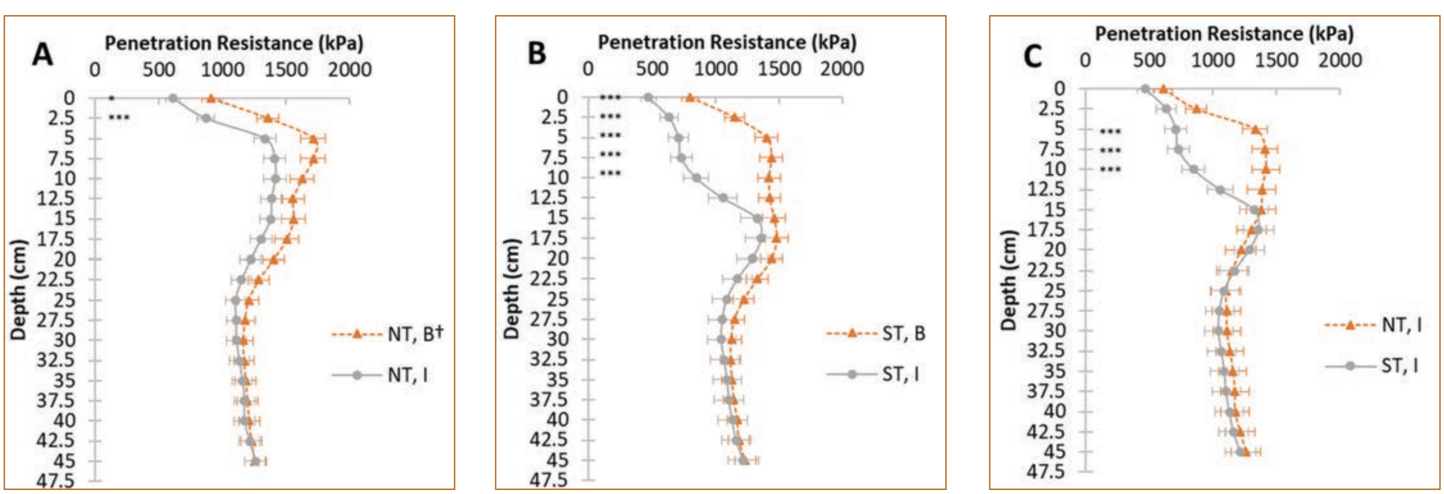


Table 1. Fertilizer placement and crop influence on corn plant population (plants ac^{-1}) from 2016-2018.

Fertilizer placement	Plant population
Deep banded	33,300a‡
Surface applied	32,400b
Crop rotation	
Corn/soybean	33,300a
Continuous corn	32,000b

‡ Yields followed by the same letter within a given year and effect are not significantly different at α=0.05.

Table 2. Fertilizer placement and tillage × fungicide × row spacing influence on soybean seed yield (bu ac^{-1}) from 2016-2018.

Fertilizer placement			Seed yield
Deep banded			68.7a‡
Surface applied			64.3b
Tillage § × Fungicide × Row space			
ST	Fungicide	15″	70.5a
NT	non-treated control	15″	67.2ab
ST	non-treated control	15″	66.9ab
ST	Fungicide	30″	66.1b
ST	non-treated control	30″	65.9b
NT	Fungicide	15″	65.7bc
NT	Fungicide	30″	61.1c
NT	non-treated control	30″	56.1d

‡ Yields followed by the same letter within a given year and effect are not significantly different at α=0.05.
§ ST, Strip-till; NT, No-till

Table 3. Fertilizer placement, tillage, and crop × fungicide influence on corn grain yield (bu ac^{-1}) from 2016-2018.

Fertilizer placement		Grain yield
Deep banded		232.5a‡
Surface applied		221.1b
Tillage		
ST (strip-till)		229.2a
NT (no-till)		216.1b
Crop rotation × Fungicide		
Corn/soybean	Fungicide	237.5a
Corn/soybean	non-treated control	229.6b
Continous corn	non-treated control	216.9bc
Continous corn	Fungicide	215.3c

‡ Yields followed by the same letter within a given year and effect are not significantly different at α=0.05.

interaction of in-furrow fungicide with crop rotation, however studies have found little response of plant population with crop rotation (Pedersen and Lauer, 2003). Improving stand viability is important as plant populations and corn grain yield are positively correlated (Pedersen and Lauer, 2002).

CANOPY COVERAGE IN SOYBEAN

Canopy reached 50% coverage earlier in 2018 than in 2017, likely due to earlier planting date in 2018 (Fig. 3). In 2017, 50% canopy coverage was reached ~5 days earlier in 30″ row spacing than in 15″ row spacing. This result contradicts most research in soybean canopy coverage which suggests earlier canopy coverage and greater light interception in narrow row spacings (i.e. 15″) (Wells, 1991). Increased plant population in 30″ row spacings could have contributed to this result. Strip-till and fertilizer placement response to canopy coverage varied by year and no response was observed from in-furrow fungicide use.

YIELD

In soybean, banded fertilizer resulted in 4.4 bu ac^{-1} (6.5%) greater yield than surface applied fertilizer, however, without a deep banded no-till treatment it is not possible to compare results to similar studies (Farmaha et al., 2011) (Table 2). Greatest soybean seed yield within the crop row spacing × tillage × in-furrow fungicide interaction was obtained by combining strip-till, in-furrow fungicide, and 15″ row spacing. However, this combination resulted in similar yield to no-till, NTC, and 15″ row spacing and to strip-till, NTC, and 15″ row spacing (Table 2).

In corn, strip-till yielded 13.1 bu ac^{-1} (5.7%) greater than no-till and banded fertilizer yielded 11.4 bu ac-1 (4.9%) higher than surface applied fertilizer (Table 3). Corn/soybean × in-furrow fungicide had greater grain yield than corn/soybean × NTC, corn/corn × NTC, and corn/corn × in-furrow fungicide (Table 3). The effect of in-furrow fungicide was dependent on crop rotation and likely was a result of differing pathogen load between rotations (Peters et al., 2003). In general, CS rotated corn yielded greater than corn/corn. A 9.3% yield increase was attributed to the CS rotated corn compared to continuous corn.

FIGURE 3. Triangles and circles denote what it took to achieve 50% canopy coverage in soybean for respective treatments by year. The lines show the 95% confidence intervals.

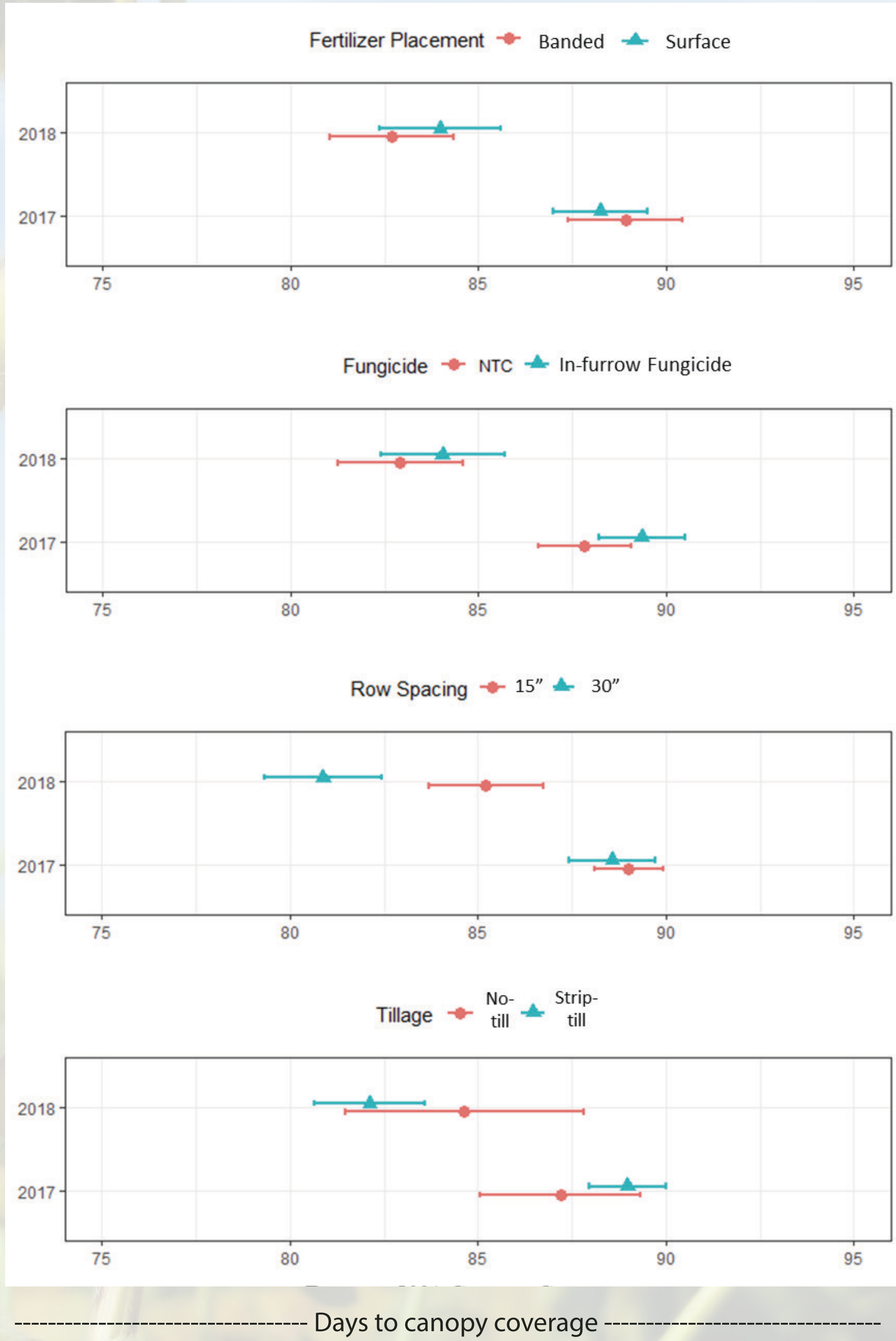
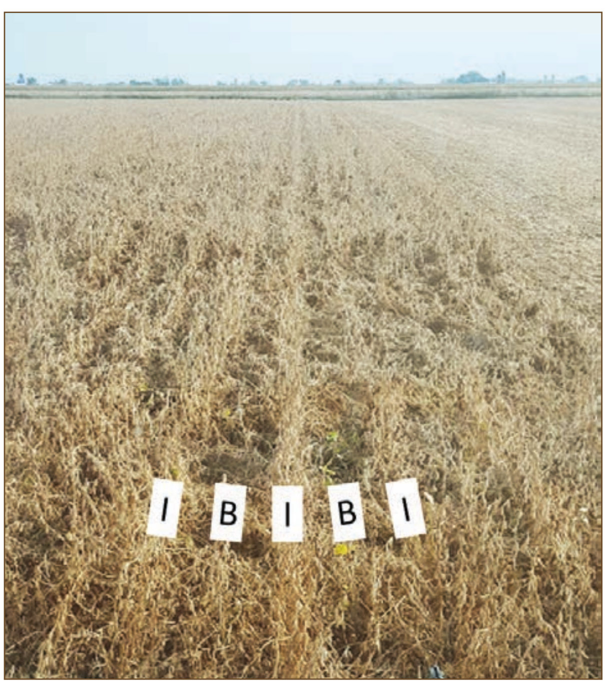


Photo 4. Kuhn Krause gladiator strip-till unit with a Montag fertilizer box used in the on-farm trial.

Table 4. On-farm treatment combinations of tillage, crop row spacing, and fertilizer placement.

Treatment I.D.	Tillage	Crop Row Spacing	Fertilizer Placement
1	Strip-till	15″	Surface
2	Strip-till	30″	Surface
3	Strip-till	15″	Banded
4	Strip-till	30″	Banded
5	No-till	15″	Surface

Photo 5. Plants in the between-row (B) location were lodged during harvest while those in the in-row location (I) were not at harvest.



EXPERIMENT 2: ON FARM TRIAL

MATERIALS AND METHODS

Field scale trials were conducted in four study sites in Walworth, WI and Sharon, WI during the 2016 and 2017 growing seasons. There were five treatments consisting of combinations of no-till and strip-till, fertilizer placement, and row spacings (Table 4). All strip-till was completed using a 12-row, 30″ till spacing Kuhn Krause gladiator strip-till unit with a Montag fertilizer box which allowed for deep banded 15-38-131 NPK fertilizer application (Photo 4). The same fertilizer rate was also applied as the broadcast treatment. Strip-till treatments were conducted each May within a week of soybean planting. Soybean was planted at 140,000 seeds ac^{-1} into all plots in either 15″ or 30″ row spacing using a split-row Case IH PT 1200 that can plant either 15″ or 30″ rows. For strip-till plots, 30″ row spacings were planted directly over strip-till rows, whereas the 15″ row spacings were planted with every other row planted directly over strip-till rows. Soil temperature, penetration resistance, and soil moisture, as well as plant population and yield were collected.

RESULTS AND DISCUSSION

SOIL TEMPERATURE

No differences in soil temperature were observed between strip-till and no-till plots for any date during the 2016 or 2017 growing seasons, therefore data for this measurement are not shown.

PENETRATION RESISTANCE

In on-farm trials a significant interaction between treatment combination × row location × depth was observed (Fig. 4). In treatments two (strip-till, 30″ row spacing, surface fertilizer) and four (strip-till, 30″ row spacings, banded fertilizer) in-row locations exhibited reduced penetration resistance compared to between-row locations for 2.5 to 12.5 cm and 0 to 7.5 cm depth respectively (Fig. 4 A and B, respectively). Within in-row locations, treatment two (strip-till, 30″ row spacing, surface fertilizer) exhibited significantly reduced penetration resistance than treatment five (no-till, 15″ row spacing, surface fertilizer) between 5-12.5-cm (Fig. 4 C). Within in-row locations, treatment four (strip-till, 30″ row spacing, banded fertilizer) had significantly less penetration resistance than treatment five (no-till, 15″ row spacing, surface fertilizer) between 5-10-cm (Fig. 4 D).

PLANT POPULATION AND YIELD

There were no differences in plant population or yield between treatment combinations in the on-farm study; however, there were obvious differences in plant vigor between plants in strip-till rows and plants between strip-till rows (Photo 5).

CONCLUSION

In soybean, small plot yield response to strip-till was affected by other management practices. Based on our results in Wisconsin, farmers utilizing 15″ row spacings should consider using no-till and surface applied fertilizer, while farmers utilizing 30″ row spacing should consider strip-till and banded fertilizer.

In-furrow fungicide yield response was management specific; more research is needed to make a clear recommendation for its use in the average planting date in farmer's fields (trial planting dates are similar to farmers planting dates). Optimum planting date is the date that planting would have resulted in highest yield (based on our analysis).

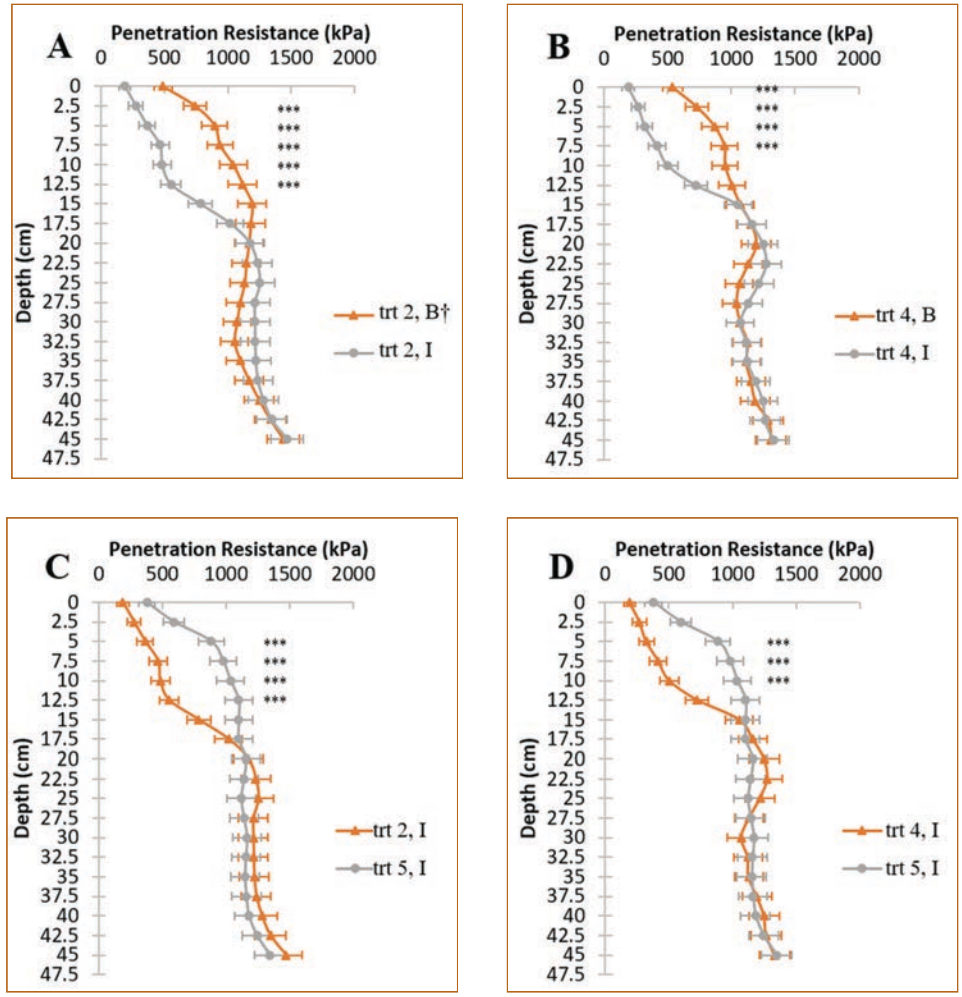


FIGURE 4. On-Farm soil penetration resistance by depth in soybean between:
A_B and I for ST+30″ row spacings + surface fertilizer (trt 2)
B_B and I for ST+30″ row spacings + banded fertilizer (trt 4)
C_ST+30″ row spacing+surface fertilizer (trt 2) and NT+15″ row spacing+surface fertilizer (trt 5) for I
D_ST + 30″ row spacing + banded fertilizer (trt 4) and NT+15″ row spacing+surface fertilizer (trt 5) for I.

Key for Figure 4

NT = no-till, ST = strip-till,
I = in-row, B = between-row

Stars denote that there was a significant difference in moisture content between the interactions being compared. The standard errors represent the standard error of the mean.
* Significant at 0.05 level
** Significant at 0.01 level
***Significant at 0.001 level

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