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Impact of Planter Type, Planting Speed, and Tillage on Stand Uniformity and Yield of Corn

By Weidong Liu, Matthijs Tollenaar, Greg Stewart and William Deen

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Spacing uniformity, timing and rate of emergence, and plant population in a corn stand are the most common characteristics used by producers in evaluating planter performance. Planter mechanisms and maintenance along with planting speed may all influence seed singulation and placement and can further affect plant spacing and emergence variability in corn. Such variability may ultimately affect plant growth and grain yield.

The effect of within-row plant spacing variability on grain yield is somewhat unclear. Various studies have demonstrated a corn yield reduction associated with spacing variability, whereas other studies indicate that spacing variability commonly observed in many commercial fields will not reduce grain yield if plant population is adequate. In contrast, uneven emergence almost always reduces grain yield, with early-emerged plants unable to compensate for the lower yield of late-emerging plants.

Excessive planting speeds can alter seeding rates, increase stand establishment variability and consequently decrease grain yield. Increasing planting speed increased the standard deviation (SD) of plant spacing by 0.4 to 0.6 cm kph^{-1} (kilometers per hour) and yield losses of 78 kg ha^{-1} kph^{-1} in planting speed in the range of 6.4 to 11.3 kph were observed in a study in 1995. The effect did not consistently occur, with only five out of 22 sites demonstrating this relationship. It was concluded in this study that future research on the effect of planting speed on grain yield should measure the effects on emergence uniformity because faster planting speeds can decrease uniformity of seeding depth and seed-to-soil contact, causing uneven emergence.

Previous research has examined the mean response of commonly used planters to planting speed and generally has ignored the possible differences of individual planters with differing mechanisms. In addition, no data have been published to determine if planter performance is the same in reduced tillage systems compared with conventional tillage (CT) systems or whether there are interactions between planter and tillage system and between planter and planting speed. A comparison of planter performance under different tillage systems and at different planting speeds may assist growers in improving planter performance, thereby increasing yield and economic returns. More practically, it may assist growers in evaluating corn planter requirements before retrofitting or replacing existing planters.

The objectives of this study were to (1) determine if planter type affects corn growth and grain yield by altering plant spacing and emergence variability and (2) assess whether plant-spacing and emergence variability resulting from various planter types is influenced by planting speed and tillage management.

MATERIALS AND METHODS

Field experiments were conducted in 2000 and 2001 at the Elora Research Station and the Woodstock Research Station in south-central Ontario, Canada. A mean accumulation of 2,650 crop heat units occurred during the growing season at Elora, and 2,850 crop heat units occurred at Woodstock. At Elora, the London loam soil is an imperfectly drained medium, mixed, weakly to moderately calcareous Typic Hapludalf with tile drainage and an organic matter content of 38 to 40 g kg^{-1}. The Guelph loam soil at Woodstock is a well-drained medium, mixed, alkaline, moderately to very strongly calcareous Typic Hapludalf with 20 to 30 g kg^{-1} organic matter.

Experimental design was a split-split plot arrangement of a randomized complete block with four replicates of each treatment. Two tillage systems were main plots, three types of planter were subplots, and two levels of planting speed were sub-subplots. Each sub-subplot consisted of four rows in 0.76-m row spacing and 25 m in length. Each main plot was bordered by eight rows. The two tillage systems were CT and no-till (NT). The CT treatments consisted of spring moldboard plowing to a depth of 16 cm followed by one or two cultivations before planting. In both years, the previous crop was alfalfa at Elora and soybeans at Woodstock.

Three planters were chosen to represent the range in planter technologies currently available to corn growers in Ontario. For the purpose of description, the three planters are referred to as (1) vacuum meter, (2) finger pickup and (3) air seeder. The vacuum meter was a John Deere 1750 MaxEmerge Plus planter that was manufactured in 1998 and equipped with a double-disk opener system, 2.5-cm-wide angled closing wheels, fingered residue removers attached in front of the furrow opener, three coulters set at a 10- to 15-cm depth and seed firmers. The finger-pickup planter was a John Deere 7000 planter manufactured in 1986 with similar components as the vacuum meter planter, except for the absence of seed firmers. The air seeder was a Gandy Orbit-Air 6224 air seeder manufactured in 1990. Unlike the previous two planters, this planter has no precision-metering device. Seed metering is achieved using a ground-driven revolving seed drum that delivers seed from the central hopper to delivery tubes to each seed furrow. Furrow opening is achieved by a single disc and furrow closing by a single angled closing wheel. No residue removers, coulters or seed firmers were on this planter.

All planters were adjusted to plant at a depth of 4 to 5 cm, a row width of 76 cm and a target population of 71,500 plants ha^{-1}. The two planting-speed treatments of 7.2 and 11.3 kph were chosen to represent low and high speeds used by farmers in Ontario.

Corn was planted on May 30, 2000, and May 9, 2001, at Elora and May 22, 2000, and May 1, 2001, at Woodstock. Roundup Ready corn hybrids DK335 and DK C42-21RR were used at Elora and Woodstock, respectively. Urea NH_4NO_3, at a rate of 150 kg N ha^{-1}, was injected between rows at approximately four to five weeks after planting. Glyphosate was sprayed five to six weeks after planting for weed control.

Corn emergence was recorded by daily counting the number of emerged plants in two central rows of each sub-subplot starting seven days after planting and continuing for 20 days. Within-row plant spacing was measured for 120 consecutive plants in the center two rows of each sub-subplot at two weeks after silking. Within-row plant-spacing variability was determined by calculating the plant-spacing SD. Number of days from planting to 50% plant emergence was calculated.

Plant samples were taken at six and 12 weeks after planting. At both sampling dates, the above-ground biomass of 10 consecutive plants in each plot was harvested from a premarked sampling area that was bordered by two rows on each side and by six plants within the row on each end. Green leaf area of all harvested plants was measured. The leaves and stems of sample plants were dried at 80°C for 72 hours before measurement of plant dry matter. At maturity, ears were hand-harvested from 6 m of the two center rows. Grain yield was adjusted to a 15.5% moisture basis. Final plant population, number of broken stalks, and number of double and barren ears were determined from the harvest area.

RESULTS AND DISCUSSION

Treatment effects were significant for most measured characters, and these effects generally were similar across years in combined variance analysis. Monthly mean air temperatures for both years were close to the 30-year average. Monthly precipitation was above the 30-year average in 2000 and below in 2001. Interactions between tillage treatment and location mostly were insignificant in combined analysis. Tillage had significant effects on all measurements. At Woodstock, feeding by wild animals caused significant damage in six plots in one replication in 2000. Also at Woodstock, several of the air seeder plots had very low populations (less than 75% of the target population) in 2001, presumably due to poor furrow closing. Yields and other data from those plots were eliminated from the analysis.

The vacuum meter produced the lowest SD, and the air seeder produced the highest SD. For the air seeder, SD was approximately two times higher than for the other two planters. The air seeder used in this study did not possess a seed-singulating mechanism, and consequently higher SD levels were expected.

In general, for all planters, SD increased as planting speed increased. The effect of planting speed on SD was greatest for the finger pickup and the air seeder under NT. Averaged over all locations and years, SD increased from 10.0 to 12.2 cm for the finger pickup and from 19.3 to 21.8 cm for the air seeder as speed increased from 7.2 to 11.3 kph under NT. Standard deviation increased an average of 0.4 cm per kilometer increase in planting speed, a value similar to that reported in an earlier study.

Tillage system had a greater impact on SD of the finger pickup and air seeder than the vacuum meter. Averaged over the location, year, and planting speed, SD increased from 9.5 cm and 19.2 cm under CT to 11.1 cm and 20.6 cm under NT for the finger pickup and the air seeder, respectively. In comparison, SD levels for the vacuum meter were similar under both CT and NT systems. The singulating mechanism used in the vacuum meter appeared to be less affected by increased jarring of the planting unit often associated with either higher planting speeds or NT conditions.

While initial corn emergence occurred on the same day for all treatments, cumulative emergence patterns, as indicated by days to 50% corn emergence, were affected by planter type and tillage. Among the three planters, the number of days required to achieve 50% emergence was similar between the vacuum meter and finger-pickup planter but differed between these two planters and the air seeder. Under CT, planting speed did not affect the emergence pattern produced by the vacuum planter or finger pickup planter. The emergence delay observed for the air seeder was probably due to poor depth control and the inability of the single closing wheel to adequately close the seed furrow.

The number of days required to achieve 50% emergence for NT was approximately 1.5 days greater than for CT. This difference was increased when planting speed was increased or when the air seeder was used. The longer time taken by corn in NT treatments to emerge may have been associated with lower soil temperature in the NT vs. the CT treatments.

Final plant population between tillage systems differed, but population was unaffected by planter type and planting speed treatment within a tillage system. When averaged across all locations and years, mean plant population was 72,670 plants ha^{-1} for CT and 70,730 plants ha^{-1} for NT.

Leaf area index (LAI) and above-ground dry matter differed between both tillage systems and among the three planters but not between low and high planting speeds. For example, averaged across planters and planting speed, mean LAI and dry matter measured 12 weeks after planting were both 18% lower in NT than in CT. Averaged across tillage and planting speed, LAI and dry matter accumulation were consistently highest for the vacuum meter and lowest for the air seeder at the two locations. Compared with the vacuum meter, mean dry matter accumulation was 14% and 10% lower for the finger-pickup planter and 36% and 14% lower for the air seeder at six and 12 weeks after planting, respectively.

Planter types and tillage systems differed in mean grain yield, and a tillage x planter interaction occurred. Averaged across all locations and years, grain yield was 7.41, 7.17 and 6.80 Mg ha^{-1} for the vacuum planter, finger-pickup planter and air seeder, respectively. Grain yield was lower in NT than in CT. Averaged over all locations and years, NT yielded 7, 8, and 15% lower than CT for the vacuum meter, finger pickup and air seeder, respectively. Averaged across locations, years and planting speeds, yield differences between air seeder and the other two planters were greater in NT than in CT. In CT, the finger pickup and air seeder produced 0.24 and 0.34 Mg ha^{-1} lower yield than the vacuum meter, respectively. In the NT system, the finger pickup and air seeder yielded 0.26 and 0.90 Mg ha^{-1} lower than the vacuum meter, respectively. Planting speed had no effect on grain yield at both locations with an exception for the air seeder under NT management. Averaged across locations and years, yield declined 0.41 Mg ha^{-1} when planting speed increased from 7.2 to 11.3 kph.

Regression analyses indicated that grain yield reductions were related to greater within-row plant spacing variability and delays in emergence. Yield decreased approximately 35.9 kg ha^{-1} for each centimeter increase in within-row plant spacing SD in the range of SD from 6.5 to 23.9 cm. Two previous studies suggested that grain yield is unaffected by the plant-spacing SD within rows, but the SD values in these studies ranged from 6.7 to 16.2 cm and 2.5 to 17.5 cm, respectively. In the present study, grain yield response may be due to the large within-row plant spacing SD (6.5 to 23.9 cm) produced by the air seeder treatment, which was two to three times higher than observed for the other two planters. With vacuum meter and finger-pickup planters, grain yield was unaffected by the SD values for within-row plant spacing.

Results of the present study confirm previous research findings on emergence delay effects on grain yield. Yield decreased 292.8 kg ha^{-1} d^{-1} whenever the time to 50% emergence was delayed by >3 days across the three planters. The number of days required to achieve 50% emergence was 1.5 to 2 days greater with the air seeder than the other two planters. Differences were accentuated when planting speed was increased.

Grain yield was lower with the air seeder than the vacuum meter in both tillage systems. In CT, the air seeder produced similar yield as the finger pickup. However, the air seeder produced lower yields than the finger pickup in NT and also yielded lower under high planting speed than low planting speed.

SUMMARY

The three planters evaluated in this study were chosen to be representative of the range of planting technologies currently available to Ontario growers. The vacuum meter represents a well-maintained planter with the most current technology for ensuring accurate seed singulation and placement. The air seeder represents a planter with poor seed singulation and placement capabilities. The finger-pickup planter represents a commonly used planter with intermediate seed singulation and placement capabilities.

The results of this study suggest that grower attention to planter mechanisms and maintenance becomes more critical under NT or when operating speeds are increased. Overall performance on plant spacing uniformity was in the order of vacuum meter > finger pickup > air seeder. The vacuum meter and finger-pickup planter produced an equivalent within-row plant spacing SD when operated under CT at a planting speed of 7.2 kph. However, under NT or at the higher planting speed, SD increased with the finger-pickup planter whereas SD remained stable with the vacuum meter planter. Emergence patterns did not differ between the vacuum meter and finger-pickup planter, whereas emergence was delayed when the air seeder was used. In general, the planter that produced the lowest within-row plant spacing SD and the most uniform emergence also achieved the highest LAI, dry matter accumulation and yield.

The air seeder used in this study could be modified so as to improve performance. Ontario growers are interested in the possibility of using this type of planter since it would enable them to plant all crops of a typical Ontario crop rotation (i.e., corn, soybeans and cereals) using a single planter. However, results from this study would suggest that this type of planter is probably not advisable for corn unless planting conditions are ideal and planting occurs at low operating speeds. If these conditions do not occur, the air-seeding system will probably need to be equipped with devices to improve seed singulation and placement.

Editor's note: *Content was adapted from the paper "Impact of Planter Type, Planting Speed, and Tillage on Stand Uniformity and Yield of Corn," which was published in Agronomy Journal, Vol. 96, November-December 2004, and is courtesy of the authors Weidong Liu, Matthijs Tollenaar, Greg Stewart and William Deen.*

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Impact of Planter Type, Planting Speed, and Tillage on Stand Uniformity and Yield of Corn

March Self-Study Examination

1. Within-row plant spacing variability:

[ ] a. conclusively results in a reduction in corn yield.
[ ] b. has no correlation with corn yield.
[ ] c. may only cause corn yield reductions when spacing variability is very high.
[ ] d. effect on corn yield is too difficult to determine.

2. Uneven emergence:

[ ] a. has no effect on grain yield.
[ ] b. almost always reduces grain yield.
[ ] c. is directly proportional to plant spacing.
[ ] d. will not affect grain yield as long as the plant population is adequate.

3. Faster planting speeds:

[ ] a. can increase seeding depth uniformity.
[ ] b. can enhance seed-to-soil contact.
[ ] c. can ensure uniform plant emergence.
[ ] d. can cause uneven emergence.

4. For this study, the soil type at both of the Canadian research stations was a:

[ ] a. Typic Hapludalf.
[ ] b. Typic Hapludoll.
[ ] c. Typic Boralf.
[ ] d. Typic Boroll.

5. The effect of planting speed on standard deviation (SD) was greatest for the:

[ ] a. finger pickup and the air seeder under CT.
[ ] b. finger pickup and the air seeder under NT.
[ ] c. vacuum meter and the air seeder under CT.
[ ] d. vacuum meter and the air seeder under NT.

6. Tillage system had a greater impact on standard deviation:

[ ] a. on the vacuum meter and air seeder than on the finger pickup.
[ ] b. on the finger pickup and air seeder than on the vacuum meter.
[ ] c. on the finger pickup and vacuum meter than on the air seeder.
[ ] d. on all three planters equally.

7. Among the three planters, the number of days required to achieve 50% emergence was:

[ ] a. similar between the air seeder and finger pickup but differed between these two planters and the vacuum meter.
[ ] b. similar between the vacuum meter and finger pickup but differed between these two planters and the air seeder.
[ ] c. similar between the air seeder and the vacuum meter but differed between these two planters and the finger pickup.
[ ] d. the same.

Over

8. The number of days required to achieve the 50% emergence for NT was approximately:
[ ] a. 1.5 days greater than for CT.
[ ] b. 1.5 days less than for CT.
[ ] c. 2.5 days greater than for CT.
[ ] d. 2.5 days less than for CT.

9. The results of the study suggest that grower attention to planter mechanisms and maintenance becomes more critical:
[ ] a. under NT or when operating speeds are increased.
[ ] b. under CT of when operating speeds are increased.
[ ] c. under NT or when operating speeds are decreased.
[ ] d. under CT or when operating speeds are decreased.

10. The planter that produced the lowest within-row plant spacing standard deviation and the most uniform emergence also achieved the:
[ ] a. lowest LAI.
[ ] b. lowest dry matter accumulation.
[ ] c. highest yield.
[ ] d. highest LAI, dry matter accumulation and yield.

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