Feasibility of Carbon Capture from Plants

Plants are very effective in capturing carbon from the atmosphere. The question to ask is how feasible is it to use plants for carbon capture?

Florida backyard, note biodiversity versus standardized mediocrity in the landscape

Feasibility of Carbon Capture from Plants

- Good afternoon, I have had a career in chemistry, chemical engineering and statistics, My BS degree was in chemistry and then went on to get a MS in statistics and a MS in chemical engineering. My forte especially in later years was problem solving.
- The key to problem solving is to ask the correct questions.
- When we moved to Florida, every January I would plan our trips for the year to visit our grandchildren around the country and sometimes around the world. My wife would ask can we afford all these trips? The correct question to ask is can we afford not to?
- We worry about the rain forest, look for exotic methods to remove CO2 from the atmosphere but what about our own backyard?

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- A question to ask is do we pursue a “plant” farm like the wind farms and harvest plants specifically to capture carbon from the atmosphere or do we change our home landscape to maximize plant diversity and change how we maintain our yards?
- We currently pay $50/ton for yard waste disposal. If it were possible to remove half the leaf water in the field, twice the amount of yard waste could be removed for the same price. Could some type of devise be added to landscape trucks to remove water in the field (spray dryer, rotary dryer, etc)?
- There is also cost savings in more business trimming plants rather than trips to the landfill. What would be the true economic impact?
- Would low moisture contribute to a more “compostable” or “usable” waste?
- Also, relatively low temperature are can be effective in removing pathogens.

Feasibility of Carbon Capture from Plants

- The first step is to determine how much carbon plants absorb from the atmosphere. Cellulose ($C_6H_{10}O_5$) is over 40% carbon while celery is 90% water. The expectation is that plant leaves will have somewhere between these two levels of carbon. (Should mention the celery water is a measurement of the stalk, no idea what the level would be in the leaves)
- Also important is how the water is attached – physically or chemically bonded and exactly how it is bonded. Sucrose ($C_{12}H_{22}O_{11}$), which we get from sugar cane by a separation process, can be dehydrated with sulfuric acid to yield carbon. Can the chemistry be studied separate from the separation process?
- Folks here from the north experience 4 seasons – plants leaf out in spring and lose their leaves in the fall but this presentation looked at tropical and subtropical plants. They can hold their leaves for years rather than months making harvesting of the leaves independent of season. The leaves also don't change color as much. Most tropical and subtropical plants don't like the cold.

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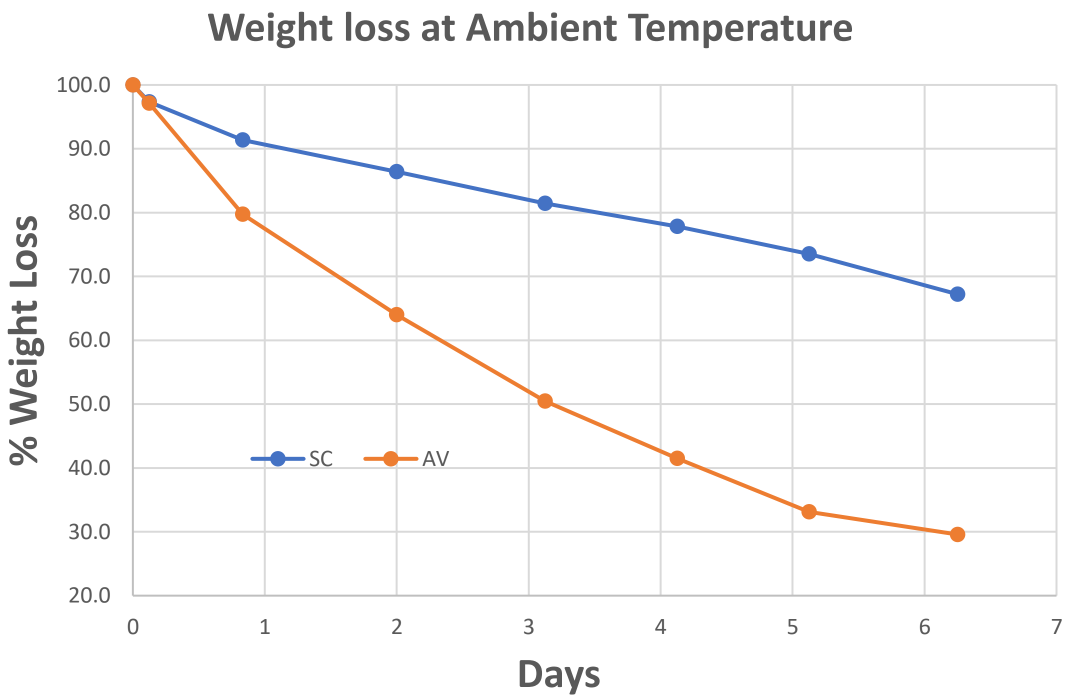
- To determine what plants are most suitable to carbon capture, I selected three species to examine. They were dehydrated at 190°F and the resulting material weight after 2 hours varied from 20 to 40% of the starting leaf weight. It is assumed that most of the volatile loss is water and a large amount of the remaining material is carbon. Palm leaves retain 40% of their starting weight even after 4 hours at 190°F. (There are over 2500 species of palms in the world.)
- From left to right Schefflera(SC), Awabuki Viburnum(AV), Zamia Furfuracetria(CB)

Cardboard plant can be spray painted for Halloween, July 4

Feasibility of Carbon Capture from Plants

- The next question to ask is why heat the leaves, why not just let them dry out in the yard? The answer is that could take days or even never happen. We do have air plants that grow without soil and we have leaves that root themselves if they drop to the ground (Jade plant).


Cymbidium Orchid - air plant, does not require watering or nutrients (40lbs before hurricane Ian)



Days are needed to dry plants at ambient temperature

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- My expectation was that when heated the leaves would lose weight exponentially – simple first order decay rate.
- This leads to two parameters, when do the leaves lose half their weight and when do the leaves lose half of their potential water loss. A palm that can lose 60% of its weight at 190°F will have half its potential water removed at 30% weight loss.
- The third step was to determine when in the dehydration process the leaves stop active exchange with the atmosphere. This last step was done by determining at what point carbon dioxide stops being generated by the leaves. Fresh cut leaves can generate 150 ppm carbon dioxide per gram per hour. This ability to produce carbon dioxide can be reduced or eliminated by dehydration.
- **What was not done was to measure the volatiles that are generated even at low temperature from the leaves. This would be an interesting study in itself.**

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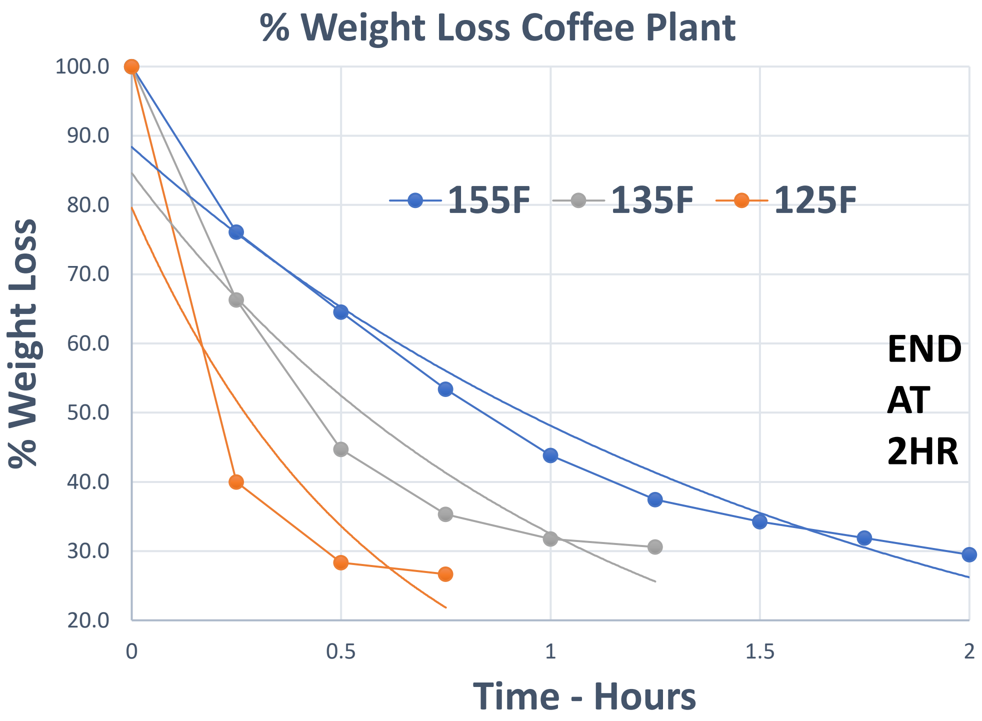
- Before discussing the 3 target plants I should note some early work on the Florida coffee plant (*Psychotria nervosa*). Statistical results are for a first order decay fit of LnW = LnW_o -kT. Can generate a 3D plot of weight loss vs time and temperature



Statistical results

	Wt % 125F		
Intercept	4.481693	R Square	0.962946
X Variable 1	-0.60782	Adjusted R Square	0.957653
	Wt % 135F		
Intercept	4.508974	R Square	0.951096
X Variable 1	-1.16949	Adjusted R Square	0.934794
	Wt % 155F		
Intercept	4.509928	R Square	0.935943
X Variable 1	-2.52226	Adjusted R Square	0.871887

DFWI

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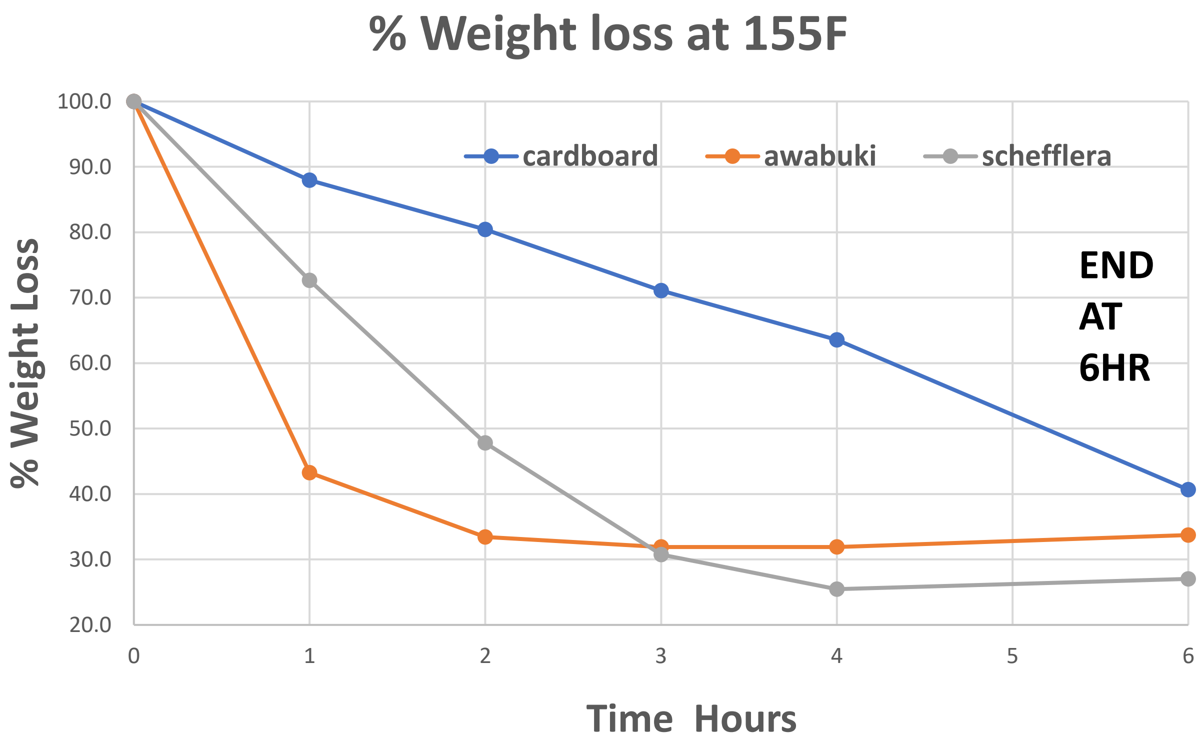
- Now the results for SC, AV, and CB. All evergreen and all common in Florida landscape.



AV

SC

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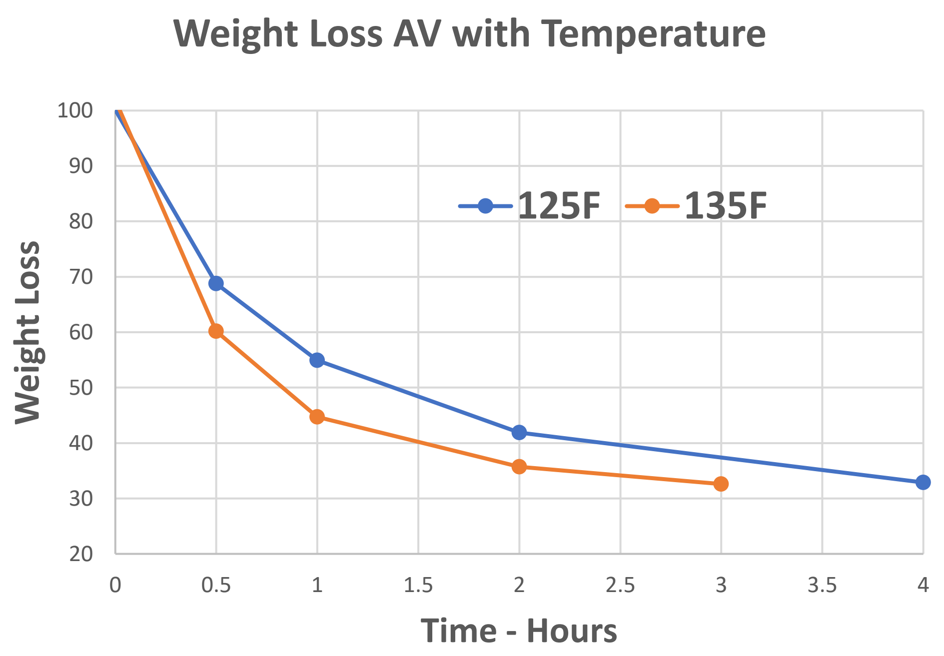
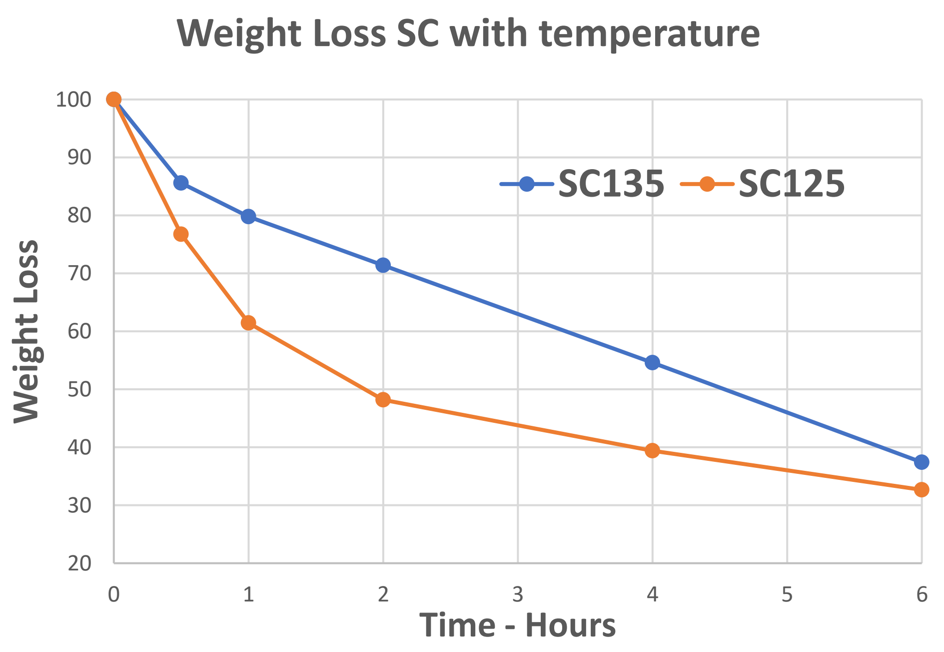
- The weight loss results are not as expected at lower temperatures
- Why low temperature? – feasible for solar dehydration
- SC AV lose more weight at 125F than 135F - What happened?





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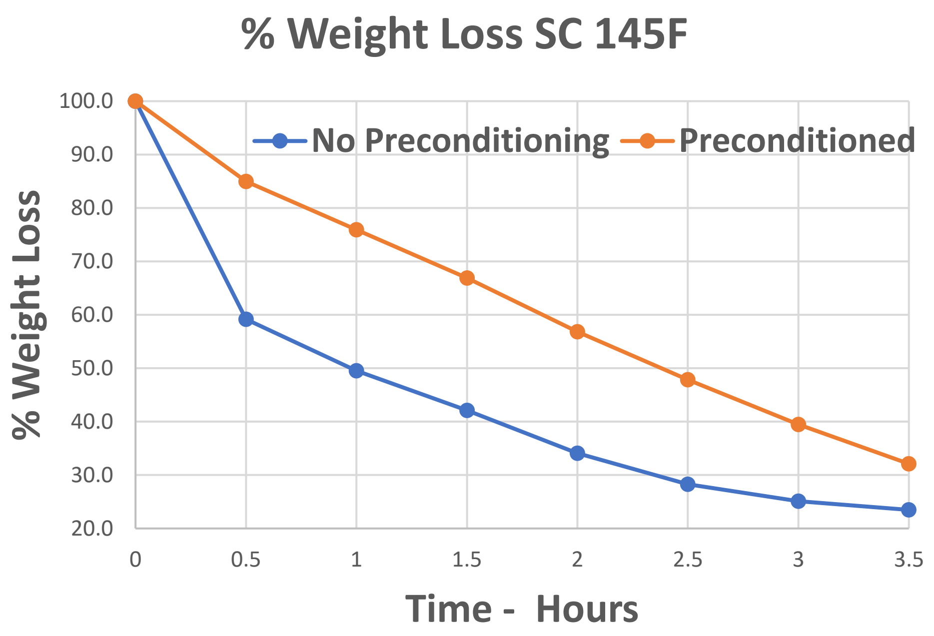
- Maybe the leaves are wet with dew, maybe the results will be more consistent bringing the leaves inside and leaving them at room temperature for some period of time. Experiment with "preconditioning"



One hour at 145F weight loss is 50% with no preconditioning vs 24% with preconditioning

Hypothesis

Plants have a stoma under the leaves which facilitate the transfer of O_2, CO_2, and H_2O - transpiration
At lower temperatures plants don't feel the need to "close" the stoma.
Plants can be slow to respond

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SC precond at end point

SC no precond at end point

AV quick to change color at 125F
Leaf doesn't wilt but loses water and chemistry changes – no chlorophyl?
Change in tugor? - water pressure inside cell to maintain structural integrity

$CuSO_4 \cdot 5H_2O$ *vs* anhydrous
$CuSO_4$ *Loss of hydrated water*?

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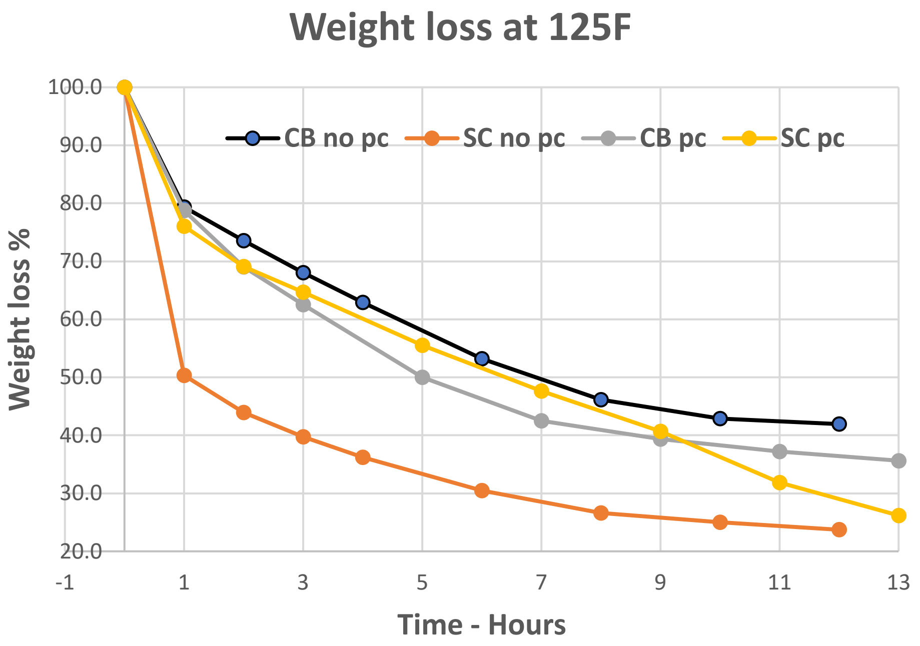
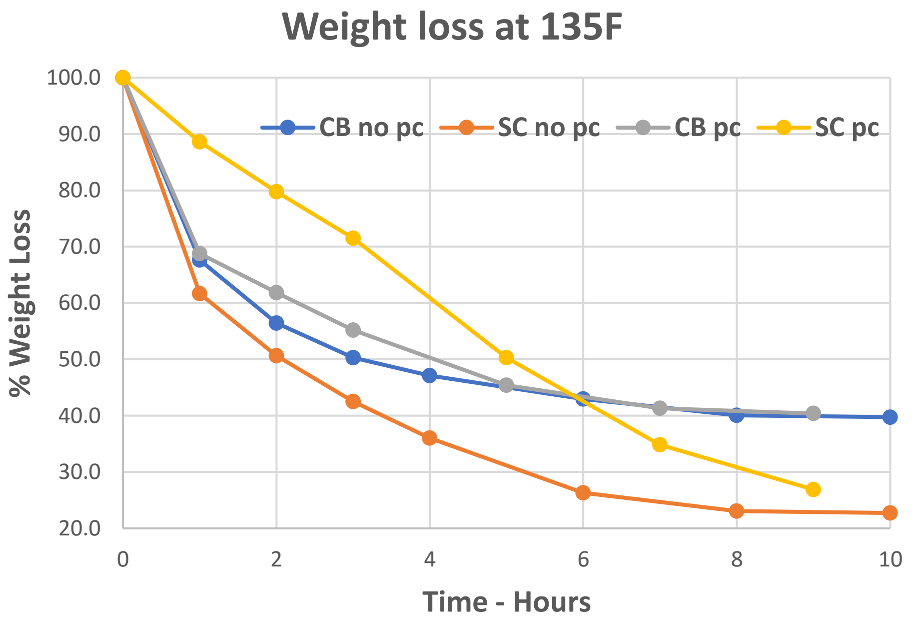
- Result for CB SC with and without preconditioning





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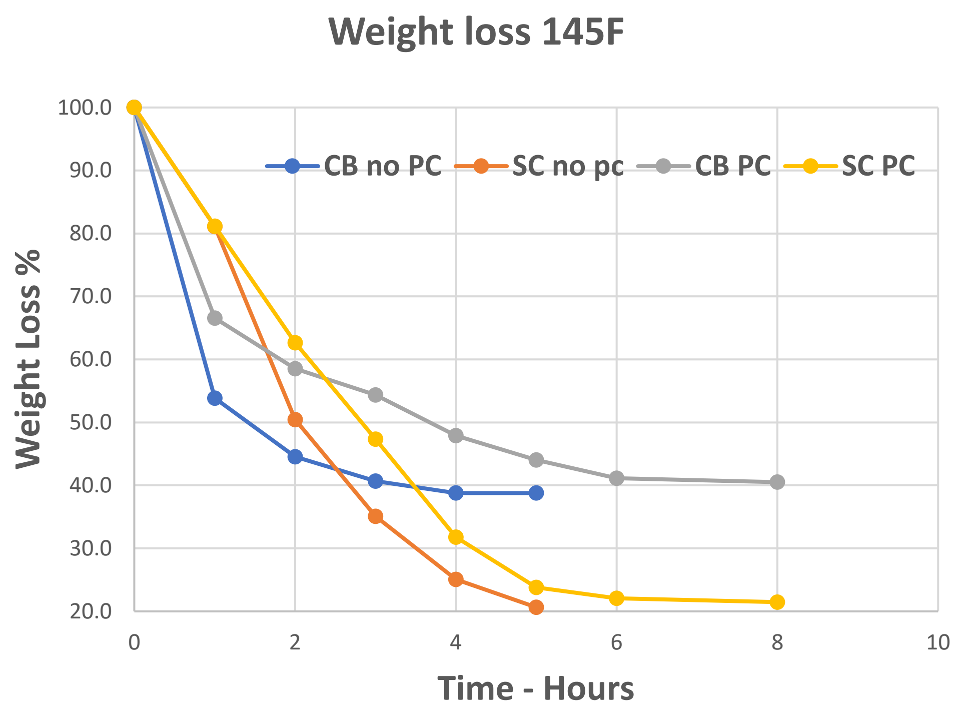
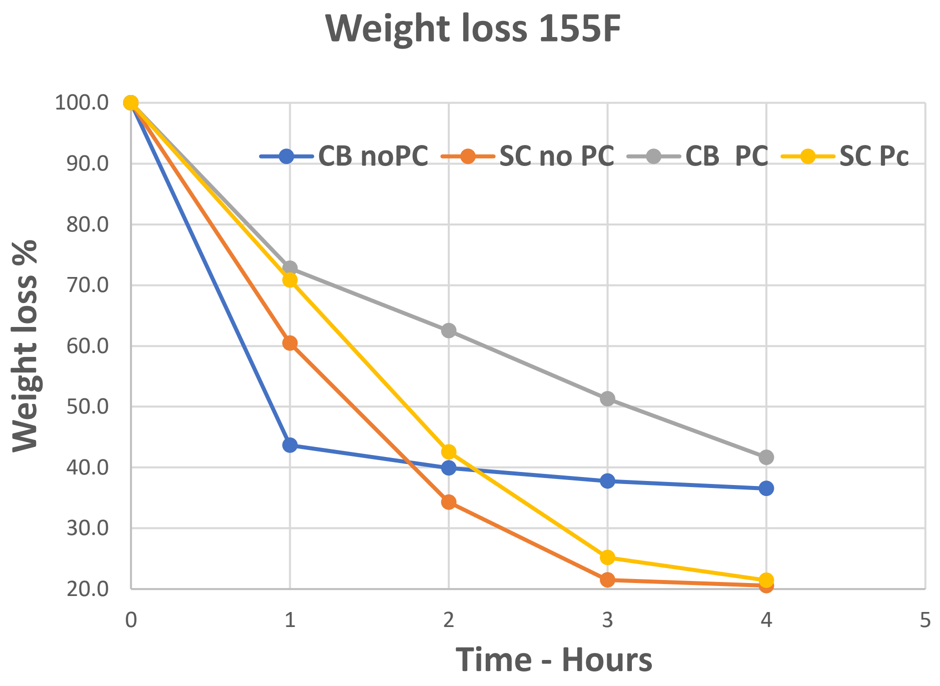
- Results for CB SC with and without preconditioning





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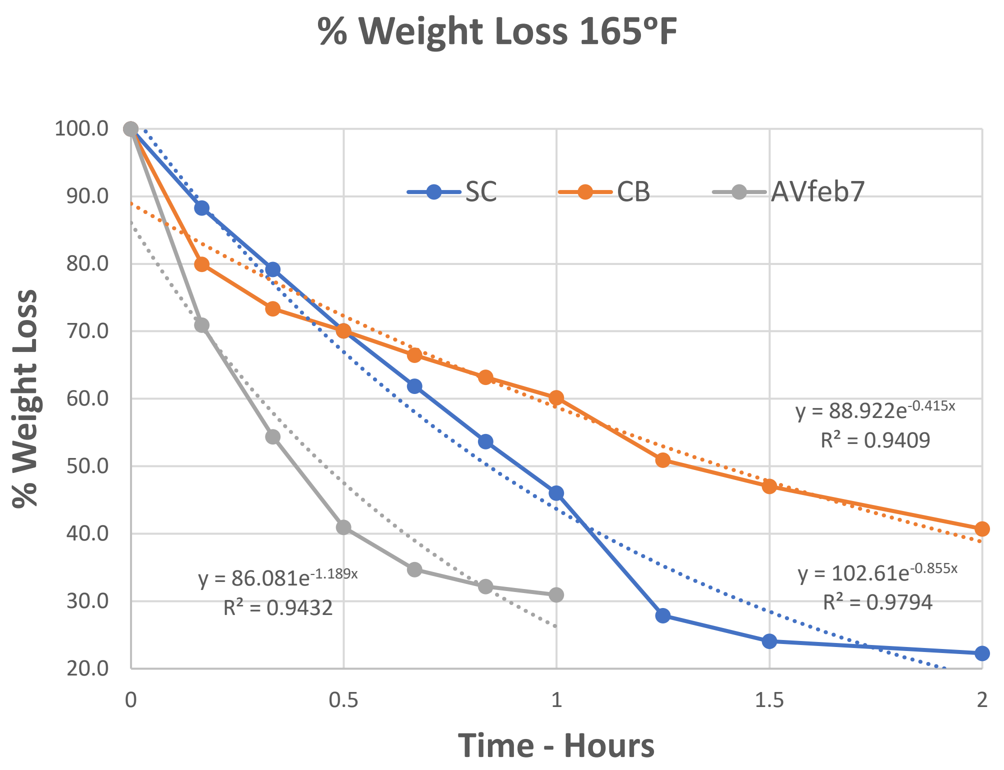

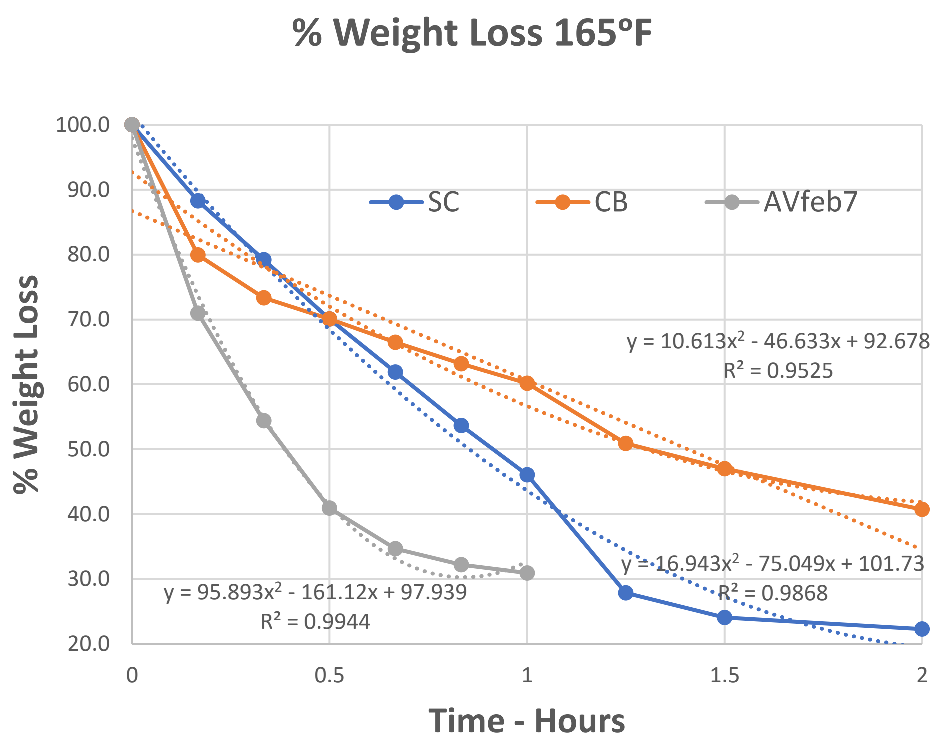

Regression data for SC CB and AV at 165 F. Somewhat better fit for a polynomial equation than a exponential decay

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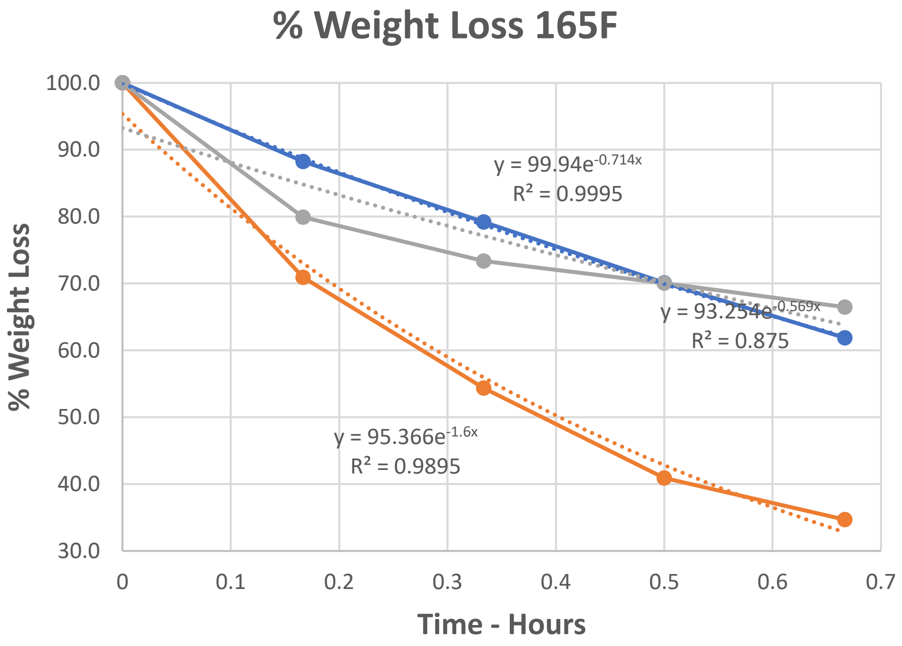

Are there two mechanism driving the loss of water. The first one a quick initial loss of loosely bound water followed by a slower loss by more tightly bound water?

Previous data using only first four points provides a better fit for a first order decay for AV and SC

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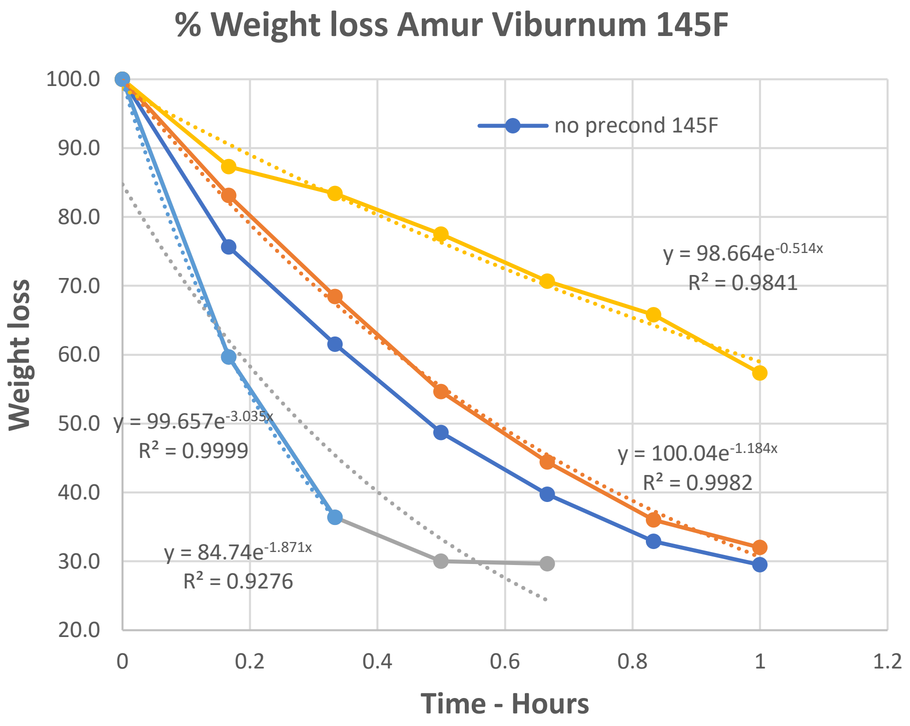

Much better results with plants that lose weight rapidly

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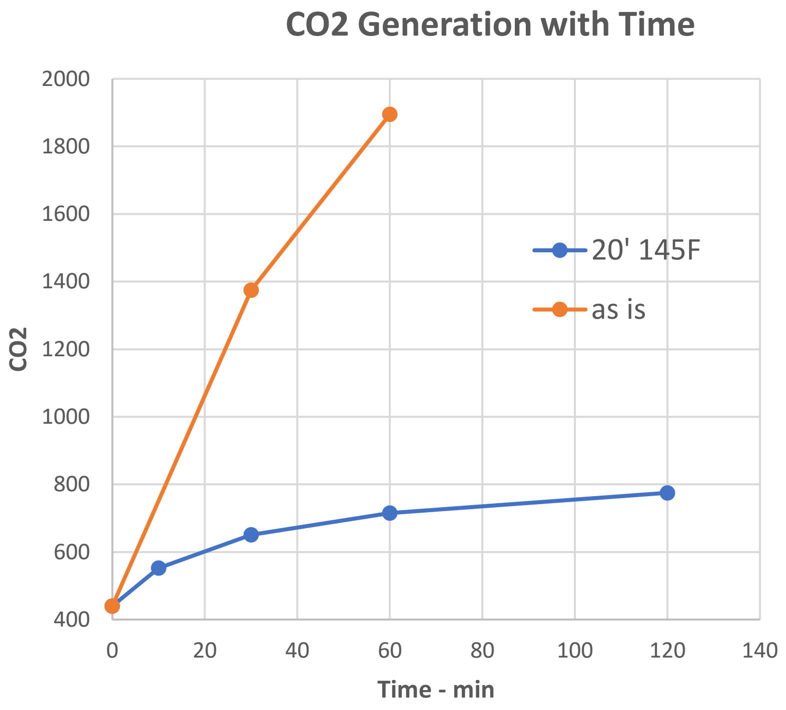

Final step to determine when leaves no longer generate CO_2

Summary

- Plants leaves can contain 20 to 40 % carbon
- Water can be removed at relatively low temperature and short time
  - 125°F to 165°F between 2 and 8 hours
- Removal of the water does stop leaves from emitting CO_2
- Many questions and topics for study remain
- If nothing else - can we improve marijuana?