Corn Planting Depth: Soil Temperature and Moisture Flux in the Furrow

Key Findings:

- Shallow planting shortened the time to the start of corn emergence, but lengthened the duration of emergence resulting in a less uniform stand.
- Soil moisture was lower and more variable closer to the soil surface, which likely contributed to the less-uniform emergence with shallower planting.
- Planting depth affected yield in a higher organic matter field, but had no effect in a lower organic matter field.

Objectives

- A three-year field study was conducted to assess effects of soil temperature and moisture flux on emergence of corn planted in fields with varying soil classifications and characteristics, and to determine the impact of planting depth on emergence and yield.
- This research was conducted by Dr. Peter Thomison and Dr. Alex Lindsey, Ohio State University, as a part of the Pioneer Crop Management Research Awards (CMRA) Program.

Study Description

- **Years:** 2017 to 2019
- **Location:** South Charleston, Ohio
  - Field 1: Strawn-Crosby silt loam (2.0-3.1% organic matter)
  - Field 2: Kokomo loam (3.8-4.6% organic matter)

  Research fields were within 0.5 miles of each other, so were subject to similar weather conditions
- **Planting Dates:**
  - May 16 (2017), May 11 (2018), June 4 (2019)
- **Previous Crop:** Soybean (all years)
- **Nitrogen Fertility Program:**
  - 2017-2018: 180 lbs N/acre applied as anhydrous ammonia (82-0-0) prior to planting
  - 2019: 180 lbs N/acre applied as UAN (28-0-0) at V6 (program changed due to excessive spring rain in 2019)
- **Seeding Rate:** 35,300 seeds/acre
- **Hybrid/Brand[1]:** P1197AM™ (AM, LL, RR2)
- **Experimental Design:** Randomized complete block design with four replications of planting depth treatments; plots were 10 x 150 ft (four 30-inch rows)
- **Planting Depth (Targeted):**
  - 1 inch, 2 inches, 3 inches

Data Collection and Analysis

- A combination soil moisture and soil temperature sensor (CS655, Campbell Scientific) was installed at seeding depth in each plot. Once installed, the sensors were connected to a datalogger and continuously recorded average temperature and soil moisture every twenty minutes until the V3 growth stage.
- Soil moisture data was adjusted to plant available water content (AWC) for each field using field-specific calibrations (AWC of 100% = field capacity; AWC of 0% = permanent wilting point).
- Emergence curves were modeled using a sigmoid function:

$$Emerge_t = d + \frac{a}{1 + e^{(b-c*x)}}$$

where $Emerge_t$ (emergence at point t) is the dependent variable, x is days after planting (DAP) or soil accumulated growing degree days (GDDs, 50 F base), and *a, b, c, d* were the model parameters used to best fit the equation.

Results

- Actual planting depths for the 2 and 3 inch treatments were slightly less than the targeted depths in both fields (Table 1).
- Emergence in the higher organic matter field was delayed slightly compared to the lower organic matter field.
- The time to 50% emerged for all depths was within 0.8 days and 5.8 GDDs for the low organic matter field, and within 0.6 days and 11.0 GDDs for the high organic matter field.

Table 1. Actual depth to seed, time to 50% emergence (T_{50}) and the time from 10% emergence (T_{10}) to 90% emergence (T_{90}) as measured in calendar days and soil accumulated growing degree days for each planting depth treatment and field.

Field	Target Depth	Actual Depth	T_{50}	T_{10}-T_{90}	T_{50}	T_{10}-T_{90}
	inches		days		GDDs	
Crosby (low OM)	1	1.1 c	5.0	2.2	131.2	37.8
	2	1.7 b	5.1	1.5	127.0	36.6
	3	2.5 a	5.8	1.5	132.8	35.1
Kokomo (high OM)	1	1.0 c	6.9	5.9	170.6	86.1
	2	1.8 b	6.3	4.0	162.0	57.9
	3	2.4 a	6.7	2.9	159.6	47.5

- In both fields, the patterns of emergence differed with planting depth. Emergence commenced earliest with the shallowest planting depth, but also had the longest emergence window (time from 10% to 90% emerged).

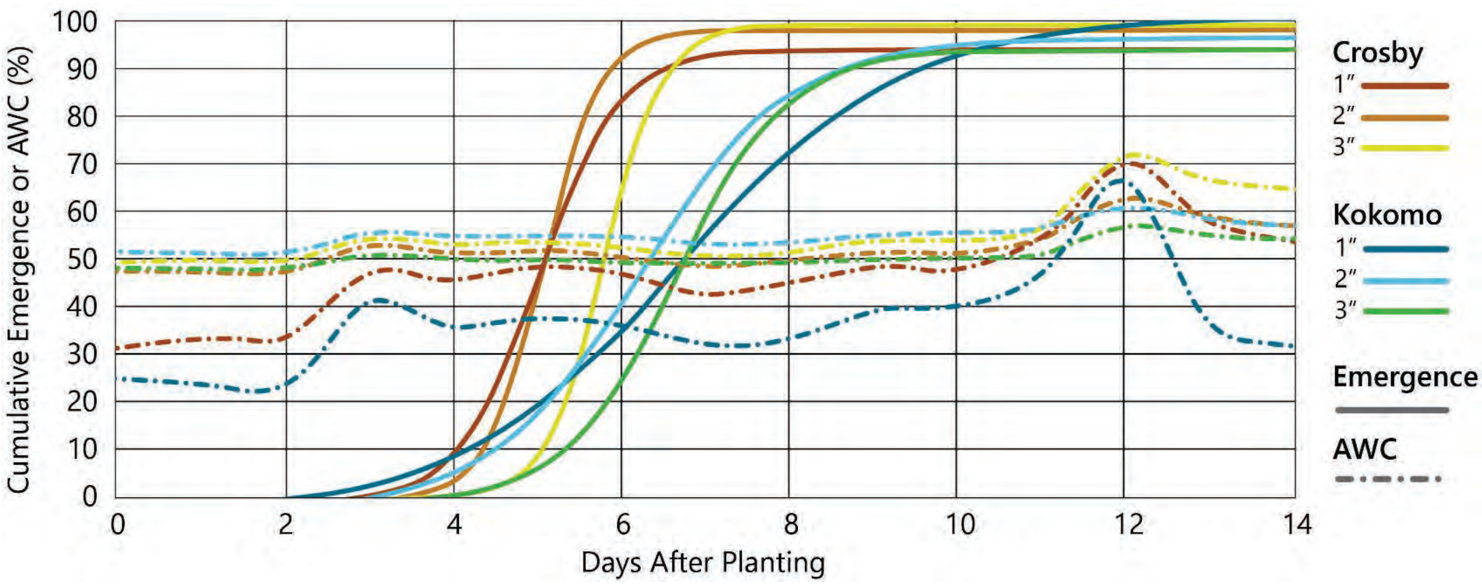

Figure 1. Cumulative daily emergence and available water content for the 1, 2, and 3-in planting depths in the Crosby (low organic matter) and Kokomo (high organic matter) fields. Models were built for data collected from 2017-2019.

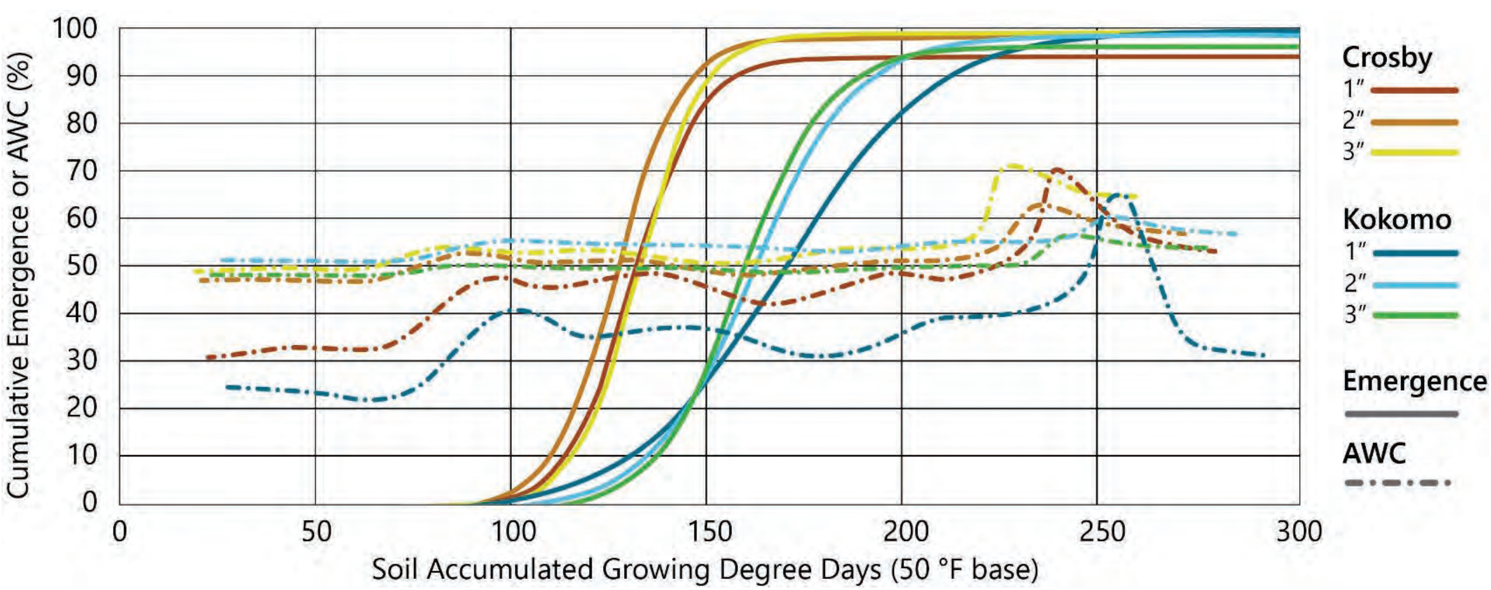

Figure 2. Cumulative emergence and available water content for the 1, 2, and 3-in planting depths in the Crosby (low organic matter) and Kokomo (high organic matter) fields as influenced by soil growing degree day accumulation. Models were built for data collected from 2017-2019.

- The longer emergence window with shallow planting can be seen in the flatness of the sigmoidal curves in Figure 1, where model parameters b and c were significantly different ($P < 0.05$) between the 1-in and 3-in emergence curves in both fields.
- The longer emergence window with shallower planting may have been due to differences in available water content at planting, where AWC was 20-25% less at the shallowest depth.
- Soil water increased after approximately 3 days in the trials due to timely rainfall (Figure 1).
- Emergence began latest with 3-inch planting depth in both fields (Figure 1), but exhibited the shortest T_{10}-T_{90} interval (Table 2).
- When evaluating emergence as driven by soil accumulated GDDs, the patterns changed from calendar dates slightly (Figure 2).
- The difference between emergence curves for the 1-inch and 3-in depths were no longer evident in the low organic matter field, but were still evident in the high organic matter field.
- This was also reflected in the T_{10}-T_{90} values, where the low organic matter field differed by 2.7 GDDs between depths but the high organic matter field differed by 38.6 GDDs (Table 1).

Installation of the soil moisture and temperature sensor in furrow in 2017.

- Planting depth did not affect plant biomass at the V3 growth stage, dominant ear leaf number, total leaf number, percent of runt plants, or stalk strength (data not shown).
- Planting depth did impact kernel per ear and had a marginal effect on total kernel dry weight per plant (Table 2), where the greatest values were observed at the 3-in depth.
- Basal emptiness was greatest with 1-inch planting depth.
- The difference in total kernel number may have been driven by improved pollination or decreased kernel abortion leading to marginally greater kernel numbers per row (data not shown).
- Across years, there was a significant (P = 0.030) planting depth by field interaction for corn yield (Table 3).
  - Yields were similar across planting depths in the low organic matter field (ranging from 213 to 217 bu/acre).
  - In the high organic matter field, corn yield was significantly lower with the 1-inch planting depth compared to the 2-inch and 3-inch depths.
  - Lower yield with shallow planting may have been a result of the longer emergence window (T_{10}-T_{90}) as shown in Table 1.

Table 2. Ear yield components as impacted by planting depth across fields. There were no significant field or depth by field interactions for any yield component. Data were combined across 2017-2019 for analysis.

Target Depth	Kernels Per Ear	Basal Empty	100 Kernel Weight	Total Kernel Dry Weight per Plant
inches	— count —		——— g ———	
1	467 b	1.31 a	27.8	132.4
2	484 ab	1.21 ab	27.7	135.7
3	508 a	1.16 b	27.7	141.8
P-Value	0.009	0.021	0.958	0.112

Table 3. Grain yield as affected by planting depth across years. Letters denote differences for the interaction of field by planting depth.

Field	Target Depth	Grain Yield
	inches	bu/acre
Crosby (low organic matter)	1	217 ab
	2	216 ab
	3	213 ab
Kokomo (high organic matter)	1	211 b
	2	227 a
	3	232 a
P-values	Field	0.690
	Depth	0.147
	Field x Depth	0.030

Conclusions

- Planting depth impacted emergence patterns in both a higher and lower organic matter field.
- In each field, the emergence was most uniform at the 2-inch and 3-inch planting depth settings, which resulted in actual depths of 1.7-2.1 and 2.5-2.7 inches on average, respectively.
- Although first emergence was delayed in the 3-inch depth treatment compared to the 1-inch depth, the final emergence was reached more rapidly at the 3-inch depth compared to the 1-inch depth.
- Less uniform emergence with shallow planting was likely driven by lower and more variable soil moisture in combination with faster temperature accumulation..

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