Compost-heated Winter Greenhouse Field Day — notes and photos

Feb 15 2018
Terra Firma Farms
Revelstoke, BC
Field Day Notes by Andrew Bennett
Contact: 250-521-2500, Andrew@kbfa.ca

Following my notes on the field day, below, are a number of supporting documents provided by Terra Firma Farms and Okanagan College:

- Compost Construction notes
- Compost Heating System Plans and Materials List
- Terra's Soil Recipe
- Recommended Varieties
- Greenhouse Assembly Plans
- Research Fact Sheet
- Data Summary

Terra Park and Rob Jay of Terra Firma Farms, Revelstoke, BC, in their double-walled greenhouse. Warm water pipes coming from the compost pile are visible on the ground, connecting the cedar-walled raised beds filled with soil mix over a wood chip floor.

Hoophouse Details

- Purchased "Paul Boers" 50x20, gothic arch.
- Can hold 40 lb/sf of snow load.
- Standard 6mm greenhouse clear polyethylene.
- After three seasons, year-round use, seems to be when it needs replacing, although often warrantied to 4 years for UV damage. Damage from UV, wind, holes from wiggle wire, and snow clearing. Poly lasts 4 seasons at Terra Firma Farms when they take it off for the winter.
- Moveable on 3" angle-iron skids, pulled by tractor.
- Slider doors both ends, no roll-up sides as open ends provide sufficient ventilation in the summer.
- (Participant: recommended "woven" greenhouse coverings….[Getting info])

Wind Damage

- Although the winter hoophouses were okay, another set of 12' wide hoops on the property was lifted up and badly damaged by 50km/h winds. The weakness appeared to be insufficient anchoring.
- Winter hoophouses were anchored with 4-foot long "deadmen" buried 2-feet deep and cable-tied.

Double vs Single Wall

- Snow shedding much easier from double-wall, would tend to stick to single-wall. Double wall would "bounce back" as snow came off, helping to slide snow.
- Much more condensation and drip off single-walled.
- Although data shows only slight increases in average temperature (2°C) and extreme minimum temperatures (°1C), noticeably higher yields and less disease.
- Less damage from extreme cold.
- Less light coming through two layers of plastic. Some varieties grew better under lower light with more warmth, other varieties preferred more light.

Snow Clearing Issues

- Approximately 4 hours of work per week to clear snow from two 50x20 greenhouses using a front-end loader (Revelstoke has a large snow load).

- A snow blower on the tractor would have made the work faster and more effective.
- Damage to hoop house plastic a problem as the tractor sometimes hits arches.
- Need sufficient space between greenhouses to run loader through without getting too close to the hoops.
- Clearing necessary, or else the snow would be at least 6' deep on the sides and covered over the top.
- Snow rake needed to pull snow off, but easy with the gothic arches.
- Must clear snow evenly from both sides: if all the snow is cleared off one side, the pressure from snow on the other side will bend and threaten to collapse the greenhouse.
- Single-walled plastic was harder to clear, required hacking at a hard melted layer on the plastic, compared to easy-sliding off double-walled.

Propane Blower?

- Participant recently visited Hermann and Louise Brun's farm in Mara. There they use a propane blower to heat greenhouses after a snowfall to clear the snow off the top without digging.

Compost for Heat and Soil

- 100 cubic yards (10 large truckloads) of good bark mulch, contains lots of foliage and twigs. Supplier takes woodier stuff elsewhere.
- 100 cubic yards of very green horse manure
- Suspect a fairly good 30:1 C:N ratio, not measured.
- Mixed with a loader.
- Compost from the un-turned hoophouse heating pile is not ready to put on the field for at least two years. Other composts on Terra Firma get turned throughout the winter, and are ready to apply within 6 months (ie. at the beginning of spring.) In both cases, this new compost is only suitable for cover crops for a couple seasons.
- After five years, the resulting soil is "incredible." Terra Firma's previous land was very rocky, and they amended the entire area with compost to make for excellent growing conditions.
- Originally did a circular heap with circular coils of pipe. It has turned out to be much easier to do a linear berm, currently about 20' wide by 70' long, and about 10' high when first built.
- Compost thermometers are very useful. From any grow store. Vernon Grower Supply was recommended.
- Another way to measure compost temperature quickly and easily is with an infrared sensor (Canadian Tire) when the pile is turned and the core is exposed.

Back-up Heat

- Recommendation to have a reliable back-up heat source to protect crops during cold snaps. Back-up heat would have saved lots of plants in this experiment.
- (Participant: recommended wood chip boilers, currently produced nearby in Eagle Bay for a reasonable cost and high BTU. Wood chips are cheap (free) and plentiful in Revelstoke. [Getting info])

Pipes and Compost

- To build the berm, first 1 to 2 feet of wood chips is laid down, followed by Big-O drain tile to get air into the pile, followed by a long winding run of water pipes, spaced 8" apart.
- Levels were added with about 1 to 2 feet of compost material in between each layer, for a total run of 5000 to 7000 feet of piping.
- Terra Firma suspected some of the pile was anaerobic, and would put in more Big-O in the future.
- Extracting the pipes is difficult, unless the piping is just to be thrown away. An excavator or other machine is required to loosen up the pile. Pipe is hard to get out without damaging it.
- When a circular compost heap was made, only very short pieces of pipe could be salvaged. In the long berm, hopefully longer pieces (50') pieces can be salvaged.
- Setting up the compost pile and pipes took 2 days of work.

Cold Compost?

- 18 months potential heating claimed, but not what is being experienced. Current berm was 160F in November when first built, is now at 60F.
- Terra Firma suspected the pile, capped by heavy snow, had gone anaerobic. If they were to try again, they would put more Big-O in the pile to keep it aerated. Another option considered would be to provide the compost with a shelter that allows airflow over top and keeps snow off.
- Terra Firma's other wood chip piles and composts were still blowing off heat and melting the snow on top of them. My own wood chip and compost piles have easily melted most of the snow on them. The heating compost pile, however, has 3' of snow on it and is cold. (See photo). This suggests that so much heat was taken from the pile and put into the greenhouse that the pile itself was cooled right down. 60F was not sufficient to keep the greenhouse warm and the farm has started to use a boiler to add heat.

Terra and Rob beside the compost windrow used to heat the greenhouses. Note the pile of snow above the pile, suggesting that the compost was made substantially cooler as a result of the heat drawn out of it. Other compost piles and wood chip piles on the property had much less snow on them, having melted it off. Also, Rob is holding a 3' compost thermometer, pretty much essential equipment to make sure a pile is composting properly.

Indoor Compost?

- What about having the compost inside the greenhouse? It seems without attention and the ability to turn the pile, it easily goes anaerobic, producing methane that would be bad for the plants (and humans.)

Cedar-walled Raised Beds

- 3'x5' cedar plank raised beds (see photos).
- Would continue to use "some" of them for particular crops, depending on purpose, ability to move it.
- Most beds to be "in-ground" in the future.
- Hibertex Pro seems to be a similar "-10°C" product: http://www.duboisag.com/en/hibertex-pro-frost-protection-fabric-5673.html

Simple half-inch poly pipe was used to distribute compost-heated water to the cedar raised-beds. Here, the line in the further bed has frozen, causing the fitting to pop off. This was presented as a silver-lining, making it easy to identify where the ice plugs were.

Row Cover

- Regular remay is a "waste of time" to retain heat.
- Recommend "DeWitt Ultimate" row cover, 2.5 oz and 10°C protection. Lets in very little light, but not necessary when temps are cold. As soon as the weather warms and the light is up, remove the cover. Suspended over beds with 9 gauge wire hoops.
- (Participant: double layer of remay row cover in a poly tunnel for his winter harvests of fall-planted spinach and kale, and transplants beginning in February.)

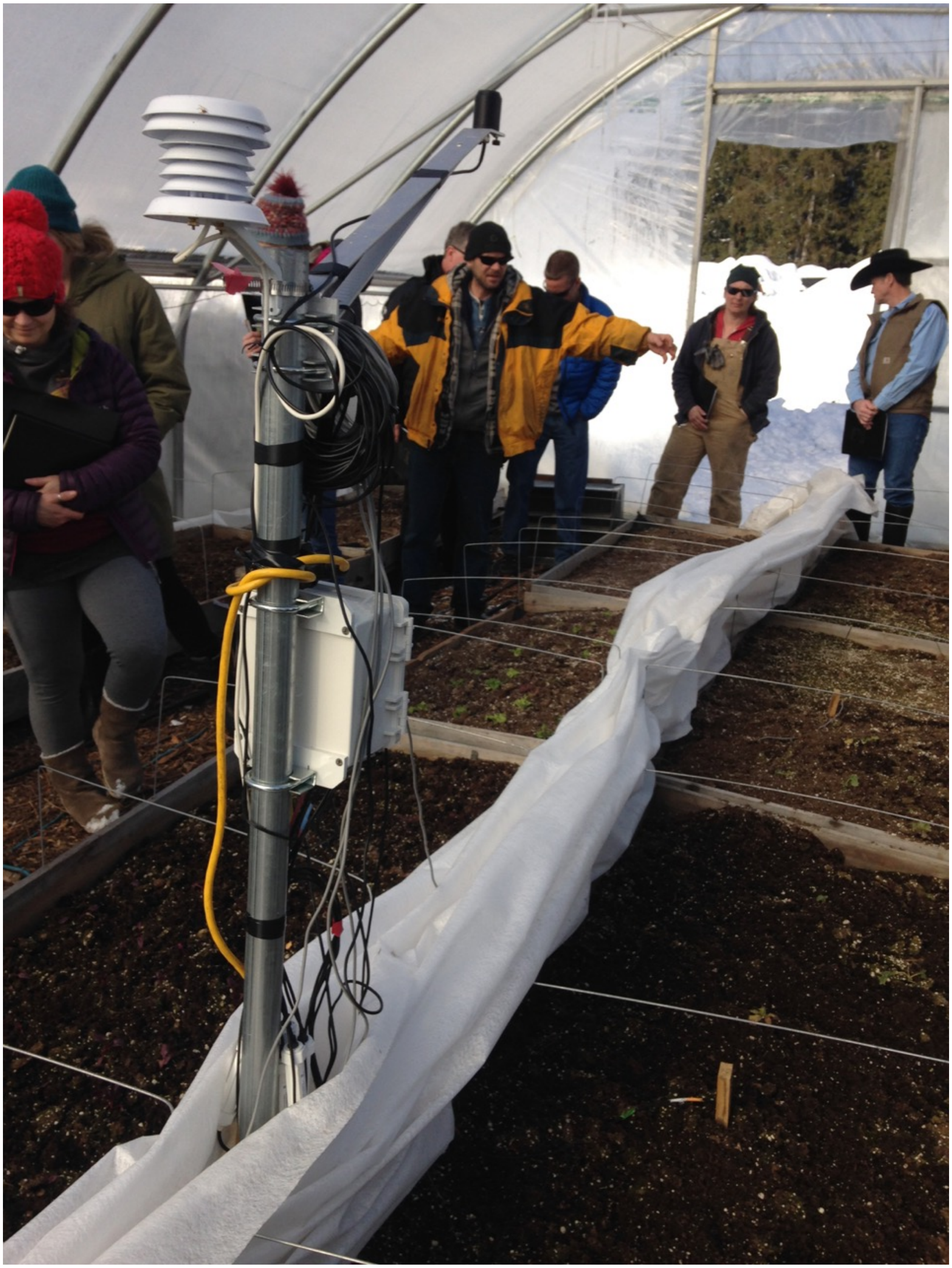
Pipes in Beds

- All beds were connected in series to the incoming warm water from the compost. In the beds, pipes "zig-zagged" in the soil medium.

- Freezing problems in water in pipes in beds (no freezing issues in compost pile). When a pipe freezes, it pops off one of it's elbow connectors outside the raised bed, making the problem easy to identify (at least!)
- Inconsistent soil heating. Data suggests there was a lot of variability in soil temperature between and within beds.
- Pipes exposed to greenhouse air, not under row cover or in soil, loses heat to greenhouse air where it is less available to warm soil/plants.
- Set-up is time consuming.
- Poly pipe pinched easily, and the 1/2" pipe over long distances has cumulative friction. Next time Terra Firma would consider other materials. Suggestions included pex and steel.
- Solution to pipe freezing could be some kind of temperature-controlled variable flow: high flow when it's cold out, low flow when it's warm out.

Data

- See attached sheets for data collected by Okanagan College researchers.
- Physical variables included: light intensity, air temperature, humidity, soil temperature, soil moisture.
- Biological variables included: marketable weight, total dry weight, leaf area.
- Too much variability in soil temperatures and soil moisture to get useful conclusions.
- Extreme minimum inside temperature was -6°C.
- Double wall greenhouse got approximately 20% to 25% less light
- Double wall greenhouse had 23 nights below 0°C compared to 29 nights below 0°C in the single-wall.
- Big cost in data collection was the live-to-internet data transmitter. On-farm experiments can use temperature probes for lower cost with a data logger that is downloaded from time to time.



The data collection hub in the middle of the single-walled greenhouse, connected to a variety of sensors. Both greenhouses had a central data logger that sent data regularly to a website. It is less expensive to have a data logger that collects data for occasional download, rather than transmitting it.

Varieties

- Four recommended: Salanova, Rainbow Kale, Red Devil Beet, Flamingo Chard. See separate handout on varieties.
- No go: Red Kitten Spinach - Don't do it in any season. Bolts even in the hoop house after a February planting.
- None of these varieties are tolerant of heavy frost, but other greens are.

Plant Starts

- Indoors, 3-4 weeks before planting out in mid February
- Standard 128-plug trays
- Short hardening off period (apologies, I missed the details here.)

- (Participant: considering the "Voltarc Trilight" as a super-bright alternative to T5s… more lumens, can possibly have fewer bulbs raised higher over plants.)

Hoophouse watering

- Total of 2-3 waterings between November and February.
- In March, watering every 2nd day
- Using cold water

Disease/Pests

- High humidity in late spring (lack of ventilation) seemed to lead to mold issues, with up to 50% of salad lost, and an increase in processing time to remove rotten leaves.
- Double-walled hoophouse had less disease.
- (Participant: Microgreen grower in Revelstoke, indoors under lights. Uses H_2O_2 to soak seeds and is always cleaning everything. "I feel like a professional dishwasher.")
- Issues with voles were very problematic at first, solved with combination of traps and cats.

Feb-April Yield

- Current hoop houses have 400 s.f. in growing space (1000 s.f. total space)
- Yield per hoop house is approximately 70lbs of marketable salad from February plantings harvested in April in the double-walled hoops, approximately 50lbs from the single-walled.
- If relative amount of growing space was increased, losses to frost were avoided with a back-up boiler, and only successful varieties were grown, perhaps 150lbs would be achievable.
- At $8/lb, that's a gross income of approximately $1200 per greenhouse.

Nov-Feb Yield

- No winter harvests were successful yet. The primary issue is the need to get plants growing in the fall, such as September plantings, but the greenhouses are still full of hot season crops (e.g. tomatoes) until into October. October plantings do not grow enough before they go dormant, and in the absence of a back-up heat source they have been killed off.
- With a moveable greenhouse, such that plantings can be started in August or September outdoors, and then have the greenhouse pulled over in October after the tomato harvest, could allow for ongoing harvests of dormant plants through the winter.

- An additional 150lbs harvested at $8/lb this way would add $1200 in gross income.

Total potential Yield

- A 20x50 double-walled hoophouse might be able to yield about 300 lbs of salad in combined winter and spring harvests, for a total gross winter income of $2400.
- The 20x50 double-walled hoophouse costs $7000
- A 30x100 double-walled hoophouse from the same manufacturer costs $13000 and, by extrapolation, could produce 750lbs for a total gross winter income of $6000.
- Terra Firma will be upgrading to a 30x100.

Benefits and advantages

- Despite low yields, the main advantage to Terra Firma of winter/spring offerings is "customer relations". In the early spring the farmers are busy in their fields, not marketing, so "it's easy for customers to forget about us." In this sense, the winter greens are a loss-leader to maintain customer connection.
- It is a distinct advantage to have a space to move plant starts into in the late winter/early spring, freeing up space under the lights for new starts. Without the heated hoophouse and with limited (and expensive) growing space under lights, there's a bottleneck in production.

Disadvantages

- More winter work, when they normally would take a less intense winter to recharge.
- Not profitable.
- Terra Firma is not likely to continue with the compost heating experiment, but will have a winter greenhouse heated by a boiler, likely a woodchip burner to use a readily available and free resource in Revelstoke.

Pile needs ample quantities of carbon, nitrogen, oxygen and water. The carbon in the inner layer of the pile will be unavailable at first. The lignins and cellulose in wood chips and sawdust resist decay but that is actually a good quality because the gradual oxidation allows for an extended thermophilic condition that can allow a large compost pile to last up to 18 months.

Compost Construction of Round Design

1. Find level area with good drainage.

2. Put down two 75’ lengths of Big-O piping on the ground. Make it so the ends are exposed.

3. Add compost 30’ diameter 3’ thick.

4. Unravel 3/4” poly tubing. Leave one end sticking out the pile 20’. Label intake.

5. Start laying down the tubing in large coils working into the inside.

6. Add two more feet of compost completely burying layer out coil.

7. Repeat steps five and six until you have about 20’ of tubing left so you can run it parallel to the 20’ of tubing that is sticking out from the bottom of the pile that you started with.

8. Pressure test the tubing before completely burying the pile.

9. Make sure that there is 4’ of material covering all of the tubing without burying the ends of the Big-O tubing.

10. Run the two ends into the greenhouse.

Compost Construction of Linear Design

1. Find a level flat piece with good drainage 30’ wide 80’ long.

2. Put down 150’ of Big-O tubing with the ends exposed.

3. Spread out bark mulch 3’ deep, 20’ x 70‘.

4. Start running lengths of three-quarter inch poly tubing lengthwise. Make sure you leave 20’ sticking out of the pile. Label intake.

5. Bury the lengths in horse manure or bark mulch 2’ deep.

6. Repeat steps four and five until you have 20’ left of tubing. Run that down beside the 20’ that are sticking out of the pile.

7. Pressure test the tubing before completely burying the pile.

8. Bury the pile with 4’ of mulch. Make sure the Big-O piping ends are exposed.

Manifold and Bed Construction

1. Install 20’ of 1/2” tubing in each bed with 2” of both ends sticking out on the same side of the box.

2. Take a piece of 3/4” PVC pipe and add 3 T-connecters and 2 NPT couplers on the ends. Install 1/2” barb fittings.

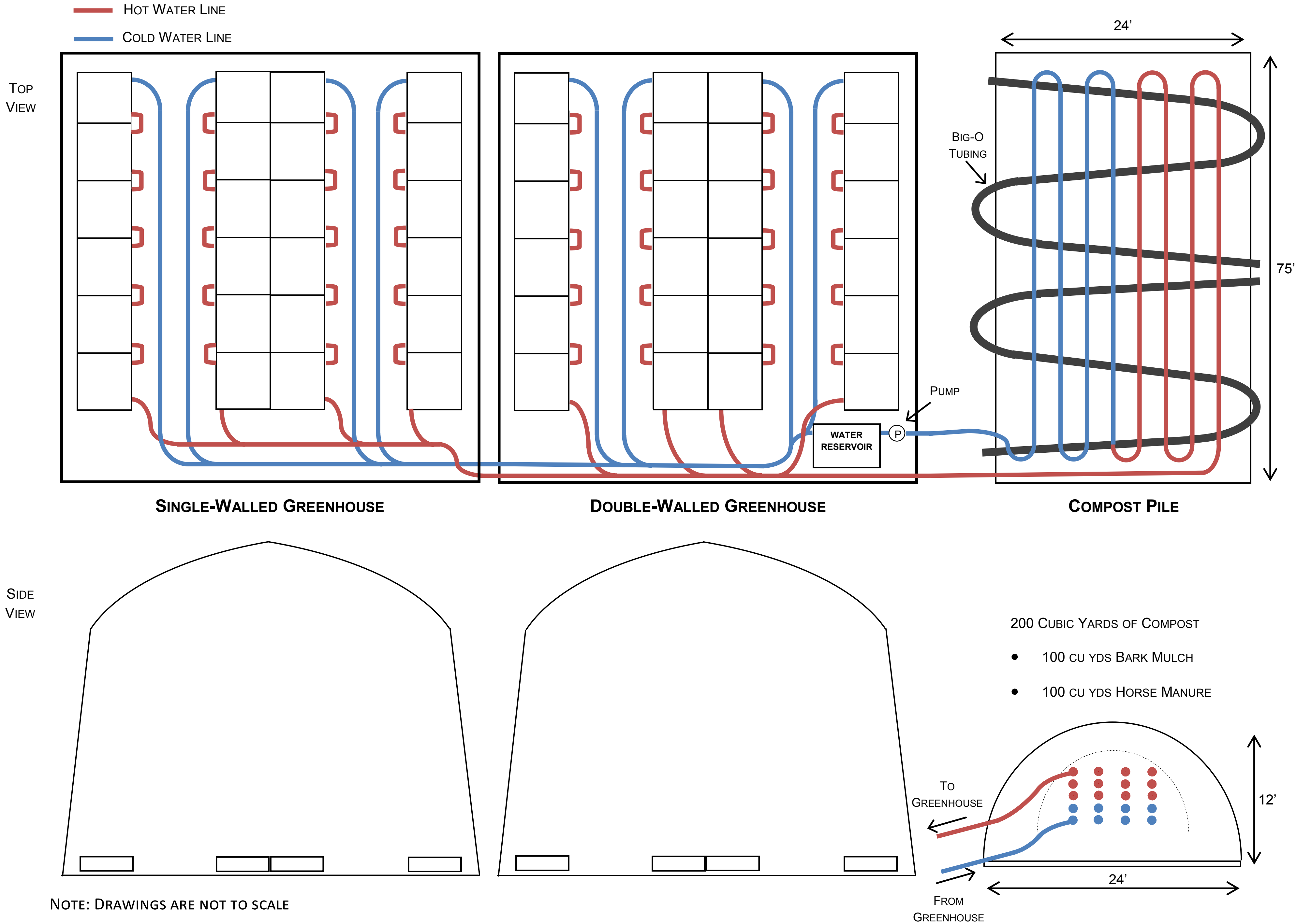
3. Repeat step 2. You will need 4 manifolds in total. On 2 of the manifolds install 1/2” valves with barb fittings on them. These are your return manifolds.

4. Connect 3/4” tubing to the return manifolds. Long enough so they can drain into the 45 gallon drum (reservoir).

5. Plumb a circulating pump in to the drum. Hook that up to the line labeled intake going into the pile. Hook the other line up to a T-connector that connects to the two manifolds without the valves.

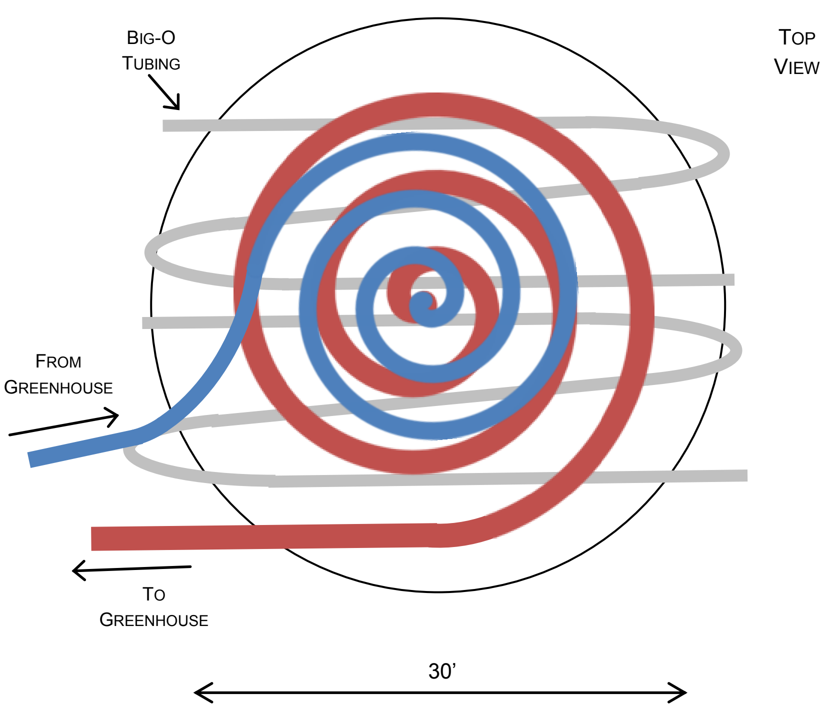
6. Hook up the beds to the manifolds.

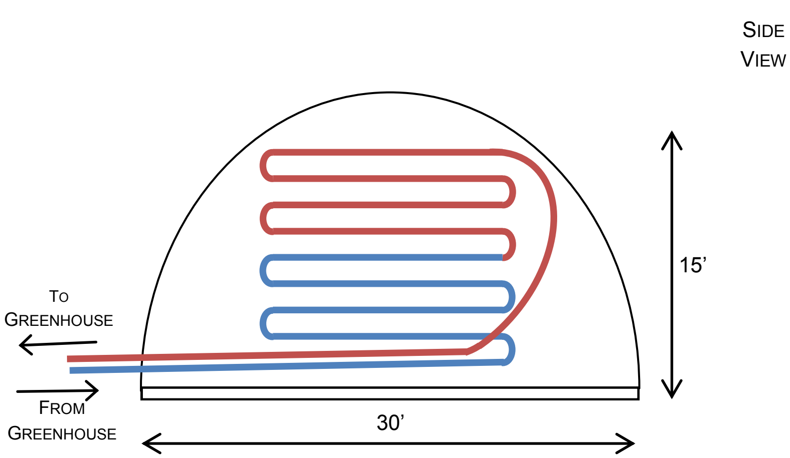
2017/2018



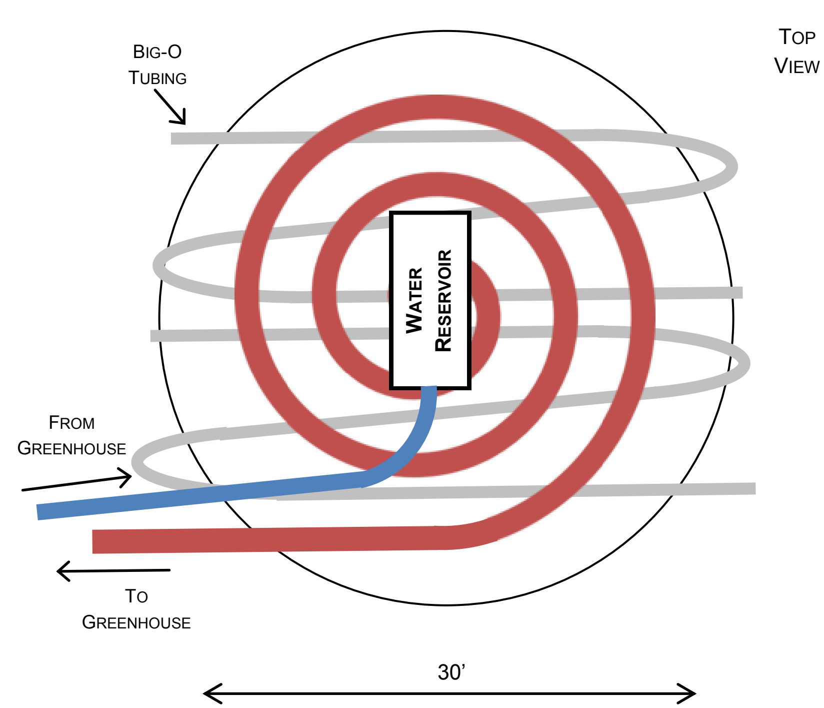
Note: Drawings are not to scale

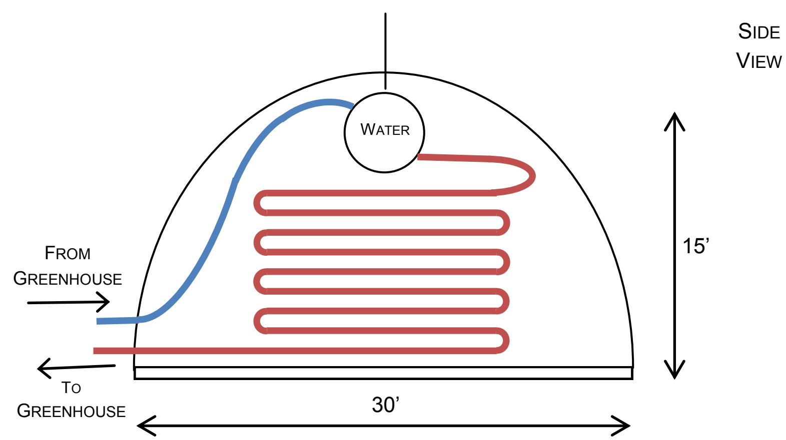
Compost Pile 2016/2017





Compost Pile 2015/2016





Note: Drawings are not to scale

Materials List for Compost Heat System

Compost Pile 2016-2017

- 40 cu yds Bark Mulch
- 75’ of 6’ Perforated Big-O Pipe
- 2000’ of ¾” Poly Tubing

Compost Pile 2017-2018

- 100 cu yds Bark Mulch
- 100 cu yds Horse Manure
- 150’ of 6” Perforated Big-O Pipe
- 5000’ of ¾” Poly Tubing

Heating Manifold

- 45 Gallon Drum
- Grundfos Circulation Pump
- 12 - ¾” NPT - ¾” Barb Connectors
- 6’ of 1” Steel Pipe (attached to drum to refill vertical mounted)
- 100’ of ¾” Poly Tubing (pile to manifolds)
- 20’ of ¾” PVC Pipe
- 12 - ¾” PVC T to ¾” NPT
- 4 - ¾” PVC 90 to ¾” NPT
- 8 - ¾” NPT Valve to ½” Barb (return control)
- 2 - ¾” Ball Valves (pile to manifold)

Beds

- 48 - 20’ rolls of ½” Heavy Poly Tubing
- 400’ of ½” Poly Tubing Return Lines
- 96 - ½” Barbed Elbows

Terra’s Soil Recipe

1 bale peat moss

4 - 5 gallon buckets of perlite

2 - 5 gallon buckets worm castings

9 cups Gaia Green All Purpose Fertilizer

Recommended Varieties

Salanova

Salanova lettuce was commercially available in 2013. Spring mix is comprised of harvesting lettuces or greens at a baby stage; because of the tenderness it has a short shelf life. In contrast Salanova is harvested at a mature full head stage with the core cut out to fall apart into individual leaves. The denseness of the leaves increases the shelf life. A typical head of lettuce is comprised of about 50 leaves while Salanova can have up to 200 bite sized leaves. It has been the work horse of our salad green production in summer and has shown that it can tolerate the freeze and thaw cycles of our winters with the use of row covers and double layered greenhouse.

Rainbow Kale

Rainbow Kale is a cross between Lacinato and Redbor Kale. The leaves can show a lot of variation in the colour on the same plant, from dark green to a deep purple with green or purple stems. We harvested it at baby leaf stage to add to salad mix as well as larger leaves for bunching and braising mixes over an extended period.

Red Devil Beet

Red devil beet is a variety of beet grown specifically for salad green production. Its leaves are bright magenta in cooler weather and can fade into partially green leaves when temperatures increase. The leaves can be harvested over an extended period of time with larger sized leaves used in braising mixes. Grows very slow during cooler months but has rapid growth in March and April when temperature and daylight increase.

Flamingo Chard

Flamingo chard has very glossy leaves with striking neon pink stems that create a beautiful contrast to the salad mix. This variety grew very well for us from our February plantings. There was a high percentage of crop loss from our fall planted crops. We do not recommend growing this variety until February.

Vates Kale

Vates Kale is an open-pollinated variety which makes it an inexpensive choice for the larger quantities needed for salad production. It performed well in each of the February plantings. There were some germination issues as well as crop loss in our final year planting so it will be difficult to tell if it performs as well as Rainbow Kale.

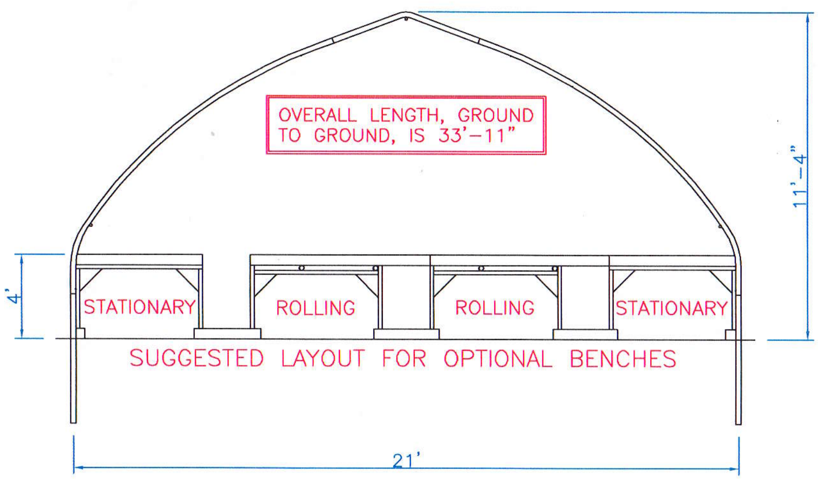
Extended harvests and multi-stage harvesting from both varieties of kale, flamingo chard and red devil beets allowed us to have multiple product on our market table. We were able to sell an attractive salad mix, braising mix as well as bunches of chard and kale early in the season. This improved customer retention from previous years.

Recommended Planting Dates

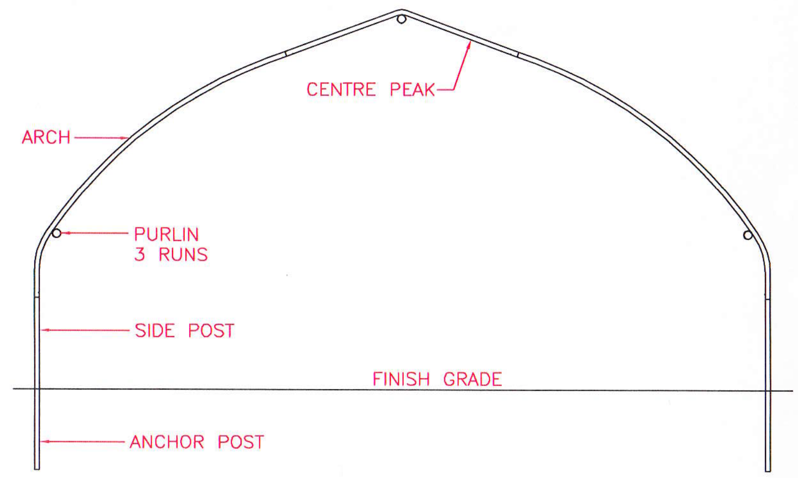
Survival of February planted crops were high with maturity about 60 days after transplanting from a 3-4 week old transplant.

October plantings had a 100% crop loss in 2015/16 and 2016/17 with additional protection of Remay fabric. In the October 2017 planting over 50% of crop was lost in the single layer greenhouse and about 25% crop loss in double layer greenhouse. The higher survival rate is likely from the addition of a Dewitt Ultimate Overwinter Cover. The estimated days to maturity from this planting is 160 days.

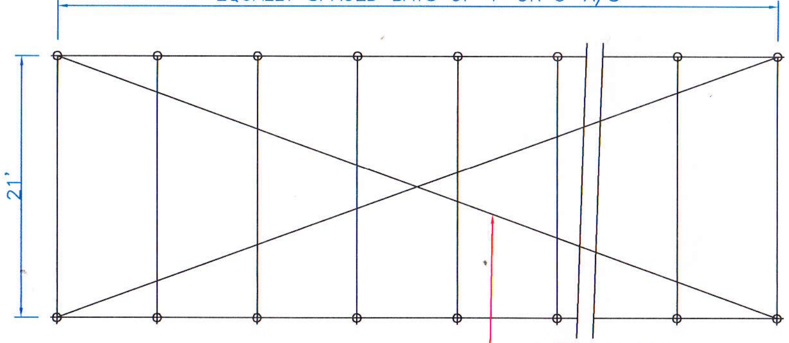
Although much of the 2017/2018 crop survived the winter (with temperatures below -10˚C for extended periods), they remained dormant during the coldest darkest months. Considering the increased days to maturity from the early planting we see no advantage to planting in the fall over a February planting.



SUGGESTED LAYOUT FOR OPTIONAL BENCHES

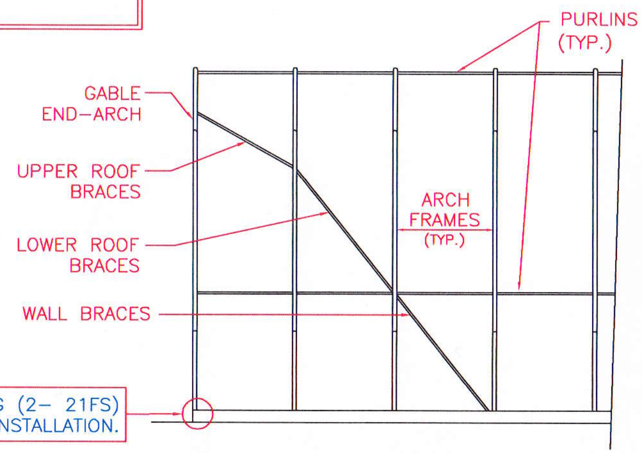


DESIGN DATA ACC. TO NGMA1996
GROUND SNOW LOAD 40 PSF
WINDLOAD 70MPH
CONTINUOUSLY HEATED IN WINTER SEASON
ALL STEEL IS 50 KSI MIN. YIELD & GALVALUME COATED
ALL HARDWARE IS GRADE 5 MIN QUALITY



ANCHOR POST LAYOUT

STND 36" SIDE POST
UPPER ROOF BRACES
4 A/S ø1 1/4" X 54 3/4"
5 A/S ø1 1/4" X 66 1/2"
LOWER ROOF BRACES
4 A/S ø1 1/4" X 93 3/8"
5 A/S ø1 1/4" X 100 1/8"
WALL ROOF BRACES
4 A/S ø1 1/4" X 73 7/8"
5 A/S ø1 1/4" X 82 1/4"

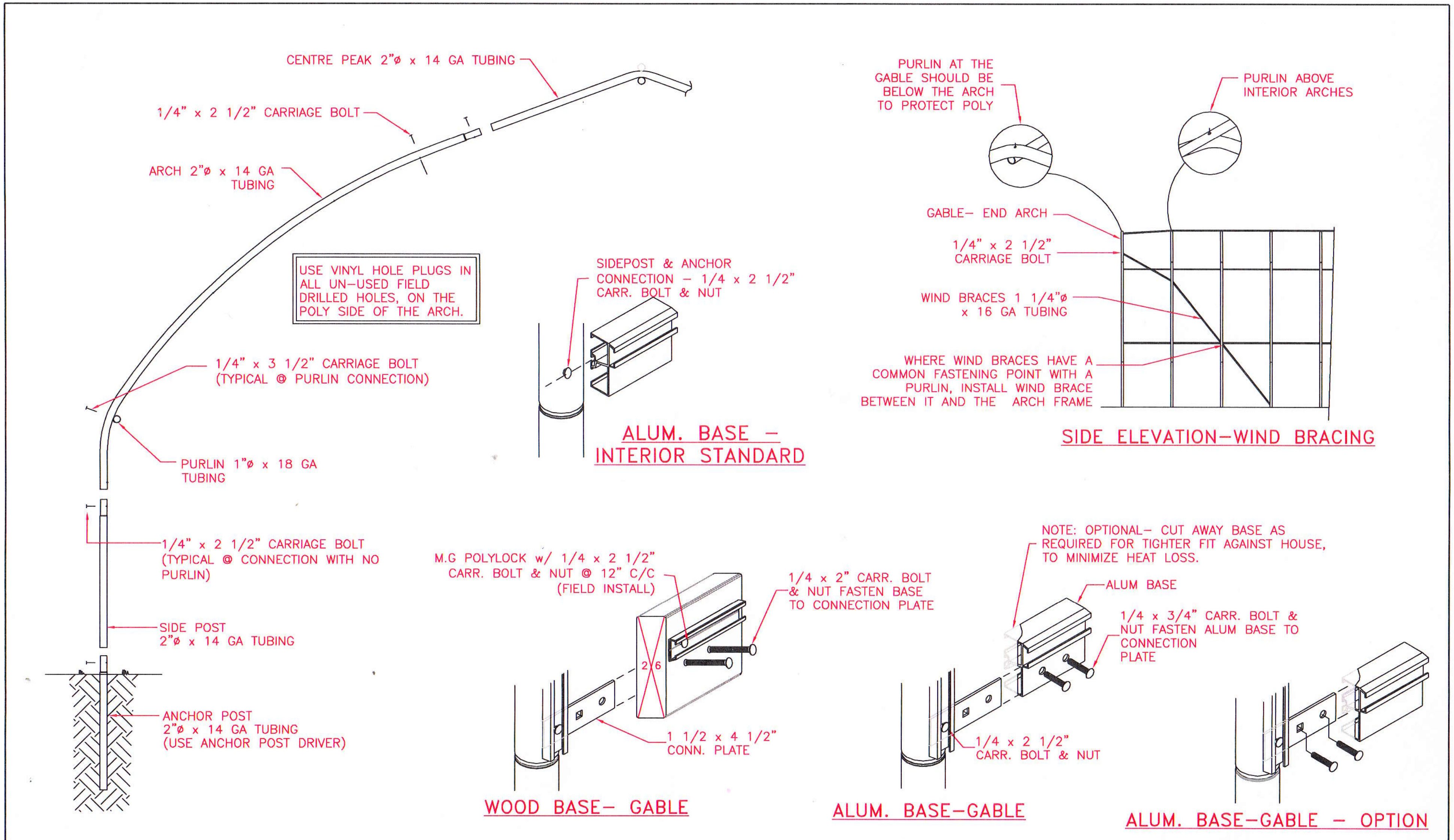


SEE ASSEMBLY DETAIL DRAWING (2- 21FS) FOR BASE OPTION INSTALLATION.

SIDE ELEVATION-WIND BRACING

CUST:	DESCR: 21' FREESTANDING GREENHOUSE ASSEMBLY	DWN. BY: F.S.	DATE: JUN. 14/05
		CHK. BY:	DWG NO: 1-21

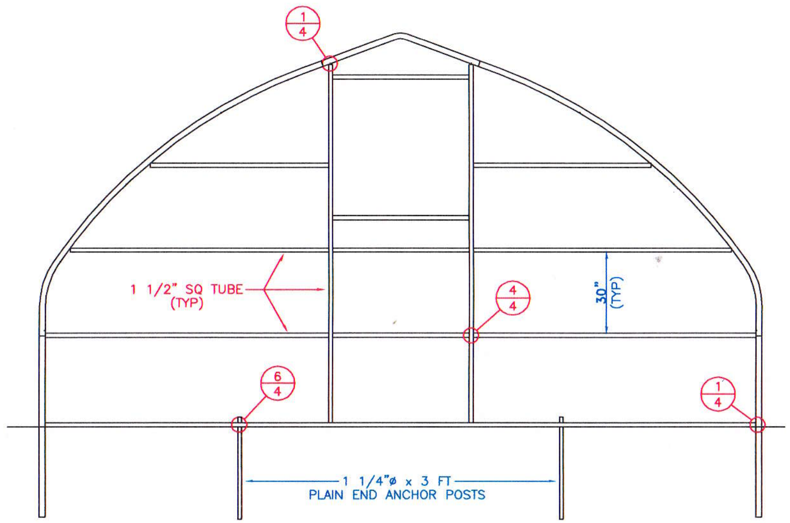
PaulBoers
TOTAL GROWING SYSTEMS
Tel: 905-562-4411
Fax: 905-562-5533
support@paulboers.com

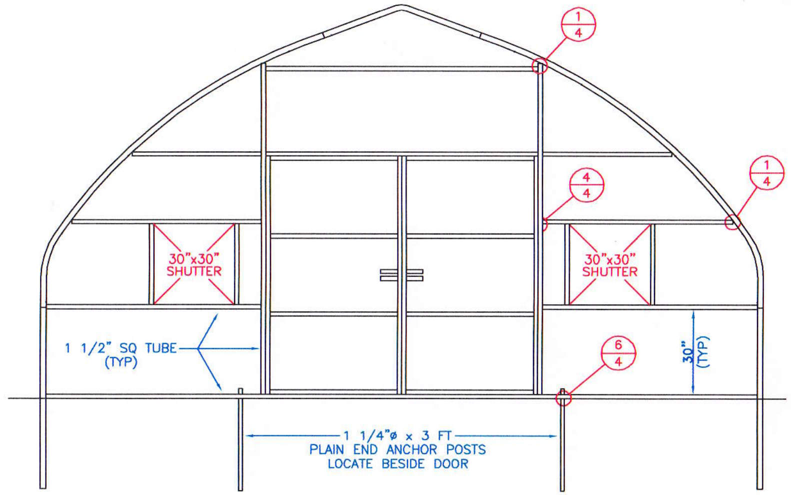


CUST:	DESCR: 21' FREESTANDING GREENHOUSE ASSEMBLY DETAILS	DWN. BY: F.S.	DATE: FEB. 02/09	PaulBoers TOTAL GROWING SYSTEMS	Tel: 905-562-4411
		CHK. BY:	DWG NO: 2-21		Fax: 905-562-5533 support@paulboers.com

FRAMING NOTES

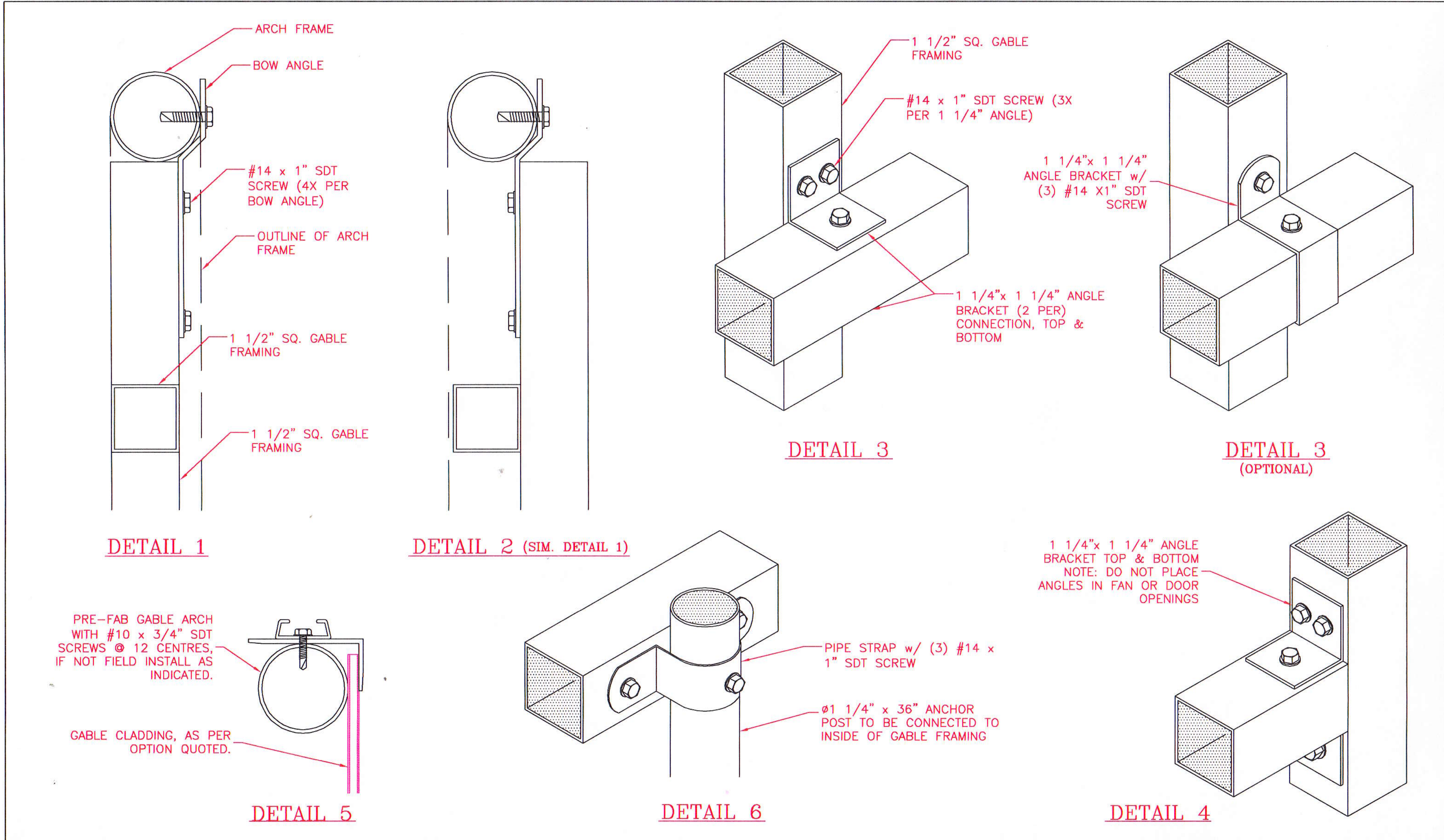
1. FOR DOOR FRAMING DIMENSIONS, SEE SEPARATE DRAWING.
2. FOR FRAMING DIMENSIONS OF FANS AND SHUTTERS, MEASURE THE ACTUAL UNIT. BE SURE TO ALLOW FOR ANY BOLT HEADS ON THE OUTSIDE OF THE UNIT.



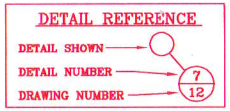


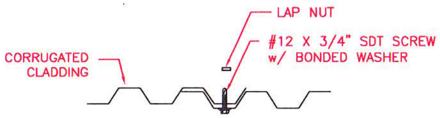
CUST:	DESCR:	DWN. BY:	DATE:	
	21' FREESTANDING GREENHOUSE ASSEMBLY GABLE FRAMING-DOOR SAMPLE	F.S.	MAY. 04/04	PBL Paul Boers TOTAL GROWING SYSTEMS
		CHK. BY:	DWG NO: 3-21	

Tel: 905-562-4411
Fax: 905-562-5533
support@paulboers.com



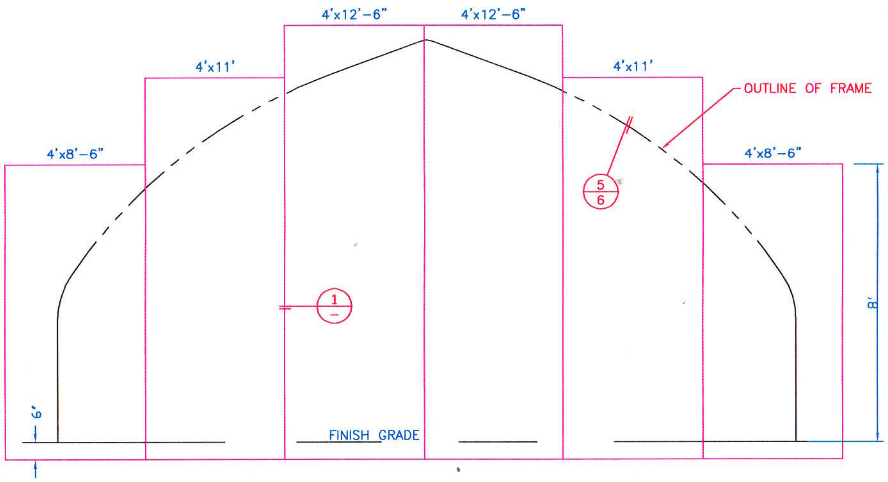
CUST:	DESCR:	DWN. BY:	DATE:		
	FREESTANDING "WIDESPAN" GREENHOUSE	F.S.	JUN. 14/05	PBL Paul Boers TOTAL GROWING SYSTEMS	Tel: 905-562-4411
	GABLE FRAMING DETAILS	CHK. BY:	DWG NO: 4-21GF		Fax: 905-562-5533
					support@paulboers.com



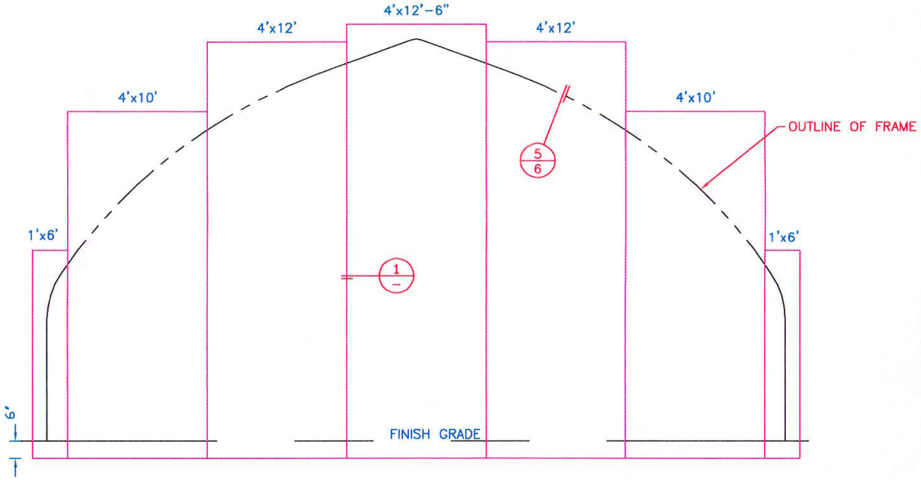


DETAIL 1
PANEL JOINT

DETAIL 1
PANEL JOINT

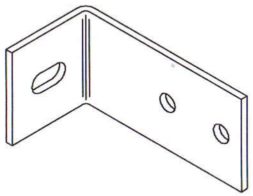


DOOR GABLE

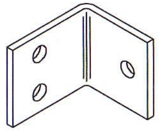


FAN GABLE

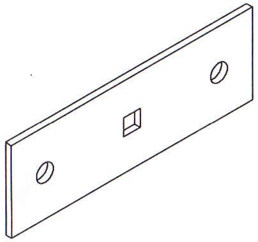
CUST:	DESCR:	DWN. BY:	DATE:		
	21' FREESTANDING GREENHOUSE ASSEMBLY GABLE CLADDING-DOOR/ FAN SAMPLE	F.S.	MAY. 04/04	Paul Boers TOTAL GROWING SYSTEMS	Tel: 905-562-4411 Fax: 905-562-5533 support@paulboers.com
		CHK. BY:	DWG NO: 5-21		



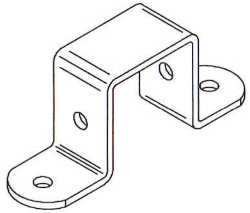
LONG ANGLE CLIP
PT #PSGEN4318



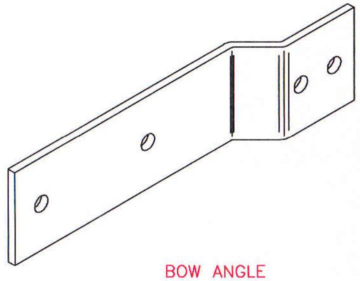
SMALL ANGLE CLIP
PT #PSGEN4256



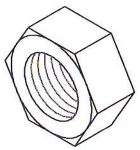
CONNECTION PLATE
PT #ASGEN6673



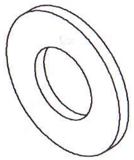
PURLIN CLIP
PT #PSGEN3298



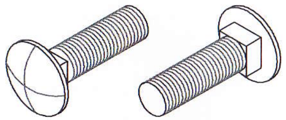
BOW ANGLE
PT #ASGEN8292



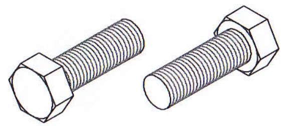
PLAIN HEX NUT OR
NYLON INSERT LOCKNUT
(MANY SIZES AVAILABLE)



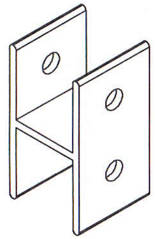
ROUND STEEL WASHER OR
BONDED STEEL/RUBBER WASHER
(MANY SIZES AVAILABLE)



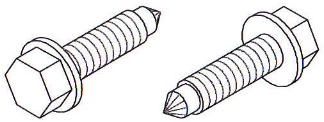
CARRIAGE BOLT
(MANY SIZES/LENGTHS AVAILABLE)



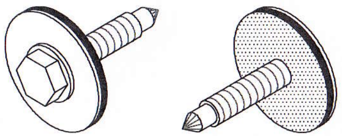
HEX BOLT
(MANY SIZES/LENGTHS AVAILABLE)



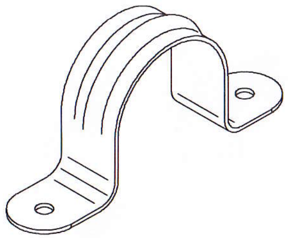
ALUMINUM 'H' SASHBRACKET
PT #ASVEN1677



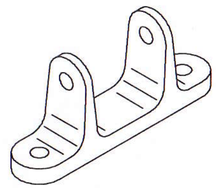
SELF DRILLING/TAPPING SCREW
WITHOUT WASHER
(MANY SIZES/LENGTHS AVAILABLE)



SELF DRILLING/TAPPING SCREW
WITH BONDED RUBBER WASHER
(MANY SIZES/LENGTHS AVAILABLE)



PIPE STRAP
(MANY SIZES AVAILABLE)



RIDDER ALUMINUM SASHBRACKET
PT #PSVEN1509

REV.	REV. DATE	DESCRIPTION	APP.

CUSTOMER: PARTS SHOWN ARE NOT TO SCALE. YOU MAY NOT RECEIVE ALL PARTS SHOWN. REFER TO PACKING LIST FOR ALL PARTS.	TITLE: PART IDENTIFICATION DRAWING	DWG #: PART IDENTIFICATION DRAWN BY: TKM DATE: 2005/06/09 PAGE: 1 OF: 1	Paul Boers Ltd.

BUILDING YOUR NEW PAUL BOERS FREESTANDING HOUSE

Thank you for the recent purchase of your Freestanding structure. The intention with this booklet is to make this a very positive experience for those who have built before, as well as those who have not. As we go through the procedures, you will be able to see some helpful hints added, which have been compiled by feedback from professional builders, as well as customers and builders who have called in their comments.

It is very important that you study your drawings and material lists. Quite often, you may see special instructions on your material list, which may only apply to your structure, depending on the options purchased. Some time spent comparing the material list with the components you received will pay off. In the past, some customers have had to remove or disassemble something they did not do correctly. Of course this is not the most cost-effective way of building! Please keep in mind, we are always a phone call away, and there is no need to guess what to do.

REQUIRED TOOLS

A few things you will need to have ready for site preparation:

- Measuring Tape (preferably 100')
- Sledge Hammer
- Mason String (a good quality string that can be pulled tight without breaking)
- Orange or other bright color paint which could be used to paint the 4 corner anchor posts (this is optional, but may be considered to make it easier to see them from a distance)
- A helper would be an asset when laying out the anchor posts. Especially when the house is longer than 24'.
- Stakes
- Step Ladder
- Pipe Wrench, or Screwdriver – (for turning anchor posts into alignment)
- 7/16" & 1/2" Wrench or Socket & Ratchet – Fits ¼" & 5/16" hex nut. A ratchet & socket combination will allow for faster installation of the bolts, but be careful when tightening the hex nuts with the ratchet. Otherwise, you could break the bolts!

STEP # 1 – PARTS IDENTIFICATION

This step will help to familiarize you with the components you receive with your order. The easiest way to do this is to have your material list(s) and drawing(s) together at the start. Compare the drawings to the material list. This should be enough for you to make a positive identification of the components.

STEP # 2 – SITE PREPARATION

This is perhaps one of the most important steps to follow prior to starting the building of your coldframe. Without proper site preparation, as you proceed with the building, you will discover that things will not go together as easily as they would, had you prepared the site adequately beforehand. (Refer to drawing # 02)

- Level building site to enable surface water to run off. Do not exceed slope of 6" over 100'

- The idea is to not have to fill any low spots, as this reduces the "bearing" capacity of the soil around the post.

STEP # 3 – ANCHOR POST INSTALLATION

- A helper would be an asset when laying out the anchor posts. Especially when the house is longer than 24'.

- Using stakes and a 100' tape, lay out the 4 corner posts using the 3,4,5 squaring method (see drawing #s 02 and 03). The 4 corner stakes you install can represent the actual placement of the posts. An accurate layout of posts will definitely facilitate an easier assembly of your structure. When you are measuring out for the next anchor post, always take your measurements from the end post (i.e. from the end post to 4', 8', 12' or 5', 10', 15' etc.). Otherwise, if your first post is out a little (also known as "drifting"), you will duplicate the mistake to other bays of the structure.

- Use Mason string for sides to keep posts in line. Measure the post spacing down the sides using the 100' tape. Mark the post spacing by pressing the post into the ground.

- An anchor post driver is supplied with each greenhouse. This slips over the top of the anchor post, and prevents the top of the post from becoming deformed. Do not try pounding the posts into the ground with as few drives as possible, as this could damage the post driver prematurely, and result in damage to the swaged part of the anchor. Keep the hole in the anchor 90 degrees to the length of the house. If the post turns in the ground, and the hole goes out of alignment, use a pipe wrench to turn the post to the correct position. Also, a screwdriver could be slipped through the holes in the anchor post to turn it to the proper location.

STEP # 4 – ARCH & FRAME ASSEMBLY

- As in drawing # 03, lay out the sideposts, arches, center peaks, etc. Assemble arches as in the drawing. Also, lay the purlins down the sides of where you are to build the structure. Place the bracing at the gable ends. Assemble all components for a complete arch using fasteners as indicated in your drawing and listing package. Do not tighten bolts at this time. Once you have completed an arch, lay it alongside the anchor posts, which have already been driven into the ground (refer to drawing 03-A) in your drawing booklet.

- When all of the arches have been assembled, you are ready to start placing them onto the anchor posts. For this job, it is recommended that you have another person assist. This way, the entire arch can be placed onto the anchor posts, and at the same time, the proper fastener can be slid through the hole in the arch and anchor connection. Again, it is recommended that the bolts are left loose at this time. This enables you to adjust the frame as required, making installation of purlins and bracing easier (refer to drawing 04).

- Once you have installed at least 4 complete arches onto the anchor posts, you may decide to start to install the purlins at this time. If you do, it is more practical to start with the ridge purlin. It is recommended that you install the ridge purlin on the outside of the frame, whereas the 2 runs of side purlin can be installed on the inside of the structure. The reason for having the ridge purlin on the outside of the frame is to keep the poly from stretching too much between the arches (refer to drawing # 04A).

- Starting with the un-swaged end of the purlin facing the outside of gable end of the house, slip a ¼ X 3 ½" carriage bolt through the hole in the purlin and arch. Put on a hex nut, but do not tighten yet. Put the next bolt through, and when you get to the last hole in the purlin, slip the next purlin into the first one, and bolt through this connection into the arch. Carry on this way until all purlins are installed.

- When installing the wind bracing (refer to drawing # 04B & 04C), start by installing on end onto the arch to anchor post connection of the second arch from the gable. The brace will share the bolt at this connection. Again, do not tighten the hex nut at this time.

- Then take your next brace, and install one end onto the connection where the side purlin meets the square gable arch (see drawing # 04C with exploded detail). For this connection, the brace will share the purlin-to-arch bolt. Pin the brace underneath the purlin, and thread on a hex nut.

- Once you have these connections in place, have an assistant hold the gable arch steady with a level placed against the outside of it. Once you are certain that the gable arch is level, the purlins, which you have already installed, should pull the other arches level as well. Now is the time to bring both loose ends of the braces together, and center the holes in the bracing on the arch. You can mark the hole location with a marker then drill the hole, or drill through the bracing hole (using a 17/64" drill bit) into the arch. This connection will be bolted with a ¼" x 2 ½ " carriage bolt and hex nut. Leave the hex nuts on the structure finger-tight until the frame is complete.

- Once you have assembled the entire structure, it is time to tighten the hex nuts. If you are using a ratchet and socket, be careful not to over tighten the hex nuts, or you could snap the bolt off!

This booklet covers the basic structure only. There are various options, which can be added, and will be accompanied by the appropriate drawings and instructions as they are purchased with your order.

We at Paul Boers hope that your building experience will be a pleasant one, and wish you all the best in your business endeavors!

RELEASED MAY 1, 2001

Climate Action Initiative
BC AGRICULTURE & FOOD

Adapting to low light/low temperature conditions using high-tunnel structures in Revelstoke, British Columbia

Research Factsheet

Farm Adaptation Innovator Program

Terra Park[1], Rob Jay[1], Andrew Perkins[2], Brian May[3] and Michael Mitsch[3]

Geographic Applicability: This study was conducted in Revelstoke and findings may be applied to other regions in British Columbia with limited light exposure and reduced temperatures.

Commodity Relevance: This study was conducted on a variety of salad greens grown under low light/low temperature conditions with different greenhouse insulation conditions. The findings may be extended to other hardy greenhouse crops.

Study Timeline: September 2015 - January 2018

[1] Owner, Terra Firma Farms, Revelstoke
[2] Professor, Faculty of Geography, SFU, Burnaby
[3] Professor, Faculty of Science, Okanagan College, Salmon Arm

Background

This demonstration project studied the viability of winter salad green production in a low-cost, high-tunnel greenhouse structure heated with compost in low light conditions without supplemental lighting over a three-year period. Many communities in the Columbia Basin and in other regions of British Columbia face similar challenges with their growing conditions as a consequence of regional climates, and potential influences of climate change, such as increased severity and frequency of winter storms, resulting in more extreme fluctuations in light intensity. Transportation of food into these communities creates a variety of attendant issues, including higher costs of transporting produce, and attendant increases in the use of petroleum fuels (and consequent emission of greenhouse gases). The project trialed seven different varieties to find a mix of cold-hardy greens that will provide a high quality mixed green salad for customers.

Study Objectives

- Determine if high-tunnel greenhouses can withstand snow load and temperature variations.
- Identify salad green varieties that may be commercially viable under low light/low temperature conditions with low-cost input.
- Compare single and double layered high-tunnel greenhouse structures for insulation/heat retention abilities and effects on plant yields.

Key Findings

- Double layered, insulated high-tunnel greenhouse is: 1-2°C warmer, soil temperature is 0.72°C higher, reduces PAR by 15.5 µE/m²s and relative humidity by 2.1% compared to a single layer, uninsulated high-tunnel greenhouse.
- Plant viability was demonstrated from February–April with certain varieties preferring the warmer double layered, insulated greenhouse (Salanova and Pearl lettuce), others preferred higher PAR of single walled uninsulated greenhouse (Red kitten spinach, Red devil lettuce, Rainbow kale, Flamingo chard, Rouge d'hiver lettuce), while some varieties (Vates Kale, Refugio and Winter density lettuce) showed no preference.
- First year approximately 100lbs wet yield, 5% more in double layer high tunnel structure.
- Second year approximately 125lbs wet yield, 40% more in double layer high tunnel structure.
- Not all greens handled the stress of cold, low light conditions the same. Salanova Lettuces, Vates Kale and Flamingo Chard have been clear winners.

Definitions

PAR: photosynthetically active radiation; light from visible spectrum absorbed by plants

High tunnel structures: large peaked greenhouses needed for snow shedding/ removal and sunlight accession.

Design

This project was conducted on one site located in Revelstoke. One high tunnel structure had double layer plastic with air insulation while the other had only a single layer covering. Environmental conditions (air and soil temperature, relative humidity, photosynthetically active radiation (PAR), and soil moisture) were collected via automated HOBO data link. Seedlings were planted in February and representative plants collected from replicate plots in April for dry weight and leaf area analysis (2016 and 2017) and commercial wet weights recorded.

Limitations

This study was conducted on an operational farm using a low-cost/input system subject to environmental and seasonal variation in temperature and light exposure resulting in variability between production years. Results indicate all year production is not possible as productivity is very low due to poor environmental conditions.
The current processes can extend the season an extra month but the extra effort clearing snow may not be worth it. Winter is a great time for farmers to rest and rejuvenate!

Next steps

While the findings from this study provide useful information to producers, future work is required to apply these findings to the industry. Environmentally controlled experiments in the greenhouse would provide more information on specific thresholds which farmers can use as guidelines for management practices. The practice is low-cost and low-tech, making it a good fit for communities with limited skills in greenhouse production. Having product ready for the early spring markets is valuable for customer retention but more energy intensive efforts are required for year round production in cold climates with limited sunlight.

Climate Adaptation Implications

Adoption of this technology and agricultural practice may accelerate/extend growth season of salad green production in low temperature/low light regions.

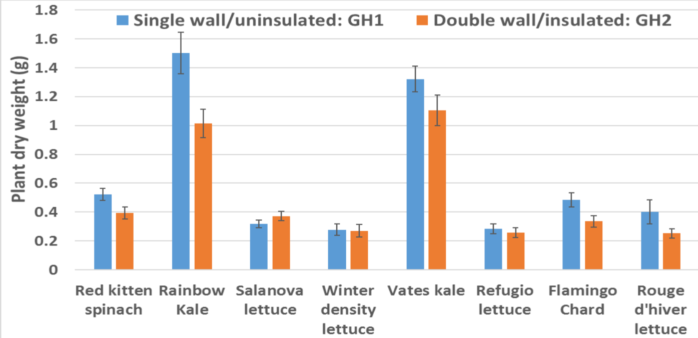


Figure 1: Plant dry weights (g) Feb-April 2016

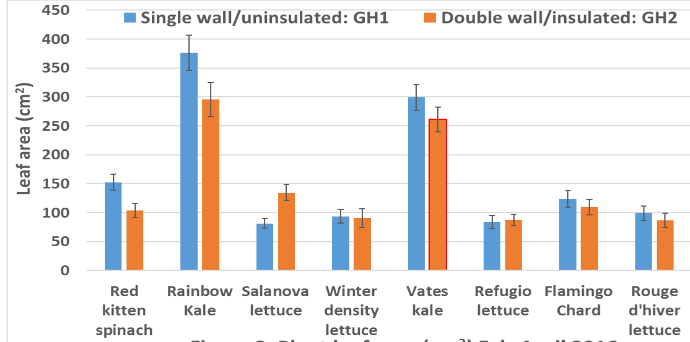


Figure 2: Plant leaf area (cm^2) Feb-April 2016

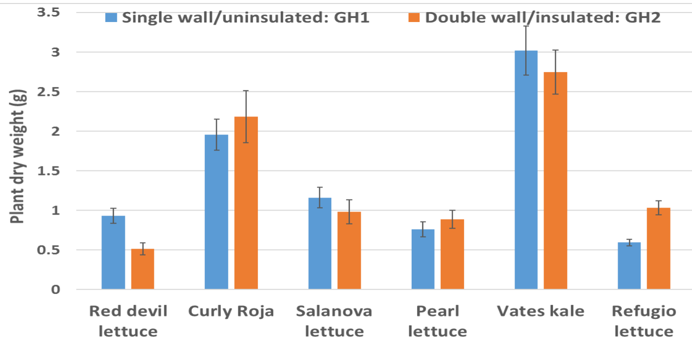


Figure 3: Plant dry weights (g) Feb-April 2017

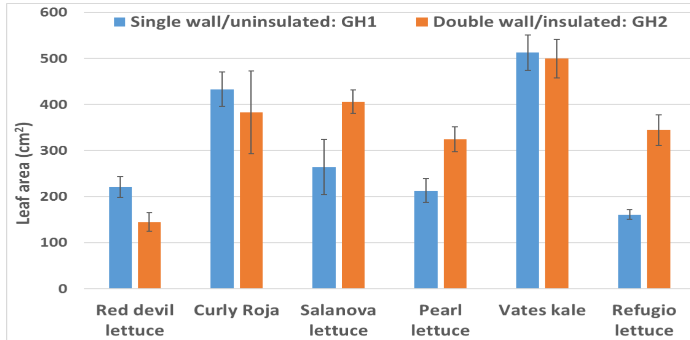


Figure 4: Plant leaf area (cm^2) Feb-April 2017

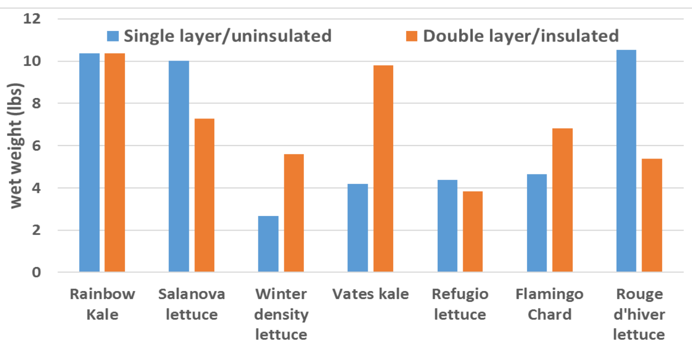


Figure 5: Marketable wet weight (lbs) Feb-April 2016

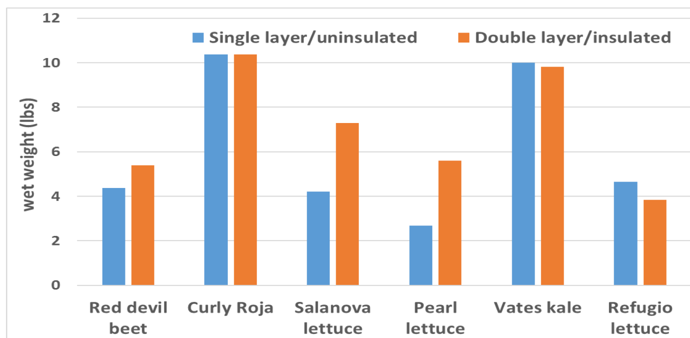


Figure 6: Marketable wet weight (lbs) Feb-April 2017

Comparison of plant growth between single layered uninsulated and double layered insulated high-tunnel greenhouse structures.

For more information related to this project and greenhouse production in general:

For more details on this project visit the Climate Action Initiative website:
https://www.bcagclimateaction.ca/faip-project/fi14/

High tunnel greenhouse environmental data from this research available at:
http://www.lowlightgreenhouses.com/index.html

B.C. greenhouse production
https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/greenhouse-vegetables

Commercial greenhouse production stats
https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1443

Greenhouse season extension
http://www.acornorganic.org/resources/library/video/season-extension-strategies-without-a-greenhouse-greenberg

Harrow Research and Development Centre
http://www.agr.gc.ca/eng/science-and-innovation/research-centres/ontario/harrow-research-and-development-centre/?id=1180624240102

The future of greenhouse production
https://www.greenhousecanada.com/inputs/crop-culture/a-look-into-the-future-3209

Funding and support for this project was provided in part by:

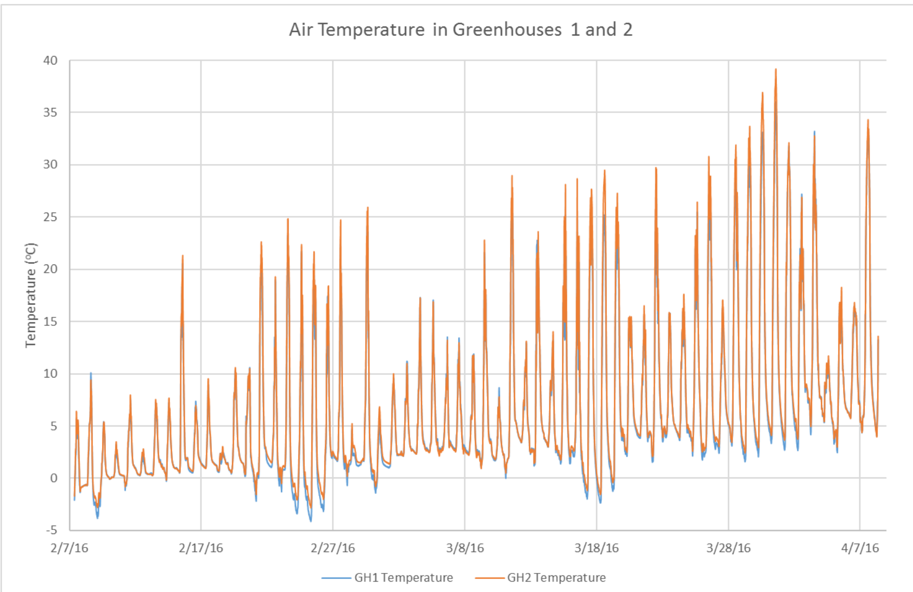
Growing Forward 2
Investment Agriculture Foundation of British Columbia
ardcorp
Climate Action Initiative BC Agriculture & Food
British Columbia
Canada

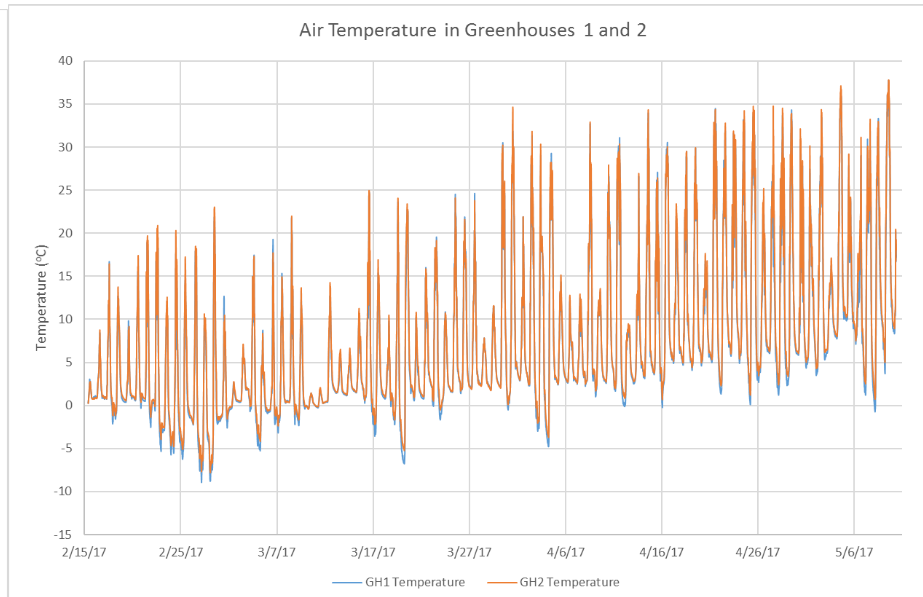
Low-Light Growing Adaptation – Data Summary

1. Air Temperature

Air temperature measurements – taken roughly 2 m above ground in each greenhouse.

Fig 1. Air temperature – Year 1 and Year 2.



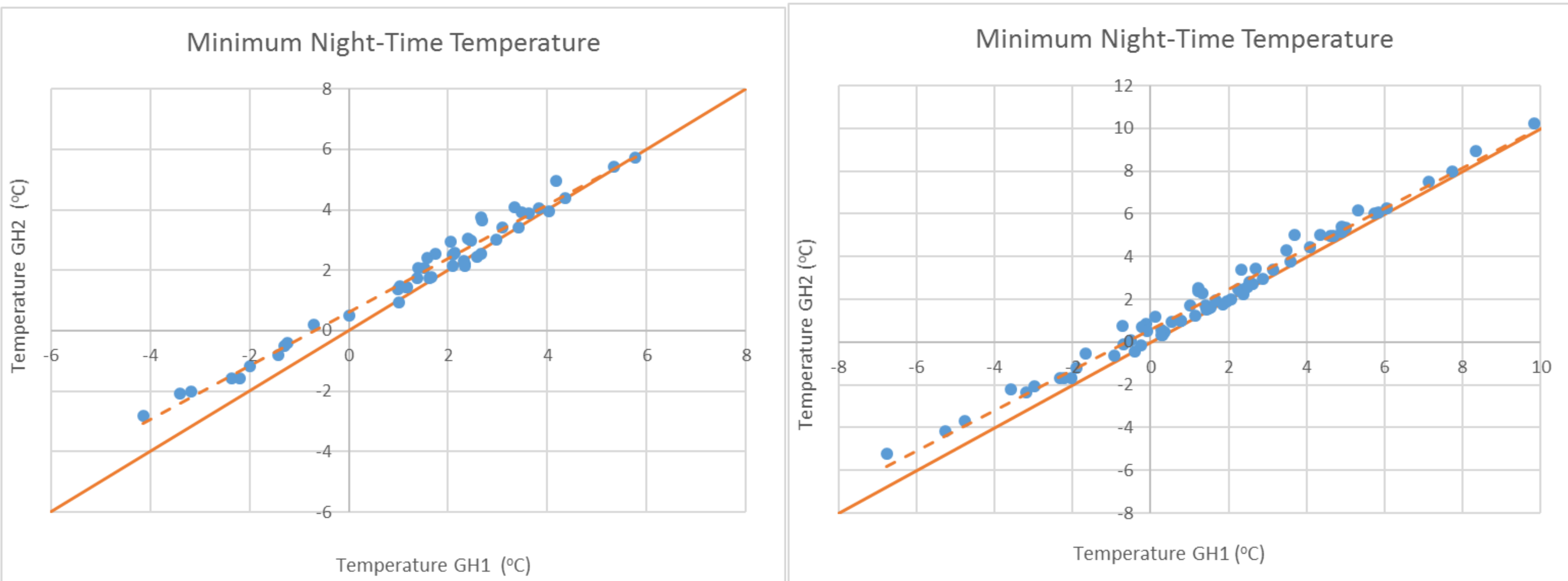


- Greenhouse 2 is **warmer** than Greenhouse 1.
  Year 1: Average temperature difference is 0.43 ± 0.15 ^{o}C
  Year 2: Average temperature difference is 0.50 ± 0.09 ^{o}C

2. Night-Time Minimum Temperature

The night-time minimum daily temperature was calculated for each greenhouse.

Fig. 2 Night-time minimum temperatures – Year 1 and Year 2.



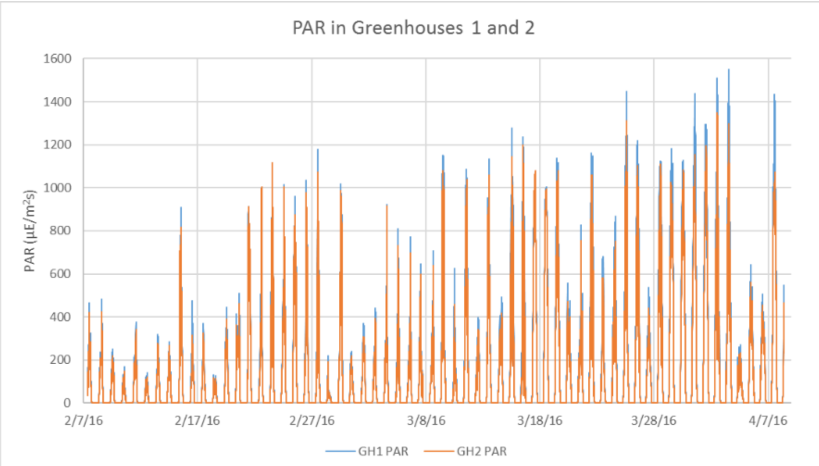
- Greenhouse 2 is **warmer** than Greenhouse 1.
  Year 1: Average minimum night-time temperature difference is 0.39 ± 0.10 ^{o}C
  Year 2: Average minimum night-time temperature difference is 0.52 ± 0.10 ^{o}C

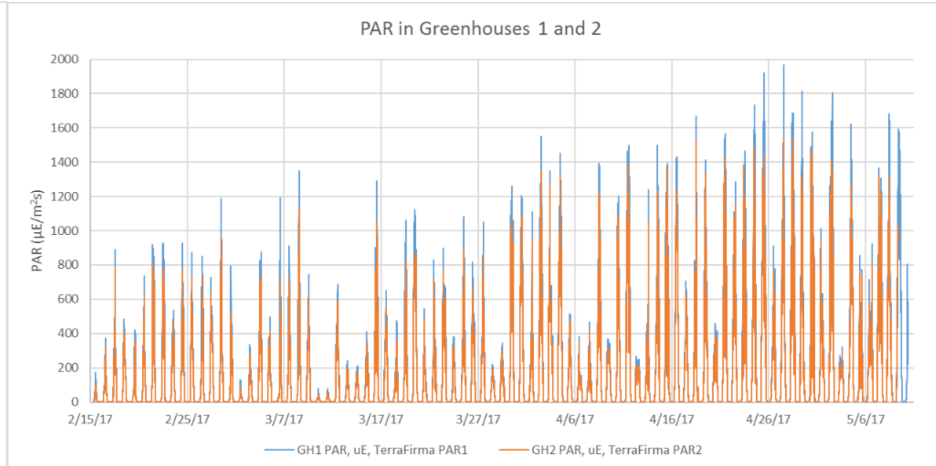
- Greenhouse 2 has **fewer** sub-zero nights than Greenhouse 1
  Year 1: Greenhouse 1 had 15 sub-zero nights; Greenhouse 2 had 14 sub-zero nights
  Year 2: Greenhouse 1 had 29 sub-zero nights; Greenhouse 2 had 23 sub-zero nights
  The temperature difference is more pronounced for sub-zero nights (0.71 ± 0.24 ^{o}C and 0.84 ± 0.16 ^{o}C)

3. Photosynthetically Active Radiation (PAR)

Light intensity was measured at roughly 2 m above ground in each greenhouse.

Fig. 3 PAR - Year 1 and Year 2



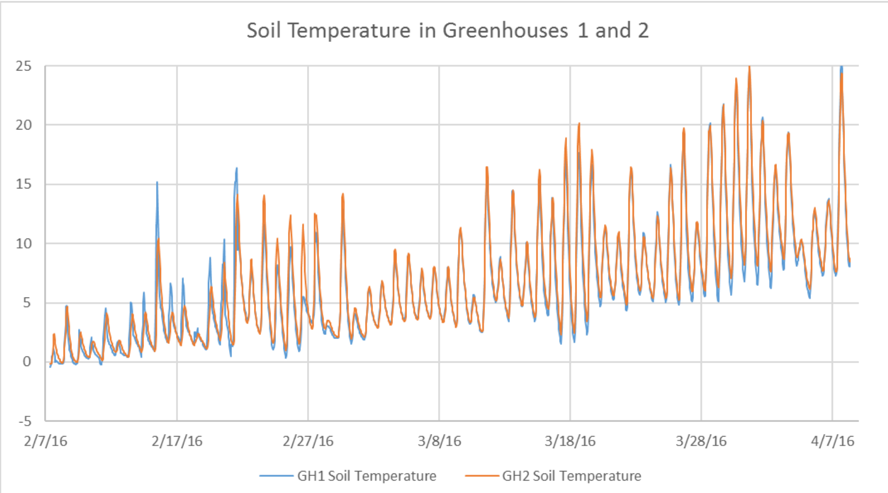


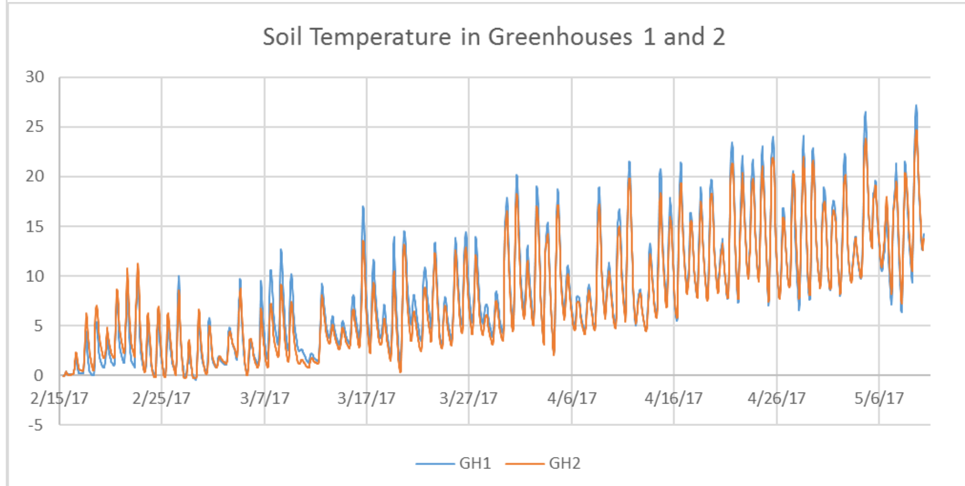
- Greenhouse 1 is **brighter** than Greenhouse 2.
  Year 1: Average PAR difference is 15 ± 2 $\mu E/m^2s$
  Year 2: Average PAR difference is 23 ± 3 $\mu E/m^2s$

4. Soil Temperature

Soil temperature was measured in a number of beds (and averaged for each greenhouse).

Fig. 4 Soil Temperature - Year 1 and Year 2



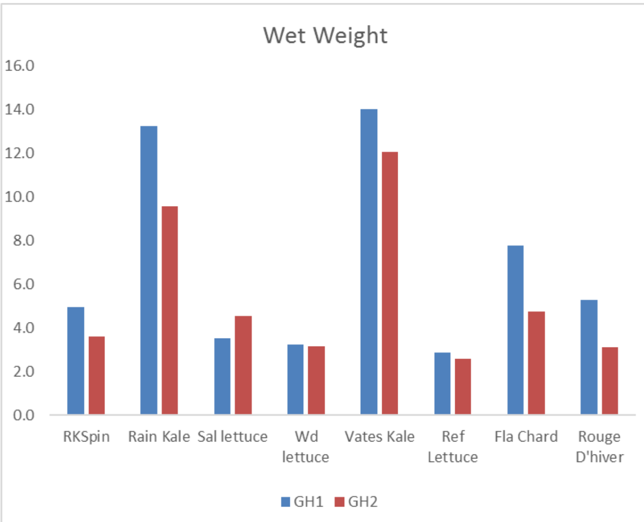


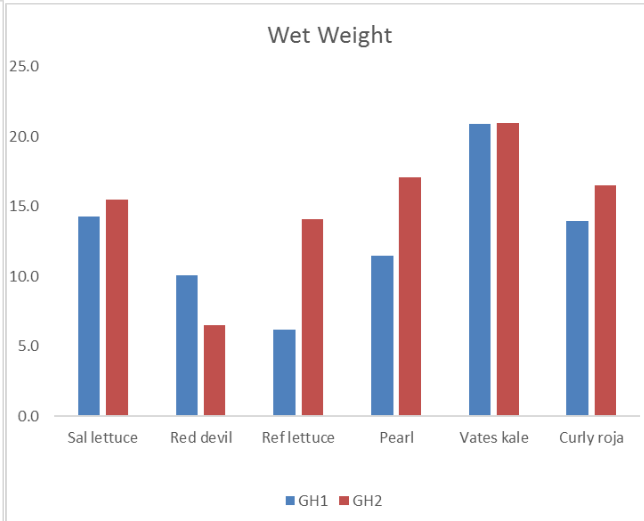
- Soil temperature is **warmer** than air temperature on average.
- Soil temperature is **less variable** than air temperature.
- Differences between greenhouses are hard to evaluate due to bed-to-bed differences and dependence on precise sensor placement in the soil.

5. Plant Dry and Wet Weights

Samples of each plant variety were collected and weighed in the Lab.

Fig. 5 Plant Wet and Dry Weights - Year 1 and Year 2





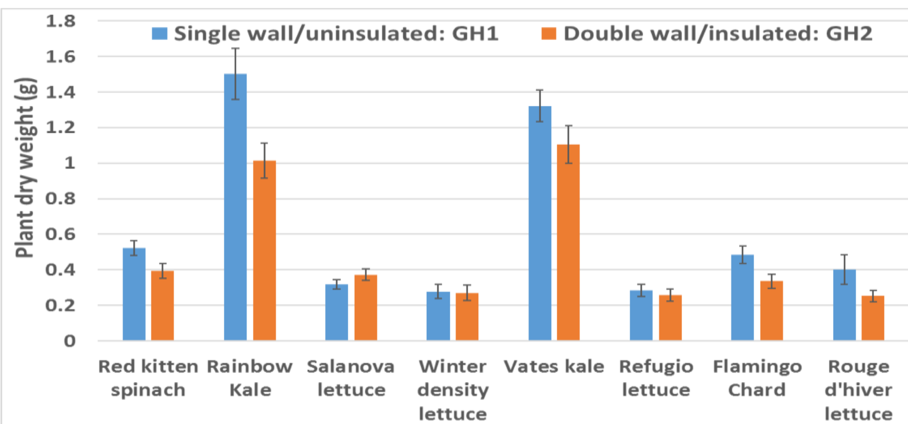


Figure 1: Plant dry weights (g) Feb-April 2016

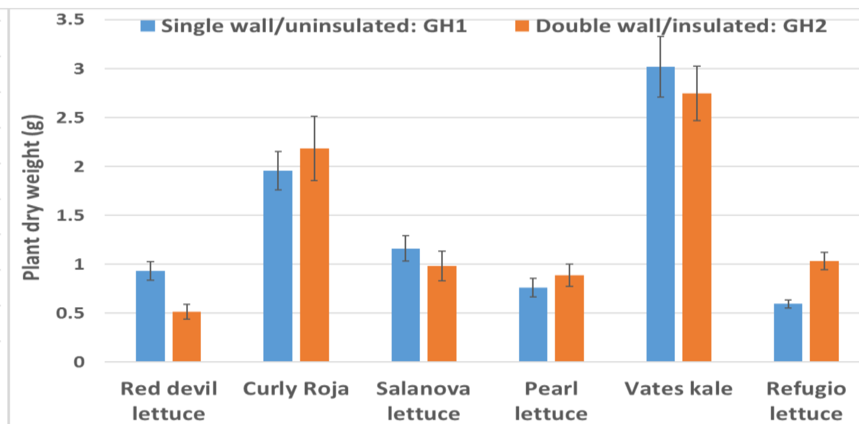


Figure 3: Plant dry weights (g) Feb-April 2017

- Some plant varieties do better in Greenhouse 1, while others do better in Greenhouse 2.

6. Plant Leaf Area

Samples of each plant variety were collected and leaf area estimated for each sample.

Fig. 6 Plant Leaf Area - Year 1 and Year 2

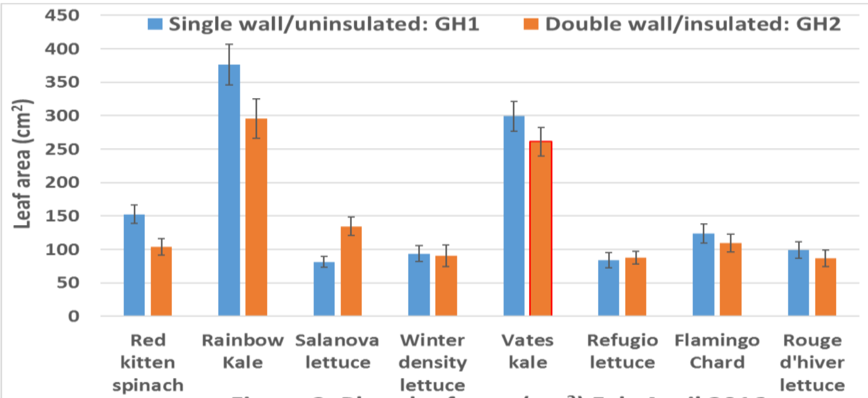


Figure 2: Plant leaf area (cm^2) Feb-April 2016

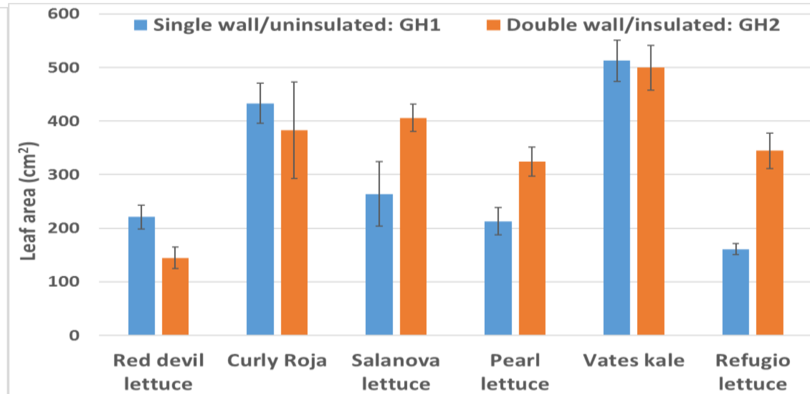


Figure 4: Plant leaf area (cm^2) Feb-April 2017

- Some plant varieties have larger leaf area in Greenhouse 1, while others have larger leaf area in Greenhouse 2.

7. Marketable Yield

Fig. 7 Marketable Yield - Year 1 and Year 2

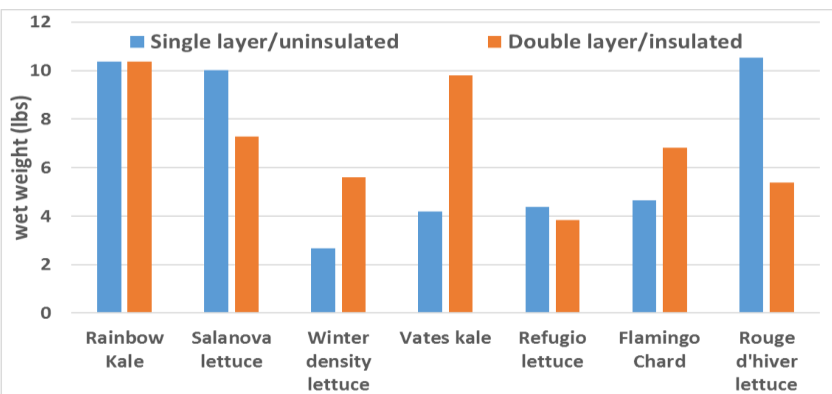


Figure 5: Marketable wet weight (lbs) Feb-April 2016

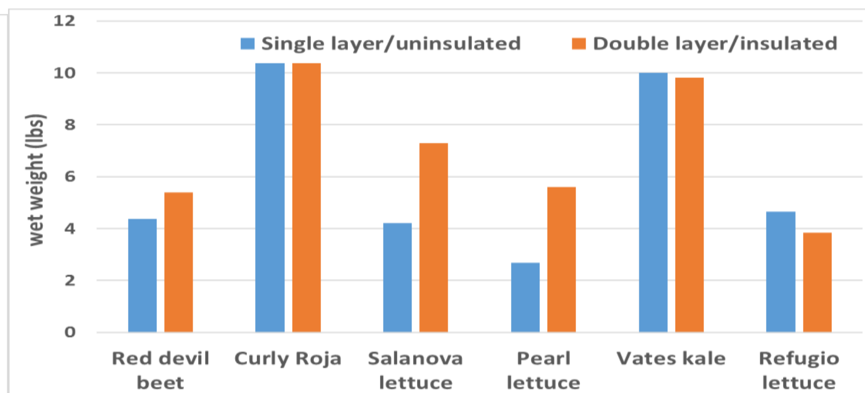


Figure 6: Marketable wet weight (lbs) Feb-April 2017

- Some plant varieties did better in Greenhouse 1, while others did better in Greenhouse 2.