2019-2020
Spreckels Sugar
RESEARCH REPORT

Spreckels Sugar Brawley, CA

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At What Plant Stand is Replanting Needed?

Final report

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Justification: Establishing an optimum sugar beet plant stand is important to maximizing extractable sucrose yield in the Imperial Valley of California. If conditions are right at planting, then an optimum stand is the result. If there are problems such as seed quality, hot weather, or crusting soil, the stand will be reduced. Currently, the growers in the Imperial Valley aim for a plant stand of 30 sugar beet plants per ten feet of row for optimum production. At what plant stand should a grower decide to replant when the emergence is sub-optimal? The current answer to the question is 15 to 16 sugar beet plants per 10 feet of row. Since the advent of glyphosate resistant sugar beet varieties, there has been no research information from the Imperial Valley about replanting thresholds.

Objective: Determine the threshold plant stand that requires replanting in early and late harvested sugar beet production.

Methods and Materials: The treatments are listed in Table 1. The study was a randomized complete block design with 4 replications. There were seven plant stand treatments to represent different plant population thresholds. Stands were thinned after emergence. Treatments 1, 2, 3, and 4 were thinned to an even stand while treatments 5, 6, and 7 were thinned unequally simulating an uneven stand that would occur when poor emergence would occur (gappy). Treatment 8 was similar to when a replant decision was made. Five sites were established during the study from Fall 2017 to Summer 2020, Table 2. There were two early harvest and three late harvest sites. The planting, thinning, and harvest dates are listed in Table 2. All locations were planted with Beta 5460. Root yield was determined on the dates reported in Table 2. Root quality was determined by the Spreckels Sugar Tare Laboratory.

Table 1. Treatments for the proposed reduced stand study.

Treatment	Sugar beet per 10 feet of row
1.	34
2.	30
3.	26
4.	22
5.	18 gaps
6.	14 gaps
7.	10 gaps
8.	30 replant – planted at 4-5 weeks after original planting.

Table 2. Planting, thinning, and harvest dates for the replanting study.

Site	Planting date	Thinning date	Replant	Harvest date
Site 1 2017-2018	Oct. 2, 2017	Oct. 30, 2017	Nov. 15, 2017*	June 5, 2018 (early)
Site 2 2017-2018	Oct. 6, 2017	Nov. 9, 2017	Nov. 13, 2017	July 17 and 18, 2018 (late)
Site 1 2018-2019	Oct. 19, 2018	Nov. 27, 2018	Dec. 12, 2018	July 15, 2019 (late)
Site 1 2019-2020	Sept 14, 2019	Oct 17, 2019	Nov. 1, 2019	April 06, 2020 (early)
Site 3 2019-2020	Oct. 12, 2019	Nov. 11-12, 2019	Dec. 6, 2019	June 17, 2020 (late)

* birds ate seed from the previous planting in early November.

Results:

Growing season 2017-2018

Early harvest 2017-2018 Site 1: The root yields and quality were good for an early harvest location. The population treatments significantly affected root yield, extractable sucrose per acre, brei nitrate, and stand, Table 3. Extractable sucrose per ton and purity were not affected by the treatments. The root yields for all of the population treatments, 1 through 7 were not significantly different, Table 4. The root yield for the replant treatment, 8, was significantly less that the root yields for the other treatments. Extractable sucrose per acre was the greatest for treatment 3. The stand was significantly affected by the treatments. This shows that the treatment did get established as intended. Brei nitrate was significantly increased by the replant treatment (8). The late planting of treatment 8 caused most of the significant differences that occurred at this site.

Table 3. Statistical analysis for the Early Harvest Replanting Trial – Site 1 2017-2018.

Statistics	Root yield	Extractable sucrose per ton	Extractable sucrose per acre	Purity	Brei nitrate	Stand
Rep	0.77	0.14	0.29	0.29	0.13	0.36
Treatment	0.0001	0.32	0.0001	0.61	0.04	0.0001
C.V. (%)	5.7	3.7	5.7	1.0	44.7	5.0
Grand mean	59.7	281	16766	90.14	18	89
$LSD_{0.05}$	5.0	NS	1407	NS	12	6.5

Table 4. Means for root yield, extractable sucrose per ton, extractable sucrose per acre, purity, brei nitrate, and stand for early harvest replant study, Site 1, 2017-2018.

Treatment	Root yield	Extractable sucrose		Purity	Brei nitrate	Stand
plants per 10 ft of row	ton/A	lb/ton	lb/A	%	ppm	plants/plot
1 (34)	61.4	281	17238	90.3	13	133
2 (30)	63.6	273	17335	89.8	18	116
3 (26)	65.2	292	19031	90.9	13	101
4 (22)	64.5	286	18388	90.1	15	85
5 (18 gappy)	63.3	278	17568	90.1	17	68
6 (14 gappy)	63.9	280	17893	90.4	16	55
7 (10 gappy)	61.2	279	17044	89.7	20	39
8 (30 replant)	34.5	279	9631	89.9	34	112

Late harvest 2017-2018 Site 2: The root yield and quality for this sites was very good for a late harvested sugar beet crop. The plant stand treatments did not significantly affect the extractable sucrose per ton, purity or brei nitrate-N, Table 5 and 6. Root yield was only affected by the replant treatment, 8. Treatment 6 was superior in root yield while treatment 5 was superior in extractable sucrose per acre. The stand was significantly affected by the treatments. This shows that the treatments did get established as intended. The late planting of treatment 8 caused most of the significant difference that occurred in this study.

Table 5. Statistical analysis for the Late Harvest Replanting Trial – Site 2 2017-2018.

Statistics	Root yield	Extractable sucrose per ton	Extractable sucrose per acre	Purity	Brei nitrate	Stand
Rep	0.38	0.47	0.20	0.52	0.95	0.66
Treatment	0.0001	0.20	0.0001	0.88	0.56	0.0001
C.V. (%)	4.9	4.4	4.8	1.2	28.9	2.1
Grand mean	89.7	245	21989	87.0	162	92.9
$LSD_{0.05}$	6.5	NS	1561	NS	NS	2.8

Table 6. Means for root yield, extractable sucrose per ton, extractable sucrose per acre, purity, brei nitrate, and stand for early harvest replant study, Site 2, 2017-2018.

Treatment	Root yield	Extractable sucrose		Purity	Brei nitrate	Stand
plants per 10 ft of row	ton/A	lb/ton	lb/A	%	ppm	plants/plot
1 (34)	86.9	244	21169	87.0	155	131
2 (30)	90.7	238	21531	86.6	183	122
3 (26)	92.4	249	22975	87.3	153	113
4 (22)	95.1	245	23247	86.8	162	89
5 (18 gappy)	92.3	259	23918	87.6	119	69
6 (14 gappy)	96.3	240	23065	86.8	170	56
7 (10 gappy)	94.4	240	22682	86.7	162	40
8 (30 replant)	71.6	247	17595	87.2	190	124

Growing season 2018-2019

Late harvest 2018-2019 Site 1: The root yields and quality were good for a late harvest location. The population treatments significantly affected root yield, extractable sucrose per ton, extractable sucrose per acre, purity, brei nitrate, and stand, Table 7. The root yields for all of the population treatments, 1 through 6 were not significantly different, Table 8. Root yield for the treatment, 7, was significantly less that the root yields for treatments 1, 2, 4 and 6. The root yield for the replant treatment, 8, was significantly less that the root yields for the other treatments.

Extractable sucrose per ton was the greatest for treatment 3. The extractable sucrose for treatments 1, 2, 4, 5 and 6 were significantly less than the greatest extractable sucrose per ton while extractable sucrose per ton for treatment 7 was 5 lb per ton less than the middle group. The replant sugar beet for treatment 8 had the least amount of extractable sucrose per ton.

The extractable sucrose per acre at this site was over 20,000 lb per acre for sugar beet treated with planting treatments 1, 2, 3, 4, 5, and 6. Treatment 7 had less extractable sucrose per acre than the other non-replanted treatments. The replanted treatment, 8, had the least amount of extractable sucrose per acre.

Purity was only significantly affected by the replanted treatment 8. The rest of the sugar beet planted to the different stands were similar.

Brie nitrate-N in the sugar beet root was affected by the plant stand treatment. The replant treatment, 8, had the greatest brie nitrate-N while the sugar beet roots from the other treatments were less. There was no relationship between the plant stand and the amount of brie nitrate-N in the sugar beet roots.

The stand was significantly affected by the treatments. This shows that the treatment did get established as intended.

Table 7. Statistical analysis for the Late Harvest Replanting Trial – Site 1 2018-2019.

Statistics	Root yield	Extractable sucrose per ton	Extractable sucrose per acre	Purity	Brei nitrate	Stand
Rep	0.25	0.001	0.77	0.66	0.89	0.31
Treatment	0.0001	0.0001	0.0001	0.03	0.0007	0.0001
C.V. (%)	6.6	1.5	6.6	0.7	21.2	4.7
Grand mean	69.6	285	19841	90.25	66	85
$LSD_{0.05}$	6.8	6.1	1920	0.92	20	5.9

Table 8. Means for root yield, extractable sucrose per ton, extractable sucrose per acre, purity, brei nitrate, and stand for early harvest replant study, Site 1, 2017-2018.

Treatment	Root yield	Extractable sucrose		Purity	Brei nitrate	Stand
plants per 10 ft of row	ton/A	lb/ton	lb/A	%	ppm	plants/plot
1 (34)	78.9	286	22544	90.4	61	131
2 (30)	77.7	285	22103	90.6	66	118
3 (26)	74.4	297	22050	91.1	43	106
4 (22)	77.2	284	21932	90.4	62	85
5 (18 gappy)	72.9	285	20742	90.1	75	71
6 (14 gappy)	77.3	286	22086	90.2	46	52
7 (10 gappy)	70.2	279	19596	90.1	73	40
8 (30 replant)	27.9	276	7679	89.2	96	77

Growing season 2019-2020

Early harvest 2019-2020 Site 1: The root yields and quality were good for an early harvest location. The population treatments significantly affected root yield, extractable sucrose per acre, and stand, Table 9. The root yields for all of the population treatments, 1 through 7 were not significantly different, Table 10. The root yield for the replant treatment, 8, was significantly less that the root yields for the other treatments.

The mean extractable sucrose per acre at this site was 9507 lb per acre. The significant difference in extractable sucrose per acre occurred for treatment 8 compared to the other treatments. The replanted treatment 8 extractable sucrose per acre was half compared to the other treatments (1, 2, 3, 4, 5, 6, and 7).

Extractable sucrose per ton, root purity, and brei nitrate-N were not affected by the stand treatments.

The stand was significantly affected by the treatments. This shows that the treatment did get established as intended.

Table 9. Statistical analysis for the early harvest replanting trial – Site 1 2019-2020.

Statistics	Root yield	Extractable sucrose per ton	Extractable sucrose per acre	Purity	Brei nitrate	Stand
Rep	0.63	0.28	0.31	0.11	0.29	0.31
Treatment	0.0001	0.76	0.0001	0.33	0.78	0.0001
C.V. (%)	8.3	3.0	7.2	0.6	76.7	5.1
Grand mean	34.5	275	9507	89.44	10	88
$LSD_{0.05}$	4.2	12.2	1012	0.73	11	6.6

Table 10. Means for root yield, extractable sucrose per ton, extractable sucrose per acre, purity, brei nitrate, and stand for early harvest replant study, Site 1, 2019-2020.

Treatment	Root yield	Extractable sucrose		Purity	Brei nitrate	Stand
plants per 10 ft of row	ton/A	lb/ton	lb/A	%	ppm	plants/plot
1 (34)	36.7	279	10225	89.7	8	124
2 (30)	37.2	274	10201	89.4	11	104
3 (26)	38.6	272	10507	89.2	13	105
4 (22)	36.7	280	9818	89.6	9	85
5 (18 gappy)	38.2	276	10544	89.8	7	69
6 (14 gappy)	35.8	277	9882	89.3	9	56
7 (10 gappy)	36.1	274	9878	89.5	14	40
8 (30 replant)	18.6	270	5000	89.0	7	122

Late harvest 2019-2020 Site 3: The root yields and quality were good for a late harvest location. The population treatments significantly affected root yield, extractable sucrose per ton, extractable sucrose per acre, brei nitrate, and stand, Table 11. The root yields for population treatments, 1 through 6 were not significantly different, Table 12. The root yield for treatment 7 (gappy 10 plants per 10 feet of row) and the replant treatment, 8, were significantly less that the root yields for the other treatments.

Extractable sucrose per ton at this site was very good. The overall average was 315 lb sucrose per ton of beet root processed. The uniform stands of 30 and 26 plants per 10 feet of row had the greatest extractable sucrose. The extractable sucrose per ton for 14 gappy, 22 uniform, and 34 uniform plants per 10 feet or row were statistically similar to the best stands. The least amount of extractable sucrose per ton occurred with sugar beet with stands of gappy 10, gappy 18, and the replant treatment of 30 uniform plants per 10 feet of row.

The mean extractable sucrose per acre at this site was 16451 lb per acre. The significant difference in extractable sucrose per acre occurred for treatment 8 compared to the other treatments. The replanted treatment 8 extractable sucrose per acre was a little over half the extractable sucrose per acre compared to the better treatments (1, 2, 3, 4, 5, and 6).

Root brei nitrate is statistically affected by the plant stand. In general, as the stand was reduced the amount of brei nitrate in the root increased.

Root purity, was not affected by the stand treatments.

The stand was significantly affected by the treatments. This shows that the treatment did get established as intended.

Table 11. Statistical analysis for the late harvest replanting trial – Site 3 2019-2020.

Statistics	Root yield	Extractable sucrose per ton	Extractable sucrose per acre	Purity	Brei nitrate	Stand
Rep	0.03	0.16	0.02	0.16	0.02	0.52
Treatment	0.0001	0.05	0.0001	0.14	0.006	0.0001
C.V. (%)	6.2	2.0	5.7	0.7	18.5	1.9
Grand mean	52.2	315	16451	90.48	17	92
$LSD_{0.05}$	4.7	9.1	1362	0.82	4.8	2.6

Table 12. Means for root yield, extractable sucrose per ton, extractable sucrose per acre, purity, brei nitrate, and stand for late harvest replant study, Site 3, 2019-2020.

Treatment	Root yield	Extractable sucrose		Purity	Brei nitrate	Stand
plants per 10 ft of row	ton/A	lb/ton	lb/A	%	ppm	plants/plot
1 (34)	57.3	314	17977	90.4	20	135
2 (30)	55.1	322	17752	90.8	15	120
3 (26)	56.4	322	18154	90.8	15	105
4 (22)	58.5	316	18452	91.0	12	88
5 (18 gappy)	56.1	310	17379	90.3	17	71
6 (14 gappy)	53.9	316	17034	90.4	19	57
7 (10 gappy)	48.2	311	16007	89.9	21	40
8 (30 replant)	31.7	311	9850	90.2	21	122

Summary:

Growing season 2017-2018

In the growing season of 2017-2018, the replanting of a reduced stand of sugar beet would not have been advisable. This is not what was expected, as the population was reduced to 1 sugar beet per foot of row and gappy in distribution yielded very well. The late harvest site sugar beets from the gappy reduced populations (Treatments 5

to 7) were very difficult to harvest and would be a large problem for commercial harvesting equipment. The large beets caused issues with plugging the harvester. The replant treatment, 8, was not as successful as originally thought. At the early harvest site, the replanting was delayed by irrigation water scheduling and the fact that it was replanted again because of bird feeding damage. At the late harvest site, the replant may not have yielded well because of the later than originally planned replanting.

Growing season 2018-2019

In the growing season of 2018-2019, the replanting of a reduced stand of sugar beet would not have been advisable. This is not what was expected. As the stand was reduced to 1.4 sugar beet plants per foot of row and with an uneven distribution of plants in the row, the sucrose yield was the same as a uniform stand at an optimum density. The treatment with only 1 sugar beet per foot of row did have reduced root yield, extractable sucrose per ton, and extractable sucrose per acre compared to the other non-replanted treatments. The reduction may not have been enough to overcome the reduction in yield from a three-week delay in replanting. The sugar beets from the gappy reduced populations (Treatments 5 to 7) were very difficult to harvest and would be a large problem for commercial harvesting equipment. The large beets caused issues with plugging the harvester. The replant treatment, 8, was not as successful as originally thought. The replanting treatment had to be replanted because of bird feeding damage so the planting was significantly delayed.

Growing season 2019-2020

In the growing season of 2019-2020, the replanting of a reduced stand of sugar beet would not have been advisable. This is not what was expected. As the stand was reduced to 1.4 sugar beet plants per foot of row and with an uneven distribution of plants in the row, the sucrose yield was the same as a uniform stand at an optimum density. At both early and late harvest locations, the treatment with only 1 sugar beet per foot of row did have reduced root yield, extractable sucrose per ton, and extractable sucrose per acre compared to the other non-replanted treatments. The reduction may not have been enough to overcome the reduction in yield from a three-week delay in replanting. Unlike previous experience with late harvested sugar beets, the sugar beets from the gappy reduced populations (Treatments 5 to 7) were not difficult to harvest at Location 1 early harvest. At location 3 late harvest the gappy reduced populations were difficult to harvest similar to late harvest sites in years past. The replant treatment, 8, was not as successful as originally thought.

Combined Results:

The effect of plant stand on extractable sucrose per acre from all sites is shown in Figure 1. In all cases except for the Early 1 1920 site, the optimum stand can range from 18 to 33 plants per 10 ft of row.

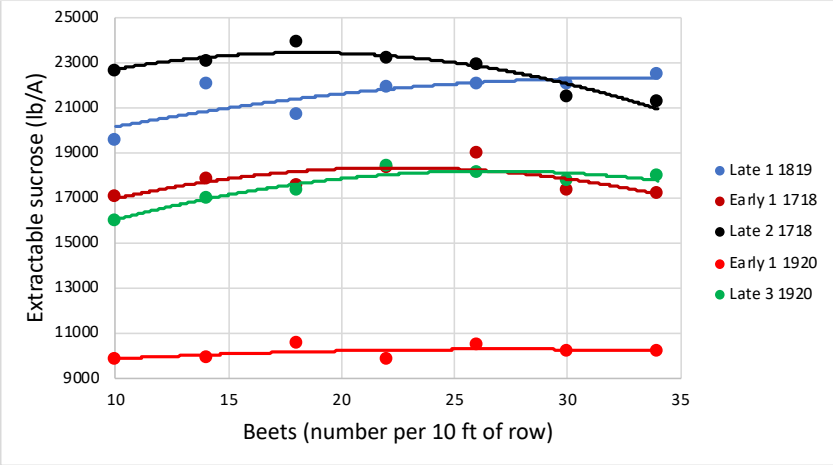

Figure 1. Plant stand effects on extractable sucrose per acre 2017-2020.

The economic effect will depend on the price of sucrose, Table 13. If sucrose is at $0.13 per lb, a reduction in return from optimum plant stand to 14 plants per 10 feet of row can range from 0 to $194.89 per acre. If the plant stand is

reduced to 10 plants per 10 feet of row, the economic loss would be from 0 to $284.01 per acre. These values need to be compared to the cost of replanting to make the decision.

Table 13. Optimum plant stand for extractable sucrose per acre at five locations in the Imperial Valley from 2017 to 2020.

	Optimum stand	Economic loss from optimum in $/A (assume $0.13 per lb sucrose)	
Site	Plants/10 feet of row	14 plants/10 feet of row	10 plants/10 feet of row
Late 1 – 1819	33	-$194.89	-$284.01
Early 1 – 1718	22	-$82.53	-$179.22
Late 2 – 1718	18	-$26.29	-$95.64
Early 1 – 1920	No optimum	0	0
Late 3 – 1920	27	-$162.21	-$281.14

Summary points from this research for use in sugar beet production in the Imperial Valley of California are:

1. Conduct a careful evaluation of the plant stand of the field before deciding to replant.
2. A sugar beet stand goal would be 30 plants per 10 feet of row.
3. Current information would indicate that decision of replanting is not influenced by harvest date.
4. The optimum plant stand in recent studies is around 24 plants per 10 feet of row.
5. Good yields of extractable sucrose per acre can be obtained most of the time with a stand as low as 14 plants per 10 feet of row. Current research information would not recommend replanting a stand greater than 14 plants per 10 feet or row.
6. A population of less than 14 plants per 10 feet of row late harvest sugar beet can cause harvest issues because of variable size roots.

Nitrogen rate and timing study in Imperial Valley

2017-2020 Final Report

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Justification: Growers in the Imperial Valley have recently adopted glyphosate resistant varieties in their sugar beet production system. One of the advantages of the use of glyphosate resistant varieties is the reduction of the need to cultivate for weed control at layby (November). This cultivation operation at layby was also combined with a split application of nitrogen. The cultivation at layby required that irrigation basins be deconstructed for equipment access to the field. With the advent of glyphosate resistant varieties, weed control is obtained without cultivating and thus the irrigation basins do not need to be deconstructed. This requires growers to apply all of their nitrogen fertilizer pre-plant instead of the former split application. Some research from the Imperial Valley has been conducted on the effect of N application timing in recent times, (Kaffka 2007). This report suggested that delaying N application until January was not needed and that the optimum N application rate for sugar beets harvested in June and July was 220 lb N/A with another 100 lb nitrate-N/A in the surface 43 inches of soil at planting. Nothing has been reported if the layby N application is not used. New information is needed because of the introduction of glyphosate resistant varieties and the absence of a layby application of N fertilizer.

Objective: Determine the effect of nitrogen rate and timing on sugar beet root yield and quality.

Materials and Methods: A study was established at four locations from 2017 to 2020. The locations were at the Imperial Valley Research Center in 2017-2018, Imperial Valley Research Center and in a grower's field near Westmorland, CA in 2018-2019, and in a grower's field near Brawley, CA in 2019-2020. The treatments were a factorial combination of eight nitrogen application rates (0, 40, 80, 120, 160, 200, 240, and 280 lb N/A) and two application times (pre-plant and layby), Table 1. The nitrogen source used for the pre-plant and lay-by treatments at both sites was liquid UAN (32-0-0). Variety, planting date, fertilizer treatment dates, petiole sampling date, harvest date, and soil nitrate-N information is presented for each site in Table 2. At layby, all plots were cultivated to insure irrigation water flow. The study had four replications. Petioles were sampled from the most recently matured leaves to determine the effect of the treatments on the nitrogen status of the sugar beet plants. The roots were harvested and quality was determined by the Spreckels Sugar tare laboratory.

Table 1. Treatments for the Nitrogen rate and application time study.

Treatment number	N rate (lb/A)	N application timing
1	0	Pre-plant
2	40	Pre-plant
3	80	Pre-plant
4	120	Pre-plant
5	160	Pre-plant
6	200	Pre-plant
7	240	Pre-plant
8	280	Pre-plant
9	0	Layby
10	40	Layby
11	80	Layby
12	120	Layby
13	160	Layby
14	200	Layby
15	240	Layby
16	280	Layby

Table 2. Summary of soil test, planting date, variety, harvest date, and fertilizer applications for the 2017-2020.

Activity	Imperial Valley Research Center 2017-18	Imperial Valley Research Center 2018-19	Westmorland, CA 2018-19	Brawley, CA 2019-20
Variety	SES 2014	SES 604	SES 604	SES 604
Planting	November 20, 2017*	October 12, 2018	October 16, 2018	September 13, 2019
Pre-plant fertilizer application	October 19, 2017	October 11, 2018	October 4, 2018	September 12, 2019
Lay-by fertilizer application	January 22, 2018	January 4, 2019	December 3, 2018	November 1, 2019
Petiole sampling	March 21, 2018	March 13, 2019	March 13, 2019	March 5, 2020
Harvest	June 26, 2019	June 12, 2019	June 28, 2019	April 6, 2020
Soil nitrate-N 0-4 ft. (lb/A)	71	108	65	282
Soil nitrate-N 0-2 ft. (lb/A)	60	92	57	180
Soil nitrate-N 2-4 ft. (lb/A)	11	16	8	102
Olsen-P (ppm)	22	11	3	15
Soil test K (ppm)	476	530	97	324

* Replanted because of poor emergence.

Results from 2017-2018:

This study had several production issues early in the growing season. The plant emergence from the initial planting was very poor. It was decided to replant. This late planting delayed growth and thus the layby treatment was not applied until January 22, 2018. The statistical analysis for the N timing by N rate study is presented in Table 3. The means for the effect of N timing are presented in Table 3 while the results for the application rate of N are reported in Table 4.

Table 3. The statistical analysis of the N timing by N rate study at the Imperial Valley Research Center, 2017-2018.

Source of variation	Root yield	Sucrose concentration	Extractable sucrose			Purity	Petiole nitrate-N
	ton/A	%	%	lb/ton	lb/A	%	ppm
Rep	0.08	0.12	0.20	0.20	0.04	0.23	0.02
N timing	0.65	0.93	.074	0.74	0.83	0.51	0.0001
N rate	0.0001	0.03	0.005	0.005	0.0003	0.0009	0.0001
N timing X N rate	0.88	0.31	0.52	0.52	0.85	0.90	0.0001
C.V. (%)	6.8	3.1	4.6	4.6	8.9	1.3	30.0
Grand mean	46.6	15.8	12.7	255	11802	87.42	1410

The timing of N application did not affect root yield, sucrose concentration, extractable sucrose percentage, extractable sucrose per ton, extractable sucrose per acre, or purity, Table 4.

Table 4. The effect of N timing on root yield, sucrose concentration, extractable sucrose percentage, extractable sucrose per ton, extractable sucrose per acre, and purity at the Imperial Valley Research Center, 2017-2018.

Application time	Root yield	Sucrose concentration	Extractable sucrose			Purity
	ton/A	%	%	lb/ton	lb/A	%
Pre-plant	46.8	15.8	12.7	253	11818	87.34
Layby	46.4	15.8	12.7	254	11784	87.50

There is a significant response to N fertilizer application for root yield, sucrose concentration, extractable sucrose percentage, extractable sucrose per ton, extractable sucrose per acre, and purity, Table 3 and 5. The agronomic optimum N rate (AONR) for root yield was 71 lb N/A, Figure 1. When you account for the 20 lb N/A in the pre-plant phosphorus fertilizer (11-52-0) and the amount of soil N as nitrate the AONR would be 142 lb N/A. Sucrose concentration was maximized at a N application of 70 lb N/A, Figure 2. Above 70 lb N/A the extractable sucrose per ton decreased very quickly. The agronomic optimum N rate (AONR) for extractable sucrose per acre was 64 lb N/A, Figure 3. Combine this with the initial soil nitrate of 71 lb N/A to a depth of 4 feet the total N and the 20 lb N/A in the phosphorus fertilizer, the AONR would be 135 lb N/A. These AONR values are less than the 250 lb N/A that is recommended for sugar beet production in the Imperial Valley of California. One possible reason could be the shortened growing season for this study caused by the late replant November 20, 2017.

There was an interaction between the N application time and the N rate for petiole nitrate-N taken on March 21, 2018, Table 6. In general, petiole-nitrate-N increased with increasing N rate. It also was greater for the sugar beet treated at layby as opposed to pre-plant application. The interaction is caused by the greatest petiole nitrate-N increased at different rate for lay-by versus pre-plant applications, Figure 4.

Table 5. The effect of N application rate on root yield, sucrose concentration, extractable sucrose percentage, extractable sucrose per ton, extractable sucrose per acre, and purity at the Imperial Valley Research Center, 2017-2018.

N rate	Root yield	Sucrose concentration	Extractable sucrose			Purity
lb/A	ton/A	%	%	lb/ton	lb/A	%
0	36.9	15.8	12.7	253	9414	87.68
40	46.0	15.9	12.8	256	11783	87.85
80	44.6	16.2	13.1	261	11867	87.85
120	48.1	16.0	13.0	259	12421	88.00
160	47.9	15.8	12.8	256	12280	88.14
200	47.6	16.1	13.0	260	12257	87.62
240	49.6	15.6	12.4	247	12267	86.75
280	49.9	15.4	11.9	238	11882	85.61

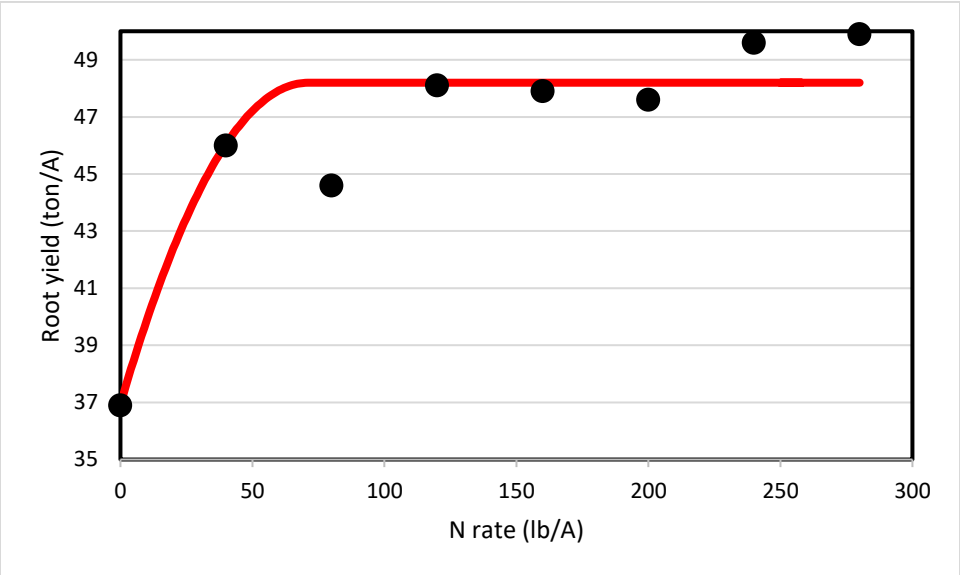

Figure 1. The effect of N application on root yield in the 2017-2018 growing season.

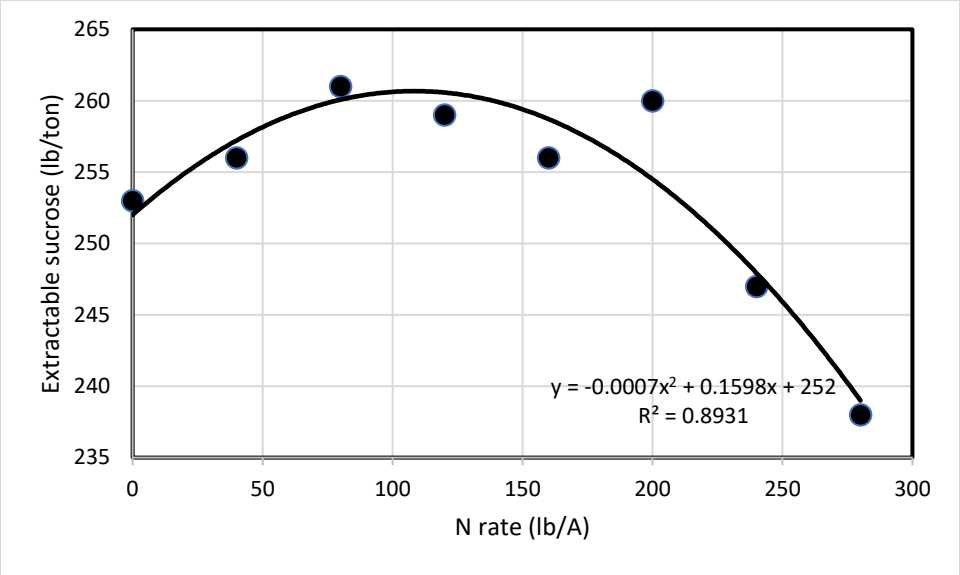

Figure 2. The effect of N rate on extractable sucrose per ton in the 2017-2018 growing season.

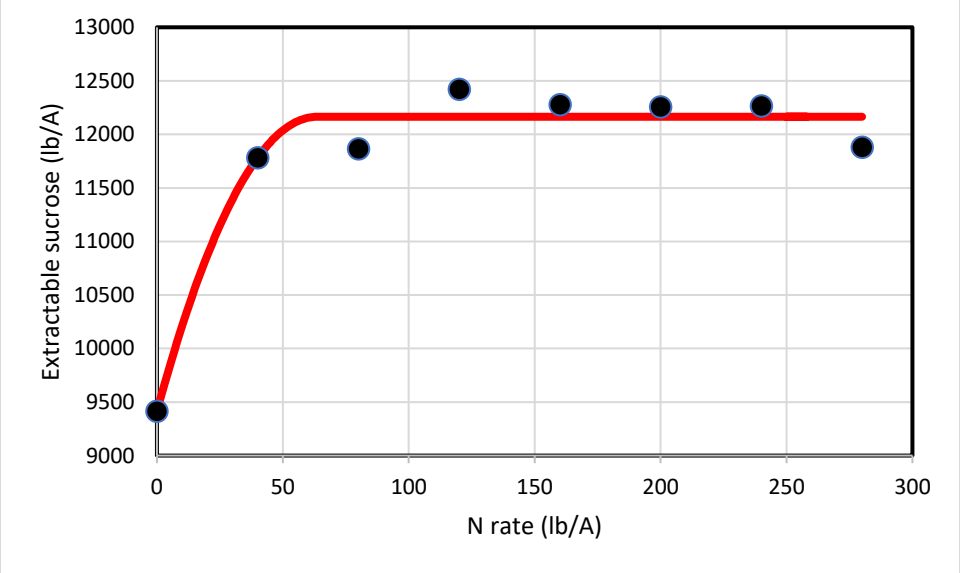

Figure 3. The effect of N application to extractable sucrose per acre in 2017-2018. The AONR was 64 lb N/A.

Table 6. The effect of N application rate and time of application on sugar beet petiole nitrate-N at the Imperial Valley Research Center, 2017-2018.

N rate	Pre-plant	Layby	Mean
lb/A	---------- ppm-N ----------		
0	367	236	301
40	476	356	416
80	390	588	489
120	1139	1334	1222
160	1120	2100	1610
200	606	1256	931
240	1901	3648	2775
280	2804	4221	3512
Mean	1100	1730	1410

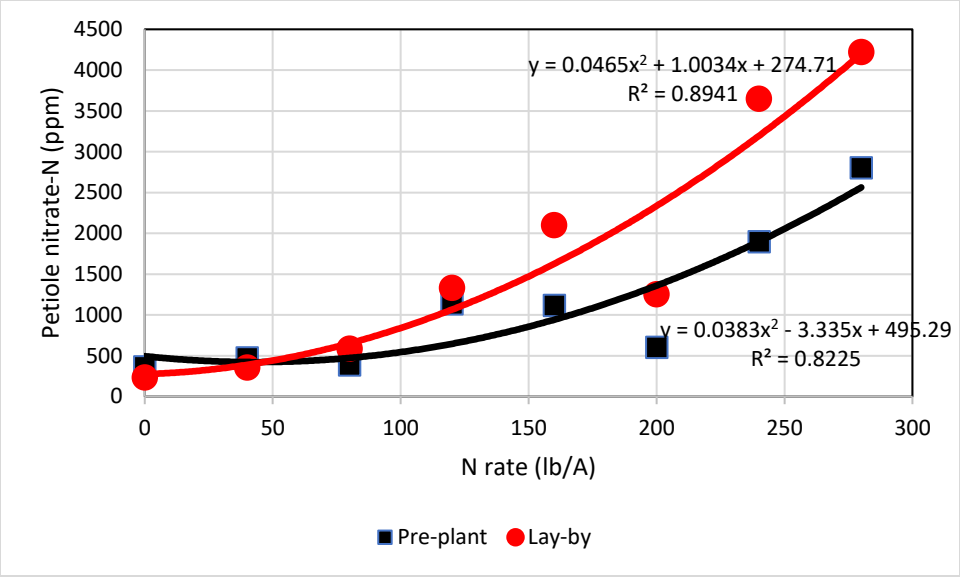

Figure 4. Petiole nitrate-N for pre-plant and lay-by treatments.

Results from 2018-2019:

IVRC

The statistical analysis for the N timing by N rate study is presented in Table 7. There was an interaction between N timing and N rate for root yield, extractable sucrose per acre, purity, and petiole nitrate-N. Sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton did not have an interaction with N timing and N rate but were affected by N timing and N rate.

Table 7. The statistical analysis of the N timing by N rate study at the Imperial Valley Research Center, 2018-2019.

Source of variation	Root yield	Sucrose concentration	Extractable sucrose			Purity	Petiole nitrate-N
	ton/A	%	%	lb/ton	lb/A	%	ppm
Rep	0.28	0.13	0.21	0.21	0.15	0.24	0.0007
N timing	0.21	0.02	.002	0.02	0.90	0.06	0.0001
N rate	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
N timing X N rate	0.02	0.29	0.22	0.22	0.04	0.08	0.007
C.V. (%)	6.1	2.5	3.3	3.3	6.5	0.7	43.5
Grand mean	59.0	17.3	14.4	288	16931	89.51	971

Sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton:

Because sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton were not affected by an interaction between the time of application and N rate treatments, they will be discussed together. Time of application significantly affected all three of these parameters. The pre-plant treatments resulted in greater sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton compared to the layby treatments, Table 8. The N rate also affected these parameters. For N rates from 0 to 200 lb N/A, sucrose was not affected by N application but at N rates greater than 200 lb N/A sucrose declined, Table 8 and Figure 5.

Table 8. The effect of N timing on sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton at the Imperial Valley Research Center, 2018-2019.

Application time	Sucrose concentration	Extractable sucrose	
	%	%	lb/ton
Pre-plant	17.4	14.5	291
Layby	17.2	14.2	285

Table 9. The effect of N application rate on sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton at the Imperial Valley Research Center, 2018-2019.

N rate	Sucrose concentration	Extractable sucrose	
lb/A	%	%	lb/ton
0	17.5	14.8	295
40	17.4	14.6	291
80	17.5	14.7	294
120	17.4	14.5	290
160	17.4	14.5	290
200	17.4	14.5	291
240	17.1	14.1	283
280	16.5	13.3	267

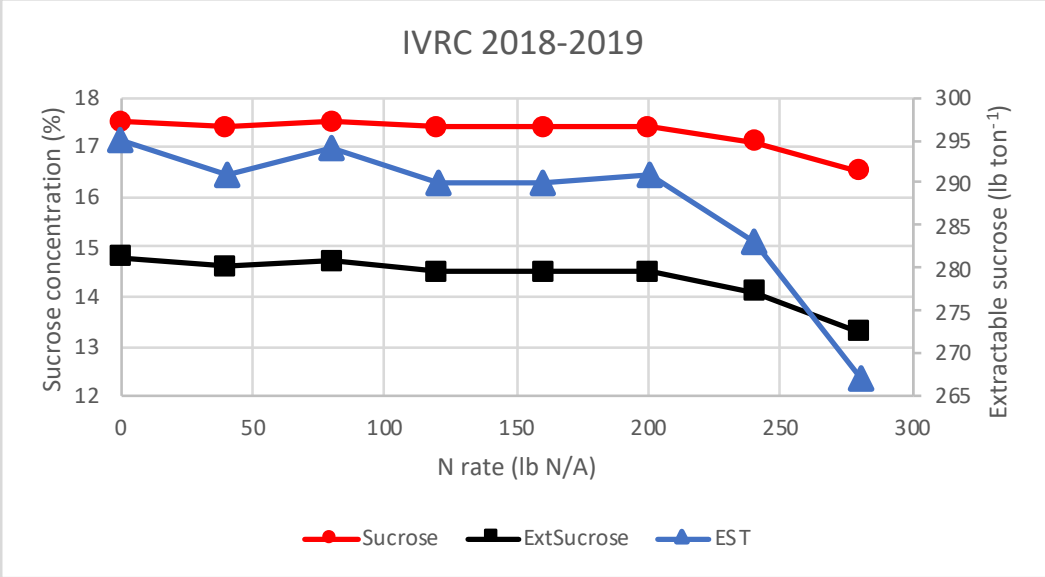

Figure 5. The effect of N rate on sugar beet sucrose at the Imperial Valley Research Center, 2018-2019.

Root yield:

The mean root yield at the Imperial Valley Research Center site was 59 tons A^{-1}. There was a statistically significant interaction between N application time and N application rate, Figure 6. While the time of N application did perform differently at different N rate, there was no constant trend. The N application time did not significantly affect root yield. The N rate did increase root yield, Table 7, 10, and Figure 7. At this site, N rate continued to increase root yield through the greatest N rate, 280 lb N/A.

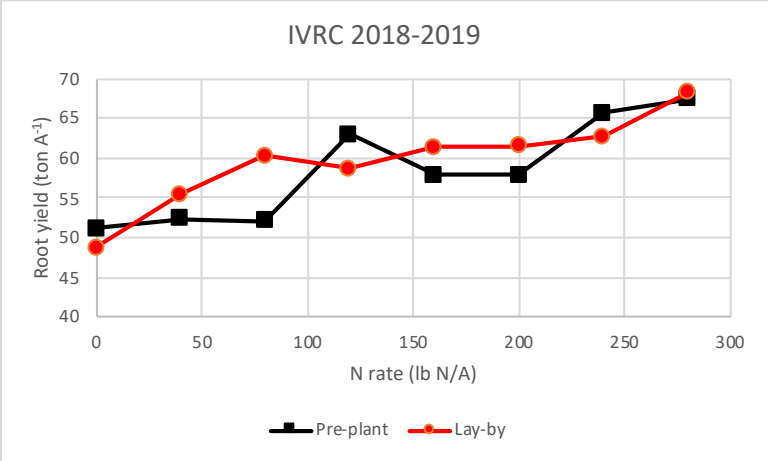

Figure 6. The effect of N rate and time of N application on root yield at the Imperial Valley Research Center, 2018-2019 growing season.

Table 10. The effect of N application rate and time of application on root yield at the Imperial Valley Research Center, 2018-2019.

N rate	Pre-plant	Layby	Mean
lb/A	---------- tons/A ----------		
0	51.1	48.7	49.9
40	52.4	55.4	53.9
80	52.1	60.3	56.2
120	63.0	58.7	60.9
160	57.8	61.4	59.6
200	57.9	61.5	59.7
240	65.7	62.7	64.2
280	67.4	68.2	67.8
Mean	58.4	59.6	59.0

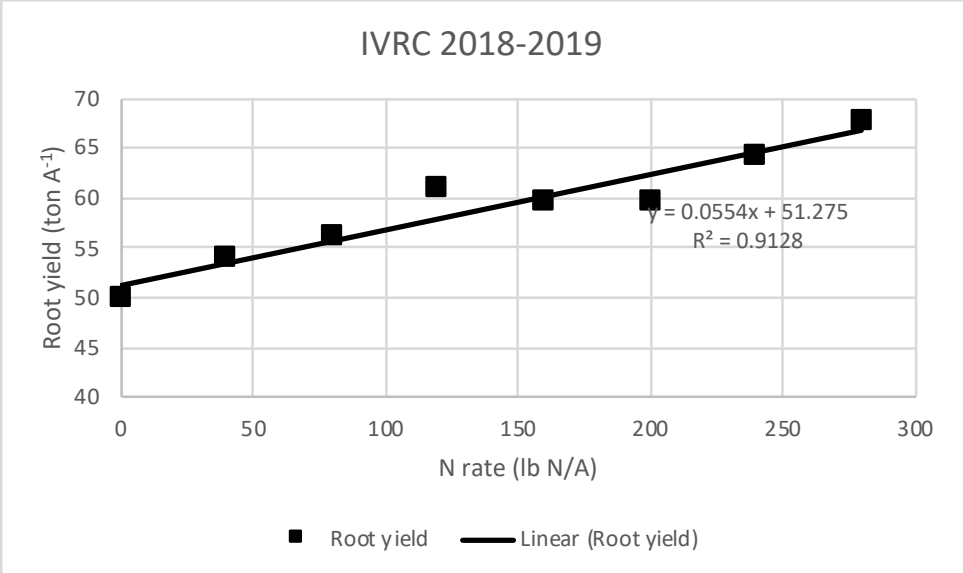

Figure 7. The effect of N rate on root yield at the Imperial Valley Research Center, 2018-2019 growing season.

Extractable sucrose per acre:

Similar to root yield, extractable sucrose per acre had a significant interaction from N application time and rate, Table 7. Figure 8 and Table 11 present the response to N rate at both N application times. Similar to root yield, the interaction for extractable sucrose per acre was not consistent over the N rates and N application time did not significantly affect extractable sucrose per acre on its own. The response of extractable sucrose per acre to N rate was positive and maximized at the application of 260 lb N/A, Figure 9. With the amount of nitrate-N in the soil before the study plus the N in the pre-plant phosphorus fertilizer, that would bring the total to 388 lb N/A. This amount of N is much greater than expected.

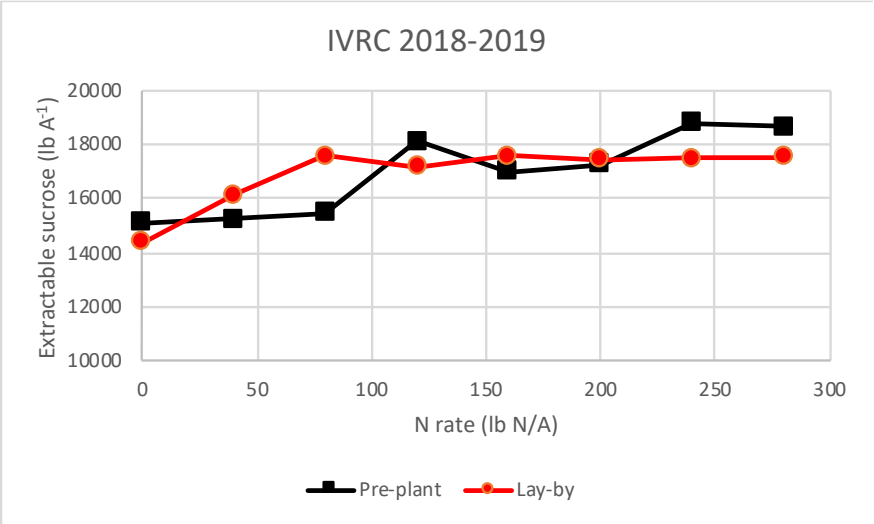

Figure 8. The effect of N rate and time of N application on extractable sucrose per acre at the Imperial Valley Research Center, 2018-2019 growing season.

Table 11. The effect of N application rate and time of application on extractable sucrose per acre at the Imperial Valley Research Center, 2018-2019.

N rate	Pre-plant	Layby	Mean
lb/A	---------- lb/A ----------		
0	15094	14365	14730
40	15231	16154	15693
80	15458	17553	16506
120	18111	17177	17644
160	17001	17576	17288
200	17246	17455	17351
240	18797	17489	18143
280	18645	17535	18090
Mean	16948	16913	16931

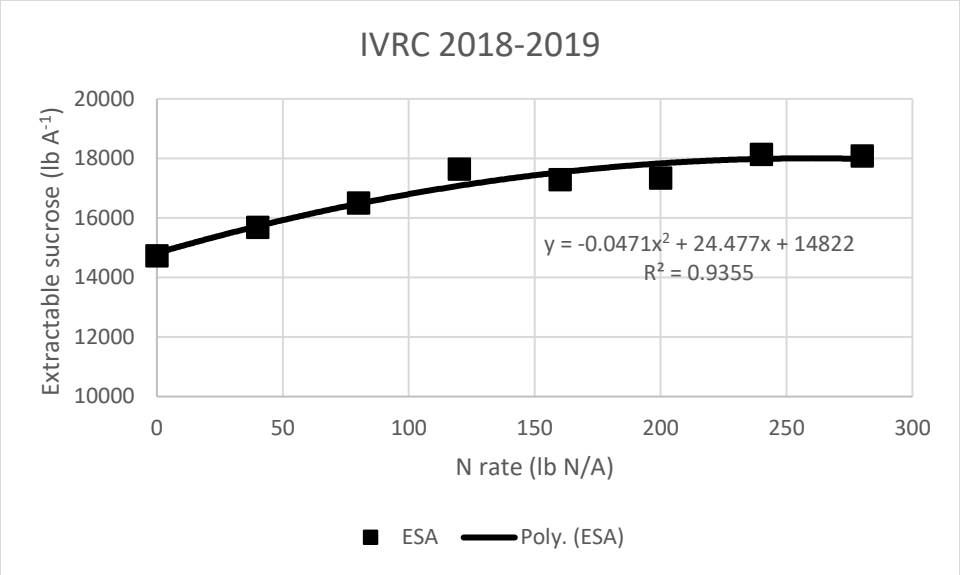

Figure 9. The effect of N rate on extractable sucrose per acre at the Imperial Valley Research Center, 2018-2019 growing season.

Sugar beet purity:

Application time of N and N rate significantly affected sugar beet purity, Table 7. Sugar beet purity decreased with increasing N application for both application times, Table 12 and Figure 10. The N applied at lay-by decreased the purity at the greater N rates more than the N applied pre-plant. This could be caused by the application time at lay-by being closer to harvest than the pre-plant application.

Table 12. The effect of N application rate and time of application on sugar beet purity at the Imperial Valley Research Center, 2018-2019.

N rate	Pre-plant	Layby	Mean
lb/A	---------- ppm-N ----------		
0	90.39	90.33	90.36
40	89.96	90.06	90.01
80	90.52	89.57	90.05
120	89.09	89.92	89.51
160	89.85	89.37	89.61
200	89.89	89.41	89.65
240	89.13	88.87	89.00
280	88.56	87.33	87.94
Mean	89.67	89.36	89.51

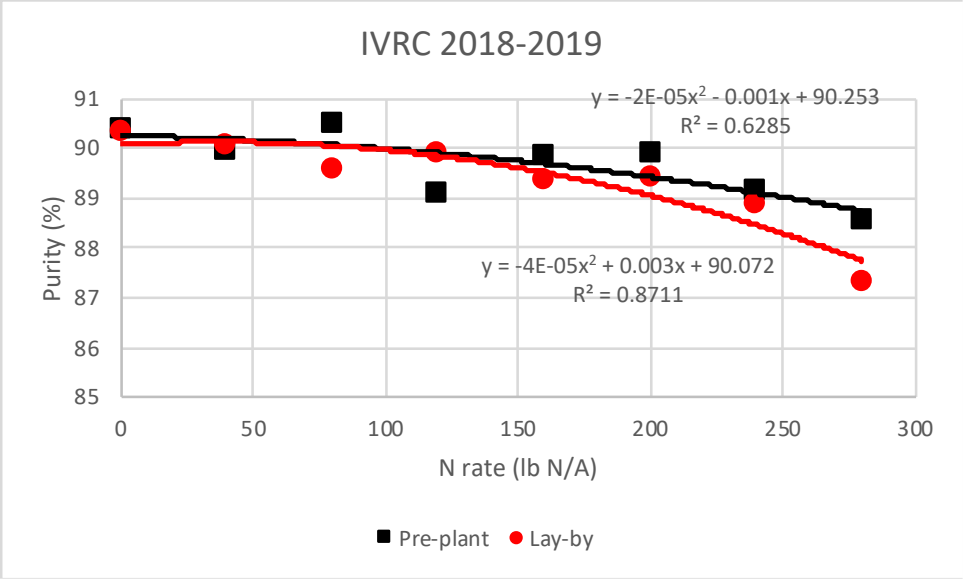

Figure 10. The effect of N rate and time of N application on sugar beet purity at the Imperial Valley Research Center, 2018-2019 growing season.

Sugar beet petiole nitrate-N on March 13, 2019:

Sugar beet petiole nitrate-N concentration was significantly affected by N application time and N application rate, Table 7. There also was an interaction between N application time and N application rate on the petiole nitrate-N concentration on March 13, 2019, Table 7. As the N rate increased, the petiole nitrate-N increased, Table 13. This increased petiole nitrate-N was greater for the sugar beet that was treated at lay-by as opposed to the pre-plant application of N, Figure 11. This would indicate that the difference in application dates did affect the nitrogen status of the sugar beet at this site. This also would suggest that the reduced sugar beet purity at lay-by compared to pre-plant applications was a product of a later application time.

Table 13. The effect of N application rate and time of application on sugar beet petiole nitrate-N at the Imperial Valley Research Center, 2018-2019.

N rate	Pre-plant	Layby	Mean
lb/A	---------- ppm-N ----------		
0	109	176	143
40	138	285	212
80	112	828	470
120	423	1560	992
160	444	1939	1191
200	286	1068	677
240	1129	2602	1865
280	1720	2709	2214
Mean	593	1396	971

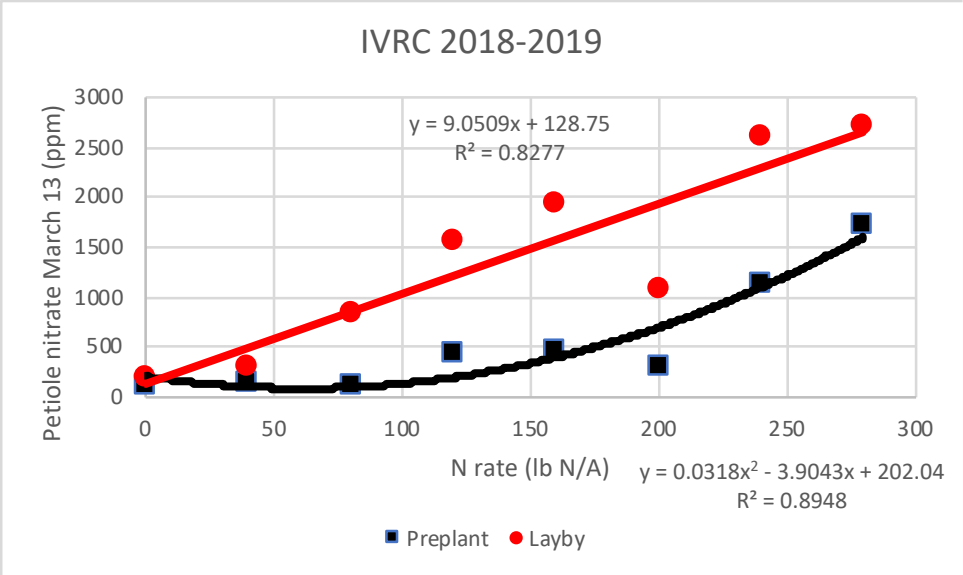

Figure 11. Petiole nitrate-N for pre-plant and lay-by treatments.

Summary IVRC:

The application of N fertilizer increased root yield and extractable sucrose per acre. Root yield was not maximized by the use of N at this site. The soil test N (108 lb/A in the surface four feet plus 20 lb N/A in the pre-plant phosphorus fertilizer plus 280 lb N/A did not maximize root yield. This is considerably more than expected. The extractable sucrose per acre was maximized with the application of 250 lb N/A or 378 lb N/A soil test nitrate-N in the surface four feet plus N in pre-plant phosphorus fertilizer application. The time of application did affect sucrose concentration, extractable sucrose concentration, extractable sucrose per ton petiole nitrate-N concentration and purity. The application of N fertilizer at lay-by resulted decreases in the quality when compared to the pre-plant application of N fertilizer.

Westmorland

The statistical analysis for the N timing by N rate study at Westmorland is presented in Table 14. Purity was not affected by the nitrogen treatments, time or rate. Root yield, sucrose concentration, extractable sucrose concentration, extractable sucrose per ton, and extractable sucrose per acre were only affected by N application rate. There was an interaction between N timing and N rate for petiole nitrate-N.

Table 14. The statistical analysis of the N timing by N rate study near Westmorland, 2018-2019.

Source of variation	Root yield	Sucrose concentration	Extractable sucrose			Purity	Petiole nitrate-N
	ton/A	%	%	lb/ton	lb/A	%	ppm
Rep	0.0001	0.06	0.04	0.04	0.0001	0.70	0.0001
N timing	0.95	0.23	.29	0.29	0.88	0.65	0.0001
N rate	0.003	0.004	0.002	0.002	0.09	0.67	0.0001
N timing X N rate	0.86	0.80	0.76	0.76	0.60	0.30	0.009
C.V. (%)	9.0	4.5	4.9	4.9	7.5	1.2	29.0
Grand mean	67.8	16.2	13.4	267	18010	89.13	1787

Root yield, sucrose concentration, extractable sucrose concentration, extractable sucrose per ton, and extractable sucrose per acre:

The mean root yield at the Westmorland site was 68 tons/A. Root yield was not affected by the time of N application. Nitrogen application rate did increase root yield, Table 15, and Figure 12. Nitrogen rate of application maximized root yield at 160 lb N/A. With the N applied before the treatments and in the soil, this would indicate maximum root yield occurred at 271 lb N/A.

Table 15. The effect of N application rate on root yield, sucrose concentration, extractable sucrose concentration, extractable sucrose per ton and extractable sucrose per acre at the Westmorland site, 2018-2019.

N rate	Root yield	Sucrose concentration	Extractable sucrose		
lb/A	ton/A	%	%	lb/ton	lb/A
0	60.2	17.0	14.0	280	16756
40	67.0	16.5	13.7	274	18336
80	68.2	16.0	13.1	261	17732
120	70.3	16.5	13.6	272	19010
160	71.2	15.9	13.1	262	18303
200	63.4	16.6	13.8	275	17437
240	71.7	15.7	12.9	259	18565
280	71.8	15.6	12.7	254	18194

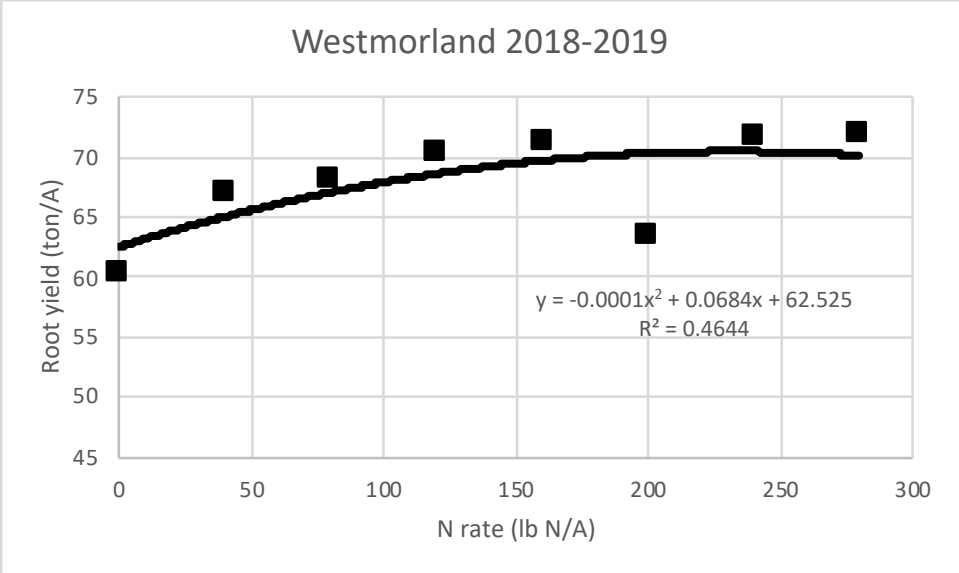

Figure 12. The effect of N rate on root yield at Westmorland, 2018-2019 growing season.

Extractable sucrose per acre:

Similar to root yield, extractable sucrose per acre was not affected by the time of N application. Extractable sucrose per acre was increased significantly from N application rate, Table 15. Figure 13 presents the response to N rate. The maximum extractable sucrose occurred at 175 lb N/A application rate. Accounting for the N in the pre-plant applications and the soil nitrate-N, the optimum extractable sucrose per acre occurred with 286 lb N/A.

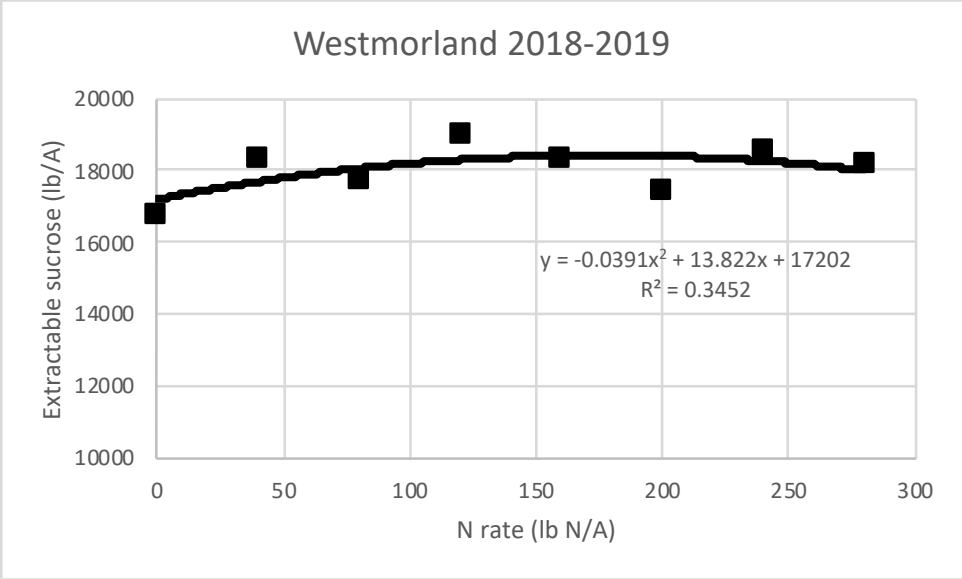

Figure 13. The effect of N rate on extractable sucrose per acre at Westmorland, 2018-2019 growing season.

Sugar beet purity:

Sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton:

Because sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton were not affected by N application time, they will be discussed together. Nitrogen application rates from 0 to 200 lb N/A, sucrose was not affected by N application but at N rates greater than 200 lb N/A sucrose declined, Table 15 and Figure 14.

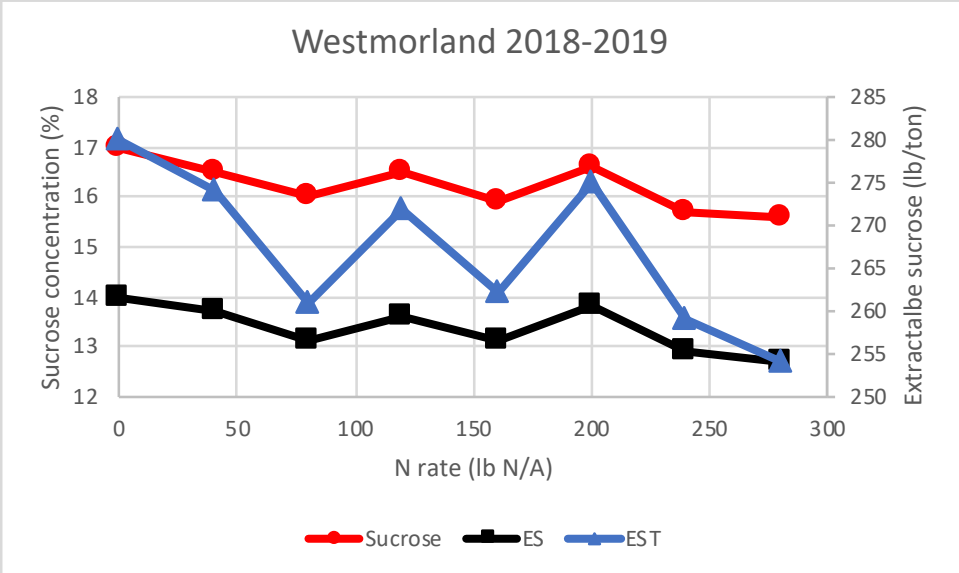

Figure 14. The effect of N rate on sugar beet sucrose at Westmorland, 2018-2019.

Sugar beet petiole nitrate-N on March 13, 2019:

Sugarbeet petiole nitrate-N concentration was significantly affected by N application time and N application rate, Table 14. There also was an interaction between N application time and N application rate on the petiole nitrate-N concentration on March 13, 2019, Table 14 and 16. The interaction between petiole nitrate-N concentrations was because the response to N application rate at pre-plant was different than the response to N application at lay-by, Figure 15. Petiole nitrate-N concentrations from the pre-plant N applications increased as the N rate applied

increased. The petiole nitrate-N concentrations for N applications at lay-by increased as N applications increased. The petiole nitrate-N concentrations reflect that there was more N available to the plants on March 13 for the plants with N applied at lay-by compared to the plants that had N applied at pre-plant. This would indicate that the difference in application dates did affect the nitrogen status of the sugar beet at this site.

Table 16. The effect of N application rate and time of application on sugar beet petiole nitrate-N at Westmorland, 2018-2019.

N rate	Pre-plant	Layby	Mean
lb/A	---------- ppm-N ----------		
0	539	548	541
40	1039	801	920
80	1127	1475	1301
120	1162	2752	1957
160	1755	2767	2261
200	1163	1454	1308
240	2132	3514	2823
280	2808	3562	3185
Mean	1465	2108	1787

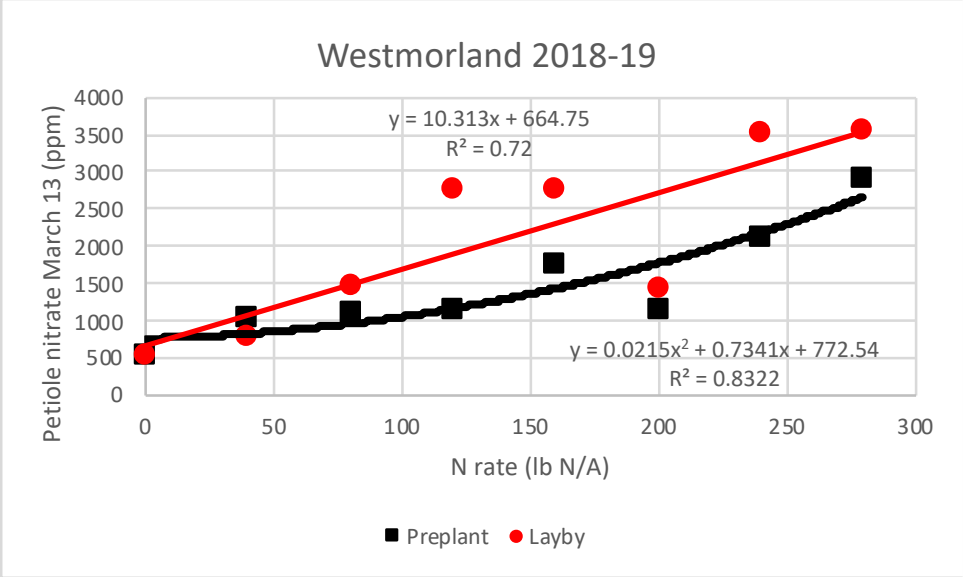

Figure 15. Petiole nitrate-N for pre-plant and lay-by treatments at Westmorland, 2018-2019.

Summary Westmorland:

The application of N fertilizer increased root yield and extractable sucrose per acre. Root yield and extractable sucrose per acre were maximized by the use of N at this site. The soil test N (65 lb/A in the surface four feet plus 46 lb N/A in the pre-plant phosphorus fertilizer plus 160 lb N/A did maximize root yield (271 lb N/A. This is 20 lb N/A more than expected. The extractable sucrose per acre was maximized with the application of 120 lb N/A or 231 lb N/A soil test nitrate-N in the surface four feet plus N in pre-plant fertilizers. At N application rates above 200 lb/A, sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton was reduced. Purity was not affected by N addition at this site.

Summary 2018-2019:

The application of N fertilizer increased root yield and extractable sucrose per acre at both sites in the 2018-2019 growing season. At the IRVC site root yield was not maximized by the use of N. The soil test N (108 lb/A in the surface four feet plus 20 lb N/A in the pre-plant phosphorus fertilizer plus 280 lb N/A made the maximum amount

of N at IRVC of 408 lb N/A. The extractable sucrose per acre at IRVC site was maximized with the application of 250 lb N/A or 378 lb N/A soil test nitrate-N in the surface four feet plus N in pre-plant phosphorus. The N application caused a reduction of sucrose and decreased purity in the roots. The time of application did affect sucrose concentration, extractable sucrose concentration, extractable sucrose per ton, petiole nitrate-N concentration and purity. The application at lay-by resulted in decreases in the quality compared to the pre-plant application.

At the Westmorland site, the application of N fertilizer increased root yield and extractable sucrose per acre. Root yield and extractable sucrose per acre were maximized with a total N amount of 271 lb N/A and 231 lb N/A for root yield and extractable sucrose per acre, respectively. The optimum N rate for extractable sucrose was within the expected value. At N application rates above 200 lb/A, sucrose concentration, extractable sucrose concentration, and extractable sucrose per ton was reduced. Purity was not affected by N addition at this site.

At both locations, root yield and extractable sucrose per acre were not affected by time of N application.

Results from 2019-2020:

Brawley, CA

The site for the 2019-2020 growing season was in a grower field east of Brawley, CA. This site had some border issues that required the data to be analyzed using a co-variate for the location of the plots within the site to adjust the results. The co-variate was significant for root yield, extractable sucrose per acre, and purity, Table 17.

Table 17. The statistical analysis of the N timing by N rate study at the Brawley, CA, 2019-2020.

Source of variation	Root yield	Sucrose concentration	Extractable sucrose			Purity	Petiole nitrate-N
	ton/A	%	%	lb/ton	lb/A	%	ppm
Co-variate	0.0001	0.46	0.19	0.18	0.0001	0.007	0.07
Rep	0.37	0.15	0.26	0.26	0.44	0.65	0.74
N timing	0.50	0.04	0.01	0.008	0.03	0.005	0.06
N rate	0.0009	0.02	0.004	0.005	0.16	0.03	0.09
N timing X N rate	0.29	0.20	0.10	0.10	0.11	0.12	0.22
C.V. (%)	7.4	5.8	6.5	6.5	10.2	1.1	90
Grand mean	38.8	16.1	13.1	262	10119	88.4	706

Root yield was only affected by the application of N fertilizer. The timing of the application did not affect root yield. The optimum N fertilizer application was 252 lb N/A, Table 17 and Figure 16. With the soil nitrate-N to 4 feet and the 20 lb N/A applied with the phosphorus at pre-plant, the optimum root yield occurred at 554 lb N/A. This is at a much greater N level than expected.

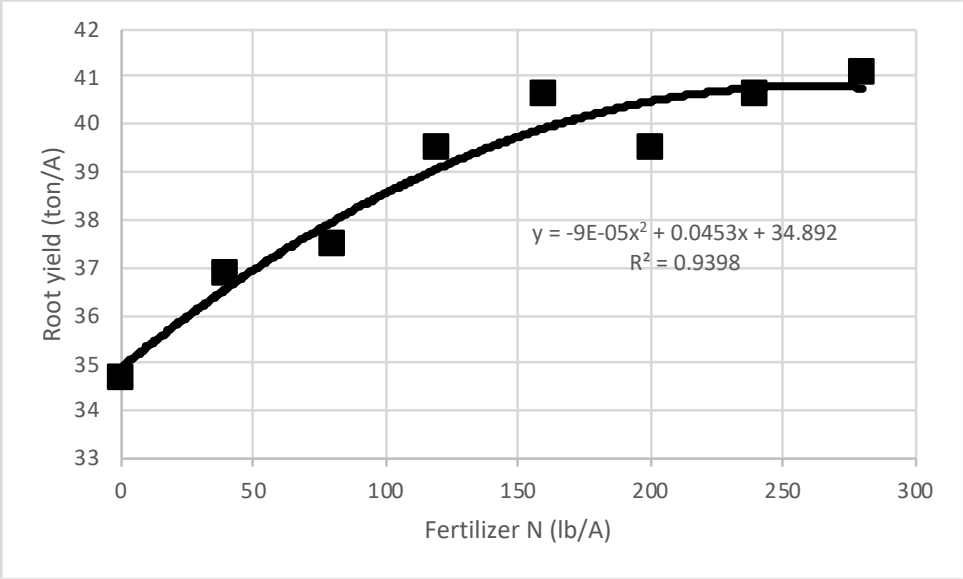

Figure 16. Root yield response to N fertilizer application at Brawley, 2019-2020.

Sucrose was affected by both N rate and N timing. Sucrose concentration was decreased with increasing amounts of N fertilizer. The sucrose concentration was less when the N fertilizer was applied at lay by than when applied at pre-plant, Figure 17.

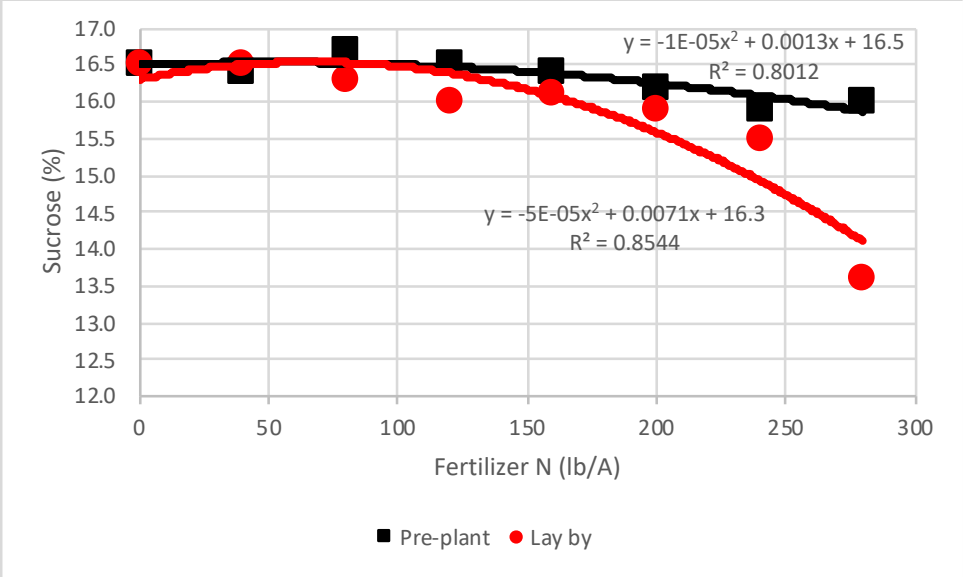

Figure 17. Sucrose concentration for pre-plant and lay-by treatments at Brawley, 2019-2020.

There were interactions between N timing and N rate for extractable sucrose (%, lb/ton, and lb/A) and purity, Table 17. Extractable sucrose concentration was decreased by the addition of N fertilizer more when the N fertilizer was applied at lay by then when N fertilizer was applied at pre-plant, Figure 18. The same is also occurring for extractable sucrose (lb/ton), Figure 19. Extractable sucrose per acre was increased by the addition of N fertilizer at both application times. For the pre-plant application of N fertilizer, the optimum N rate was 257 lb N/A while for the lay by application the optimum N rate was 132 lb N/A, Figure 20. When accounting for the pre-plant and soil test nitrate-N, the optimum would be 559 and 434 lb N/A, respectively.

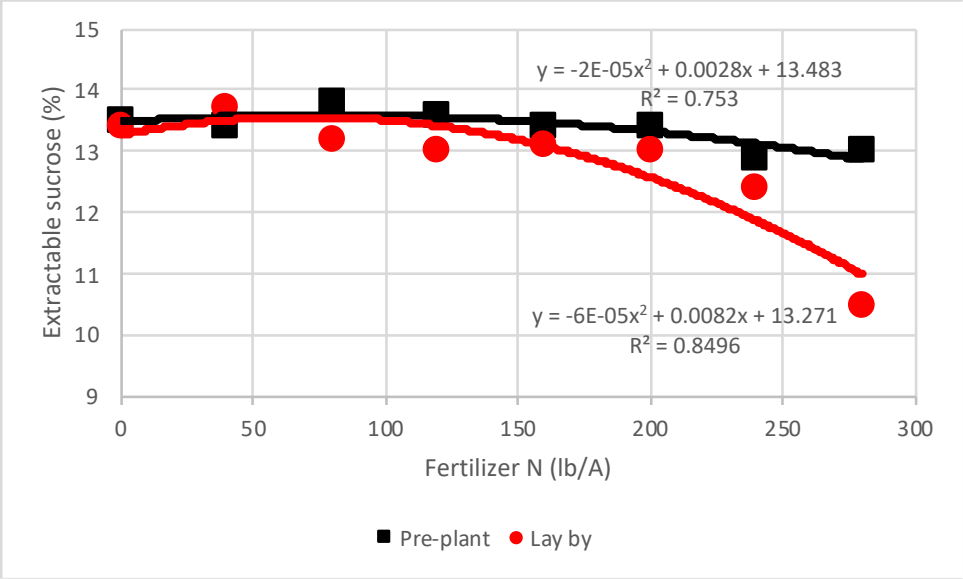

Figure 18. Extractable sucrose concentration for pre-plant and lay-by treatments at Brawley, 2019-2020.

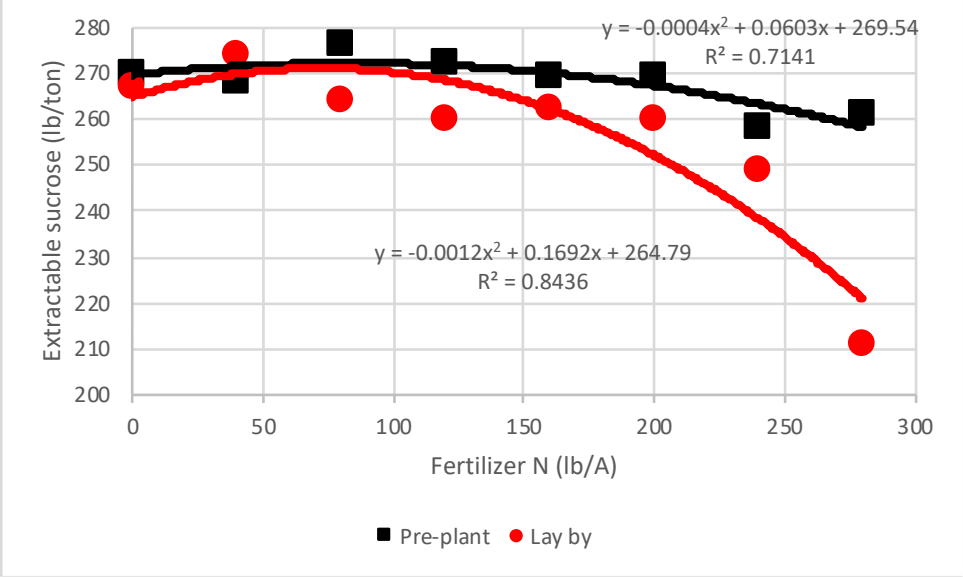

Figure 19. Extractable sucrose per ton for pre-plant and lay-by treatments at Brawley, 2019-2020.

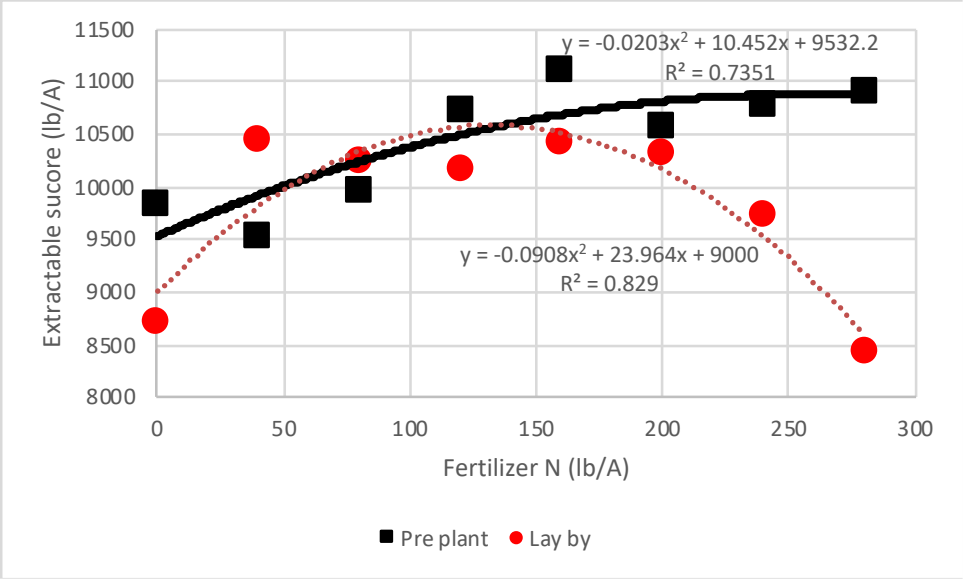

Figure 20. Extractable sucrose per acre for pre-plant and lay-by treatments at Brawley, 2019-2020.

While purity was significant affected by N application and the timing of the application, the difference was only 1% and not applicable to the real world.

Petiole nitrate-N was affected by N application (P>= 0.09) and N timing (P>= 0.06), Table 17. The interaction was caused by the lack of response to N application when the fertilizer was applied pre-plant while the petiole nitrate-N concentration increased to increasing N rate to above the 80 lb/A N rate, Figure 21. The N applied pre-plant could have been used by the plant by the time the petiole sample were taken while there was nitrate-N in the plant from the lay-by application at the time of petiole sampling.

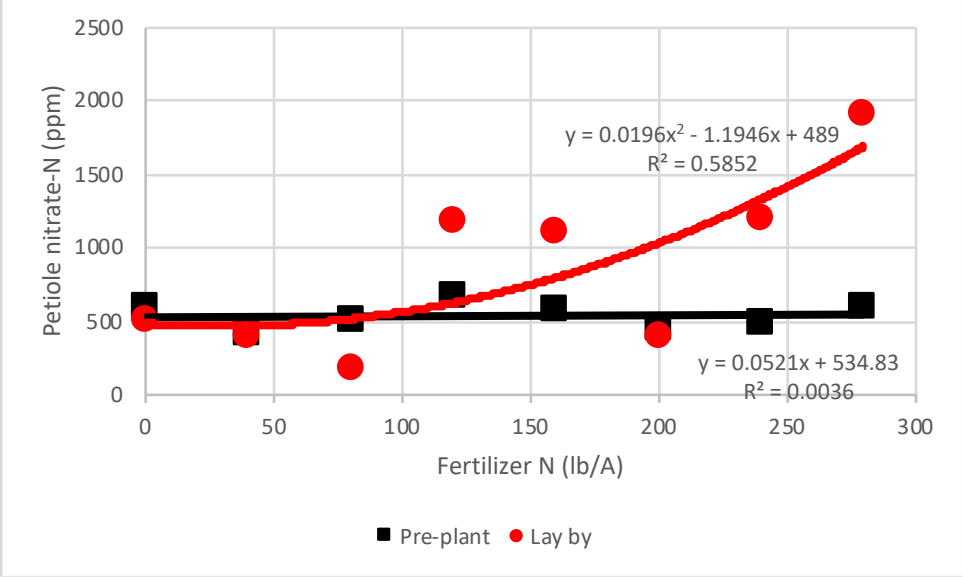

Figure 21. Petiole nitrate-N concentration for pre-plant and lay-by treatments at Brawley, 2019-2020.

Summary: 2017-2020

A study to examine the effect of N fertilizer application in the Imperial Valley of California was conducted from 2017 to 2020. Five sites were established. Four were harvested as one had too poor of a plant stand. Root yield was increased by N application at all sites while extractable sucrose per ton was decreased by increasing N application at all sites. The application time of N, pre-plant or layby did not affect the root yield or extractable sucrose per ton.

Extractable sucrose per acre was increased with the N fertilizer application at all four sites, Figure 22. At one of those sites, Brawley 2019-2020, extractable sucrose per acre was affected by application time. At this location, the N fertilizer applied at layby was more efficient compared to the pre-plant application time. The optimum N level (soil test nitrate-N to 4 feet plus N in pre-plant phosphorus fertilizer plus N fertilizer) for maximum extractable sucrose per acre was less for the sugar beet treated with the layby N application time compared to the sugar beet grown with all N applied pre-plant, Table 18.

The optimum total N for the maximum extractable sucrose was greater than the current suggested guideline for maximum extractable sucrose per acre at all four sites. The optimum total N for the Brawley site was particularly greater than the current guidelines. This site had a very large amount of residual nitrate-N.

The amount of N needed in this study was not related to the extractable sucrose per acre yield. Also, the time of application at three of the sites did not affect the amount of extractable sucrose per acre. In most cases, the time of N application is not a factor in management of N on heavy textured soils of the Imperial Valley of California.

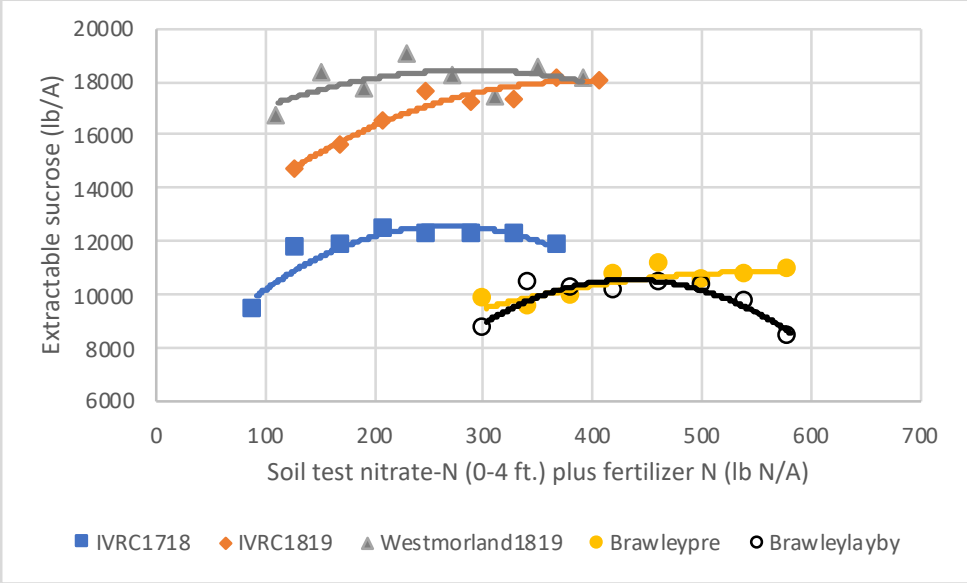

Figure 22. Extractable sucrose per acre as affected by soil nitrate-N, pre-plant N in phosphorus fertilizer, and N fertilizer application at four sites in the Imperial Valley of California from 2017 to 2020.

Table 18. Regression equations, R^2, and optimum N values for extractable sucrose per acre in the Imperial Valley of California from 2017 to 2020.

Site	Equation	R^2	Optimum N rate (lb/A)
IVRC 2017-2018	$Y = -0.0847\ X^2 + 45.278\ X + 6540$	0.84	267
IVRC 2018-2019	$Y = -0.0471\ X^2 + 36.529\ X + 10918$	0.94	385
Westmorland 2018-2019	$Y = -0.0391\ X^2 + 22.511\ X + 15186$	0.35	288
Brawley Pre 2019-2020	$Y = -0.0203\ X^2 + 22.725\ X + 4522$	0.74	560
Brawley Layby 2019-2020	$Y = -0.0908\ X^2 + 78.789\ X - 6516$	0.83	434

Literature Cited:

Kaffka, S.R., 2007. Fertilizer N management for high-yielding sugar beets in California. Proceedings of IIRB Summer Congress, Marrakech, Morocco. Brussels, Belguim: International Institute for Beet Research.

Use of PCC on Sandy Soils in the Imperial Valley of California

Final Report

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Justification: Precipitated Calcium Carbonate (PCC) is a by-product of the refining of sucrose from sugar beet. Since the opening of the Brawley, CA Spreckels Sugar Company refinery in 1949, a large amount of PCC has accumulated. There has been a push by the regulatory agencies in California to reduce the size of this accumulation. In other sugar beet growing areas, the use of PCC has been documented to be beneficial for crop production. The benefit comes from improved soil physical properties, the addition of micronutrients to the soil, and reduced disease incidence. Research has been conducted in the Imperial Valley of California on heavy textured soils. The outcome for the California work indicated that PCC did not reduce yield or quality of sugar beet, alfalfa, or wheat. Because PCC has been shown to improve soil properties in other sugar beet growing areas, the question arises if application could be beneficial to sandy soils in the Imperial Valley.

Objectives: The objective of this proposed research is to identify the effect of PCC application on sandy soils in the Imperial Valley of California.

Materials and Methods: To meet the proposed objective, a study was established in September 2019 for the 2019-2020 sugar beet growing season on a Vint loamy very fine sand (Typic Torrifluvents) in the Imperial Valley of California. Soil samples were taken prior to PCC application for pH, organic matter, nitrate-N, Olsen-P, potassium, sulfate-S, salts, zinc, boron, magnesium, calcium, and copper. The PCC was applied in randomized replicated field strips at four application rates; 0, 4, 8, and 12 wet tons per acre. The analysis for the PCC applied is presented in Table 1. There were three replications. The crop grown was onion. Soil samples were taken five times; November 15, 2019, December 17, 2019, January 20, 2020, February 27, 2020, and April 1, 2020. These soil samples were analyzed for pH, organic matter, nitrate-N, Olsen-P, potassium, sulfate-S, salts, zinc, boron, magnesium, calcium, copper, sodium, and CEC.

Table 1. Analysis of Spreckels PCC on a wet basis.

		Total Nutrient	Total Nutrient (lb/A)		
Nutrient	Analysis	(lb/ton)	4 ton/A	8 ton/A	12 ton/A
Moisture	25.2%	-	-	-	-
Ammonium-N	0.02 %	0.4	1.6	3.2	4.8
Nitrogen, Organic	0.14%	2.8	11.2	22.4	33.6
Nitrogen, Total	0.16%	3.2	12.8	25.6	38.4
Phosphorus as P_2O_5	0.60%	12.0	48.0	96.0	144.0
Potassium as K_2O	0.06%	1.2	4.8	9.6	14.4
Sulfur	1570 ppm	3.1	12.4	24.8	37.2
Zinc	27.2 ppm	<0.1	<0.4	<0.8	<1.2
Iron	393 ppm	0.8	3.2	6.4	9.6
Copper	13.7 ppm	<0.1	<0.4	<0.8	<1.2
Calcium	17 %	340	1360	2720	4080
Magnesium	4100 ppm	8.2	32.8	65.6	98.4
Sodium	270 ppm	0.5	2	4	6

Results: This study was established on sandy soil in the Imperial Valley in the Fall of 2019. The initial soil samples are reported in Table 2. The values in Table 2 are normal for a sandy soil located in the Imperial Valley.

Table 2. Initial soil chemical properties for sandy soil PCC study, September 4, 2019.

Soil chemical property	Sample depth (inches)	Value
pH	0 – 6	8.0 (unitless)
Organic matter	0 – 6	0.7 %
Nitrate-N	0 – 6	42 lb N/A
Nitrate-N	6 – 12	38 lb N/A
Olsen-P	0 – 6	16 ppm
Potassium	0 – 6	80 ppm
Sulfate-S	0 – 6	82 lb/A
Sulfate-S	6 – 12	72 lb/A
Salts	0 – 6	0.49 mmhos cm^{-1}
Salts	6 – 12	0.45 mmhos cm^{-1}
Zinc	0 – 6	0.47 ppm
Boron	0 – 6	0.59 ppm
Magnesium	0 – 6	311 ppm
Calcium	0 – 6	2714 ppm
Copper	0 – 6	0.28 ppm

After the PCC treatments were applied and incorporated, the soil for each treatment was sampled on November 15, 2019, Table 3. Boron, Mg, Ca, Cu, and CEC were significantly affected by the addition of PCC. All of the significant differences were increases in concentration of the chemical measured because of the PCC application. The CEC was also increased. This increased CEC could have been caused by the increase in Mg and Ca in the soil solution that caused the method of measurement to not be accurate. The actual CEC of the soil may not have been changed.

Table 3. Soil chemical values and statistic as affected by PCC application on a sandy soil PCC study for the 0 to 6 inch depth, November 15, 2019.

Soil chemical property	0 tons/A	4 tons/A	8 tons/A	12 tons/A	Statistic for PCC rate
pH (unitless)*	-	-	-	-	-
Organic matter (%)	0.67	0.80	0.80	0.87	0.21
Nitrate-N (lb N/A)	28	34	39	34	0.79
Olsen-P (ppm)	27	29	44	40	0.22
Potassium (ppm)	89	90	92	91	0.85
Sulfate-S (lb/A)	109	115	117	115	0.59
Salts (mmhos/cm)	0.65	0.69	0.68	0.69	0.79
Zinc (ppm)	2.0	1.9	2.1	1.9	0.66
Boron (ppm)	0.59	0.64	0.60	0.63	0.02
Magnesium (ppm)	299	331	358	373	0.005
Calcium (ppm)	2794	3455	3969	4424	0.09
Copper (ppm)	0.30	0.31	0.34	0.38	0.02
Sodium (ppm)	140	149	153	152	0.63
CEC (meq/100g soil)	17.3	20.9	23.7	26.1	0.08

* pH was not determined on the soil on this sampling date.

The second soil sampling occurred on December 17, 2019, Table 4. At this sampling time the concentrations for Olsen-P, B, Mg, Ca, and Na were significantly increased. Again these increases were caused by the addition of PCC. The CEC was also increased but again, the increase could be from the method used to determine CEC being affected by the increased Mg, Ca, and Na in the soil solution.

Table 4. Soil chemical values and statistic as affected by PCC application on a sandy soil PCC study for the 0 to 6 inch depth, December 17, 2019.

Soil chemical property	0 tons/A	4 tons/A	8 tons/A	12 tons/A	Statistic for PCC rate
pH (unitless)	8.1	8.1	8.1	8.1	0.98
Organic matter (%)	0.57	0.60	0.67	0.73	0.16
Nitrate-N (lb N/A)	44	46	48	46	0.99
Olsen-P (ppm)	27	30	39	55	0.02
Potassium (ppm)	88	84	93	89	0.48
Sulfate-S (lb/A)*	-	-	-	-	-
Salts (mmhos/cm)	0.59	0.67	0.67	0.73	0.46
Zinc (ppm)	2.67	2.28	2.38	2.26	0.82
Boron (ppm)	0.57	0.58	0.60	0.62	0.02
Magnesium (ppm)	287	297	352	373	0.001
Calcium (ppm)	2814	3032	3997	4442	0.006
Copper (ppm)	-	-	-	-	-
Sodium (ppm)	117	124	138	151	0.003
CEC (meq/100g soil)	17.2	18.4	23.8	26.2	0.005

* Sulfate-S was not determined on the soil on this sampling date.

The third soil sampling occurred on January 20, 2020, Table 5. Soil concentrations for Mg, Ca, Cu, and Na were increased from the application of PCC. The CEC was still increased by the PCC application similar to the earlier soil sampling times. The method of determining CEC could be the reason for these differences as CEC is considered a stable chemical property in soils.

Table 5. Soil chemical values and statistic as affected by PCC application on a sandy soil PCC study for the 0 to 6 inch depth, January 20, 2020.

Soil chemical property	0 tons/A	4 tons/A	8 tons/A	12 tons/A	Statistic for PCC rate
pH (unitless)	8.0	8.2	8.0	8.2	0.08
Organic matter (%)	0.53	0.57	0.57	0.63	0.32
Nitrate-N (lb N/A)	63	74	57	55	0.39
Olsen-P (ppm)	34	24	42	37	0.16
Potassium (ppm)	95	94	105	103	0.50
Sulfate-S (lb/A)	115	120	120	120	0.29
Salts (mmhos/cm)	0.55	0.74	0.76	78	0.29
Zinc (ppm)	2.11	1.94	2.32	2.04	0.55
Boron (ppm)	0.62	0.66	0.64	0.66	0.37
Magnesium (ppm)	311	327	368	410	0.002
Calcium (ppm)	2747	3610	4209	5024	0.0007
Copper (ppm)	0.37	0.38	0.45	0.47	0.003
Sodium (ppm)	127	146	163	186	0.02
CEC (meq/100g soil)	17.1	21.6	25.1	29.6	0.0004

The fourth soil sampling occurred on February 27, 2020, Table 6. Soil concentrations of magnesium, sodium, and CEC were affected by the addition of PCC.

Table 6. Soil chemical values and statistic as affected by PCC application on a sandy soil PCC study for the 0 to 6 inch depth, February 27, 2020.

Soil chemical property	0 tons/A	4 tons/A	8 tons/A	12 tons/A	Statistic for PCC rate
pH (unitless)	7.8	8.0	8.0	8.1	0.13
Organic matter (%)	0.60	0.60	0.63	0.70	0.57
Nitrate-N (lb N/A)	52	40	90	83	0.33
Olsen-P (ppm)	26	32	46	44	0.38
Potassium (ppm)	100	94	104	102	0.65
Sulfate-S (lb/A)	120	120	120	120	1.00
Salts (mmhos/cm)	0.91	0.97	1.24	1.27	0.18
Zinc (ppm)	3.64	2.27	2.97	2.50	0.14
Boron (ppm)	0.69	0.66	0.63	0.72	0.51
Magnesium (ppm)	313	348	377	435	0.02
Calcium (ppm)	2987	3734	4008	4847	0.12
Copper (ppm)	0.56	0.44	0.48	0.61	0.39
Sodium (ppm)	170	192	212	260	0.04
CEC (meq/100g soil)	18.5	22.7	24.4	29.3	0.08

The fifth soil sampling occurred on April 1, 2020, Table 7. Soil concentrations of magnesium, calcium, and CEC were affected by the addition of PCC.

Table 7. Soil chemical values and statistic as affected by PCC application on a sandy soil PCC study for the 0 to 6 inch depth, April 1, 2020.

Soil chemical property	0 tons/A	4 tons/A	8 tons/A	12 tons/A	Statistic for PCC rate
pH (unitless)	8.1	8.3	8.4	8.2	0.16
Organic matter (%)	0.63	0.70	0.63	0.77	0.23
Nitrate-N (lb N/A)	6	8	9	11	0.70
Olsen-P (ppm)	36	46	38	55	0.49
Potassium (ppm)	83	83	88	84	0.17
Sulfate-S (lb/A)	98	107	87	113	0.38
Salts (mmhos/cm)	0.45	0.56	0.40	0.74	0.18
Zinc (ppm)	5.77	3.11	3.01	2.90	0.24
Boron (ppm)	0.72	0.73	0.76	0.71	0.58
Magnesium (ppm)	316	381	367	418	0.06
Calcium (ppm)	2940	4731	4636	4709	0.04
Copper (ppm)	0.53	0.54	0.54	0.63	0.51
Sodium (ppm)	140	191	178	221	0.63
CEC (meq/100g soil)	18.2	27.9	27.2	28.2	0.04

Summary:

Olsen – P, boron, magnesium, calcium, copper, and sodium soil concentrations and the soil CEC were increased at least one of the five soil sampling times from with the addition of PCC.

Olsen-P was significantly affected at one of the sampling times. This was the second sampling date, Figure 1. At the second sampling time the twelve ton/acre application increased the Olsen-

P amount more than the other application rates. On the other soil sampling dates, there was no significant difference between the application rates of PCC.

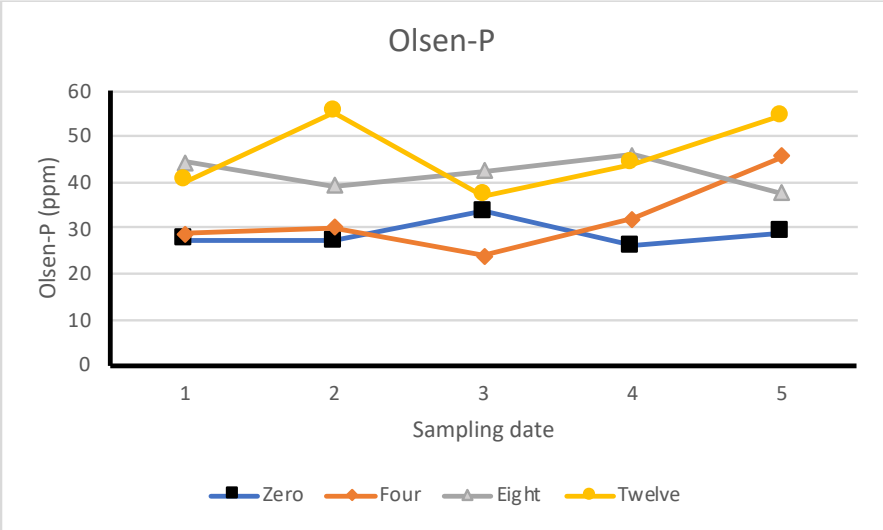

Figure 1. The concentration of Olsen-P in the soil for the four application rates at the five sampling dates.

The concentration in the soil of boron was affected by the PCC application rate on first and second soil sampling dates, Figure 2. On the first sampling date, the boron concentration was greater for four and twelve tons per acre PCC application compared to the zero and eight ton per acre application rate. This cannot be explained. On the second soil sampling date, the twelve tons PPC per acre rate increased the soil boron concentration compared to the other application rates. At the later soil sampling dates there were no differences between PCC application rates.

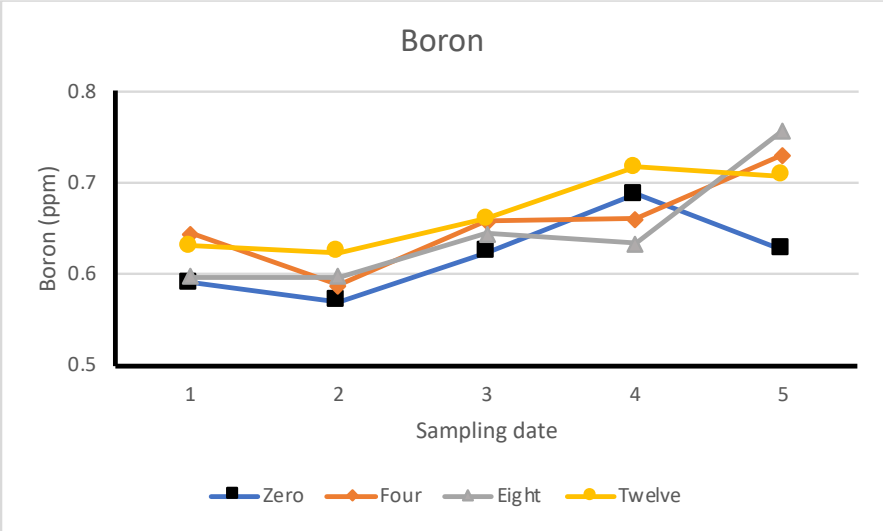

Figure 2. The concentration of boron in the soil for the four application rates at the five sampling dates.

The soil concentration of copper was not analyzed in the second soil sampling, Figure 3. Copper concentration was increased for the eight and twelve tons PCC per acre application rates

compared to the zero and four ton PCC per acre application rates on soil sampling one. There were significant differences recorded between application rates on the third soil sampling date. Again, the two greater PCC applications had a greater soil copper concentrations. On the later two soil sampling dates, there were no differences in soil copper concentration between the PCC application rates.

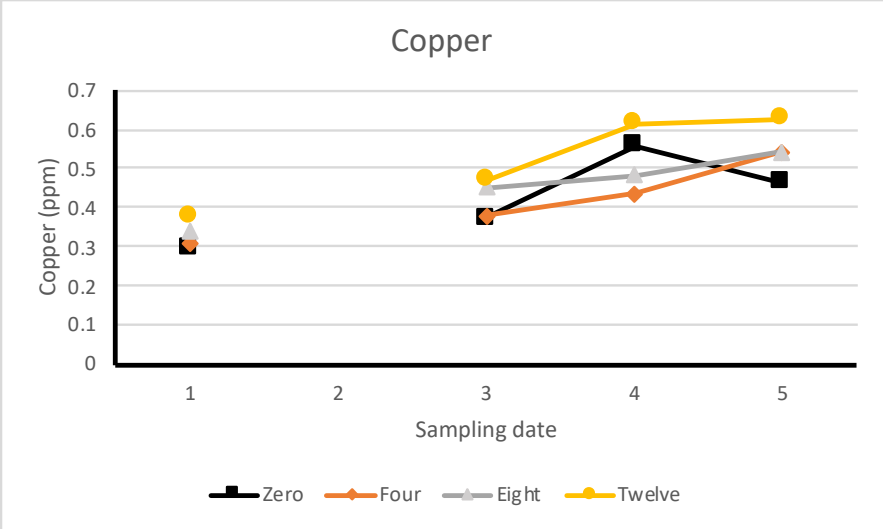

Figure 3. The concentration of copper in the soil for the four application rates at four sampling dates.

The soil concentration of sodium was not affected by PCC application on the first and fifth soil sampling date, Figure 4. On the other soil sampling dates, the soil sodium concentration was increased with increasing rates of PCC applied. From the second to the fourth soil sampling date, the sodium concentration in the soil increased. Between the fourth and fifth soil sampling date the sodium concentration decreased. This could be possible because of irrigation.

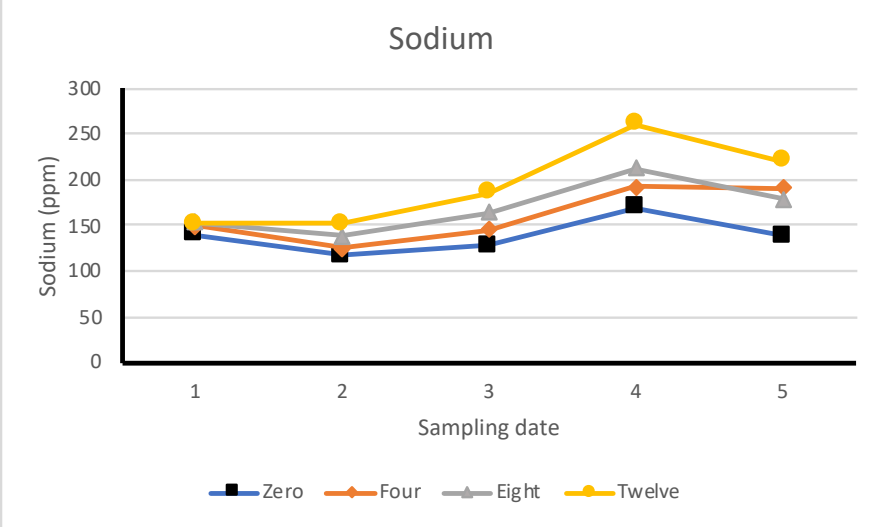

Figure 4. The concentration of sodium in the soil for the four application rates at the five sampling dates.

The soil concentrations of magnesium and calcium were significantly affected by the application of PCC, Figure 5. When PCC was applied at any rate, the concentration of magnesium and calcium were increased for all soil sampling dates. The soil concentrations did not decrease over time.

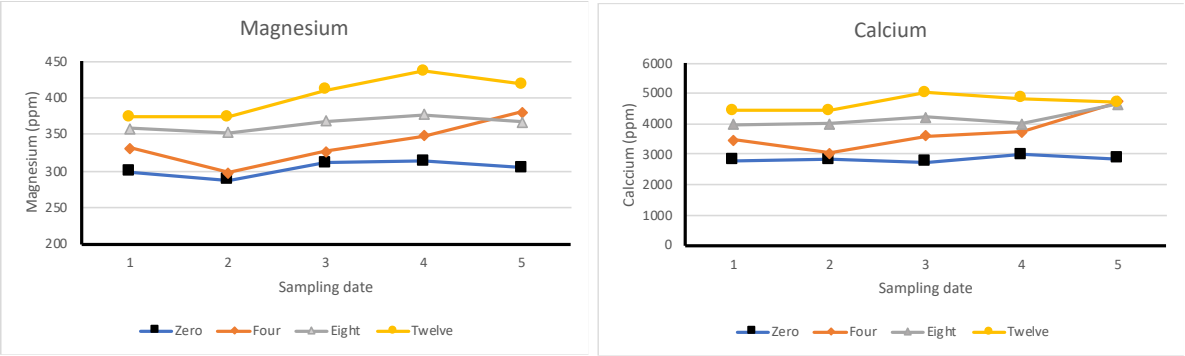

Figure 5. The concentration of magnesium and calcium in the soil for the four application rates at the five sampling dates.

Because of the increases in magnesium, calcium, and sodium, the CEC was increased with the addition of PCC, Figure 6. The method of determination of CEC involves the measurement of magnesium, calcium, and sodium concentrations with other cations and then all of these cations are added together. The amount of calcium, magnesium, and sodium were increased with the PCC application but the number of cation exchange sites in the soil that make up the CEC did not. This increase CEC was caused by the laboratory method used and not the use of PCC. The actual CEC of the soil was not changed.

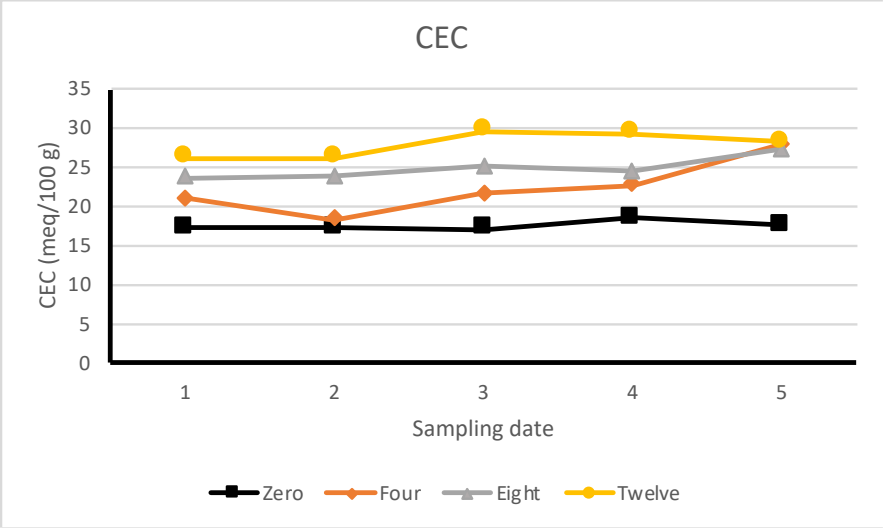

Figure 6. The soil CEC for the four application rates at the five sampling dates.

2019 – 2020 Imperial Valley Official Variety Trial Results

Imperial Valley Early Harvest Official Variety Trials
3 Year Data (2018-2020)

Variety	Approval Status for 2020-21 crop	Extractable Sugar/ Acre	Extractable Sugar/ Ton	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Final Stand[1/]	% Bolt	Purity	Percent Emergence		Curly Top	% of Mkt.	Erwinia Root Rot+ (DI)	% of Mkt. Avg.	Powdery Mildew	% of Mkt. Avg.	Rhizomania Root Rating
												--- M = 150 ---		--M = 300		-- M = 100		
SV 983	Full Approval																	
2020 Trial		10,786	299.9	12,785	36.0	17.8	207	0.0	90.4	53.1		5.3	94.4	--	--	--	--	2.3
2019 Trial		11,241	327.2	13,126	34.2	19.1	211	0.0	91.1	64.5		5.5	93.2	3.2	14.5	7.0	142.4	1.8
2018 Trial		11,762	293.9	14,101	40.3	17.6	201	0.0	89.6	38.0		6.1	91.5	5.5	17.3	3.7	72.8	1.6
Average		11,263	307.0	13,337	36.8	18.2	206	0.0	90.4	51.9								
BTS 582N																		
2020 Trial		9,718	290.0	11,768	33.5	17.6	234	0.0	89.0	76.0		5.4	96.2	--	--	--	--	2.1
2019 Trial		10,097	323.0	11,838	31.1	18.9	213	0.0	91.0	68.7		5.9	100.0	27.1	122.5	4.2	85.4	1.6
2018 Trial		10,417	290.8	12,812	34.9	17.9	207	0.0	87.9	53.3		--	--	--	--	4.9	96.4	
Average		10,077	301.3	12,139	33.2	18.1	218	0.0	89.3	66.0								
BTS 5678	Full Approval																	
2020 Trial		10,111	279.4	12,137	36.2	16.8	233	0.0	89.8	69.9		5.2	92.7	--	--	--	--	1.6
2019 Trial		11,448	316.8	13,453	36.1	18.6	213	0.0	90.8	65.1		5.7	96.6	31.3	141.7	6.1	124.1	1.5
2018 Trial		11,230	295.0	13,466	38.2	17.7	207	0.0	89.6	43.9		6.6	99.0	51.4	161.6	5.2	102.3	1.6
Average		10,930	297.1	13,019	36.8	17.7	218	0.0	90.1	59.6								
SV501	Full Approval																	
2020 Trial		9,900	283.0	11,804	35.0	16.9	209	0.0	90.1	36.8		5.6	99.8	--	--	--	--	2.2
2019 Trial		11,306	326.4	13,240	34.8	19.1	196	0.0	91.0	42.0		5.8	98.3	2.2	10.0	4.7	95.6	2.1
2018 Trial		11,438	279.3	13,896	40.7	17.0	192	0.0	88.9	35.9		6.7	100.5	4.1	12.9	5.1	100.3	1.4
Average		10,881	296.2	12,980	36.8	17.7	199	0.0	90.0	38.2								
BTS 5775	Full Approval																	
2020 Trial		9,158	279.7	11,050	32.8	16.9	214	0.0	89.4	44.3		5.8	103.3	--	--	--	--	2.1
2019 Trial		11,514	328.2	13,478	35.1	19.2	214	0.0	91.0	61.8		6.0	101.7	36.2	163.8	3.8	77.3	2.1
2018 Trial		10,491	277.2	12,877	37.6	17.0	202	0.0	88.2	52.2		6.8	102.0	57.0	179.2	3.6	70.8	1.5
Average		10,388	295.0	12,468	35.2	17.7	210	0.0	89.5	52.8								
BTS 5460	Full Approval																	
2020 Trial		9,540	280.2	11,489	34.1	16.9	228	0.0	89.5	57.3		5.2	92.7	--	--	--	--	1.6
2019 Trial		10,945	313.3	12,903	35.1	18.5	212	0.0	90.6	71.0		5.8	98.3	45.3	204.9	4.3	87.5	1.4
2018 Trial		11,246	285.2	13,616	39.4	17.3	204	0.0	89.0	46.4		6.2	93.0	52.4	164.8	4.8	94.4	1.0
Average		10,577	292.9	12,669	36.2	17.6	215	0.0	89.7	58.2								
SV 972	Full Approval																	
2020 Trial		9,938	273.1	11,861	36.4	16.3	176	0.0	90.2	26.5		5.8	103.3	--	--	--	--	2.2
2019 Trial		11,957	309.0	14,052	38.9	18.1	208	0.0	91.0	49.9		6.1	103.4	12.3	55.6	3.9	79.3	1.8
2018 Trial		11,343	279.9	13,586	41.2	16.8	203	0.0	89.7	48.2		6.8	102.0	11.9	37.4	6.1	120.0	1.0
Average		11,079	287.3	13,166	38.8	17.1	196	0.0	90.3	41.5								
SV 981	Full Approval																	
2020 Trial		11,120	274.8	13,288	40.5	16.4	222	0.0	90.1	54.5		5.9	105.1	--	--	--	--	2.3
2019 Trial		11,841	309.0	13,987	38.5	18.3	210	0.0	90.5	46.9		6.1	103.4	2.8	12.7	6.3	128.1	1.8
2018 Trial		12,260	275.6	14,801	44.9	16.6	207	0.0	89.6	46.1		--	--	--	--	5.5	108.2	--
		11,740	286.5	14,025	41.3	17.1	213	0.0	90.1	49.2								
SV 602	Full Approval																	
2020 Trial		10,439	276.1	12,454	37.8	16.5	184	0.0	90.2	22.4		6.1	108.7	--	--	--	--	2.3
2019 Trial		12,058	305.9	14,191	39.1	18.0	209	0.0	90.8	50.1		6.0	101.7	5.3	24.0	6.7	136.3	1.7
2018 Trial		12,201	275.6	14,692	44.1	16.6	198	0.0	89.4	37.1		6.9	103.5	14.0	44.0	5.7	112.1	1.7
Average		11,566	285.9	13,779	40.3	17.0	197	0.0	90.1	36.5								

Imperial Valley Early Harvest Official Variety Trials
3 Year Data (2018-2020)

Variety	Approval Status for 2020-21 crop	Extractable Sugar/ Acre	Extractable Sugar/ Ton	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Final Stand[1/]	% Bolt	Purity	Percent Emergence		Curly Top	% of Mkt.	Erwinia Root Rot+ (DI)	% of Mkt. Avg.	Powdery Mildew	% of Mkt. Avg.	Rhizomania Root Rating
											2020 Mean	5.6	100	--	--	--	--	2.1
Mean of Fully Approved (19-20)		10,903	292.4	13,014	37.4	17.5	205.7	0.0	90.0		2019 Mean	5.9	100	22.1	100	4.9	100	1.8
97% of Fully Approved (19-20)		10,576	283.6	12,623	36.2	16.9	199.5	0.0	87.3		2018 Mean	6.7	100	31.8	100	5.1	100	1.4
Pr>F																		
2020 Trial		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	--	<0.0001	<0.0001		<0.0001						<0.0001
2019 Trial		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	n/a	0.036	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001
2018 Trial		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	n/a	<0.0001	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001
CV																		
2020 Trial		4.9	1.7	5.0	5.3	1.2	3.8	--	0.6	7.8		3.6						n/a
2019 Trial		8.3	1.9	8.2	8.5	1.4	3.4		0.7	12.0		4.2		44.2		25		n/a
2018 Trial		6.1	2.6	5.9	5.8	1.8	5.4		0.8	16.7		4.0		37.8		12.5		n/a
LSD (0.05)																		
2020 Trial		482.9	4.9	586.3	1.9	0.2	8.3	--	0.6	4.1		0.2						0.2
2019 Trial		922.3	6.0	1014.2	3.0	0.3	7.1		0.6	6.6		0.3		7.8		n/a		0.6
2018 Trial		633.5	7.1	743.3	2.1	0.3	10.6		0.7	7.6		0.4		n/a		0.6		0.6

Cooperator	Planted	Harvested	Plot Size	Notes:
Cameron Ranches	9/14/19	4/6/20	Plot Size: 2 rows. 30" rows.	Experimental Trial Design : 4X4 lattice
Imperial Ag	10/31/19	6/5/19	Plot Size: 2 rows. 30" rows.	Experimental Trial Design : 4X5 lattice
Paul Cameron	9/21/17	4/17/18	Plot Size: 2 rows. 30" rows.	Experimental Trial Design : 5X5 lattice

* Emergence counts taken prior to thinning and converted to a percent.
** Final Stand counts converted to beets per 100 foot of row. Final stand counts taken after thinning.
*** 2018 Powdery Mildew Ratings taken from 2017-2018 Mamer Warva Early Harvest Official Trial Location. Ratings are on 1-10 scale. 1=clean, 10= completely covered in disease.
Ratings taken by Israel Santiago and Mark Bloomquist.

Imperial Valley Early Harvest Official Variety Trials
2 Year Data (2019-2020)

Variety	Approval Status for 2020-21 crop	Extractable Sugar/ Acre	Extractable Sugar/ Ton	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Final Stand[1/]	% Bolt	Purity	Percent Emergence		Curly Top	% of Mkt.	Erwinia Root Rot (DI)	% of Mkt. Avg.	Powdery Mildew	% of Entry Avg.	Rhizomania Root Rating
												--- M = 150 ---		--M = 300		-- M = 100		
SV 983	Full Approval																	
2020 Trial		10,786	299.9	12,785	36.0	17.8	207	0.0	90.4	53.1		5.3	94.4	--	--	--	--	2.3
2019 Trial		11,241	327.2	13,126	34.2	19.1	211	0.0	91.1	64.5		5.5	93.2	3.2	14.5	7.0	142.4	1.8
Average		11,014	313.6	12,956	35.1	18.5	209	0.0	90.8	58.8								
SV 992																		
2020 Trial		10,323	285.2	12,374	36.2	17.1	212	0.0	89.8	38.5		5.5	98.0	--	--	--	--	2.2
2019 Trial		11,608	328.8	13,606	36.5	19.3	203	0.0	90.9	34.9		--	--	--	--	--	--	--
Average		10,966	307.0	12,990	36.4	18.2	208	0.0	90.4	36.7								
BTS 582N																		
2020 Trial		9,718	290.0	11,768	33.5	17.6	234	0.0	89.0	76.0		5.4	96.2	--	--	--	--	2.1
2019 Trial		10,097	323.0	11,838	31.1	18.9	213	0.0	91.0	68.7		5.9	100.0	27.1	122.3	4.2	85.4	1.6
Average		9,908	306.5	11,803	32.3	18.3	224	0.0	90.0	72.4								
SV501	Full Approval																	
2020 Trial		9,900	283.0	11,804	35.0	16.9	209	0.0	90.1	36.8		5.6	99.8	--	--	--	--	2.2
2019 Trial		11,306	326.4	13,240	34.8	19.1	196	0.0	91.0	42.0		5.8	98.3	2.2	10.0	4.7	95.6	2.1
Average		10,603	304.7	12,522	34.9	18.0	203	0.0	90.6	39.4								
BTS 5775	Full Approval																	
2020 Trial		9,158	279.7	11,050	32.8	16.9	214	0.0	89.4	44.3		5.8	103.3	--	--	--	--	2.1
2019 Trial		11,514	328.2	13,478	35.1	19.2	214	0.0	91.0	61.8		6.0	101.7	36.2	163.8	3.8	77.3	2.1
Average		10,336	304.0	12,264	34.0	18.1	214	0.0	90.2	53.1								
BTS 5983																		
2020 Trial		9,931	285.6	11,915	34.5	17.1	236	0.0	89.7	72.5		5.3	94.4	--	--	--	--	2.1
2019 Trial		11,037	320.3	12,884	34.4	18.7	215	0.0	91.3	47.0		--	--	--	--	--	--	--
Average		10,484	303.0	12,400	34.5	17.9	226	0.0	90.5	59.8								
BTS 5678	Full Approval																	
2020 Trial		10,111	279.4	12,137	36.2	16.8	233	0.0	89.8	69.9		5.2	92.7	--	--	--	--	1.6
2019 Trial		11,448	316.8	13,453	36.1	18.6	213	0.0	90.8	65.1		5.7	96.6	31.3	141.7	6.1	124.1	1.5
Average		10,780	298.1	12,795	36.2	17.7	223	0.0	90.3	67.5								
BTS 5460	Full Approval																	
2020 Trial		9,540	280.2	11,489	34.1	16.9	228	0.0	89.5	57.3		5.2	92.7	--	--	--	--	1.6
2019 Trial		10,945	313.3	12,903	35.1	18.5	212	0.0	90.6	71.0		5.8	98.3	45.3	204.9	4.3	87.5	1.4
Average		10,243	296.8	12,196	34.6	17.7	220	0.0	90.1	64.2								
SV 981	Full Approval																	
2020 Trial		11,120	274.8	13,288	40.5	16.4	222	0.0	90.1	54.5		5.9	105.1	--	--	--	--	2.3
2019 Trial		11,841	309.0	13,987	38.5	18.3	210	0.0	90.5	46.9		6.1	103.4	2.8	12.7	6.3	128.1	1.8
Average		11,481	291.9	13,638	39.5	17.4	216	0.0	90.3	50.7								
SV 972	Full Approval																	
2020 Trial		9,938	273.1	11,861	36.4	16.3	176	0.0	90.2	26.5		5.8	103.3	--	--	--	--	2.2
2019 Trial		11,957	309.0	14,052	38.9	18.1	208	0.0	91.0	49.9		6.1	103.4	12.3	55.6	3.9	79.3	1.8
Average		10,948	291.1	12,957	37.7	17.2	192	0.0	90.6	38.2								
SV 602	Full Approval																	
2020 Trial		10,439	276.1	12,454	37.8	16.5	184	0.0	90.2	22.4		6.1	108.7	--	--	--	--	2.3
2019 Trial		12,058	305.9	14,191	39.1	18.0	209	0.0	90.8	50.1		6.0	101.7	5.3	24.0	6.7	136.3	1.7
Average		11,249	291.0	13,323	38.5	17.3	197	0.0	90.5	36.3								

Imperial Valley Early Harvest Official Variety Trials
2 Year Data (2019-2020)

Variety	Approval Status for 2020-21 crop	Extractable Sugar/ Acre	Extractable Sugar/ Ton	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Final Stand[1/]	% Bolt	Purity	Percent Emergence		Curly Top	% of Mkt.	Erwinia Root Rot (DI)	% of Mkt. Avg.	Powdery Mildew	% of Entry Avg.	Rhizomania Root Rating
Mean of Fully Approved (19-20)		10,693	297.6	12,676	36.0	17.7	208	0.0	90.4	49.8	2020 Mean	5.6	100	--	--	--	--	2.1
97% of Fully Approved (19-20)		10,372	288.7	12,296	34.9	17.1	202	0.0	87.7	48.3	2019 Mean	5.9	100	22.1	100	4.9	100	1.8
Pr>F																		
	2020 Trial	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	--	<0.0001	<0.0001		<0.0001		--		--		<0.0001
	2019 Trial	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	--	0.036	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001
CV																		
	2020 Trial	4.9	1.7	5.0	5.3	1.2	3.84	--	0.6	7.8		3.6		--		--		n/a
	2019 Trial	8.3	1.9	8.2	8.5	1.4	3.4	--	0.7	12.0		4.2		44.2		25.0		n/a
LSD (0.05)																		
	2020 Trial	482.9	4.9	586.3	1.9	0.2	8.3	--	0.6	4.1		0.2		--		--		0.2
	2019 Trial	922.3	6.0	1014.2	3.0	0.3	7.1	--	0.6	6.6		0.3		7.8				0.6

Cooperator	Planted	Harvested	Plot Size	**Notes:**
Cameron Ranches	9/14/19	4/6/20	2 rows. 30" rows.	Experimental Trial Design : 4X4 lattice
Imperial Ag.	10/31/18	6/5/19	2 rows. 30" rows.	Experimental Trial Design : 4X5 lattice

* Emergence counts taken prior to thinning and converted to a percent.
** Final Stand counts converted to beets per 100 foot of row. Final stand counts taken after thinning.

Imperial Valley Early Harvest Official Variety Trials
1- Year Data (2020)

Variety	Approval Status for 2020-21 crop	Extractable Sugar/ Acre	Extractable Sugar/ Ton	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Final Stand**	% Bolt	Purity	Percent Emergence*	Curly Top	% of Mkt.	Erwinia Root Rot (DI)	% of Mkt. Avg.	Powdery Mildew	% of Trial Avg.	Rhizomania Root Rating
											--- M = 150 ---		--M = 300		-- M = 100		
BTS 507N		9,271	300.6	11,175	30.5	18.1	227	0.0	89.2	68.0	--		--		--		--
SV 983	Full Approval	10,786	299.9	12,785	36.0	17.8	207	0.0	90.4	53.1	5.3	94.4	--		--		2.3
BTS 5042		9,661	295.5	11,725	32.9	17.9	231	0.0	88.7	67.4	--		--		--		--
BTS 5021		9,410	293.9	11,287	32.0	17.6	234	0.0	89.5	65.5	--		--		--		--
BTS 582N		9,718	290.0	11,768	33.5	17.6	234	0.0	89.0	76.0	5.4	96.2	--		--		2.1
BTS 5983		9,931	285.6	11,915	34.5	17.1	236	0.0	89.7	72.5	5.3	94.4	--		--		2.1
SV 992		10,323	285.2	12,374	36.2	17.1	212	0.0	89.8	38.5	5.5	98.0	--		--		2.2
SV 501	Full Approval	9,900	283.0	11,804	35.0	16.9	209	0.0	90.1	36.8	5.6	99.8	--		--		2.2
BTS 5460	Full Approval	9,540	280.2	11,489	34.1	16.9	228	0.0	89.5	57.3	5.2	92.7	--		--		1.6
BTS 5775	Full Approval	9,158	279.7	11,050	32.8	16.9	214	0.0	89.4	44.3	5.8	103.3	--		--		2.1
BTS 5678	Full Approval	10,111	279.4	12,137	36.2	16.8	233	0.0	89.8	69.9	5.2	92.7	--		--		1.6
SV 602	Full Approval	10,439	276.1	12,454	37.8	16.5	184	0.0	90.2	22.4	6.1	108.7	--		--		2.3
SV 981	Full Approval	11,120	274.8	13,288	40.5	16.4	222	0.0	90.1	54.5	5.9	105.1	--		--		2.3
SV 972	Full Approval	9,938	273.1	11,861	36.4	16.3	176	0.0	90.2	26.5	5.8	103.3	--		--		2.2
SV 1902N		9,120	272.9	11,080	33.4	16.6	230	0.0	89.0	60.3	--		--		--		--
Mean of Fully Approved (19-20)		9,848	278.6	11,799	35.4	16.7	207	0.0	89.9	42.9	5.6						2.1
97% of Fully Approved (19-20)		9,552	270.2	11,445	34.3	16.2	201	0.0	87.2	41.6							
Pr>F		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	--	<0.0001	<0.0001	<0.0001						<0.0001
CV		4.9	1.7	5.0	5.3	1.2	3.8	--	0.6	7.8	3.6						n/a
LSD 0.05		482.9	4.9	586.3	1.9	0.2	8.3	--	0.6	4.1	0.2						0.2

Cooperator	Planted	Harvested	Plot Size
Cameron Ranches	9/14/19	4/6/20	Plot Size: 2 rows. 30" rows.
			Experimental Trial Design : 4X4 lattice

* Emergence counts taken prior to thinning and converted to a percent.
** Final Stand counts converted to beets per 100 foot of row. Final stand counts taken after thinning.
*** Disease nursery data not available yet this season.

2019-2020 Imperial Valley Early Harvest Official Variety Trial Results - Location 1

Cooperator: Cameron Ranches

entry	Entry Code	Entry Name	Extractable Sugar per Ton	Extractable Sugar per Acre	Gross Sugar per Acre	Tons per Acre	Percent Sugar	Extractable Sugar Percent	Percent Purity	Brei N	Percent Tare	Percent Emergence	Final Stand Beets/100'	Percent Bolters
1	2019/20 IVEH	BTS 507N	300.6	9271	11175	30.5	18.1	15.0	89.2	4	1.1	68.0	227	0.0
2	2019/20 IVEH	SV 1902N	272.9	9120	11080	33.4	16.6	13.7	89.0	8	1.6	60.3	230	0.0
3	2019/20 IVEH	SV 602	276.1	10439	12454	37.8	16.5	13.8	90.2	8	0.7	22.4	184	0.0
4	2019/20 IVEH	BTS 5678	279.4	10111	12137	36.2	16.8	14.0	89.8	7	1.3	69.9	233	0.0
5	2019/20 IVEH	Filler Entry	272.9	10023	11948	36.9	16.3	13.6	90.4	7	0.7	38.0	200	0.0
6	2019/20 IVEH	BTS 5983	285.6	9931	11915	34.5	17.1	14.3	89.7	7	1.4	72.5	236	0.0
7	2019/20 IVEH	SV 992	285.2	10323	12374	36.2	17.1	14.3	89.8	6	1.1	38.5	212	0.0
8	2019/20 IVEH	BTS 582N	290.0	9718	11768	33.5	17.6	14.5	89.0	6	1.9	76.0	234	0.0
9	2019/20 IVEH	SV 972	273.1	9938	11861	36.4	16.3	13.7	90.2	9	0.7	26.5	176	0.0
10	2019/20 IVEH	SV 501	283.0	9900	11804	35.0	16.9	14.2	90.1	6	1.1	36.8	209	0.0
11	2019/20 IVEH	BTS 5042	295.5	9661	11725	32.9	17.9	14.8	88.7	8	2.0	67.4	231	0.0
12	2019/20 IVEH	BTS 5775	279.7	9158	11050	32.8	16.9	14.0	89.4	13	1.1	44.3	214	0.0
13	2019/20 IVEH	BTS 5460	280.2	9540	11489	34.1	16.9	14.0	89.5	5	1.3	57.3	228	0.0
14	2019/20 IVEH	SV 983	299.9	10786	12785	36.0	17.8	15.0	90.4	5	0.7	53.1	207	0.0
15	2019/20 IVEH	SV 981	274.8	11120	13288	40.5	16.4	13.7	90.1	6	0.7	54.5	222	0.0
16	2019/20 IVEH	BTS 5021	293.9	9410	11287	32.0	17.6	14.7	89.5	8	0.9	65.5	234	0.0
		GRAND MEAN	283.9	9903	11884	34.9	17.0	14.2	89.7	7	1.1	53.2	217	
		CV	1.74	4.90	4.96	5.32	1.19	1.74	0.61	47.98	32.92	7.82	3.84	
		LSD (0.05)	4.91	482.89	586.28	1.85	0.20	0.25	0.55	3.29	0.37	4.14	8.30	
		Pr>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	
		Error MS	22.14	217722.89	322507.08	3.23	0.04	0.06	0.28	9.97	0.13	15.51	62.86	
		Reps	8	8	8	8	8	8	8	8	8	8	8	

*Emergence counts taken prior to thinning and converted to a percent.
**Final stand counts taken after thinning and converted to beets per 100' of row.

Plant Date: September 14, 2019
Harvest Date: April 6, 2020
Plot size: 2 row, 30" rows
Experimental Design: 4X4 Partially Balanced Lattice

Imperial Valley Late Harvest Official Variety Trials

3 Year Data (2018-2020)

Variety	2020-2021 Marketing Approval	Year	Extractable Sugar/ Acre	Extractable Sugar/ Ton[+]	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Purity	Final Stand Beets/100'	% Bolt	% Rot[w]	Percent Emergence	Curly Top Rating*	% of Mkt. Avg.	Erwinia Rating (DI)*	% of Mkt. Avg.	Powdery Mildew Rating*	% of Mkt. Avg.	Rhizomania Root Rating*
													--- M = 150 ---		--M = 300		-- M = 100		
Beta 582N		2020	18,504	290.0	22,040	65.5	17.3	90.2	234	0.0	0.2	78.9	5.4	99.6	n/a		n/a		2.1
		2019	21,166	300.7	24,995	70.8	17.7	90.7	255	0.0	0.4	76.8	5.9	101.9	27.1	130.3	4.2	83.8	1.6
		2018	19,925	261.3	25,000	75.1	16.4	87.1	239	0.0	14.3	75.0	n/a		n/a		n/a		n/a
		Average	19,865	284.0	24,012	70.5	17.1	89.3	243	0.0	5.0	76.9							
Beta 5678	Full Approval	2020	21,057	294.2	24,882	72.7	17.4	90.8	231	0.0	1.9	75.9	5.2	95.9	n/a		n/a		1.6
		2019	22,333	288.7	26,465	77.2	17.1	90.5	255	0.1	0.1	67.9	5.7	98.5	31.3	150.7	6.1	121.7	1.5
		2018	21,807	256.4	27,396	85.0	16.1	86.9	237	0.0	5.6	65.0	6.6	101.7	51.4	159.3	n/a		1.6
		Average	21,732	279.8	26,248	78.3	16.9	89.4	241	0.0	2.5	69.6							
BTS 5460	Full Approval	2020	20,735	290.0	24,537	73.3	17.1	90.7	234	0.1	0.2	71.1	5.2	95.9	n/a		n/a		1.6
		2019	21,647	286.0	25,632	75.6	16.9	90.6	257	0.0	0.0	74.5	5.8	100.2	45.3	217.9	4.3	85.8	1.4
		2018	23,310	261.8	28,995	88.3	16.3	87.5	231	1.2	1.2	63.6	6.2	95.6	52.4	162.4	n/a		1.0
		Average	21,897	279.3	26,388	79.1	16.8	89.6	241	0.4	0.5	69.7							
BTS 5775	Full Approval	2020	21,856	285.0	26,032	78.3	17.0	90.3	230	0.0	0.7	65.8	5.8	107.0	n/a		n/a		2.1
		2019	22,758	277.2	27,389	82.2	16.7	89.6	254	0.0	0.5	58.1	6.0	103.7	36.2	174.2	3.8	75.8	2.1
		2018	20,793	252.3	26,362	82.9	16.0	86.5	231	0.4	6.2	70.1	6.8	104.8	57.0	176.7	n/a		1.5
		Average	21,802	271.5	26,594	81.1	16.6	88.8	238	0.1	2.5	64.7							
SV 2982N	Limited Approval	2020	18,452	261.9	22,339	71.8	15.8	89.4	233	0.4	0.0	67.8	5.4	99.6	n/a		n/a		2.2
		2019	22,301	264.3	26,987	84.3	16.0	89.4	254	0.2	0.7	69.6	5.5	95.0	8.9	42.8	6.8	135.7	2.0
		2018	19,896	237.7	25,445	83.6	15.3	85.9	242	3.7	14.7	85.8	n/a		n/a		n/a		n/a
		Average	20,216	254.6	24,924	79.9	15.7	88.2	243	1.4	5.1	74.4							
SV143N	Full Approval	2020	17,738	264.4	21,550	68.6	16.0	89.2	233	0.2	0.2	68.5	5.5	101.5	n/a		n/a		2.3
		2019	22,000	260.8	26,695	84.2	15.9	89.2	254	0.6	0.5	67.5	5.8	100.2	5.2	24.9	4.4	87.8	2.2
		2018	21,517	237.8	27,711	90.9	15.3	85.7	239	4.0	12.0	83.2	6.4	98.7	6.6	20.5	n/a		0.8
		Average	20,418	254.3	25,319	81.2	15.7	88.0	242	1.6	4.2	73.1							
SV 604N	Full Approval	2020	17,348	256.8	21,130	68.5	15.6	89.1	228	0.2	0.1	57.8	5.4	99.6	n/a		n/a		2.1
		2019	21,425	258.4	26,033	82.4	15.7	89.1	254	0.1	0.7	50.5	5.8	100.2	2.1	10.1	5.8	115.7	1.4
		2018	19,614	235.9	25,235	83.1	15.2	85.8	228	1.5	7.9	60.1	6.6	101.7	8.7	27.0	n/a		2.6
		Average	19,462	250.4	24,133	78.0	15.5	88.0	237	0.6	2.9	56.1							

[+] varieties ranked by Extractable Sugar per Ton

* Disease nursery ratings: Lower numbers are more resistant, higher numbers are more susceptible.

[w] Percent rot data for 2020 is from Westmoreland site only. No rot present at Ruegger site.

Mean of 20-21 Fully Approved	21,063	267.0	25,736	79.5	16.3	88.8
97% of 20-21 Fully Approved	20,431	259.0	24,964	77.2	15.8	86.1

Mean of Approved Varieties							
2020 Mean	5.4	100.0	n/a		n/a		1.9
2019 Mean	5.8	100.0	20.8	100.0	5.0	100.0	1.7
2018 Mean	6.5	100.0	32.3	100.0	n/a		1.4

Variety			Extractable Sugar/ Acre	Extractable Sugar/ Ton	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Purity	Stand	% Bolt*	% Rot	Percent Emergence	Curly Top* % of Mkt.	Erwinia* % of Mkt.	Powdery Mildew % of Mkt. Avg.	Rhizomania Root Rating*
													--- M = 150 ---	--M = 300	-- M = 100	
	Pr>F	2020	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				<0.0001
		2019	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
		2018	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	--	<0.0001
	LSD (0.05)	2020	775.8	6.2	859.9	3.1	0.3	0.5	2.8	0.5		4.9				0.2
		2019	1084.0	7.8	1234.0	3.8	0.4	0.7	5.1	0.5	0.8	5.0	0.3	7.8	--	0.6
		2018	1439.5	9.9	1702.8	4.9	0.4	1.0	7.4	1.3	4.2	7.0	0.4	--	--	0.6
	C.V.	2020	4.3	2.4	4.0	4.7	1.9	0.6	1.3	326.6		7.5				n/a
		2019	5.2	2.9	4.9	5.0	2.2	0.8	2.1	254.9	211.0	8.1	4.2	44.2	25.0	n/a
		2018	7.3	4.1	6.7	6.1	2.8	1.1	3.2	76.0	47.8	10.5	4.0	37.8	--	n/a

Cooperator	Planted	Harvested	Plot Size
Fritz Ruegger	10/12/2019	6/17/2020	2 rows -- 30 in. 4 x 4 lattice
Westmoreland Farms	10/10/2019	8/10-11/2020	2 rows -- 30 in. 4 x 4 lattice
Paul Cameron	10/18/2018	7/15-16/2019	2 rows -- 30 in. 4 x 5 lattice
Gary and Ryan Mamer	10/6/2017	7/16-17/2018	2 rows -- 30 in. 5 x 5 lattice

Imperial Valley Late Harvest Official Variety Trials

2 Year Data (2019-2020)

Variety	2020-2021 Marketing Approval	Year	Extractable Sugar/ Acre	Extractable Sugar/ Ton[+]	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Purity	Final Stand Beets/ 100'	% Bolt	% Rot[w]	Percent Emergence	Curly Top Rating	% of Mkt. Avg.	Erwinia* Rating (DI)	% of Mkt. Avg.	Powdery Mildew Rating*	% of Mkt. Avg.	Rhizomania Root Rating*
													--- M = 150 ---		--M = 300		-- M = 100		
Beta 582N		2020	18,504	290.0	22,040	65.5	17.3	90.2	234	0.0	0.2	78.9	5.4	99.6	n/a		n/a		2.1
		2019	21,166	300.7	24,995	70.8	17.7	90.7	255	0.0	0.4	76.8	5.9	101.9	27.1	130.1	4.2	83.8	1.6
		Average	19,835	295.4	23,518	68.2	17.5	90.5	245	0.0	0.3	77.9							
BTS 5678	Full Approval	2020	21,057	294.2	24,882	72.7	17.4	90.8	231	0.0	1.9	75.9	5.2	95.9	n/a		n/a		1.6
		2019	22,333	288.7	26,465	77.2	17.1	90.5	255	0.1	0.1	67.9	5.7	98.5	31.3	150.7	6.1	121.7	1.5
		Average	21,695	291.5	25,674	75.0	17.3	90.7	243	0.1	1.0	71.9							
BTS 5460	Full Approval	2020	20,735	290.0	24,537	73.3	17.1	90.7	234	0.1	0.2	71.1	5.2	95.9	n/a		n/a		1.6
		2019	21,647	286.0	25,632	75.6	16.9	90.6	257	0.0	0.0	74.5	5.8	100.2	45.3	217.9	4.3	85.8	1.4
		Average	21,191	288.0	25,085	74.5	17.0	90.7	246	0.1	0.1	72.8							
Beta 5983		2020	20,669	285.6	24,575	73.6	16.9	90.4	234	0.0	0.5	77.3	5.3	97.8	n/a		n/a		2.1
		2019	22,609	289.9	26,700	78.1	17.1	90.8	253	0.1	0.5	46.6	--	--	--		--		--
		Average	21,639	287.8	25,638	75.9	17.0	90.6	244	0.1	0.5	62.0							
BTS 5775	Full Approval	2020	21,856	285.0	26,032	78.3	17.0	90.3	230	0.0	0.7	65.8	5.8	107.0	n/a		n/a		2.1
		2019	22,758	277.2	27,389	82.2	16.7	89.6	254	0.0	0.5	58.1	6.0	103.7	36.2	174.3	3.8	75.8	2.1
		Average	22,307	281.1	26,711	80.3	16.9	90.0	242	0.0	0.6	62.0							
SV 2997N		2020	20,745	269.5	24,987	79.1	16.2	89.8	233	0.1	0.2	81.3	5.6	103.3	n/a		n/a		2.4
		2019	22,353	264.5	26,999	84.7	16.0	89.6	256	0.0	0.3	80.7	--	--	--	--	--	--	--
		Average	21,549	267.0	25,993	81.9	16.1	89.7	245	0.1	0.3	81.0							
SV 2982N	Limited Approval	2020	18,452	261.9	22,339	71.8	15.8	89.4	233	0.4	0.0	67.8	5.4	99.6	n/a		n/a		2.2
		2019	22,301	264.3	26,987	84.3	16.0	89.4	254	0.2	0.7	69.6	5.5	95.0	8.9	43	6.80	136	2.0
		Average	20,377	263.1	24,663	78.1	15.9	89.4	244	0.3	0.4	68.7							
SV143N	Full Approval	2020	17,738	264.4	21,550	68.6	16.0	89.2	233	0.2	0.2	68.5	5.5	101.5	n/a		n/a		2.3
		2019	22,000	260.8	26,695	84.2	15.9	89.2	254	0.6	0.5	67.5	5.8	100.2	5.2	24.9	4.40	88	2.2
		Average	19,869	262.6	24,123	76.4	16.0	89.2	244	0.4	0.4	68.0							
SV604N	Full Approval	2020	17,348	256.8	21,130	68.5	15.6	89.1	228	0.2	0.1	57.8	5.4	99.6	n/a		n/a		2.1
		2019	21,425	258.4	26,033	82.4	15.7	89.1	254	0.1	0.7	50.5	5.8	100.2	2.1	10.1	5.8	115.7	1.4
		Average	19,387	257.6	23,582	75.5	15.7	89.1	241	0.2	0.4	54.2							

[+] varieties ranked by Extractable Sugar per Ton

[w] Percent rot data for 2020 is from Westmoreland site only. No rot present at Ruegger site.

Mean of 20-21 Fully Approved	17,408	230.1	20,862	63.6	13.8	74.9
97% of 20-21 Fully Approved	16,886	223.2	20,236	61.7	13.4	72.7

Mean of Approved Varieties							
2020 Mean	5.4	100.0					1.9
2019 Mean	5.8	100.0	20.8	100.0	5.0	100.0	1.7

Imperial Valley Late Harvest Official Variety Trials

2 Year Data (2019-2020)

Variety	2020-2021 Marketing Approval	Year	Extractable Sugar/ Acre	Extractable Sugar/ Ton[+]	Gross Sugar/ Acre	Tons/ Acre	% Sugar	Purity	Final Stand Beets/ 100'	% Bolt	% Rot[w]	Percent Emergence	Curly Top Rating	% of Mkt. Avg.	Erwinia* Rating (DI)	% of Mkt. Avg.	Powdery Mildew Rating*	% of Mkt. Avg.	Rhizomania Root Rating*
													--- M = 150 ---		--M = 300		-- M = 100		
Pr>F		2020	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						<0.0001
		2019	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001		<0.0001		<0.0001
LSD		2020	775.8	6.2	859.9	3.1	0.3	0.5	2.8	0.5		4.9	0.2						0.2
		2019	1084.0	7.8	1234.0	3.8	0.4	0.7	5.1	0.5	0.8	5.0	0.3		7.8		n/a		0.6
C.V.		2020	4.3	2.4	4.0	4.7	1.9	0.6	1.3	326.6		7.5	3.6						n/a
		2019	5.2	2.9	4.9	5.0	2.2	0.8	2.1	254.9	211.0	8.1	4.2		44.2		25.0		n/a

Cooperator	Planted	Harvested	Plot Size
Fritz Ruegger	10/12/2019	6/17/2020	2 rows -- 30 in. 4 x 4 lattice
Westmoreland Farms	10/10/2019	8/10-11/2020	2 rows -- 30 in. 4 x 4 lattice
Paul Cameron	10/18/2018	7/15-16/2019	2 rows -- 30 in. 4 x 5 lattice

* Disease nursery ratings: Lower numbers are more resistant, higher numbers are more susceptible.

[+]Data not yet available.

Imperial Valley Late Harvest Official Variety Trials
1 Year Data Summary (2020)

Variety	2020-2021 Marketing Approval	Extractable Sugar/ Acre	Extractable Sugar/ Ton[+]	Gross Sugar/ Acre	Tons / Acre	% Sugar	Purity	Final Stand Beets/100'	% Bolt	% Rot[w]	Percent Emergence	Curly Top	% of Mkt. Avg.	Erwinia Root Rot (DI)	% of Mkt. Avg.	Powdery Mildew	% of Mkt. Avg.	Rhizomania Root Rating
												M = 150		M = 300		M = 100		
BTS 5678	Full Approval	21,057	294.2	24,882	72.7	17.4	90.8	231	0.0	1.9	75.9	5.2	95.9	n/a		n/a		1.6
BTS 5021		21,314	290.6	25,318	74.5	17.2	90.5	232	0.0	0.9	75.1	--	--	n/a		n/a		--
BTS 582N		18,504	290.0	22,040	65.5	17.3	90.2	234	0.0	0.2	78.9	5.4	99.6	n/a		n/a		2.1
BTS 5460	Full Approval	20,735	290.0	24,537	73.3	17.1	90.7	234	0.1	0.2	71.1	5.2	95.9	n/a		n/a		1.6
BTS 507N		18,452	287.1	22,135	65.0	17.2	89.8	232	0.0	0.3	75.7	--	--	n/a		n/a		--
BTS 5983		20,669	285.6	24,575	73.6	16.9	90.4	234	0.0	0.5	77.3	5.3	97.8	n/a		n/a		2.1
BTS 5775	Full Approval	21,856	285.0	26,032	78.3	17.0	90.3	230	0.0	0.7	65.8	5.8	107.0	n/a		n/a		2.1
BTS 5042		20,055	284.5	23,858	71.9	16.9	90.4	234	0.0	0.1	79.6	--	--	n/a		n/a		--
SV 981		21,201	274.1	25,404	78.1	16.4	90.0	230	0.0	1.2	61.8	5.9	108.9	n/a		n/a		2.3
SV 2997N		20,745	269.5	24,987	79.1	16.2	89.8	233	0.1	0.2	81.3	5.6	103.3	n/a		n/a		2.4
SV 143N	Full Approval	17,738	264.4	21,550	68.6	16.0	89.2	233	0.2	0.2	68.5	5.5	101.5	n/a		n/a		2.3
SV 1902N		17,132	263.6	20,875	66.6	16.0	89.0	232	0.0	0.1	69.7	--	--	n/a		n/a		--
SV 2982N	Limited Approval	18,452	261.9	22,339	71.8	15.8	89.4	233	0.4	0.0	67.8	5.4	99.6	n/a		n/a		2.2
SV 604N	Full Approval	17,348	256.8	21,130	68.5	15.6	89.1	228	0.2	0.1	57.8	5.4	99.6	n/a		n/a		2.1
Mean of 20-21 Full Approved		19,747	278.1	23,626	72.3	16.6	90.0					5.4	100					1.9
97% of 20-21 Full Approved		19,154	269.7	22,917	70.1	16.1	87.3											
Pr>F		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						<0.0001
LSD		775.8	6.2	859.9	3.1	0.3	0.5	2.8	0.5		4.9	0.2						0.2
C.V.		4.3	2.4	4.0	4.7	1.9	0.6	1.3	326.6		7.5	3.6						n/a

[+] varieties ranked by Extractable Sugar per Ton

Cooperator	Planted	Harvested	Plot Size
Fritz Ruegger	10/12/2019	6/17/2020	2 rows -- 30 in. 4 x 4 lattice
Westmoreland Farms	10/10/2019	8/10-11/2020	2 rows -- 30 in. 4 x 4 lattice

* 2020 Nursery data not yet available.

[w] Percent rot data is only from Westmoreland location. No rot present at Ruegger location.

2019-2020 Imperial Valley Official Variety Trials Late Harvest Results - Combined Analysis

Entry	Entry Name	Extractable Sugar per Ton	Extractable Sugar per Acre	Gross Sugar per Acre	Tons/Acre	Percent Sugar	Percent Extractable Sugar	Percent Purity	Brie N	Percent Tare	Percent Emergence*	Final Stand Beets/100'**	Percent Bolters
1	BTS 5460	290.0	20735	24537	73.3	17.1	14.5	90.7	43.3	1.4	71.1	233.5	0.1
2	SV 2997N	269.5	20745	24987	79.1	16.2	13.5	89.8	48.5	1.5	81.3	232.8	0.1
3	SV 981	274.1	21201	25404	78.1	16.4	13.7	90.0	48.2	0.9	61.8	230.0	0.0
4	SV 2982N	261.9	18452	22339	71.8	15.8	13.1	89.4	51.3	1.4	67.8	232.9	0.4
5	BTS 582N	290.0	18504	22040	65.5	17.3	14.5	90.2	44.9	2.2	78.9	234.0	0.0
6	BTS 5678	294.2	21057	24882	72.7	17.4	14.7	90.8	38.7	1.2	75.9	231.3	0.0
7	BTS 507N	287.1	18452	22135	65.0	17.2	14.4	89.8	48.7	1.1	75.7	232.4	0.0
8	FILLER	274.1	21740	26026	80.8	16.4	13.7	90.1	49.0	0.8	45.1	225.1	1.2
9	SV 143N	264.4	17738	21550	68.6	16.0	13.2	89.2	53.4	1.3	68.5	232.8	0.2
10	SV 604N	256.8	17348	21130	68.5	15.6	12.8	89.1	60.2	1.2	57.8	228.2	0.2
11	SV 1902N	263.6	17132	20875	66.6	16.0	13.2	89.0	52.9	1.4	69.7	232.0	0.0
12	BTS 5775	285.0	21856	26032	78.3	17.0	14.3	90.3	43.3	1.2	65.8	230.3	0.0
13	BTS 5021	290.6	21314	25318	74.5	17.2	14.5	90.5	42.6	1.2	75.1	231.6	0.0
14	BTS 5042	284.5	20055	23858	71.9	16.9	14.2	90.4	44.8	1.6	79.6	233.6	0.0
15	BTS 5983	285.6	20669	24575	73.6	16.9	14.3	90.4	53.6	1.6	77.3	233.8	0.0
16	FILLER	259.0	17660	21438	69.6	15.7	12.9	89.3	56.3	1.6	79.5	232.9	0.3
	Grand Mean	276.9	19666	23570	72.4	16.6	13.8	89.9	48.7	1.3	70.7	231.7	0.2
	CV	2.4	4.3	4.0	4.7	1.9	2.4	0.6	17.1	25.0	7.5	1.3	326.6
	LSD (0.05)	6.2	775.8	859.9	3.1	0.3	0.3	0.5	7.7	0.3	4.9	2.8	0.5
	Residual	45.6	712628.2	875347.3	11.4	0.1	0.1	0.3	69.3	0.1	27.9	9.4	0.2
	Total Reps	16	16	16	16	16	16	16	16	16	16	16	16

Cooperators:	**Planted**	**Harvested**	**Plot Size**	**Trial Design**
Fritz Ruegger	10/12/2019	6/17/2020	2 row, 30" rows	4x4 partially balance lattice
Westmoreland Farms	10/10/2019	8/10-11/2020	2 row, 30" rows	4x4 partially balance lattice

*Emergence counts taken prior to thinning and converted to a percent.

**Final stand counts taken after thinning and converted to beets per 100' of row.