Soil Fertility for Corn Grown after Unharvested Sugar Beets

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Justification: The goal of SMBSC is to optimize the sugar factory's capacity. To do this the grower's goal is to raise enough high quality sugar beets to meet the needs of the factory. Some years this may mean sugar beet acres will not be harvested due to greater than anticipated yield and a limited slice capacity. Little information exists on management practices for optimum corn production following unharvested sugar beets.

Objective: Determine what management practices are useful for optimum field corn production following unharvested sugar beets. Specifically answering the following questions: 1. Do the unharvested roots need to be removed, 2. Does the use of starter fertilizer help corn production, and 3. Does the corn crop need more N applied after unharvested roots compared to removed roots?

Materials and Method: A study was conducted on corn grown in 2018, 2020, 2021, and 2022 to answer these objectives. The study was located near the SMBSC factory in Renville, MN in 2018, near the Murdock piling site in 2020, near Cosmos, MN in 2021, and near Maynard, MN in 2022. In 2017, 2019, 2020, and 2021, the sites were planted to sugar beets and the beets were defoliated but not harvested except for selective treatments. Field corn was grown in the following year. The study included the treatments listed in Table 1. The experimental design was a randomized complete block with four replications. All but three treatments had unharvested sugar beets left in the plot (Photo 1 and 2). Treatments 7, 8, and 9 had the sugar beet roots harvested. Nitrogen fertilizer rates were based on the soil test to 2 feet. Since the soil nitrate-N was low, the MRTN recommendation for corn/corn was used at a price ratio of 0.10 = 155 lb N/A. Seven gallons of 10-34-0 plus 1 lb zinc/A was used as an infurrow starter on all but treatments 1 and 8. In 2018, the site was hand harvested on October 30, the 2020 site was machine harvested on November 4, the 2021 site was hand harvested on September 30, and the 2022 site was hand harvested on October 12.

Table 1. Treatments for field corn following sugar beet production trial.

Treatment	Beets	Starter	N rate
1.	Not harvested	none	0
2.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	0
3.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended – 40 lb N/A (115 lb N/A)
4.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended (155 lb N/A)
5.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended + 40 lb N/A (195 lb N/A)
6.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended + 80 N/A (235 lb N/A)
7.	Harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended (155 lb N/A)
8.	Harvested	None	0
9.	Harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	0

Results:

2018: The corn yields were variable because of the very wet weather experienced in 2018. The statistics and corn yields are reported in Table 2 and 3. Even with the large variability, grain yields were significantly affected by the treatments. The corn grown where the sugar beet roots were harvested yielded 35 bu/acre greater than the corn grown where the beet roots were not harvested, Table 3. Additional N fertilizer was needed for corn for better grain yields. The increase in grain yield was 102 bu/acre when the check was compared to the recommended N rate. Additional N was also needed for corn grown where the beet roots were not harvested. The corn grown after the not harvested sugar beet responded to an additional 80 lb N/acre above the recommended N amount. The use of starter did not have a positive effect on corn grain yield. The wet conditions in 2018 were historical.

2020: The corn yields were good because of the ideal weather experienced in 2020. The statistics and corn yields are reported in Tables 2 and 3. Grain yields were significantly affected by the treatments. There was a significant increase in corn yield of 31 bu/acre if the sugar beets were harvested. The difference in corn yield of 14 bu/acre with the use of starter (7 gallons 10-34-0 plus 1 lb Zn/acre) was significant at the P>0.07 level. The use of N fertilizer at the recommended rate significantly increased corn grain yields by 100 bu/acre over the check. The use of additional 40 lb N/acre fertilizer above the recommended rate increased grain yield 21 bu/acre, significant for corn grown where sugar beets were not harvested the previous fall. Applying 80 lb N/acre above the recommended rate did not increase the corn grain yield above the extra 40 lb N/acre application. It took 40 lb N/acre above the recommended N rate for the corn grain yield on the not harvested treatment to be equal to the corn grain yield with recommended N application for the corn grown where the sugar beets were harvested the previous fall.

2021: The corn grain yields were poor because of drought conditions during the summer of 2021. The statistics and corn yields are reported in Tables 2 and 3. Grain yields were significantly affected by the treatments. There was a significant increase in corn yield of 34 bu/acre if sugar beets were harvested. The difference in corn yield of 7 bu/acre with the use of starter (7 gallons 10-34-0 plus 1 lb Zn/acre) was significant (P>0.09). The use of N fertilizer at the recommended rate significantly increased corn grain yields by 47 bu/acre. The use of an additional 40 lb N/acre fertilizer above the recommended increased grain yield 12 bu/acre, significant at the 0.05 probability for corn grown where sugar beet was not harvested the previous fall. Applying 80 lb N/acre above the recommended rate did not significantly increase the corn grain yield above the extra 40 lb N/acre application. In 2021, additional extra N to the not harvested treatment did not make it yield as well as the corn grown where sugar beet had been harvested the previous fall.

2022: The corn grain yields in 2022 were good but not extra ordinary, Tables 2 and 3. This was caused by wet planting conditions and dry conditions from August to harvest. The corn grain yields were significantly affected by treatments. Corn grain yields were 37 bu/acre greater if sugar beet roots were harvested. The use of starter increased corn grain yields 25 bu/acre and the use of N fertilizer where the sugar beet root was not harvested increased corn grain yield by 108

bu/A. The application of 40 lb N/acre greater did increase corn grain yield where the sugar beet roots were not harvest compared to the recommended N application. Increasing the rate to 80 lb N/acre did not increase the corn grain yield above the + 40 lb N/acre application. The use of additional N did not bring the corn grain yields equal to the corn grown where the sugar beet roots were harvest and had the recommended rate of N applied.

Table 2. Corn grain yield and statistical analysis for 2018, 2020, 2021, and 2022.

				Grain yield 15.5 % (bu/A)			
Treatment	Beets	Starter	N rate	2018	2020	2021	2022
1.	Not harvested	none	0	84	107	55	87
2.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	0	69	126	61	103
3.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended – 40 lb N/A (115 lb N/A)	136	224	103	185
4.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended (155 lb N/A)	173	234	112	223
5.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended + 40 lb N/A (195 lb N/A)	203	255	124	240
6.	Not harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended + 80 N/A (235 lb N/A)	242	241	129	232
7.	Harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	Recommended (155 lb N/A)	215	251	142	250
8.	Harvested	None	0	101	150	90	120
9.	Harvested	7 gallons 10-34-0 plus 1 lb Zn/acre	0	115	160	99	154
$LSD_{0.05}$				47	21	12	17
Grand mean				149	196	102	176
Trt				0.0001	0.0001	0.0001	0.0001
Harvest vs No harvest				0.02	0.0001	0.0001	0.0001
Starter vs No starter				0.99	0.07	0.09	0.0005
0 N vs Recommended				0.0001	0.0001	0.0001	0.0001
C.V. %				21.6	7.2	8.3	6.7

Table 3. Corn grain yield means for direct comparisons of Not Harvested and Harvested sugar beet roots, use of starter fertilizer, and use of recommended N fertilizer in 2018, 2020, 2021, and 2022.

	Corn grain yield 15.5 % (bu/A)			
Comparison	2018	2020	2021	2022
Beets Not Harvested	109	156	76	138
Beets Harvested	144	187	110	175
No Starter	93	129	73	104
Starter	92	143	80	129
No N	92	143	80	129
Recommended N	194	243	127	237

Combined Analysis:

In the combined statistical analysis across all years, there was an interaction by treatment and year for corn grain yield. This interaction is because of magnitude of the grain yield response for the use of starter and the response of corn grain yield to N fertilizer application. The best way to show these responses is with graphs. In all years of this study, the corn grain yield on Not Harvested beet ground was less than corn grain yield on Harvested beet ground, Figure 1. This effect was similar in all years.

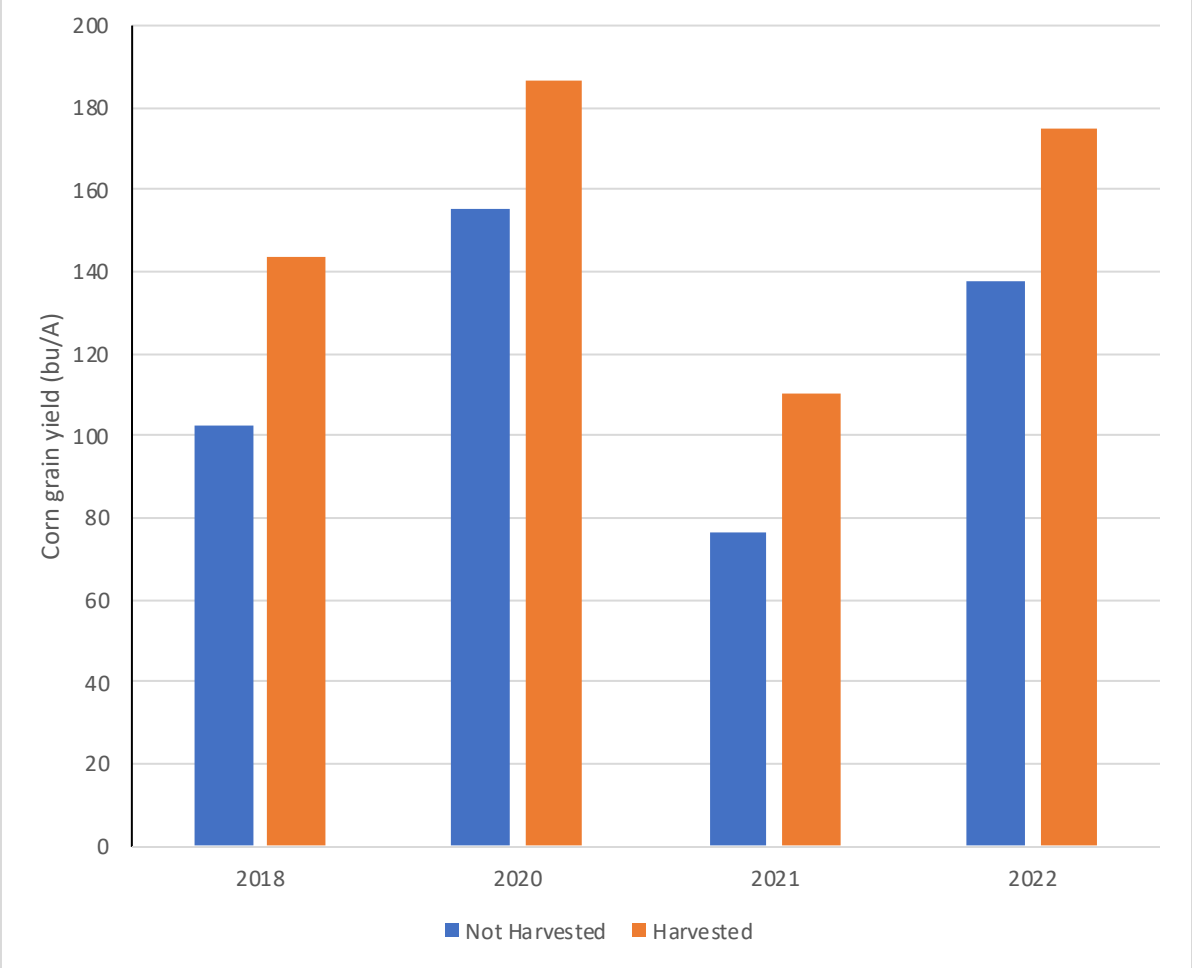

Figure 1. The effect on corn grain yield after sugar beet production with the sugar beet root not harvested or harvested in 2018, 2020, 2021 and 2022.

To make up for the loss in corn grain yield when grown on ground where the sugar beet was not harvested in the previous year, the use of starter fertilizer and additional N fertilizer were added. The use of starter did not significantly affect corn grain yield in 2018 but in 2020, 2021, and 2022 it was helpful, Figure 2.

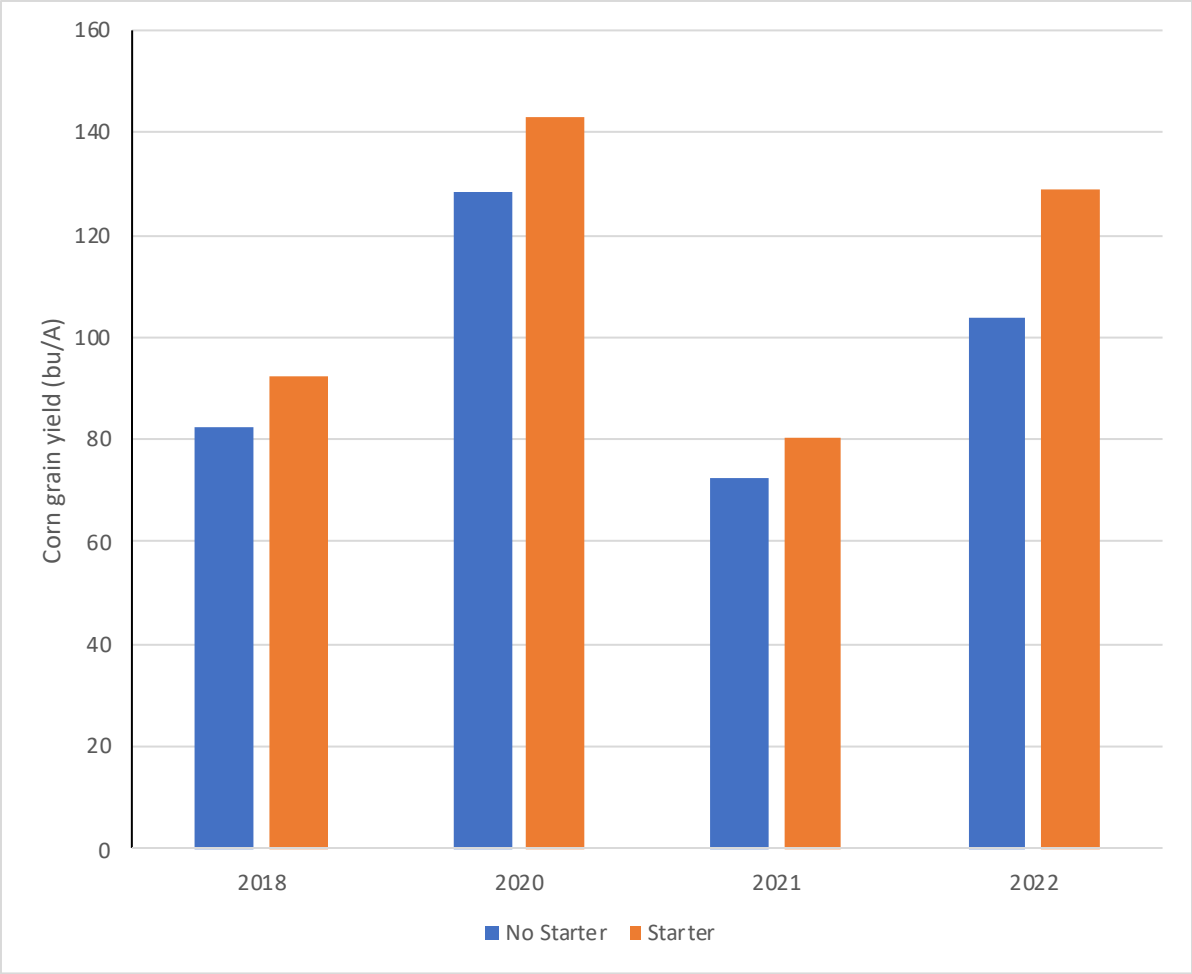

Figure 2. The effect of starter fertilizer (10-34-0 plus Zn) on corn grain yield grown on ground where the previous sugar beet roots were not harvested in 2018, 2020, 2021, and 2022.

In each year there was a corn grain yield response to N fertilizer, but the greatest grain yield occurred with N rec + 80 lb N/A in 2018, N rec + 40 lb N/A in 2020, 2021, and 2022, Figure 3. The corn yields in 2021 were reduced considerably because of drought and the grain yield responses were much smaller. The dark blue columns are the corn grain yields for corn grown on harvested beet plots with the recommended amount of N fertilizer applied. In 2018 and 2020 the corn grain yields from not harvested beet plots were similar to the harvested beet plots if at least an extra 40 lb N/A above the recommended N rate was applied.

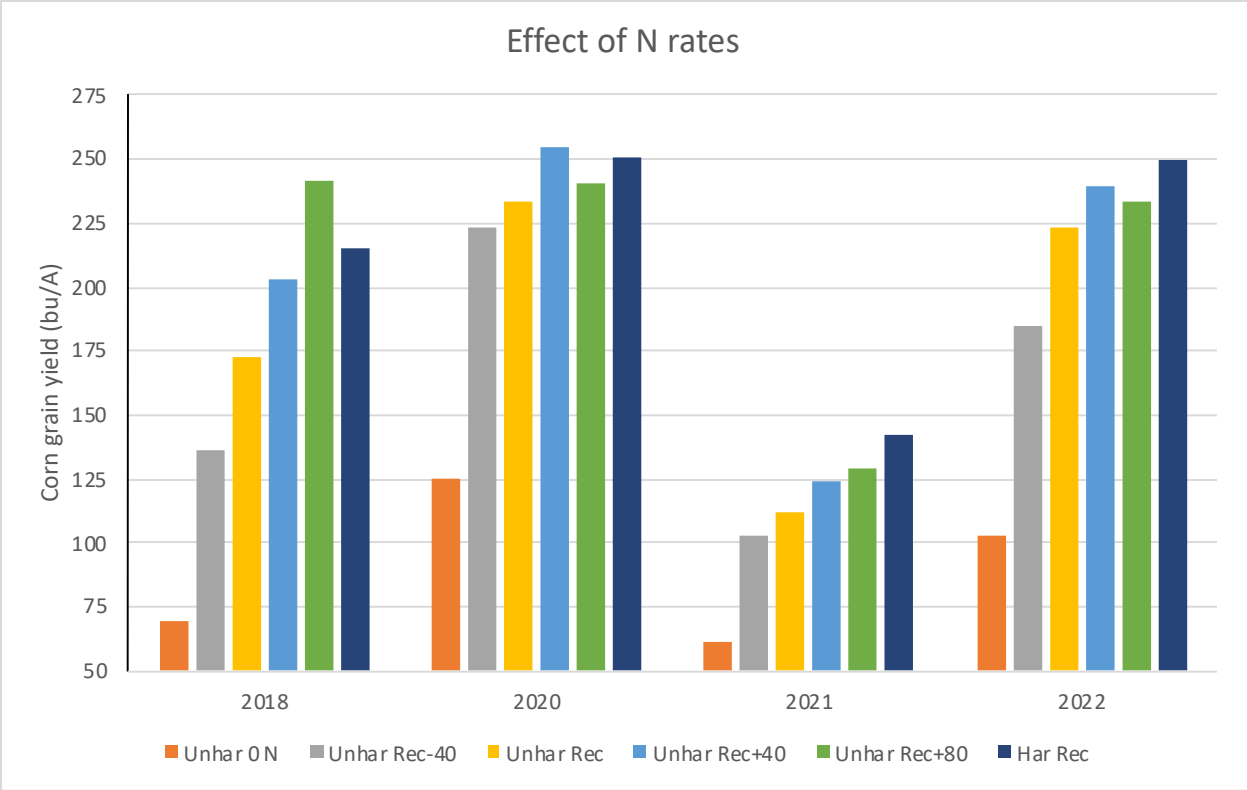

Figure 3. The effect on corn grain yield of added N fertilizer when grown on ground where the previous sugar beet roots were not harvested in 2018, 2020, 2021, and 2022.

Summary: This study was conducted in three very different climates. The climate was very wet in 2018, moisture was ideal for producing high corn grain yields in 2020, dry conditions reduced the corn grain yield in 2021, and planting was delayed by wet conditions while the fall was dry in 2022. Although every year was impacted differently by the environment there were always some visual differences between treatments including crop height and color (Photos 3 and 4). In all years, corn grown on not harvested sugar beet production ground had lower grain yields than corn grown on ground where the sugar beet root was harvested. In all production years, the use of 40 lb N/acre above the recommendation on not harvested sugar beet ground increased the corn grain yield. The use of 80 lb N/acre did not improve the grain yield over the treatment with an extra 40 lb N/acre. In 2020 and 2022, corn grain yields from an extra 40 lb N/acre applied to the ground where sugar beet was not harvested the previous fall was able to produce corn grain yields equal to the corn grown in harvested sugar beet ground. In 2021, the corn grain yields in the not harvested ground were not as good as the corn grain yields from the harvested ground. Why the difference? The extra N fertilizer was needed on the corn grown on the not harvested area because of the added carbon left in the soil by the not harvested beet roots. The not harvested root material adds carbon that temporarily ties up the soil nitrogen because of the stimulation of the micro-organisms in the soil. In 2020, there was enough soil moisture for optimum corn growth and microbial activity to overcome the tie up of the soil N. In 2021, the dry fall conditions slowed both the corn growth and the microbial activity so the extra N applied could not overcome the tie up of soil N.

Photo 1. Renville site on October 26th, 2017, during sugar beet harvest prior to planting the field corn in 2018.

Photo 2. Image taken at planting at the Cosmos site showing beet residue from the previous year in plots that were not harvested.

Photo 3. Drone image taken on July 15th, 2020, at the Murdock site showing differences in crop color and height.

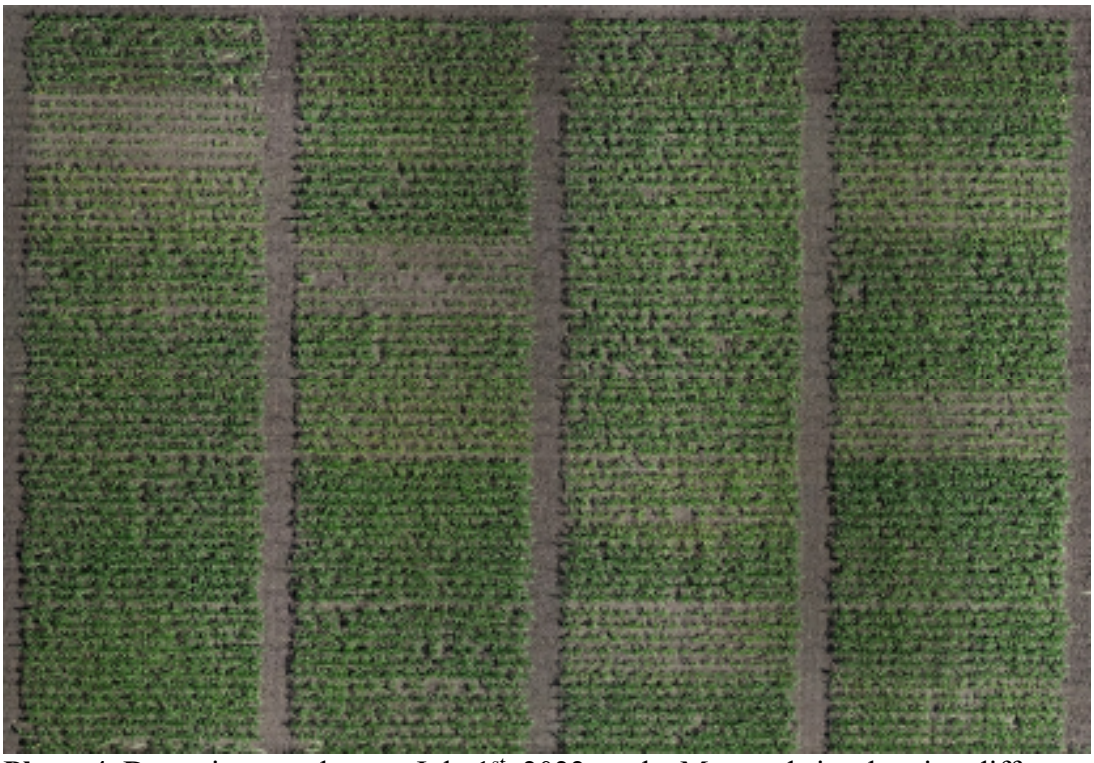

Photo 4. Drone image taken on July 1st, 2022, at the Maynard site showing differences in crop canopy fill and color.