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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 cropping systems. The goal of this project is 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 2019 soil test are shown in Fig. 1.

Experimental plots were established in a stand of winter rye (VNS) that had been seeded on Oct. 2, 2019, into a standing soybean crop. The soybeans were harvested the following week. By late April 2020, rye density was approximately 12.3 plants/ft^2, plants were approximately 2-8 inches tall, and well-tillered.

The experiment included four tillage treatments. In the conventional tillage treatment, hereafter termed BARE, rye was killed by tillage on Apr. 27, 2020, and the soil tilled several additional times to prepare for planting. In the HERB treatment, rye and weeds were killed with the herbicides glyphosate and 2, 4-D on May 21 and corn was no-till planted into the residue. In the RPRE treatment rye was killed by roller-crimping just before no-till planting the corn. In the RPOST treatment rye was killed by roller-crimping just after no-till planting the corn in standing rye. The tillage treatments were main plots, 30 ft. × 50 ft., randomized in two blocks. Two cultivars, Catalyst and Flagler, were subplots in each main plot, with 6, 50-ft. rows per cultivar. 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 51.5 lb./A on May 11 and side-dressed at 60 lb./A on June 29. Sweet corn was seeded on June 9 using a John Deere 7000 Maxemerge planter set to plant 20,600 seeds/A. Planting depth was 0.75-1 inch in the center 8 rows of BARE plots, and 1.25 inch in no-till plots and in the 4 outside rows of BARE plots, two rows on each plot edge. The depth setting was deeper in no-till plots because it did not appear that the shallower setting was placing seeds deep enough or covering them well enough in no-till conditions. Outside rows of BARE plots were planted in the same planter pass as outside rows of no-till plots and so the deeper planting depth was used for those rows. Preemergence herbicides acetochlor and atrazine were applied on June 11 and postemergence herbicides mesotrione and atrazine were applied on June 30. Overhead irrigation was applied on June 17 and Aug. 18 to supplement rainfall during dry periods.

Crop emergence was evaluated in two of the 4 inner rows in each subplot 9 days after planting (DAP) on June 18 and 17 DAP on June 26. On June 18 the number of seeds visible on surface of soil and number of seeds eaten were also counted. On June 26 the number of plants with chewed leaves were also counted. On both dates typical growth stage of plants was recorded. Bleaching of corn leaves was observed after the application of mesotrione and so on July 7 severity of symptoms was rated. For each plot there were two injury estimates: 1) the percent of plants showing any degree of bleaching, and 2) the average percent of foliage on a plant that was bleached, recorded using a modified Horsfall-Barratt scale.

When silking began the number of plants silking in two 50-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. Forty feet of row from each subplot was 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. 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 14.0.0 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 10% chance of being caused by random variation were considered significant.

Results and Discussion

The growing season was drier and slightly warmer than normal. Figure 3 illustrates the dry periods in early June and August and more frequent rains in July. June and July each accumulated at least 90 growing degree days more than normal and August was 16 growing degree days below normal. Weeds were well-controlled by the herbicide treatments.

Emergence

Emergence was poor in BARE plots planted at the shallower planter setting, averaging 23% of the planned seeding rate by July 2, and large numbers of seeds were eaten, averaging 25% of the planned seeding rate on June 18 (data not shown). Observations suggested that seed was not planted as deep as expected. In one HERB plot, emergence for Flagler was very low in the interior rows: only 12.7% of the planned seeding rate by July 2. This was probably due to a problem with the seeder unit that was not noticed at planting. In these plots, emergence, seed predation, and seed on surface in the two rows of each subplot at the outside edge of the main plot were also determined, and those data are used for comparisons among treatments discussed below. As described above, these rows on the outside edge of each main plot were planted with the same planter depth settings as all rows in no-till plots.

Corn emerged most quickly (88% by 9 DAP) and had higher total emergence (93% by 23 DAP) with conventional tillage (BARE) than with no-till treatments (Table 3). Corn no-till seeded into glyphosate-killed rye (HERB) emerged sooner (86% by 9 DAP) than ROLL treatments (20% to 31% by 9 DAP), and was similar to BARE. Rolling before versus after planting didn't significantly affect emergence. More seed was observed on the soil surface in no-till plots (10%) than BARE (0.2%), and more in rolled plots (14.3%) than in HERB plots (1.7%). More plants were chewed in no-till plots (3.0/50 ft.) than BARE (0.6/50 ft.), more in rolled plots (5/50 ft.)

than HERB (2.5/50 ft.), and more in plots rolled after planting (6.25/50 ft.) than before planting (2.75/50 ft.). Cultivars did not differ significantly in emergence.

It seems likely that several factors contributed to the treatment difference in emergence when using the deeper planter setting. First, it was more difficult to create a seed furrow of consistent depth and consistently cover seeds in the no-till treatments, especially in the rolled plots. The larger number of seeds visible on the surface in the rolled plots support this. Although we didn't record larger numbers of eaten seeds in roll plots (data not shown), it is possible that there was higher predation that was not detected because no seed remnants remained to be counted. Thirteen-lined ground squirrels are present in high numbers at the research site and were probably eating seeds. Dry soil probably slowed emergence also. Seed near the soil surface would have experienced drier conditions in the period soon after planting. This could explain slower emergence in rolled plots where seeds probably weren't consistently planted as deep as in BARE plots, and where transpiration of the growing rye crop would have used up more soil moisture than was used by the rye killed earlier by glyphosate or tillage. Soil temperature was also likely lower in no-till plots due to the residue coverage: the weather station at the research center reported 4-inch average soil temperatures of 76.3°F and 72.9°F under bare ground and grass, respectively, for the week after seeding. Armyworms were active around the time of planting, could have been responsible for the increase in chewed plants observed in no-till plots, and may have influenced final stand.

Injury

Bleaching of corn leaves attributed to mesotrione was observed on 90% of plants. Symptoms were more severe in BARE than in no-till plots, and corn in HERB plots showed somewhat more injury than in rolled plots (Table 3). Corn was largest in BARE and HERB plots at this point and that may have been related to the higher level of bleaching observed in those plots. The symptoms faded with time.

Yield

Plant number was an important factor in yield (Table 4). BARE plots had more plants than no-till plots: the stand in no-till plots was 81% of the BARE plots. The number and total weight of marketable ears and the total number of ears reflected this difference in stand. No-till plots produced 77% of the number and 80% of the weight of marketable ears, and 82% of total ears in the BARE plots. The no-till treatments did not differ in plant stand or number or weight of marketable ears. The total number of marketable plus cull ears was higher in the HERB treatment than in the rolled treatments. The number of marketable ears per plant was similar in all treatments.

Ear Size and Quality

The size and quality of marketable ears differed among treatments (Table 4). Compared to the no-till treatments, ears from the BARE treatment were slightly narrower, longer, did not have as good husk cover, and a smaller percentage were considered fancy. Ears from the two rolled treatments had better husk cover and a higher percentage of fancy than ears from the HERB treatment. Ears from the RPOST treatment were slightly longer than those from the RPRE treatment, but otherwise ears from the two rolled treatments were similar. Tipfill and average weight per ear were not significantly affected by the treatments.

The percent of all ears that were marketable was similar among treatments, but there were differences in the reasons for unmarketable ears. In the no-till plots 14.5% percent of ears were undeveloped, compared to 6% in the BARE plots. In the HERB plots 10% of ears were unmarketable due to smut, compared to 5% in the other no-till plots and 6% in the BARE plots.

Differences in yield and ear quality can be explained to a large extent by the differences in emergence. Final plant stand reflected differences in total emergence. Treatments with fewer plants produced less marketable yield. Treatments with lower emergence also had a higher number of undeveloped ears, likely associated plants that emerged late or did not establish well. Individual ears from the plots with fewer plants tended to be of higher quality, for instance better husk cover and a higher percentage fancy, which is often observed at lower plant populations.

The two cultivars differed. Catalyst produced less marketable weight per plot than Flagler, similar numbers of marketable ears per plot, but fewer marketable ears per plant. Ears of Catalyst were narrower, longer, and lighter than ears of Flagler, and husk cover was not as good. For Catalyst, a smaller percentage of all ears were marketable, and a smaller percentage of marketable ears were fancy, than for Flagler. The cultivars responded similarly to treatments in terms of plant number, total ear number and marketable ear number and weight, average weight of marketable ear, percent fancy and percent marketable, ear diameter, and husk cover.

Days to 50% Silking and Harvest

Corn in BARE plots was faster to silk by approximately 6 days and was harvested 5 days earlier than corn in no-till plots, averaged over the three no-till treatments (Table 5). The difference was largely due to delays in the rolled plots: they silked and were harvested approximately 7 days after corn in the HERB plots, which was only 1-2 days behind corn the BARE plots. The two rolled treatments silked and were harvested at the same time. The no-till with rolled rye delayed harvest by about a week compared to conventional tillage. The delay in emergence could partly explain this, but it is also possible that other factors associated with those treatments slowed corn development. Flagler was 6 days behind Catalyst in both silking and harvest. The two varieties responded similarly to the tillage treatments in terms of the delay in development.

Summary and Conclusions

This trial 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 weight occurred in crops no-tilled into rye. Marketable ear yield was similar in no-till plots whether rye was killed with glyphosate, or by roller-crimping before or after seeding. The yield differences appear largely due to differences in plant stand, which can be traced back to differences in emergence. At the same planter depth setting, emergence was best with conventional tillage, and better in the no-till system when rye was killed with glyphosate than when rye was rolled. No-till planting into rolled rye or into standing rye that was rolled after planting delayed corn development and harvest by approximately 1 week. This delay could also be attributed, at least in part, to delays in emergence. The most important change required to improve these no-till systems is improving stand establishment. It is likely that adjusting the planter to create a furrow of uniform depth and cover the seed well will improve the results in no-till plots, especially in the rolled plots. Assuring adequate moisture at seeding may contribute to improved planter performance by making it easier to cut a furrow.

Acknowledgments

G. Tragesser and Pinney-Purdue Agricultural Center staff managed field operations. J. Conner assisted with data collection and entry.

Table 1. Schedule of field activity for 2020 no-till sweet corn trial, Pinney Purdue Ag Center, Wanatah, IN.

DATE	Operation
4/27/20	tillage (BARE treatment)
5/11/20	broadcast urea, 51.5 lb N/acre
5/21, 5/27	tillage (BARE treatment)
6/9/20	roll/crimp rye, (RPRE treatment)
6/9/20	plant
6/10/20	roll/crimp rye (RPOST treatment)
6/17/20	irrigation, 0.5 in.
6/29/20	side dress 60 lb N/acre; UAN
7/27/20	install electric fence
8/18/20	irrigate, 0.5 in.
8/14 – 8/27	harvest

Table 2. Pesticide applications for 2020 no-till sweet corn trial, Pinney Purdue Ag Center, Wanatah, IN.

DATE	PRODUCT NAME	ACTIVE INGREDIENT	MANU-FACTURER	PEST	RATE
5/21/20	Durango[z]	glyphosate	Corteva	rye, weeds	24 fl. oz/A
6/11/20	Fultime NXT	acetochlor & atrazine	Corteva	weeds	2.9 qt./A
6/30/20	CallistoXtra X-99 NIS	mesotrione & atrazine	Syngenta Heartland Ag	weeds	20 fl. oz/A 1 pt./100 gal

[z]Durango was applied only to HERB treatment.

Table 3. Emergence, seed on surface, chewed seedlings, and degree of leaf bleaching from presumed mesotrione injury for two sweet corn varieties planted in four tillage treatments, Pinney Purdue Ag Center, Wanatah, IN, 2020. [z]

	Emergence			**Seed on Surface**	**Chewed**	**Bleached Leaf Area**[y]
	June 18	June 26	July 2	June 18	June 26	July 7
Treatment		(% of expected [z])			(no./50 ft.)	(%)
BARE	88%	93%	93%	0.2%	0.6	39.1
HERB	86%	80%	91%	1.7%	2.5	30.7
RPOST	31%	73%	71%	13.6%	6.2	20.3
RPRE	20%	69%	68%	15.0%	3.8	24.1
Trt. Comparisons[x]						
BARE vs No-till	*	†	*	*	**	*
HERB vs Rolled	*	NS	*	**	*	†
RPOST vs RPRE	NS	NS	NS	NS	*	NS
Cultivar						
Catalyst	59.5%	83.7%	82.5%	9.2%	3.9	32.8
Flagler	52.9%	73.5%	78.5%	6.1%	2.6	24.3
	NS	NS	NS	†	NS	NS

[z]Expected number is 20,600/A or 59 per 50 ft. row, based on planter setting.

[y]Ratings of percent leaf area that was bleached were made using a modified Horsfall-Barrat scale. Ratings were transformed to percent for analysis.

[x] †, *, **, and NS indicate significance of treatment comparisons using orthogonal contrasts or cultivar main effect at P <.1, .05, .01, or not significant, respectively.

Table 4. Yield components and ear size and quality characteristics for two sweet corn varieties grown in four tillage treatments, Pinney Purdue Ag Center, Wanatah, IN, 2020.[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)	44.3	33.8	27.3	0.77	64	0.81	1.86	8.18	3.5	4.8	43.0	79	6	6	9
HERB (H)	38.3	27.8	22.6	0.73	69	0.81	1.95	8.08	4.1	4.6	38.0	73	10	13	3
RPOST	34.8	24.5	20.3	0.71	81	0.84	1.96	8.16	5.0	5.0	33.3	75	5	17	3
RPRE	34.3	26.0	22.7	0.76	73	0.86	1.95	7.88	4.7	4.8	34.0	77	5	13	5
TRT P>F[x]	*	NS	NS	NS	*	NS	†	*	*	NS	*	NS	NS	†	NS
Contrast P values[x]															
B vs No-till	*	†	†	NS	*	NS	*	†	**	NS	*	NS	NS	*	NS
H vs Rolled	NS	NS	NS	NS	†	NS	NS	NS	*	NS	†	NS	†	NS	NS
RPOST vs RPRE	NS	NS	NS	NS	†	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
Cultivar															
Catalyst (1)	41.0	26.8	20.3	0.65	55	0.76	1.89	8.23	3.8	4.9	39.4	68	10	13	8
Flagler (2)	34.8	29.3	26.2	0.84	88	0.90	1.97	7.92	4.8	4.8	34.8	84	3	11	2
CV P>F[x]	NS	NS	*	**	**	**	†	**	*	NS	NS	**	**	NS	**
CVxTRT P>F[x]	NS	NS	NS	†	NS	NS	NS	†	NS	NS	NS	NS	*	NS	*

[z]Plot area harvested was 100 sq. ft.; multiply by 435.6 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]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, and non-significant, respectively.

Table 5. Days to 50% silking and harvest for two sweet corn varieties grown in four tillage treatments, Pinney Purdue Ag Center, Wanatah, IN, 2020. Corn was planted on June 9.

Treatment	**50% Silk**	**Harvest**
	days from planting	
BARE	46.7	68.5
HERB	48.4	69.0
RPOST	55.8	76.0
RPRE	54.9	75.3
TRT P>F [z]	***	***
Contrast P values [z]		
BARE vs No-till	***	***
HERB vs Rolled	***	***
RPOST vs RPRE	NS	NS
Cultivar		
Catalyst	48.5	69.4
Flagler	54.4	75.0
CV P>F [z]	***	***
CVxTRT P>F [z]	NS	NS

[z]P-values from ANOVA and for orthogonal contrasts comparing means: *** and NS indicate P <.001 and P>0.1, respectively.

Test	Value
OM	1.6%
pH	6.5
P	104 ppm
K	119 ppm (5.2%)
Mg	165 ppm (23.4%)
Ca	600 ppm (51.0%)
CEC	5.9 meq/100g

Test	Value
S	6 ppm
Zn	4.8 ppm
Mn	50 ppm
Fe	55 ppm
Cu	1.8 ppm
B	0.5 ppm
S	6 ppm

Interpretation for Field Crops
Very High
High
Medium
Low

Figure 1. Fall 2019 soil test results for the experimental field.

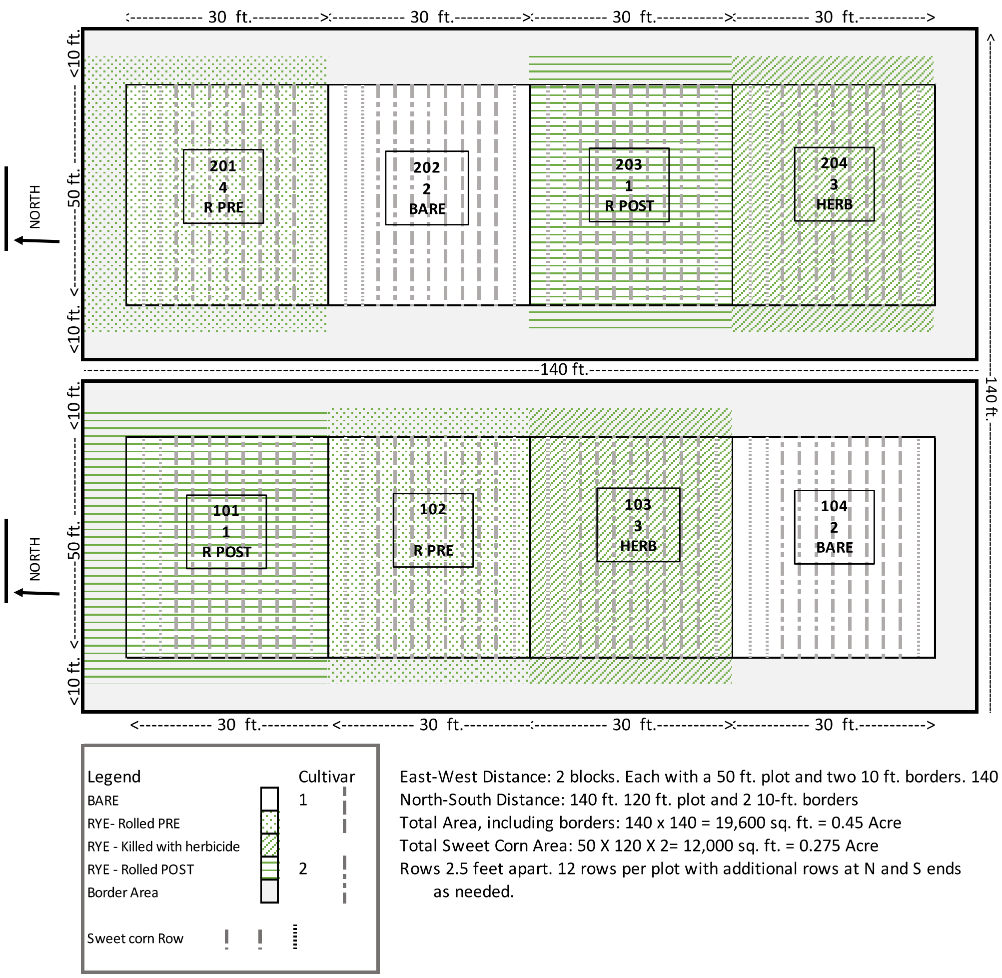
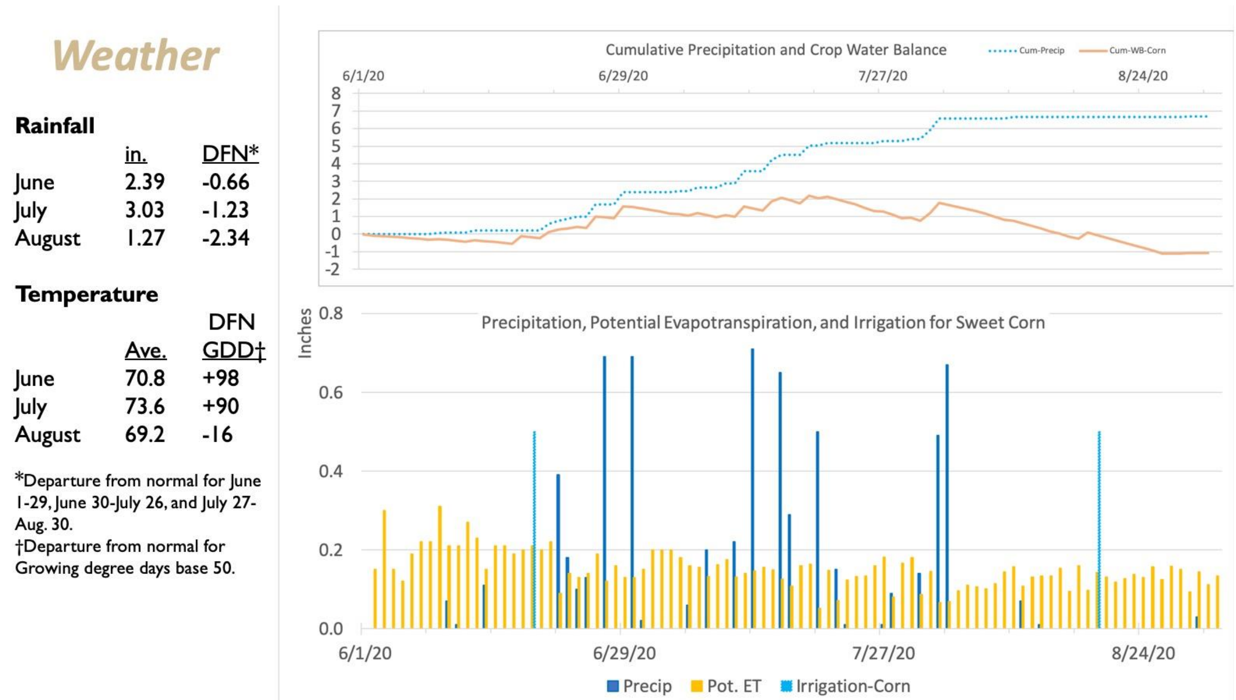


Figure 2. Diagram of no-till sweet corn trial, Pinney Purdue Ag Center, Wanatah, IN, 2020.



X

Figure 3. Weather summary for June 1- Sept. 1, 2020 at Pinney Purdue Ag Center, Wanatah. Sources: Temperature, precipitation, and potential evapotranspiration (ETo) from Indiana State Climate Office. Potential Evapotranspiration Monitoring Tool https://ag.purdue.edu/indiana-state-climate/tools/et-monitoring-tool/. Crop water balance is estimated soil water available to the crop, relative to June 1, with increases from rainfall and irrigation and decreases from estimated evapotranspiration from the crop. Departures from normal from USDA's National Agricultural Statistics Service, Indiana Field Office. Crop Progress & Condition Reports. https://www.nass.usda.gov/Statistics_by_State/Indiana/Publications/Crop_Progress_&_Condition/index.php.