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Elizabeth Maynard
Purdue University - Main Campus, emaynard@purdue.edu

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Elizabeth T. Maynard, Purdue University
625 Agriculture Mall Dr., W. Lafayette, IN 47907 emaynard@purdue.edu

No-till planting of sweet corn into a killed winter rye cover crop is not a widely used practice in Indiana, but has potential to provide soil health benefits such as reduced compaction, improved soil waterholding capacity, reduced evaporation from soil surface, and other benefits documented for other no-till systems. This paper reports on the second year of a project to develop a workable system at the Pinney Purdue Ag Center for no-till sweet corn production after winter rye that can be used for demonstration and in future research to better understand and improve production practices.

Materials and Methods

The trial was conducted at the Pinney Purdue Ag Center near Wanatah, Indiana. The soil at the experimental site is a Tracy sandy loam. Results of the fall 2020 soil test are shown in Fig. 1.

Experimental plots were established in a stand of 'Hazlett' winter rye that had been drilled on Sept. 25, 2020, after soybean harvest. In early April, 2021, rye was 4-6 inches tall, tillering, and formed a thick solid stand in the rows.

The experiment included four tillage treatments. In the conventional tillage treatment, hereafter termed 'BARE,' rye termination began with tillage on Apr. 16, 2021, followed by four additional tillage operations to complete termination and prepare for planting. In the 'HERB' treatment, rye was treated with the herbicide glyphosate on May 12. At this time rye was at the boot stage and approximately 2-2.5 ft. tall. In this treatment corn was later no-till planted into the residue. In the 'RPRE' treatment rye was killed by roller-crimping a week before no-till planting the corn. In the 'RPOST' treatment, corn was no-till planted into standing rye and rye was killed by roller-crimping three days after seeding. The tillage treatments were main plots, 30 ft. × 70 ft., randomized in two blocks. Two cultivars, Catalyst and Flagler, were subplots in each main plot, with 6, 40-ft. rows per cultivar. For each cultivar, data were collected from the center 30 ft. of two rows. These were the center two rows of a 4-row planter pass. A diagram of the experiment is shown in Fig. 2.

Field operations are listed in Table 1 and pesticide applications in Table 2. Nitrogen was broadcast at 50 lb./A on April 9 and side-dressed at 60 lb./A on July 2. Sweet corn was seeded on June 11 using a John Deere 7000 Maxemerge planter set to plant 20,600 seeds/A. For no-till plots two 70-lb. sand bags were placed on each seeder unit to provide enough weight to make a furrow of the desired depth. Planting depth was 1.25-1.5 inch. Preemergence herbicides acetochlor and atrazine were applied on June 15. Overhead irrigation was applied on June 17 and Aug. 18 to supplement rainfall during dry periods.

Emerged seedlings were counted in two of the four inner rows in each subplot 7, 10, and 17 days after planting (DAP) on June 18, 21, and 28. The typical growth stage of plants was also recorded.

When silking began the number of plants silking in two 30-ft. rows in each subplot was determined every 1 to 4 days until 90% of plants had silked. The earliest date more than 50% of plants in each row showed silk was recorded as the 50% silking date. Thirty feet of 2 rows from each subplot were harvested when ears reached marketable stage, approximately 21 days after 50% silking. The top ear from each plant was harvested. Harvested ears were graded as marketable or unmarketable due to smut, underdevelopment, or other reason including mammalian tooth marks and deformity. The number of ears in each category were counted and marketable ears were weighed. The number of marketable ears considered fancy–well-sized with very good husk cover and tipfill–were counted. Three marketable ears from each subplot were rated for husk cover and tip fill, and measured to determine average ear diameter and length after husking.

Data were analyzed using the Fit Model platform of JMP Pro version 16.1.0 with personality standard least squares and restricted maximum likelihood (REML) method. Means for tillage treatments were compared using contrasts to compare BARE vs all no-till treatments (No-till); HERB vs Roller-crimping (Rolled), and RPOST vs RPRE. Differences with less than a 5% chance of being caused by random variation were considered significant.

Results and Discussion

Fig. 3 summarizes rainfall and temperature for the 2021 growing season. June was warmer and wetter than normal, leading to more favorable soil moisture at planting than in 2020. The first half of July was drier than normal. The last half of July through August was wetter than normal, followed by a dry period in the first half of September. Temperatures were good for sweet corn growth during the season and there was enough rain that irrigation was applied only twice, just after planting and in early August.

On August 10 significant heavy rain with high winds resulted in serious lodging of corn (Fig. 4. The BARE plots sustained the most damage, and 'Catalyst' appeared to be more affected than 'Flagler.' Plants righted themselves somewhat by the time harvest began the following week, but the lodging made harvest more difficult, and where it was most severe, probably reduced quality because ears came in contact with the soil.

Emergence

Seven days after planting (DAP) emergence averaged 80%, 63%, and 0% for BARE, HERB, and the two rolled rye treatments, respectively (Fig. 5). The difference between BARE and HERB treatments was not statistically significant. By 10 DAP emergence had increased to 82%, 73%, 70%, and 75%, for BARE, HERB, RPOST and RPRE treatments, respectively, but did not differ significantly among treatments. Little additional emergence occurred by 18 DAP and no significant differences among treatments were observed. Emergence appeared to be delayed in rolled rye. The method of terminating the rye, and no-till planting versus planting into tilled soil did not significantly change total emergence. In 2020 also, the rolled rye plots emerged later than the BARE plots, and whether rye was rolled before or after planting did not significantly affect emergence. The two cultivars did not differ significantly in emergence or in their emergence response to no-till planting.

Differences in speed of emergence due to the tillage treatments could have resulted from differences in soil temperature, moisture, or both. The weather station at the research center reported 4-inch average soil temperatures of 78.9°F and 76.2°F under bare ground and grass, respectively, for the week after seeding. Unreplicated soil moisture measurements taken on June

9 suggested that RPRE plots were drier than BARE or HERB plots (data not shown). This difference in moisture is not surprising because before roller-crimping, the rye in RPRE was more than 4 ft. tall and had been actively transpiring throughout the spring, the BARE plots had essentially no vegetation and therefore little transpiration since mid-April, and rye in the HERB plots rye had been terminated 4 weeks before and was dead by June 9, so would have used less water from the soil than rye in RPRE. We observed poor furrow closure in some no-till rows and that could have delayed emergence due to poor seed-soil contact.

Yield

Yield components and ear size and quality characteristics are presented in Table 3. Plant number at harvest did not differ significantly among tillage treatments, but there was a trend towards fewer plants in no-till plots, where stand was 90% of BARE plots. The number of marketable ears per plot reflected this difference in stand as well as the smaller number of marketable ears per plant in no-till treatments: no-till plots produced just 71% of the number of marketable ears produced in the BARE plots. When rye was terminated by rolling, sweet corn produced fewer marketable ears per plant than when it was terminated with herbicide. Corn grown in plots where rye was rolled before seeding producing the fewest marketable ears per plant. The main reason for ears being unmarketable was underdevelopment, and this was much more common in the no-till plots (15% of all ears averaged across no-till treatments) than in the BARE plots (2% of all ears). It is likely that late-emerging sweet corn in no-till plots was outcompeted by earlier emerging plants, and so could not develop a large enough ear by the time most of the plants were ready for harvest.

The two varieties, Catalyst and Flagler, did not differ in number or weight of marketable ears per plot or number of marketable ears per plant. There was a trend for Flagler to have a higher percentage of marketable ears (90.4%) than Catalyst (81.9%), and a lower percentage of undeveloped ears (8.4% vs. 15.3%), but the difference was statistically significant only at $P<.10$. The cultivars responded similarly to the tillage treatments in terms of yield.

Ear Size and Quality

In the no-till plots marketable ears were significantly larger–20% heavier and 5% longer and wider–than in the BARE plots. This is likely related to the larger number of plants with undersized ears in no-till plots, which would have provided less competition for the plants that did produce ears of marketable size. Husk cover and tip fill were acceptable in all treatments, with average ratings at least 4.3 or higher averaged across varieties. Catalyst produced slightly shorter and narrower ears than Flagler. A smaller percentage of Catalyst ears (37%) were fancy than Flagler (73%).

Days to Harvest

Corn in BARE plots was harvested 4.5 days earlier than in HERB plots, and 10 days earlier than in RPOST and RPRE plots (Table 4). In 2020 the differences in harvest dates were not as great, but the same pattern was observed: BARE plots were earlier than HERB, which were earlier than the rolled rye plots. The delay in emergence could partly explain this, but it is also possible that other factors associated with those treatments slowed corn development. Light and temperature during early seedling growth, and nutrient availability are factors likely to differ that could influence corn development rate. Flagler was harvested about 4 days after Catalyst. The two varieties responded similarly to the tillage treatments in terms of the delay in development.

Summary and Conclusions

For the second year this suggests that the early and main season varieties of sweet corn respond similarly to no-till planting after winter rye killed with glyphosate or by roller-crimping. Compared to conventional tillage, reductions in marketable ear number and a trend to reductions in weight occurred in crops no-tilled into rye. This year there was a trend for marketable ear number to be lower in no-till plots where rye was killed by rolling than where rye was killed with glyphosate, but confidence that this effect would be routinely observed is low. This year's marketable yield differences seem likely related in part to differences in stand establishment, including timing and uniformity of emergence. Future work to improve the system in trial plots should include adjustments to get better furrow closure in the no-till plots.

Acknowledgments

G. Tragesser and Pinney-Purdue Agricultural Center staff managed field operations. B. Hoffman and R. Nemit assisted with crop management, data collection and entry. J. Rorick provided assistance in cover crop and soil management assessment and advice on planting equipment.

Table 1. Schedule of field activity for 2021 no-till sweet corn trial, Pinney Purdue Ag Center, Wanatah, IN.

DATE	Operation
4/9/21	Broadcast nitrogen, 50 lb /acre; urea
4/16, 5/13, 5/21, 6/3, 6/11/21	Till BARE plots
5/12/21	Kill rye with glyphosate
6/4/21	Roll/crimp rye in RPRE plots and plot borders
6/11/21	Plant plots
6/14/21	Roll/crimp rye in RPOST plots
6/16/21	Irrigate, 0.5 in.
7/2/21	Side-dress nitrogen, 60 lb/acre; UAN
7/20/21	Handweed
8/3/21	Irrigate, 0.5 in.
8/14 – 8/27	Harvest

Table 2. Pesticide applications for 2021 no-till sweet corn trial, Pinney Purdue Ag Center, Wanatah, IN.

DATE	PRODUCT NAME	ACTIVE INGREDIENT	MANU-FACTURER	PEST	RATE
5/12/21	Durango[z]	glyphosate	Corteva	rye, weeds	24 fl. oz/A
6/15/21	Fultime NXT	acetochlor & atrazine	Corteva	weeds	2.9 qt./A
8/12/21	Arctic 3.2 EC	permethrin	Winfield Solutions	corn earworm	8 fl. oz/A

[z]Durango was applied only to HERB treatment.

Table 3. Yield components and ear size and quality characteristics for two sweet corn varieties grown in four tillage treatments, Pinney Purdue Ag Center, Wanatah, IN, 2021.[z]

Treatment	Plant No	Mkt Ear No	Mkt Ear Wt (lb)	Mkt Ear	Fancy % of Mkt	Ave. Mkt Ear Wt. (lb)	Ear Diam (in)	Ear Length (in)	Husk Cover[y]	Tip Fill[y]	Total Ear No	% Mkt Ear	% Smut	% Unde-veloped	% Other Unmkt
	---------*per plot* [z]---------			*per plant*							*per plot*				
BARE (B)	58.5	57.0	58.5	0.98	0.60	1.03	1.84	7.59	5.0	4.8	58.5	97.5	0.0	2.5	0.0
HERB (H)	52.3	43.3	50.5	0.83	0.62	1.17	1.93	7.70	4.9	4.5	50.5	85.9	1.0	9.7	3.5
RPOST	52.0	41.8	49.0	0.80	0.59	1.18	1.95	8.06	4.9	4.6	49.0	84.9	1.1	14.0	0.0
RPRE	53.8	36.5	49.3	0.69	0.41	1.34	1.94	8.13	4.5	4.3	49.3	76.2	0.9	21.3	1.7
TRT Sig.[x]	NS	**	NS	***	NS	*	NS	*	**	NS	NS	*	**	*	*
Contrast P values[x]															
B vs No-till	†	**	†	***	NS	*	*	*	**	NS	†	**	***	*	*
H vs Rolled	NS	†	NS	**	NS	NS	NS	*	**	NS	NS	†	†	*	*
RPOST vs RPRE	NS	†	NS	**	NS	*	NS	NS	**	NS	NS	*	*	†	†
Cultivar															
Catalyst (1)	56.5	43.9	53.9	0.78	0.37	1.25	1.84	7.73	4.94	4.21	53.88	81.9	1.2	15.3	1.6
Flagler (2)	51.8	45.4	49.8	0.87	0.73	1.11	1.99	8.01	4.71	4.85	49.75	90.4	0.3	8.4	0.9
CV Sig.[x]	NS	NS	NS	NS	**	†	**	**	**	*	NS	†	NS	†	NS
CVxTRT Sig.[x]	NS	NS	NS	NS	NS	NS	NS	†	**	NS	NS	NS	NS	NS	*

[z]Plot area harvested was 150 sq. ft.; multiply by 290.4 to get per acre values.

[y]Husk cover: 5=more than 2 inches cover; 4=1.25-2 inches; 3=0.75-1.25 inches; 2=less than 0.75 inch; 1=ear exposed. Tip fill: 5=kernels filled to tip of cob; 4=less than 0.5 inch unfilled; 3=0.5-1 inch unfilled; 2=more than 1 inch unfilled; 1=more than 2 inches unfilled.

[x]Significance based on P-values from ANOVA for main effects of tillage treatments, cultivar, and interaction, and for orthogonal contrasts comparing means: †, *, **, *** and NS indicate P <.1, .05, .01, .001and non-significant, respectively.

Table 4. Days to harvest for two sweet corn varieties grown in four tillage treatments, Pinney Purdue Ag Center, Wanatah, IN, 2021. Corn was planted on June 1.

Treatment	Days to Harvest
BARE	68.0
HERB	72.5
RPOST	78.5
RPRE	79.5
Cultivar	
Catalyst	72.5
Flagler	76.8

Test	Value
OM	1.8%
pH	6.7
P*	90 ppm
K	135 ppm (6.5%)
Mg	210 ppm (32.7%)
Ca	650 ppm (60.8%)
CEC	5.3 meq/100g

Test	Value
S	10 ppm
Zn	4.9 ppm
Mn	54 ppm
Fe	50 ppm
Cu	1.5 ppm
B	0.3 ppm

Interpretation for Field Crops
Very High
High
Medium
Low

*Bray P1 equivalent

Figure 1. Fall 2020 soil test results for the experimental field.

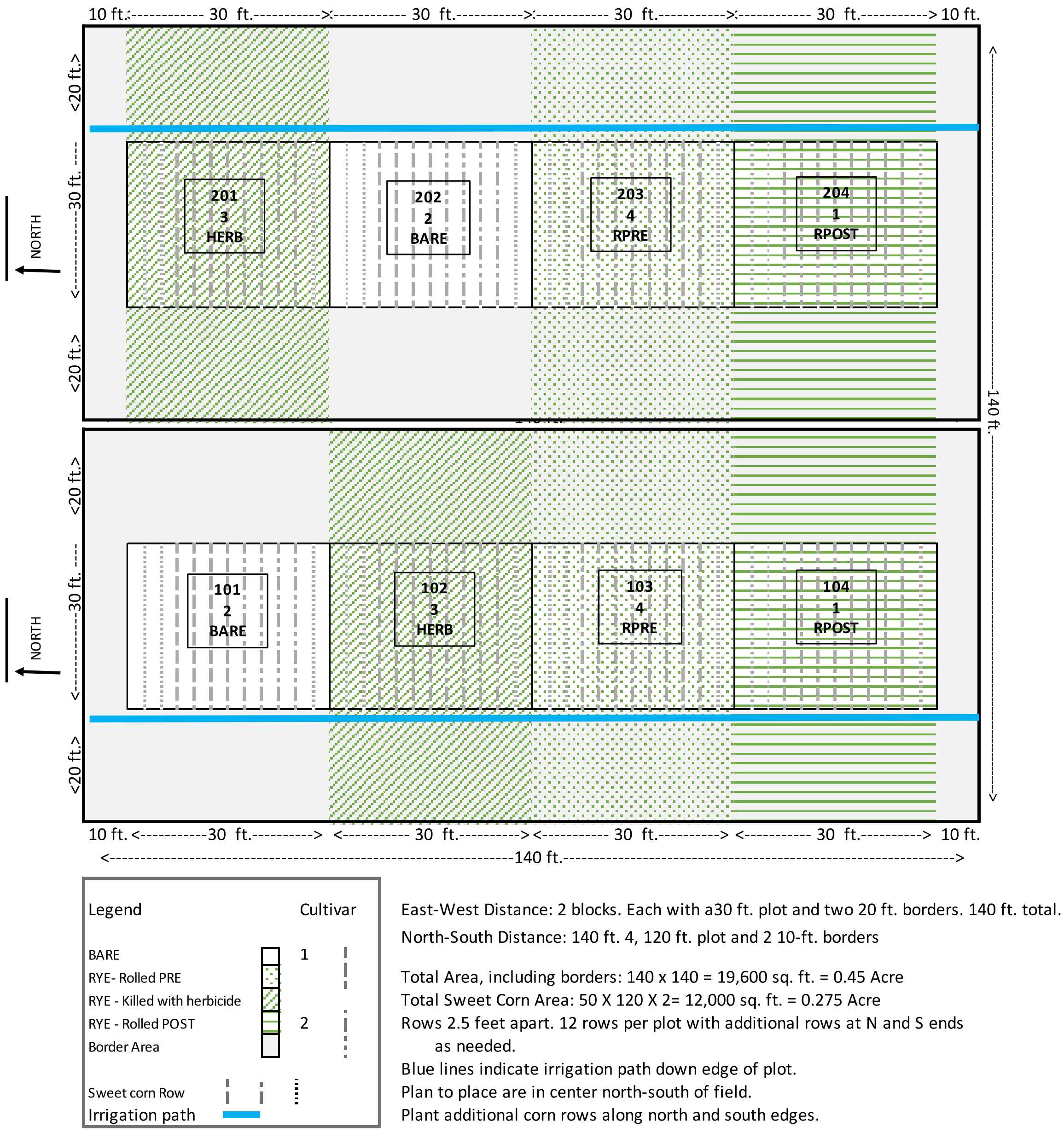


Figure 2. Diagram of no-till sweet corn trial, Pinney Purdue Ag Center, Wanatah, IN, 2021.

Rainfall

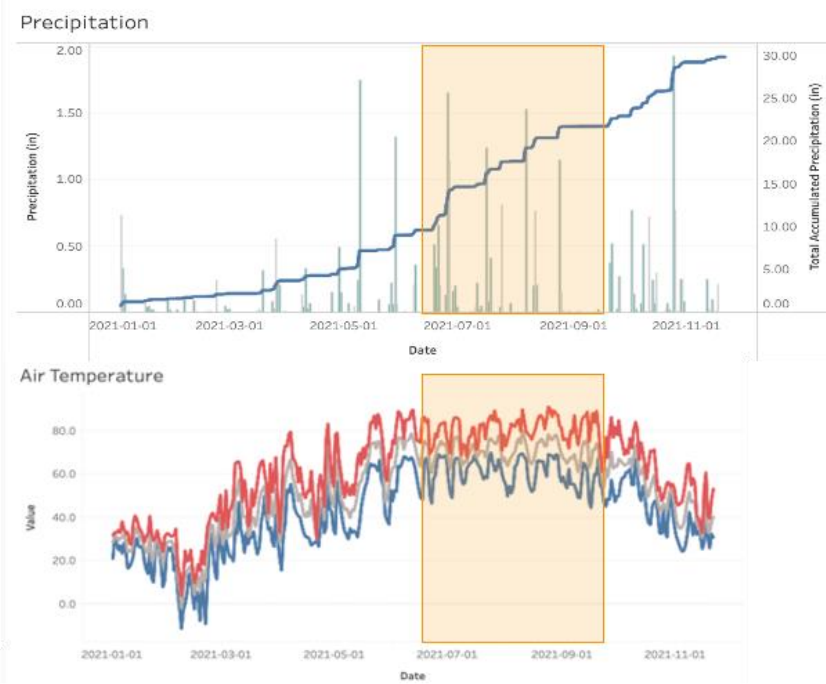
	in.	DFN*
May	2.94	-0.68
June	4.78	0.84
July 1st half	2.49	-0.31
Jul-Aug.	6.44	0.61
Sept (1-19)	0.03	-1.69

Temperature

	Ave.	DFN GDD†
May	57.3	-15
June	71.1	+93
July	70.6	-30
Aug.	72.1	115
Sept (1-19)	66.1	+33

*Departure from normal for May 3-30, May 31-June 27, June 28-July 18, July 19-Aug. 29, and Aug. 30-Sept. 19.
†Departure from normal for Growing degree days base 50.

Source: USDA NASS, Indiana Field Office https://www.nass.usda.gov/Statistics_by_State/Indiana/Publications/Crop_Progress_&_Condition/index.php acessed 11/22/2021



Source: Indiana State Climate Office. 2021. Purdue Mesonet Data Hub. https://ag.purdue.edu/indiana-state-climate/purdue-mesonet/purdue-mesonet-data-hub/. Accessed 11/22/2021.

Figure 3. Weather summary for 2021 at Pinney Purdue Ag Center, Wanatah. Sources: Temperature and precipitation from Indiana State Climate Office. Purdue Mesonet Data Hub. https://ag.purdue.edu/indiana-state-climate/purdue-mesonet/purdue-mesonet-data-hub/. Accessed 11/22/2021. Departures from normal from USDA National Agricultural Statistics Service, Indiana Field Office https://www.nass.usda.gov/Statistics_by_State/Indiana/Publications/Crop_Progress_&_Condition/index.php accessed 11/22/2021.

Figure 4. Sweet corn lodging in four tillage treatments after rain and wind on August 10, 2021, Wanatah, IN.

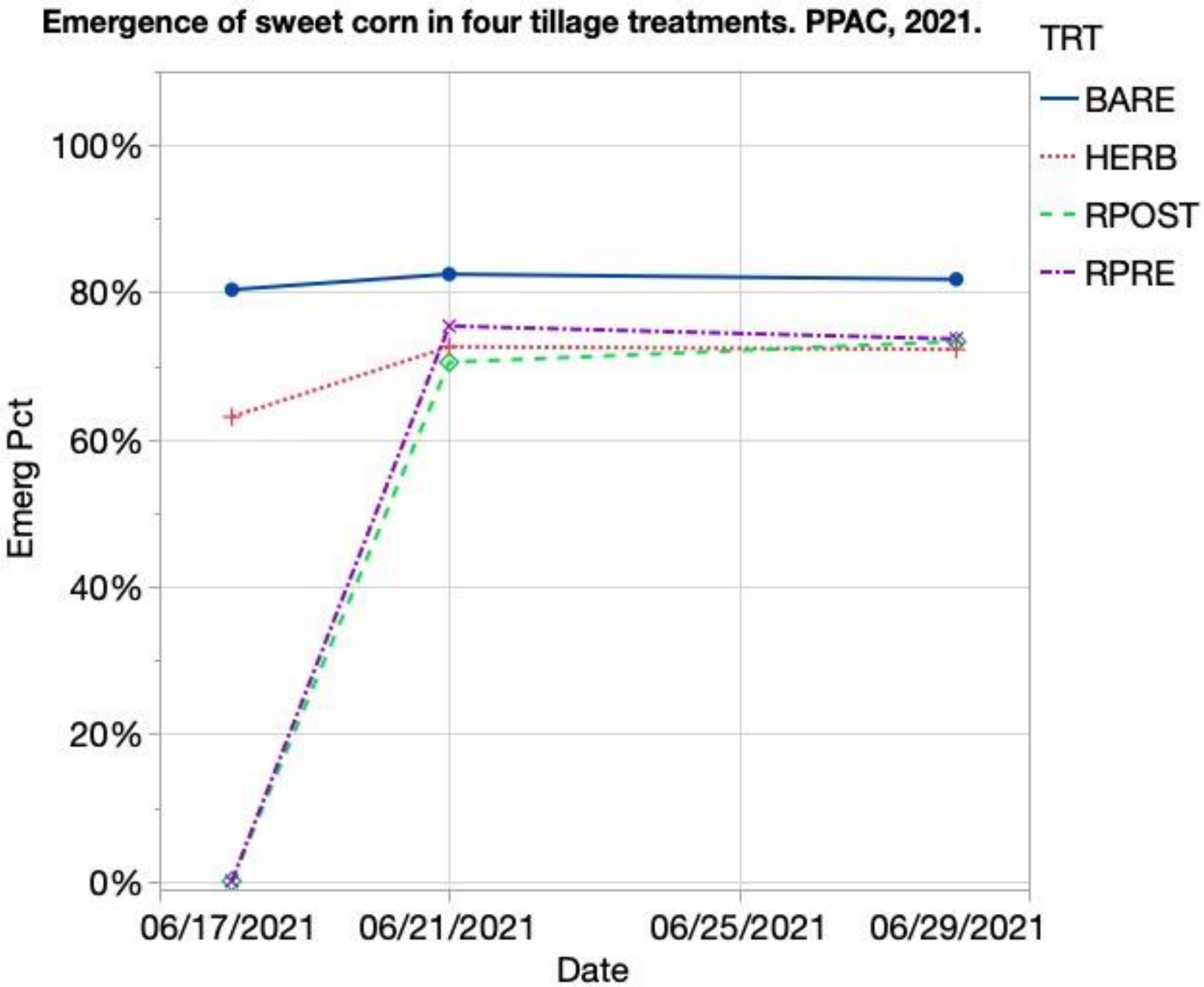


Figure 5. Emergence of sweet corn in four tillage treatments, Wanatah, IN, 2021. Sweet corn was planted on June 11, 2021. Points are means of cultivars Catalyst and Flagler for two replications of each tillage treatment.