Assessment of Sucrose Solubility in American Crystal Sugar Company's Technical Sucrose Solutions

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Terrible Sugar Joke (relevant to this presentation)

Terrible pick up line…

- Sugar dissolves in water, so please don’t walk in the rain… or I might lose a sweetie like you…

- **Warning, this presentation is full of Dry Substance…**

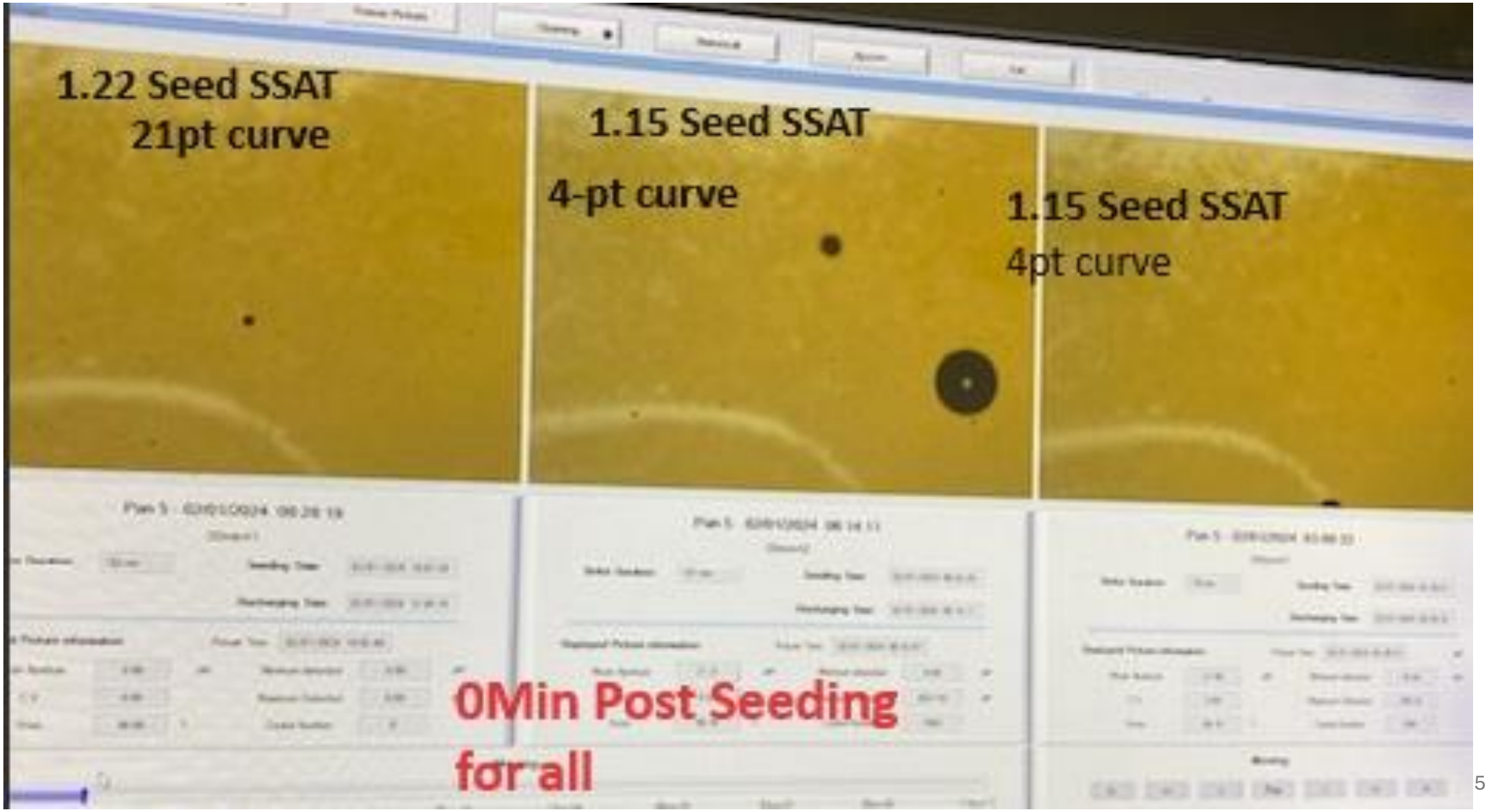
Introduction

- Changes in agricultural practices and non-sugar inputs into the factory
- Longer slice campaigns – longer storage
- Modifications in processing, including:
  - MDS extract coprocessing
  - Juice Softening (NRS)
- ACSC uses Seeding Supersaturation (SSAT) to guide pan seeding

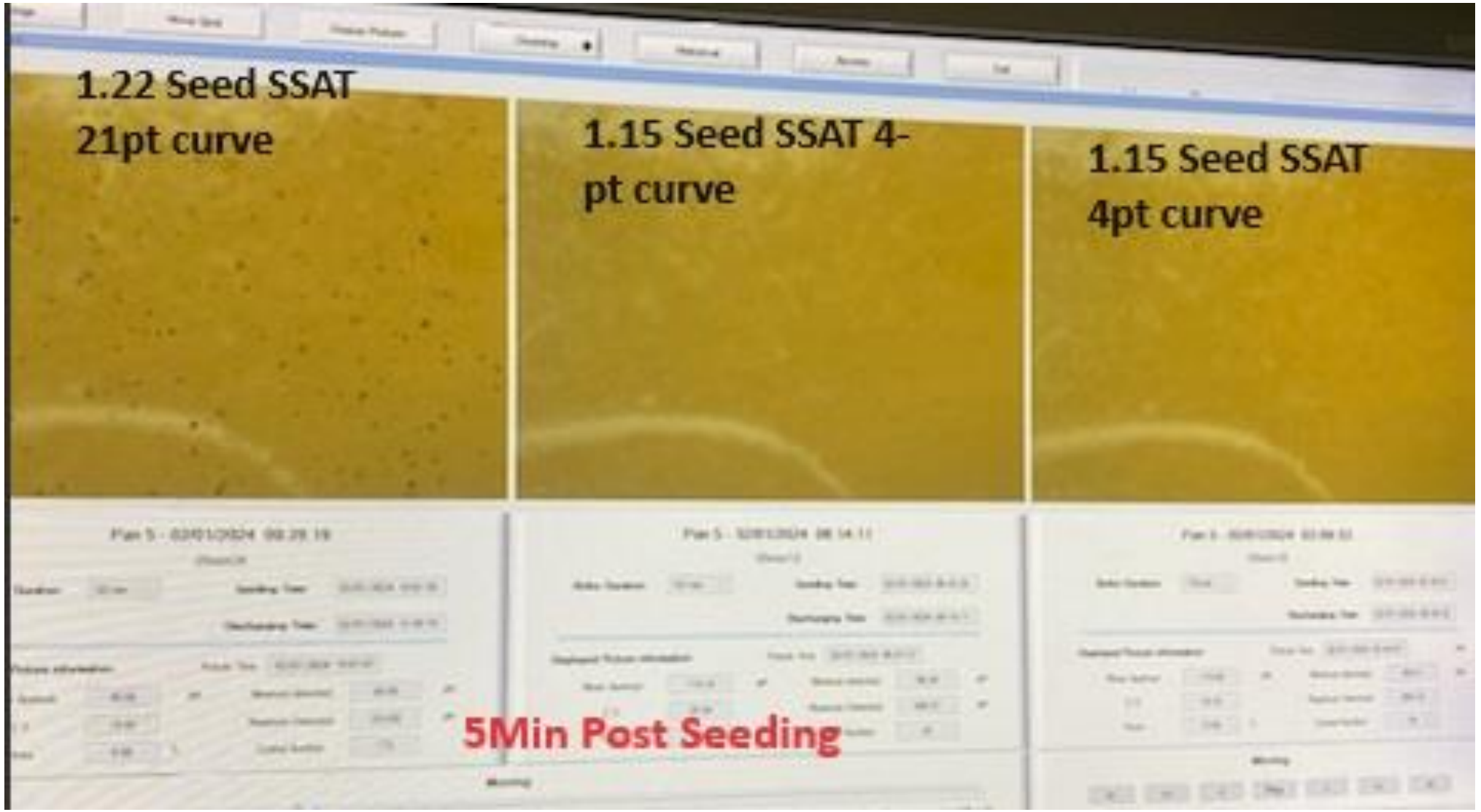
Introduction (continued)

- Observations:
  - Actual SSAT calculations using Grut coefficients have shifted
  - Grut SSAT is overstated due to understated ysat solubility
  - Increased solubility of sucrose in ACSC's technical solutions at a given ns/w ratio realized
- Need to investigate and compensate for the shift in solubilities:
  - Potential adjustments: increase seeding RDS, or decrease seeding temperature

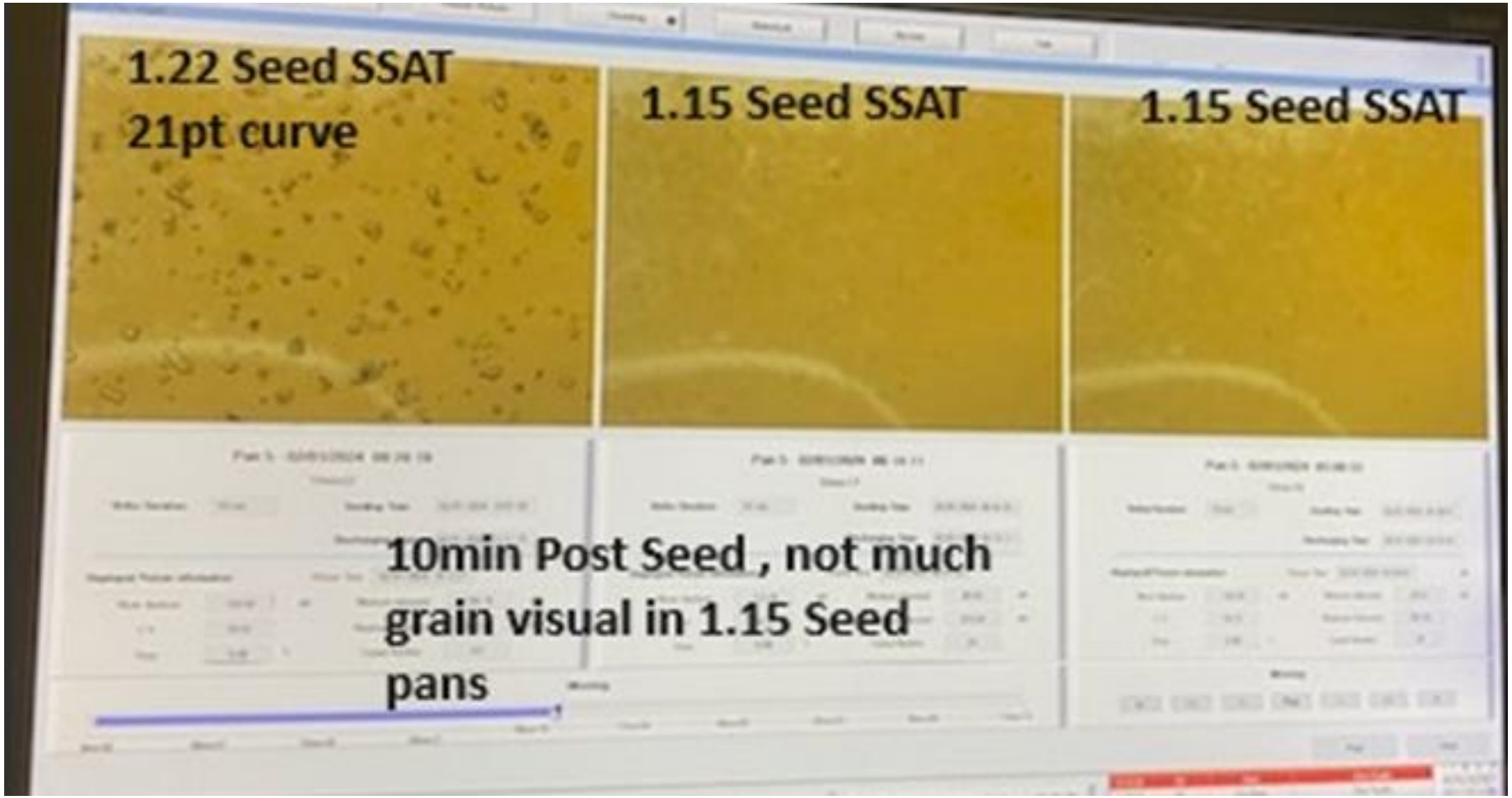
What a washed out pan looks like (At seeding)



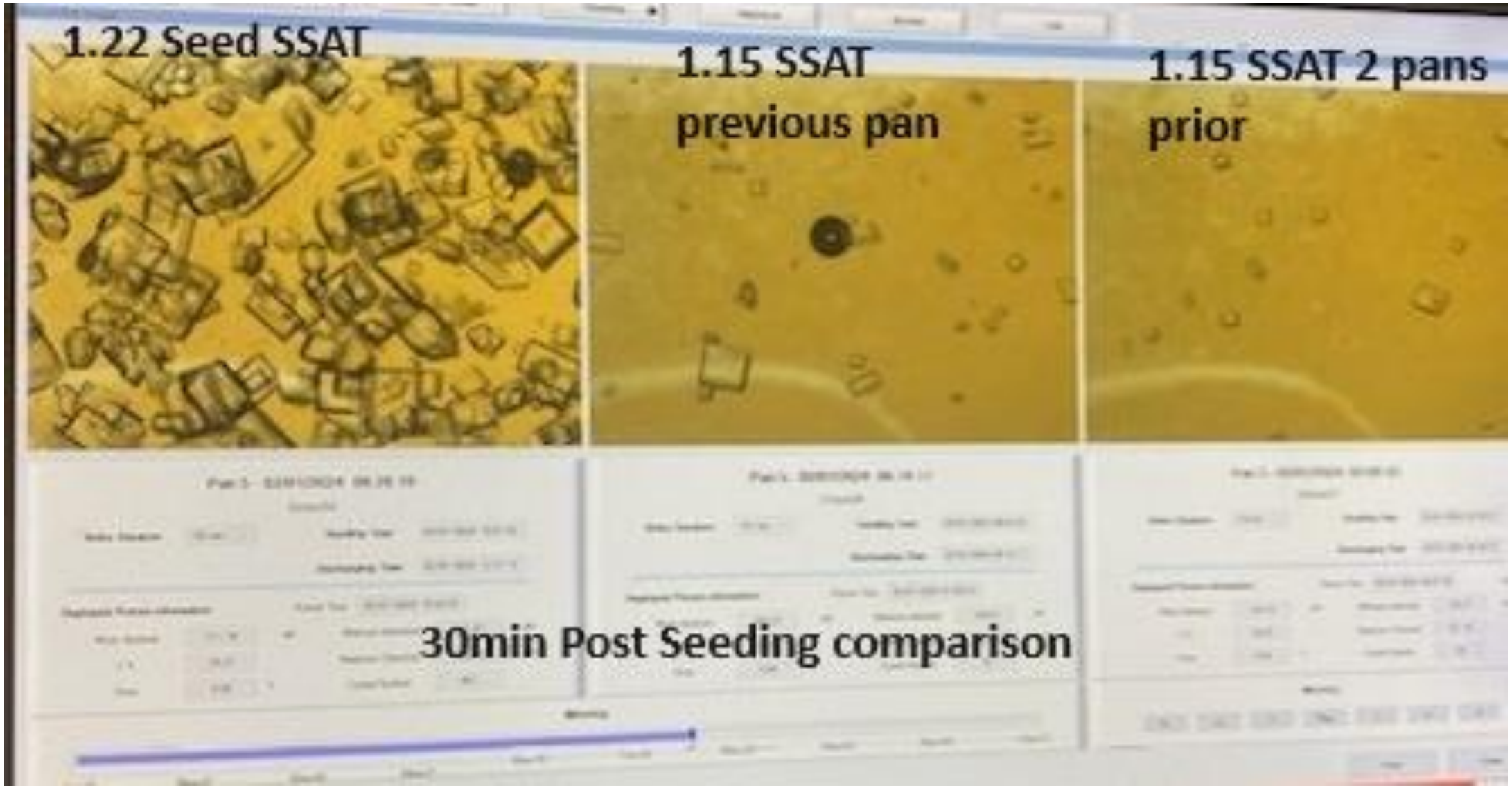
What a washed out pan looks like (5min post seeding)



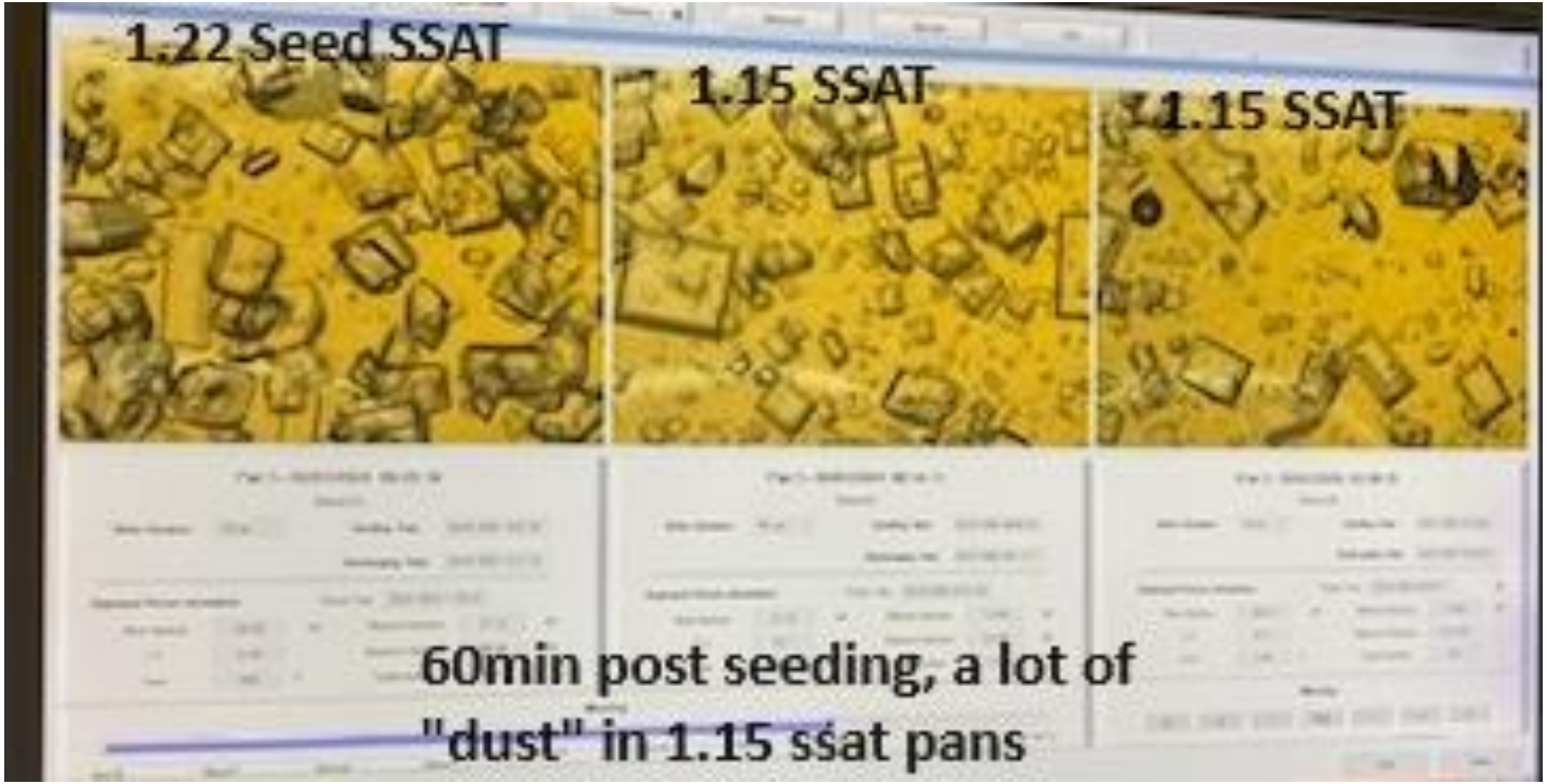
What a washed out pan looks like (10min post seeding)



What a washed out pan looks like (30min post seeding)

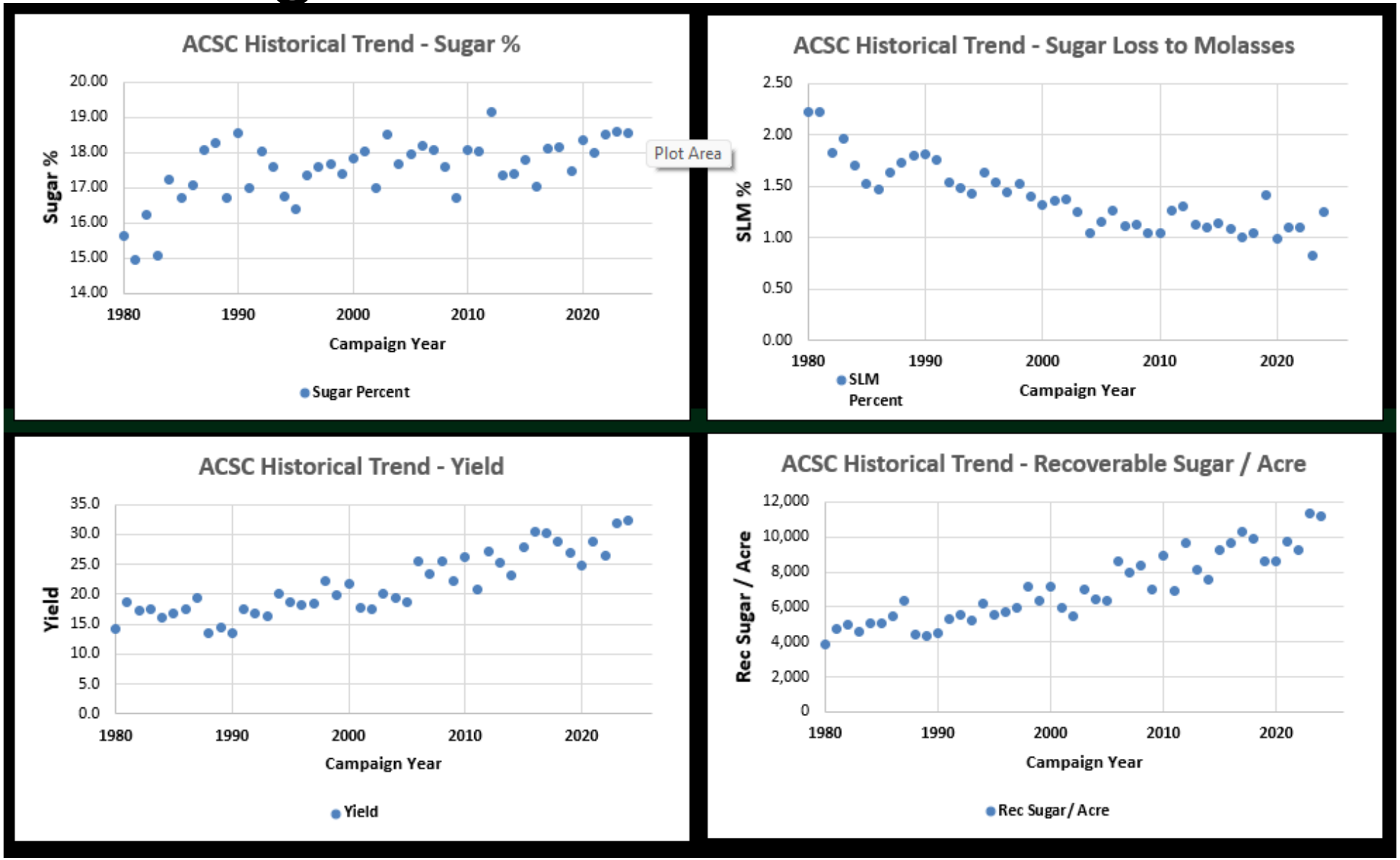


What a washed out pan looks like (60min post seeding)

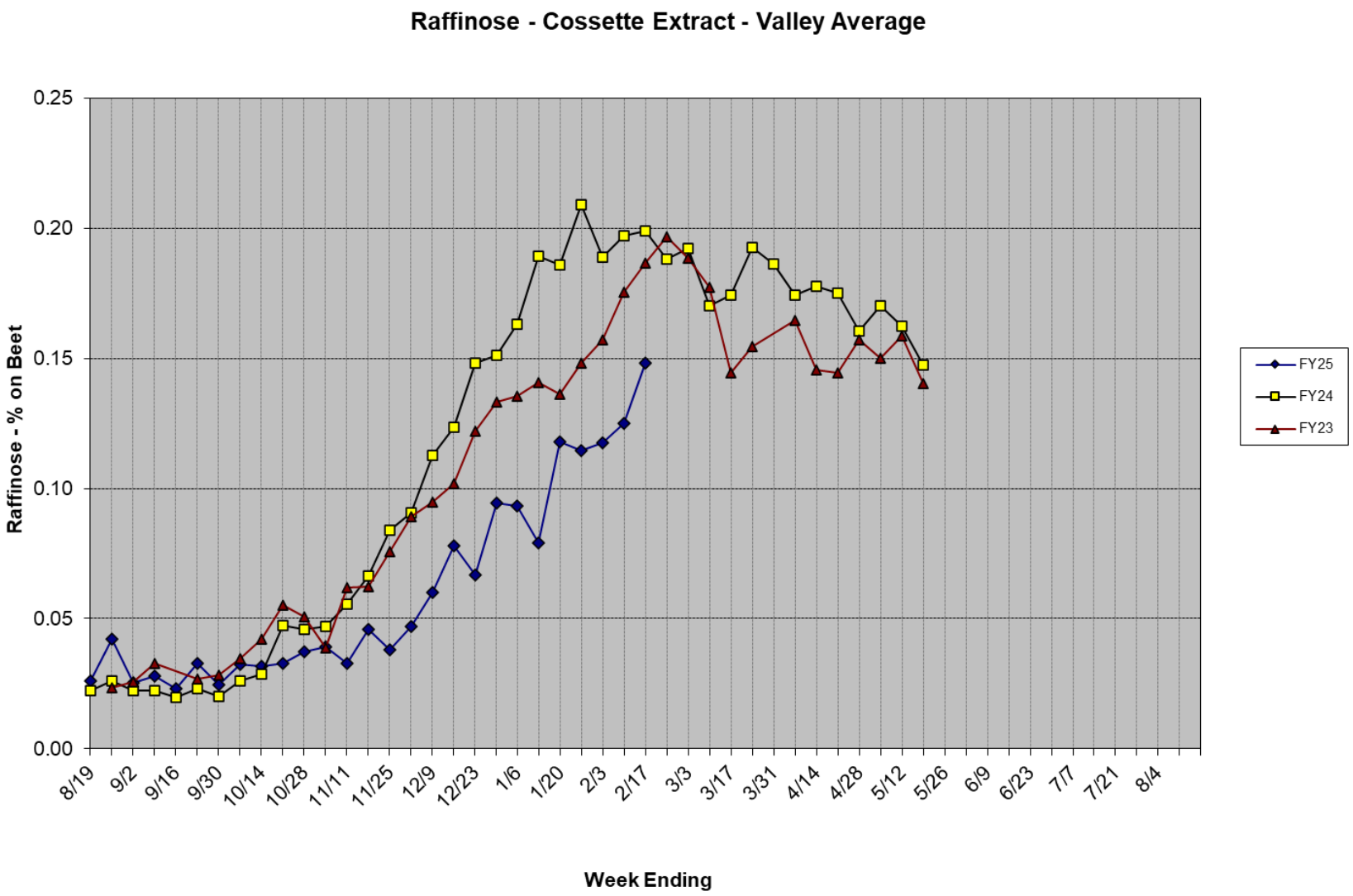


What a washed out pan looks like (80min post seeding)

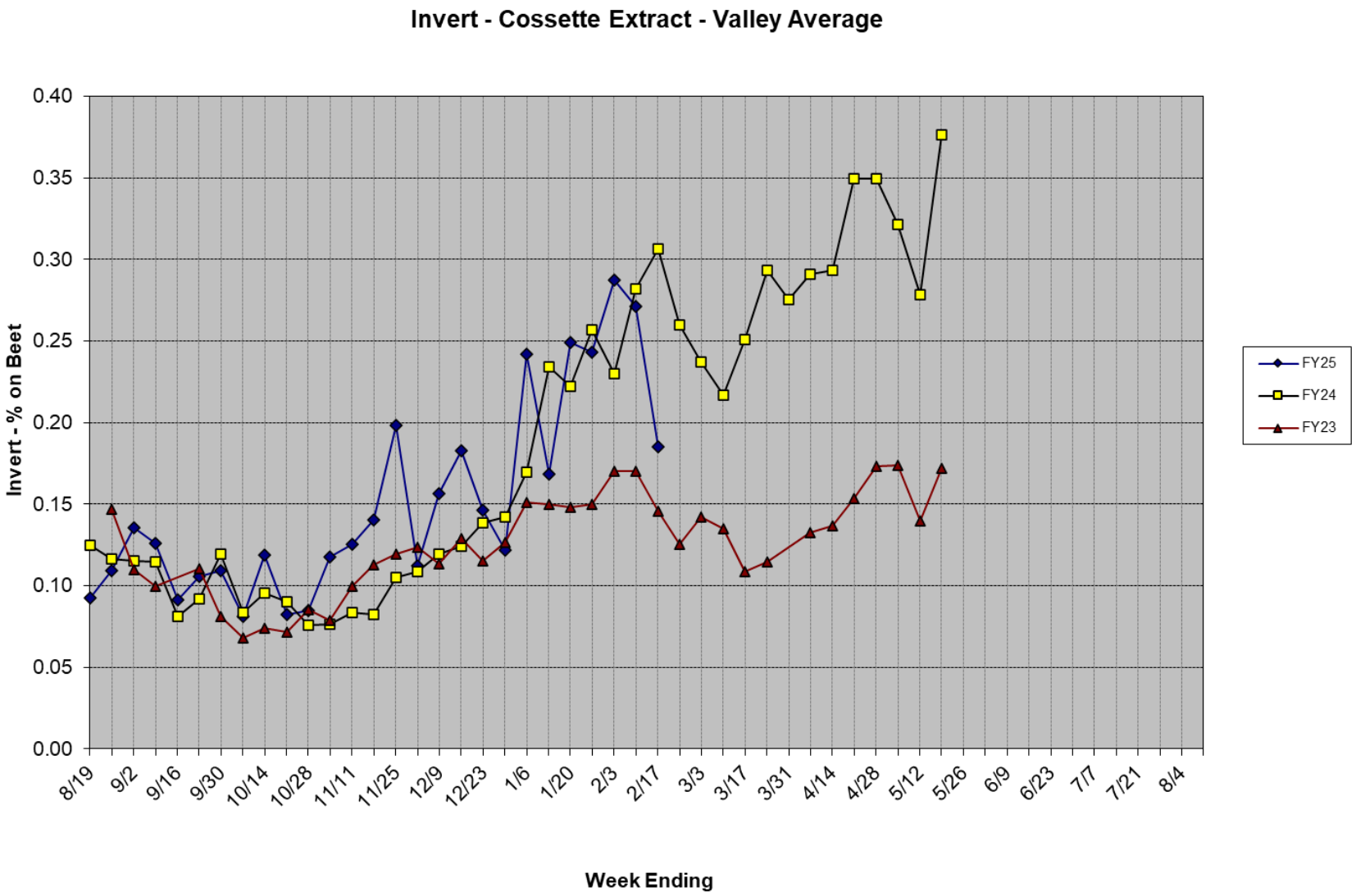
Agronomic Trends over Time



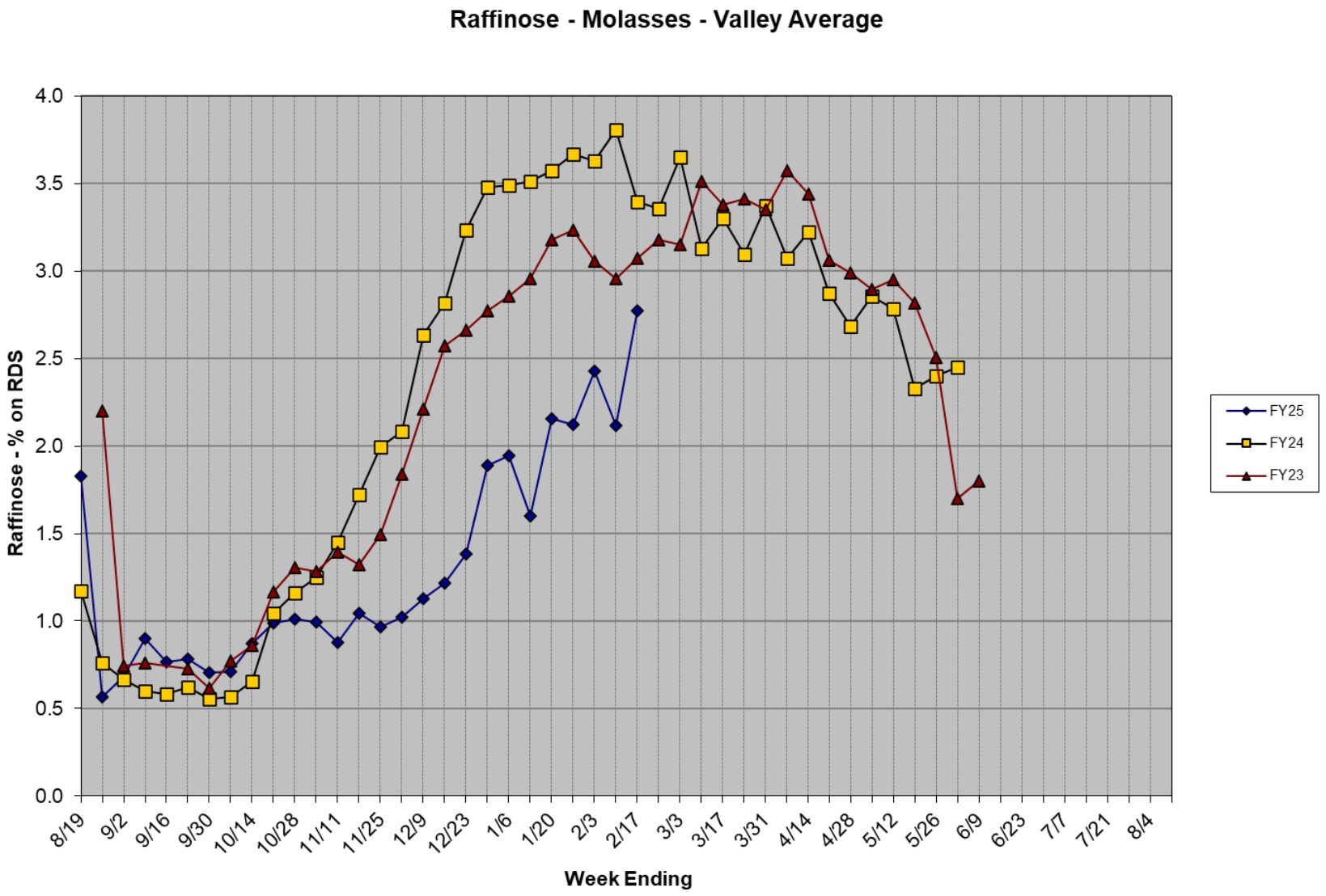
Measured Non-Sugar Profiles



Measured Non-Sugar Profiles



Measured Non-Sugar Profiles



Methods (Sample Collection)

Methods (Sample Preparation/Crystallization)

Methods (Sample Collection)

Calculations

$$y = \frac{w_s/ww}{(ws/ww)_{sat}}$$

$Y_{sat}=a*q_{NS/W}+b+(1-b)*\exp(-c*q_{NS/W})$

$Y_{sat}=0.178*q_{NS/W}+0.820+0.180*\exp\hat{}(-2.1*q_{NS/W})$

Grut Coefficients Defined:

A=0.178, B=0.820, C=2.1

Sucrose Supersaturation:

$qsat_n$=sucrose solubility of pure sucrose at a

$$Sucrose\ Supersaturation = \frac{(\frac{Brix}{1-Brix}) * Purity}{qsatp * ysat}$$

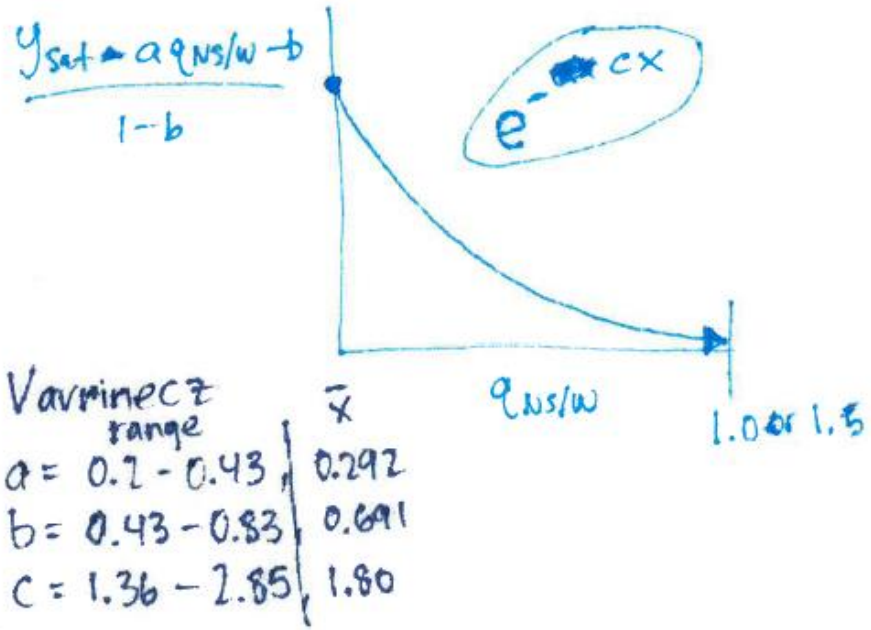
$$y_{sat} = a q_{NS/W} + b + (1-b) e^{-c q_{NS/W}}$$

$$y_{sat} - a q_{NS/W} - b = (1-b) e^{-c q_{NS/W}}$$

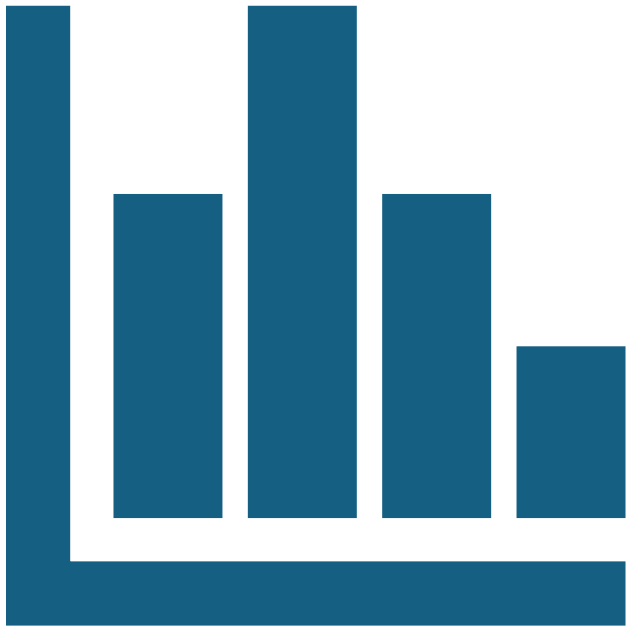
$$\frac{y_{sat} - a q_{NS/W} - b}{1-b} = e^{-c q_{NS/W}}$$

we experimentally know ysat, a, b.

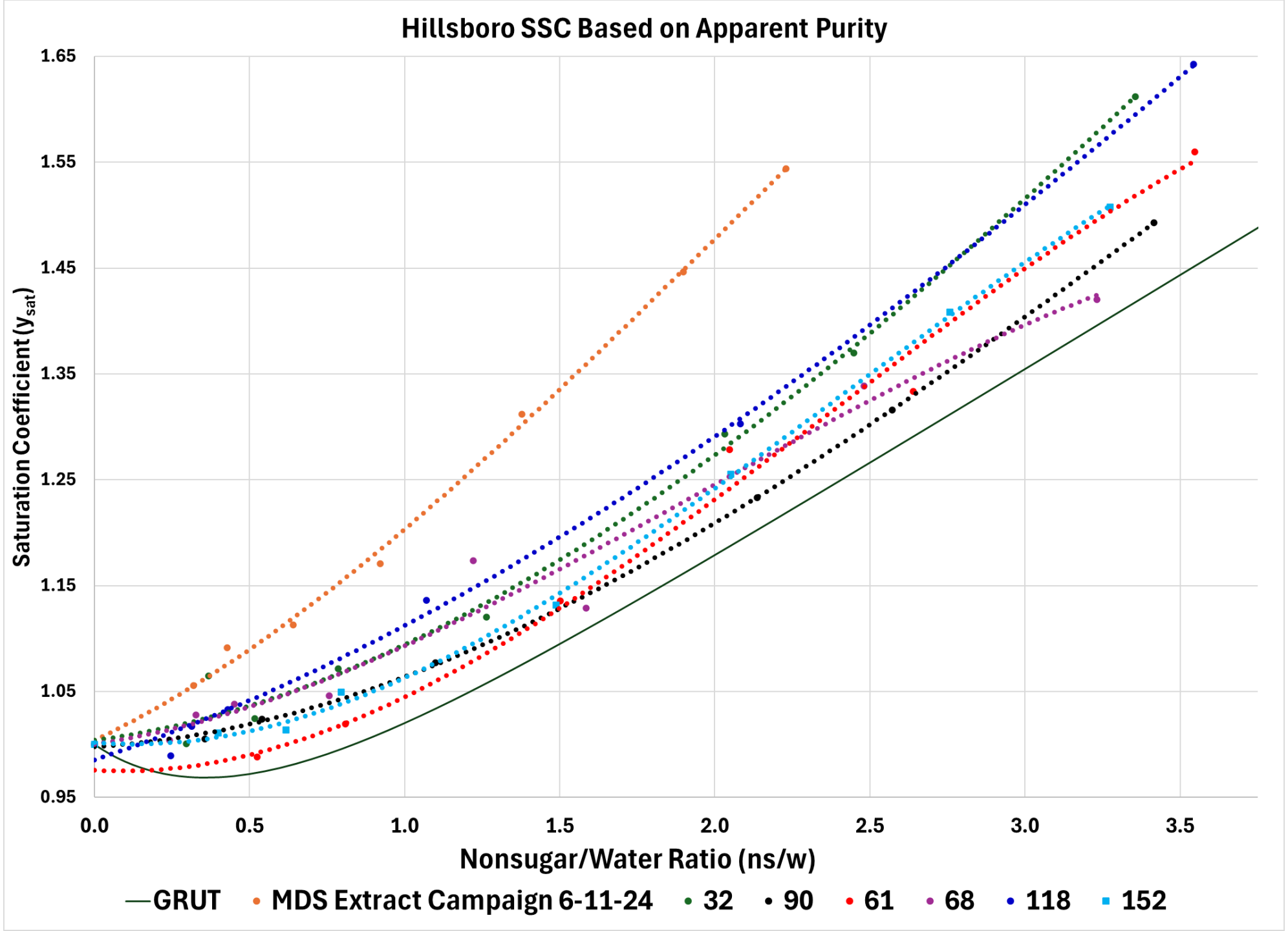
vary $q_{NS/W}$

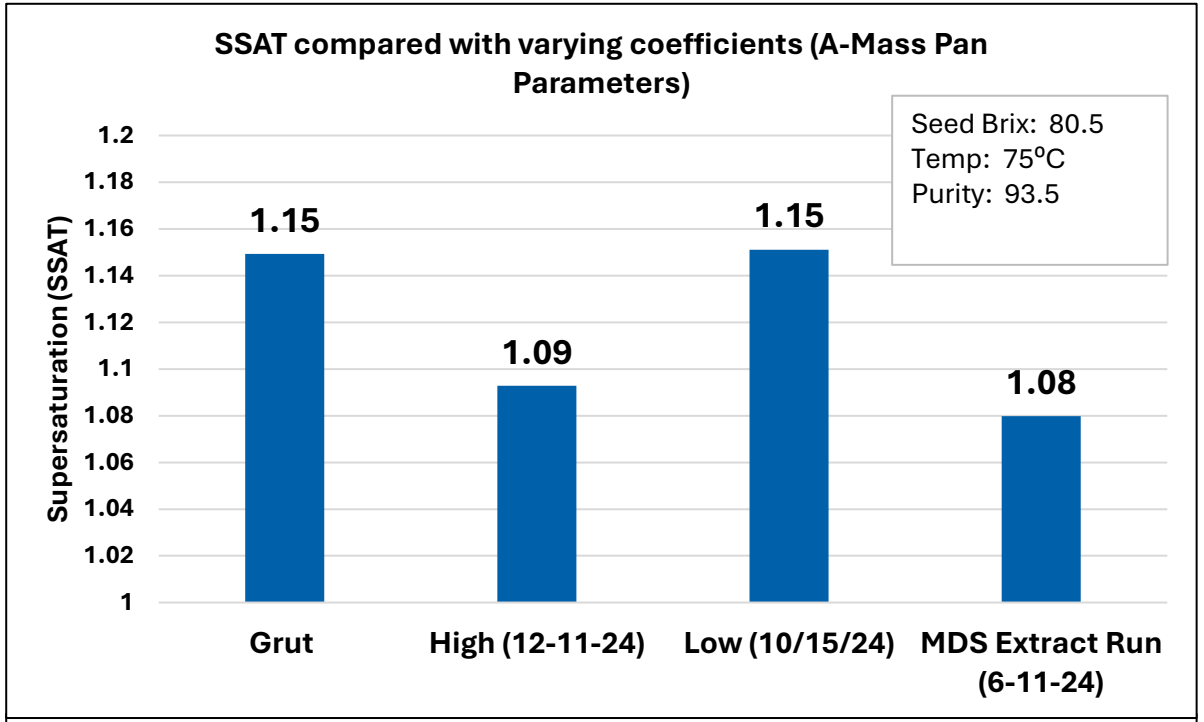


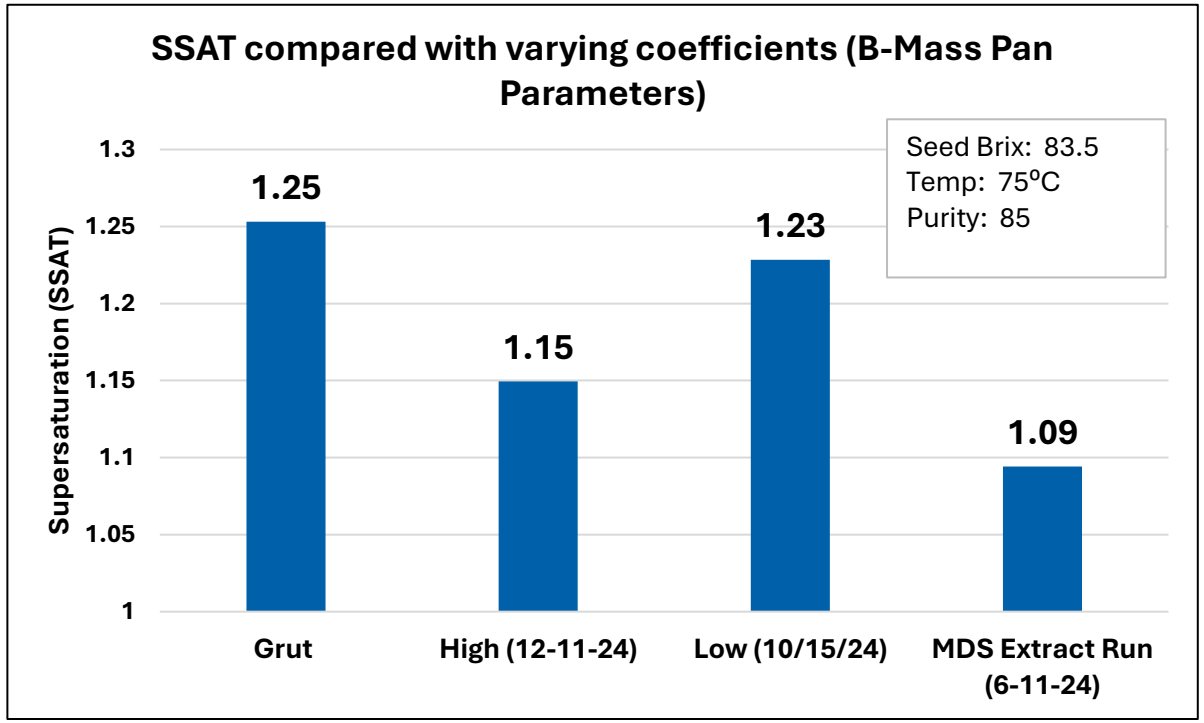
Variable	range	$\bar{x}$
a =	0.2 - 0.43	0.292
b =	0.43 - 0.83	0.691
c =	1.36 - 2.85	1.80

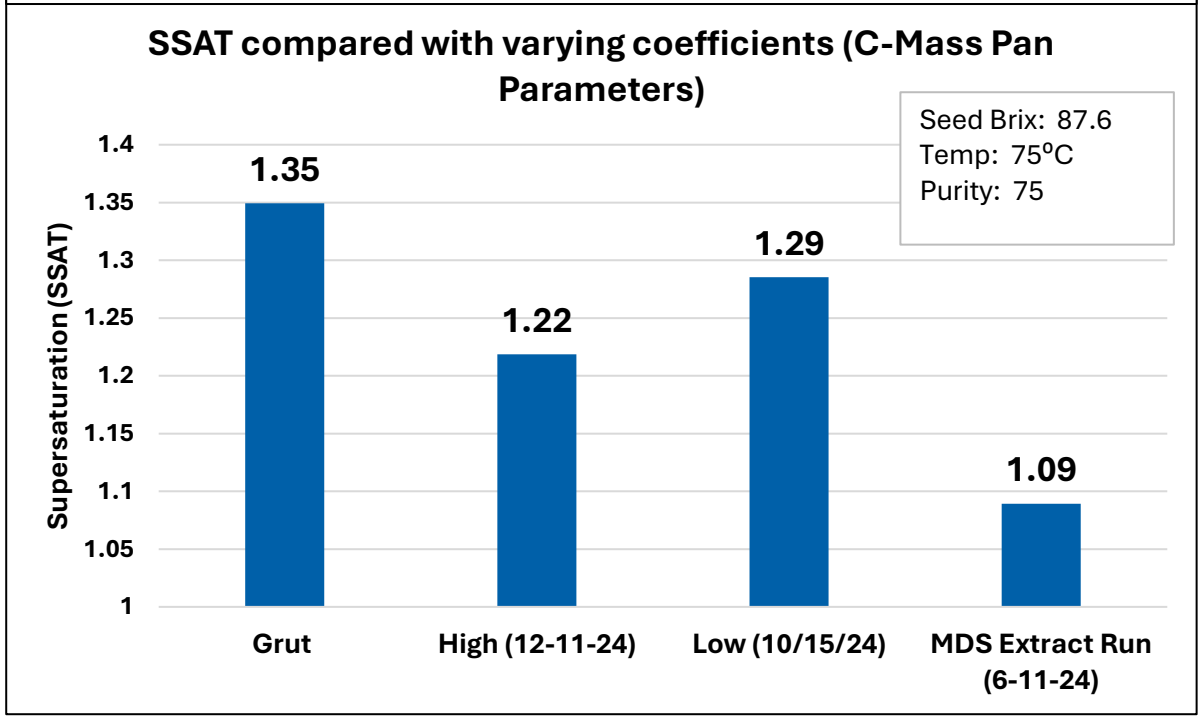


Results

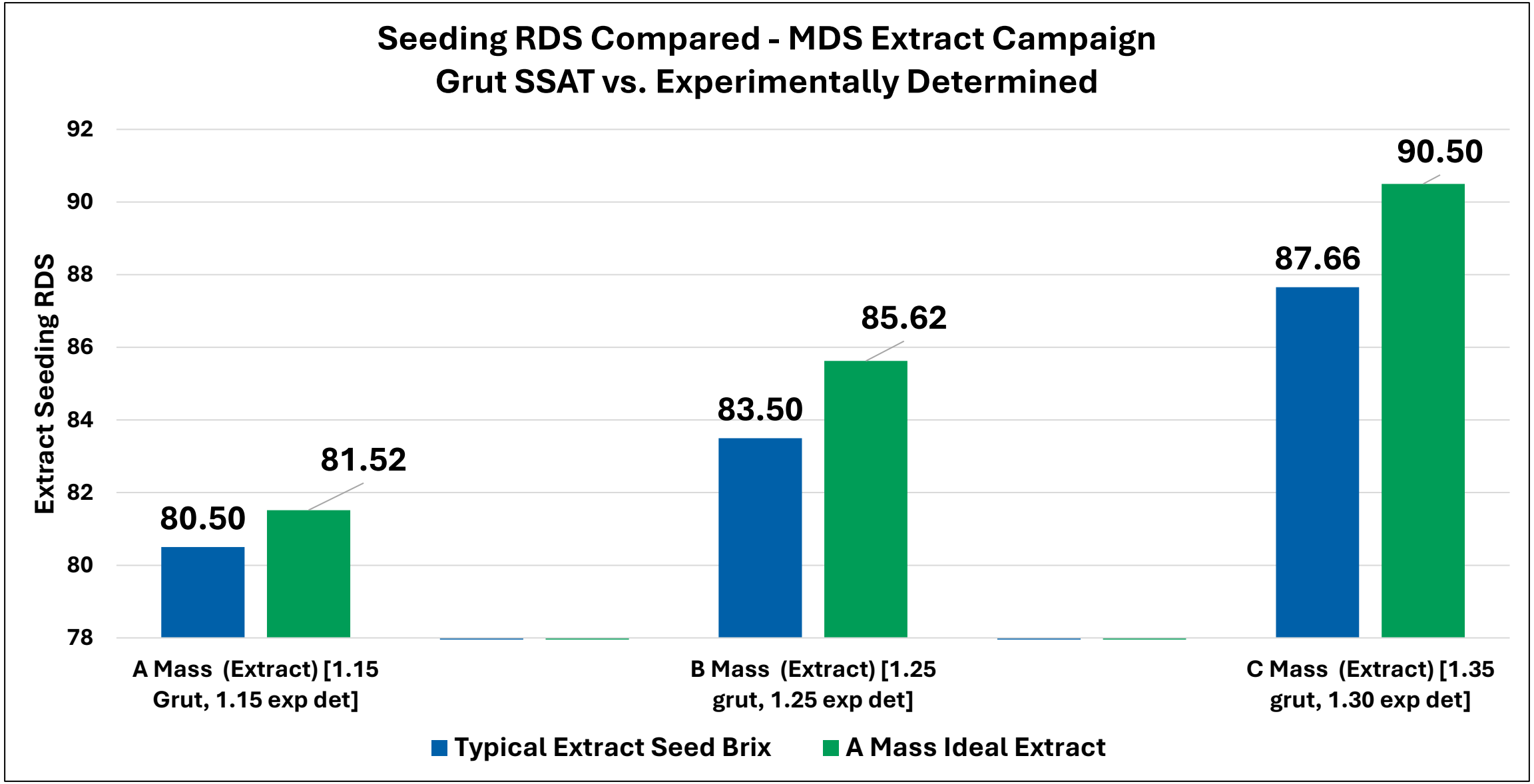

Hillsboro SSC Based on Apparent Purity
Saturation Coefficient (y_{sat})
1.65
1.55
1.45
1.35
1.25
1.15
1.05
0.95
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Nonsugar/Water Ratio (ns/w)
GRUT
MDS Extract Campaign 6-11-24
32
90
61
68
118
152







Collection Date	a Coefficient	b Coefficient	c Coefficient
6/11/2024 *Extract*	0.294	0.887	1.64
9/16/2024 Pre-Pile	0.245	0.784	1.47
10/15/2024 Stock Pile	0.199	0.843	2.89
10/22/2024 Stock Pile	0.179	0.861	1.18
11/13/2024 1month post stockpile	0.204	0.795	1.12
12/11/2024 2months post stockpile	0.232	0.819	0.98
1/14/2025 3months post harvest - Wings	0.207	0.833	1.59
Experimental Average *Excluding Extract*	**0.211**	**0.822**	**1.41**
Grut	**0.178**	**0.820**	**2.100**


Seeding RDS Compared - MDS Extract Campaign
Grut SSAT vs. Experimentally Determined
Extract Seeding RDS
92
90
88
86
84
82
80
78
80.50
81.52
83.50
85.62
87.66
90.50
A Mass (Extract) [1.15 Grut, 1.15 exp det]
B Mass (Extract) [1.25 grut, 1.25 exp det]
C Mass (Extract) [1.35 grut, 1.30 exp det]
Typical Extract Seed Brix
A Mass Ideal Extract

Financial Impacts (MDS Extract Campaign)

During the summer MDS Extract Campaign with optimization of seeding RDS

- Potential Increase in Sugar End recovery of up to 3%
- 16,655 more cwt produced
- Approximately $650,000 USD increased sugar revenue
- Savings of approximately $170,000 USD from reduced operating costs

Future Work

- Better characterization of our non-sugars, and evaluation of potential mitigation or removal to improve molasses exhaustion.
- Emphasis will be put on MDS Extract runs to turn around new sucrose solubility coefficients early to improve molasses exhaustion
  - How does our extract solubility change from campaign to campaign?
- This work allows us to better manage our seeding of ALL pans especially the raw pans.
- Better integration of SSC data to storage conditions and extended time in storage.

Summary

- ACSC's sucrose solubility in sugar end syrups are greater than Grut's technical solution solubilities.
- ACSC's sucrose solubility changes over the course of the campaign.
- MDS Extract shows the highest disparity in sucrose solubility compared to Grut.
- To maximize molasses exhaustion, diligent adjustment of seeding SSAT is necessary.
- From the solubility curves we can better estimate our equilibrium purities to see how much better we can do in our sugar ends (benchmark).
    - This data has already proven helpful in IRR calculations for future projects.

Acknowledgements

- We would also like to extend our gratitude to Chris Rhoten from SucroPro for his mentorship, guidance, and assistance in developing our experimental methods. His expertise has been instrumental in advancing our processes.
- A special acknowledgment goes to the Hillsboro factory personnel for their diligence and acceptance of this work. Their commitment and adaptability have been crucial to the success of these initiatives.
- We would also like to acknowledge Alec Johnson from American Crystal Sugar Company's Technical Services for his assistance with ad-hoc lab analysis, specifically IC analysis. His contributions have been vital to our progress.

Questions??

References:

- **McGinnis, R. A., editor. *Beet-Sugar Technology*. 3rd ed., Beet Sugar Development Foundation, 1982.**
- **Poel, Pieter Willem van der, Hubert M. Schiweck, and Thomas K. Schwartz. *Sugar Technology: Beet and Cane Sugar Manufacture*. Bartens, 1998.**
- **Chris Rhoten**
- **Internal American Crystal Sugar Documentation for SSC evaluation**