# Proposal: The Vertical Growing Strawberries in Stacked Pots System

**Responsiveness to USDA NIFA SBIR/STTR Program Priorities:** Scenic Valley Farm (SVF), the author of this proposal Vertical Growing Strawberries in Stacked Pots (VGSP) , is a working vegetable and berry farm that grows produce in 15 high tunnels. SVF has 1) developed and is manufacturing a plc base controller for the monitoring and management of agriculture high tunnels, 2) developed and is manufacturing a solar thermal heating system for growing produce in high tunnels. We researched and developed both systems using an USDA SBIR Phase 1 and 2 grant. Both will support our Phase 2 VGSP effort. SVF is researching and developing a prototype of a new composting process, "Enhance Compost" (EC), which will produce compost in 30 days using minimal labor. Current composting methods take up to a year to compost. The EC system has been developed for small and midsize farms and is the primary component of the Recycle Compost System (RCS). (See Biblio 3). A proposal for a SBIR Phase 1 grant will be submitted. The compost from this system will support the VGSP project. A national high tunnel manufacturer, Poly-Tex, will research and develop the racking system for the VGSP. It will also invest in the commercialization of the VGSP. (See attached Poly-Tex support letter.)

**Prior USDA Support:** As mentioned in the previous paragraph we will look at incorporating aspects of previous awarded SBIR Phase 1 and 2 grants. The PD is Erik Gundacker, the application title is Scalable Environmental Controller with Integrated Solar Thermal Storage and Extraction for Field Protected Agriculture. (See Biblio 4). Compost is an integral part of making the substrate for this project. As mentioned in the previous paragraph, a SBIR phase 1 proposal has been submitted and will be resubmitted titled Recycle Compost System (RCS) for Growers. The Vertical Growing Strawberries in Stacked Pots (VGSP) (See Biblio 5) will need compost, which can be made by the grower using the RCS.

The USDA Environmental Quality Incentives Program (*EQIP*) (See Biblio 15) is the *NRCS* flagship conservation program. High tunnels, an EQIP option, will provide environmental control and season extension for VGSP. If the grower meets the EQIP requirements, the program will supply these high tunnels.

**Identification and Significance of the Problem or Opportunity:** In 2023, US per capita consumption of strawberries was 7.6 lbs per person (see Biblio 9). Over 3 billion lbs are consumed annually with over 95% grown in California, which produces 1.5 lbs of berries per plant (see Bibio 18). In the upper Midwest (Iowa, Wisconsin, and Minnesota), 160 million lbs of strawberries are consumed annually. During the seven months available to grow strawberries in the upper Midwest, our goal is to provide 10 percent of the berries or 8 million lbs of berries to these three states. To accomplish this SVF will develop a multi-acre high-tunnel farm using our EMS Solar Thermal Vertical Growing System. Also strawberries will be supplied by other growers using the EMS Solar Thermal Vertical Growing System. Already we have three growers who have multiple high tunnels interested in using our vertical growing system: Little Hills Berry Farm of Northfield MN, Flyte Family Farm of Coloma WI, and Govin's Farm of Menomonia WI. Many other farms have expressed interest in the VGSP. See later discussions in this narrative. At 1.0 lbs. of berries per plant and 7,000 plants per 30 x 96 high tunnel, 350 high tunnels would be required to provide 10% of the strawberries consumed in this three-state region. According to the **USDA NIFA** (see Biblio 14) non-organic strawberry pricing for May 2010 through November 2022 averaged $1.50 per lb. A 30' x 96' tunnel with 10,000 berry plants yielding 1.0 lbs per plant will generate revenue of $15,000 per year. The estimated cost of the EMS Solar Thermal Vertical Growing System (including the high tunnel) is $30,000. With yearly operating costs estimated at $5,000, the payback would be in three years. Of course yields above 1.0 lbs per plant would shorten the payback period. The EMS Solar Thermal Vertical Growing System will be made available to all of the US and possibly abroad. Strawberries grown using this system can easily be USDA-certified organic. We are determined to make the EMS Solar Thermal Vertical Growing System economically feasible. To grow and sell strawberries at organic markets (the wholesale price is $4.25/lb) we would need yields of 0.75 lb per plant. That is our current yield. But if we can increase the yields to 1.5 lbs per plant we can reduce the price to $1.50 per lb and sell these organic berries to conventional wholesale markets. Organic sales

account for 15% of total U.S. produce sales (See Biblio 19) according to recent industry statistics.

Growing strawberries in a vertical stack system offers several advantages, including maximizing space, simplifying harvesting and maintenance, and reducing pests and diseases. In addition, environmental control measures offered by high tunnels can extend the harvesting season. Vertically growing strawberries systems are available using hydroponics, but present hydroponic systems used by large commercial farms are expensive. In general, strawberries grown hydroponically in water don't have the sugar content of soil-grown strawberries such as those produced by the VGSP system.

Finally, it is more challenging for hydropically grown strawberries than VGSP-grown strawberries to receive USDA organic certification. In an article for the National Agricultural Law Center, Jana Carraciolo reports, "On September 22, 2022, the Ninth Circuit Court of Appeals upheld a district court ruling that allows hydroponic produce growers to continue to sell their produce as organic. This is the latest development in an on-going debate where certain groups argue that under the Organic Foods Production Act (OFPA)—the legislation that Congress passed in 1990 that directed the USDA to create the National Organic Program (NOP)—hydroponics cannot be organic because they are not grown in soil." Although the 2022 ruling may have temporarily resolved the issue, Carraciolo notes that " the debate over whether hydroponics should be certified organic is likely not over." (See Biblio 1). Soil-grown organic strawberries allow producers to sidestep the entire legal quagmire.

**Background and Rationale:** Since 2012, SVF has been growing strawberries in high tunnels using plastic culture (see Biblio 2). To increase yield and efficiency in maintenance and harvesting, in 2016 SVF started developing Vertical Growing Strawberries in Stacked Pots (VGSP). A year later, in 2017, SVF was awarded a USDA SBIR Phase 1 grant to research and develop a VGSP prototype which, since 2019, we have been modifying through testing and further research.

SVF has discovered that growing strawberries vertically has greater increases of yield-per-square foot compared to field-grown strawberries, provides for space efficiency, reduces water and pesticide usage, and is easier to harvest and maintain. Growing strawberries in high tunnels using vertical systems can enable almost year-round production and can be located

closer to consumers, potentially leading to fresher produce. Since high tunnels can be secured at no cost to the grower through the USDA NCRS EQIP program, these growing spaces are preferred to the more expensive glass greenhouses; not only do high tunnels cost a fifth of the price of glass greenhouses, but they also have the additional benefit of providing a more efficient method of environmental control than glass greenhouses. See NRCS High Tunnel Initiative (See Biblio 7) and cost comparison. (See Biblio 17)

We chose soil rather than water (i.e. hydroponic growing systems) as the growing medium/substrate for the following reasons:

1. Soil-grown strawberries (as well as other produce) have a higher Brix (sugar level). SVF has discovered through its frequent Brix testing on all its fruits and vegetables that strawberries become sweeter as the season progresses. For example, in any given growing season the sugar levels increase from Brix 7.5 in July to Brix 10 in September to Brix 14 in November. In contrast, in May 2025 we purchased a one-pound bin of Bushel Boy hydroponic system's strawberries; its Brix registered 5. This aligns with a 2015 study that indicates a consistently higher Brix percentage in soil-grown strawberries compared to hydroponic-grown strawberries.

2. Since small and medium farms are acquainted with growing in soil, growers who use SVF's system will have a minimum learning curve and less investment costs.

3. The cost of our soil based vertical growing system is less than the cost of a hydroponic system. Commercial costs to install a system of hydroponically grown strawberries can be over a million dollars. (See Biblio 20) The VGSP presently costs $275 for a four-pot stack of 83 plants (cost includes the price of the plants). Most soil-based strawberry crops yield 1 lb per plant, but with results from this phase 2 VGSP project that number will increase to 1.5 lbs per plant. The projected price for a VGSP stack is $1000. The projected revenue from a VGSP stack is $934 (83 plants X 1.5 lbs/plant x $7.50/lb of organic retail price). As a result, the projected gross profit will be 71% (Revenue of $934-cost $275)/Revenue $934. The ROI is less than two years.

4. As noted above, VGSP can be certified USDA Organic whereas a hydroponic system organic certification is controversial.

We also chose high tunnels as the preferred production-housing method for the following reasons:

1. High tunnels/per ft are one-fifth the cost of a greenhouse (See Biblio 17). NRCS EQIP program provides significant financial assistance for a high tunnel (See Biblio 7).

2. Growing Day-neutral strawberries in high tunnels allows for extending the season and harvesting berries nine months a year.

3. Growing in high tunnels allows for picking and plant maintenance during inclement weather (although, it should be noted, the VGSP can be incorporated outside).

In addition, generally, since all the producers will be selling their harvest within their immediate communities, this project also has the added benefit of appealing to the overwhelming number of consumers who prefer locally grown produce.

**Relationship with Research or Research and Development:** We have concentrated our Phase 1 efforts on research, design, development and testing of a prototype on the following components:

1. Growing vessel and support system
2. Substrate
3. High tunnel efficiency
4. High tunnel pest protection
5. Strawberry variety
6. Planting density and stack spacing
7. Plant maintenance
8. Extending growing season
9. Improving production
10. Commercialization and ROI
11. Marketing

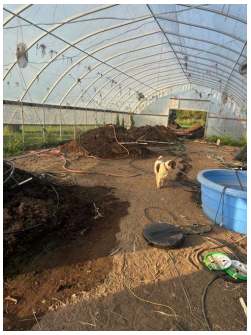
Our goal has been to improve pounds of berries per plant. We are at 0.75 lb per plant with a goal of 1.5 lbs per plant.

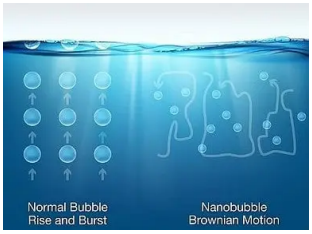
**Our Finding** for each component:

1. *Growing vessel and support system:* We have tested an array of 12 vessels, eliminating most of these vessels as viable during testing. According to University of Wisconsin strawberry researcher, Brian Smith, a minimum of two quarts

of soil was needed per strawberry plant. As a result, those vessels which could not accommodate this quantity were eliminated from further testing. When we tried stacking the remaining vessels on top of each other, the bottom pots collapsed due to the weight of the wet soil in the pots above. To address this problem, we built a racking system to support the weight of individual pots. We found in testing that a 20-gallon plastic pot with a dozen 1 ½ holes drilled in the side worked best to accommodate the plants. With four of these pots to a stack, eight plants are arranged on top of each pot, four in front and four in back, while the top pot has three additional plants placed among the eight plants. Currently the rack is built using 2x2 lumber but Poly-Tex will be designing and building a galvanized metal rack. (See attached Poly-Tex support letter.)

2. *Substrate*: Compost makes up 50% of the substrate used for the VGSP. SVF grows in 15 high tunnels with compost made on the farm. We don't use any commercial fertilizer, but occasionally we add a lacking micro ingredient such as magnesium. For the compost feedstock we use calf bedding (manure and sawdust) from a large nearby dairy, Wild Rose Dairy Farm in Rosewood, MN. We use 250 cu yards of compost a year. It used to take a year using the Windrow composting method to make the compost, but our EC ("Enhance Composting") method produces compost in less than 30 days, requiring minimal labor. The EC is a component of the Recycle Compost Systems (RCS) that will be available to small- and medium-sized farms for growers to make their own compost. The RCS is in research and prototype development (See picture) and is applying for a USDA SBIR Phase 1 grant. Compost experimentation is occurring in one of SVF's high tunnels. (See a description and project status on SVF website.)






The "Enhance Composting" uses the prototype O2Grow System (see adjacent picture) to add dissolved oxygen to irrigation water. (See Dennis Clark support letter.) The super charged oxygenated irrigation water using electrolysis improves the aerobic microbes' efficiency and reproduction in the

composting process. Dissolved oxygen using the prototype O2Grow System will be added to VGSP irrigation water to improve crop yields. Dissolved oxygen is produced using electrolysis via plates in a tank of water prior to and during irrigation. The water with dissolved oxygen is then pumped to irrigate the feedstock pile producing compost. (See paragraph 9. Improve Production.) There exists a more efficient means of adding dissolved oxygen directly into the irrigation line, "Dioxyflow" which involves using highly electrical conductive rods, such as graphite, located within the irrigation line. This method is a unique, patentable device with several agriculture applications, including for our purposes, the production of compost in 30 days and increasing yields in strawberries. (See paragraph 9. Improve production.) This project will be proposed at a later date for receiving a SBIR Phase 1 and 2 grant or possibly a NSF grant.

Through years of testing, the substrate for the best performance, determined by plant health, yield, and disease resistance, has consisted of one part compost and one part topsoil/blackdirt, elemental sulfur, gypsum, and mycorrhizae. These last three ingredients provide significant contributions to the soil: The gypsum lowers the pH and adds calcium for healthy plants and firmer berries. Elemental sulfur also lowers the pH. (Strawberries respond best to a pH of 5.5-6.0.) Mycorrhizal Fungi provides a mutual symbiotic relationship between fungi and plant roots.

3. *High Tunnel Efficiency:* Greenhouses enclosed in glass and with concrete floors are 3-5 times more expensive than high tunnels. (See Bibl. #17) While both growing locales have stand alone or integrated environment controllers, SVF has developed a plc-based Environmental Management System (ESM) via a USDA SBIR Phase 2. (See Innovation for a description.) For a less expensive method of managing the VGSP irrigation, the grower can order the VGSP with a stand alone irrigation controller such as Toro® 4-Station Indoor Irrigation Timer. In any case, the VGSP comes with a pressure compensating 1/4-inch irrigation dripline allowing for constant, even water flow. During Phase 2 we will test the VGSP outside with no controlled environment. But we need to first develop the metal rack since our current wooden rack is not weatherproof.

4. *High tunnel pest protection:* For a successful growing season, SVF will need to cover the proposed stacks with insect netting for protection from the Spotted Wing Drosophila (SWD). (See Biblio 11) Currently, SVF encloses its high tunnels with SWD insect netting, which assists the farm in growing berries in the late summer. (In fact, SVF is

currently the only farm in the Upper Midwest to grow so late in the season, strawberries, raspberries, and blackberries.) Once production with the VGSP begins, SVF will continue to cover open areas with its insect netting, ExcludeNet. This insect netting prevents roughly 95% of SWD from getting inside and infecting the ripe berries. For the SWD that does penetrate this barrier, we spray two times a year with an Organic OMRI approved insecticide, Entrust. The insect netting also prevents other pests, such as deer and rabbits, from grazing on the berries. Just this year, prior to installing the ExcludeNet, deer were constantly grazing the inground strawberries. The deer also walked through an open door in the tunnel with the VGSP stacked potted strawberries, and browsed the plants. Perhaps drawn by one of the system's harvesting advantages, the deer seem to have preferred the VGSP crops: they did not need to bend over to access the plants.

5. *Strawberry variety*: There are two types of strawberries grown in the US, June and Day Neutral. June strawberry plant that produces a large crop of berries in a short period during late spring or early summer (typically in June (thus, the name) and early July). Day-Neutral strawberry plants produce fruit continuously throughout the growing season, as long as temperatures are favorable—unlike June-bearing strawberries which have a short, concentrated harvest.

We found during early testing that June berries do not perform in pots as well as Day-Neutral berries. June berries only yield in June/July while Day-Neutral berries yield from May into November. The Phase 2 project will test extending the yielding season for Day-Netural berries from April 1 (or perhaps early March) through December. The best performing Day-Neutral varieties in the VGSP are Cabrillo, Portola, Monterey, and San Andreas.

6. *Planting density and stack spacing*: To allow for optimum sunlight to encourage growth, we are continuing experiments with spacing between rows of stacked pots and between each of the pots in the stacks themselves. Since we found that six rows in a 30-foot wide tunnel does not provide for sufficient sunlight, we are experimenting with four and five rows per each 30-foot wide tunnel. We are pleased with the results so far. Here is a row of stacks from this year's VGSP with adequate spacing between the

rows. Here is a video from last year's VGSP. We are also experimenting with the distance between individual stacks.

Another concern is the individual stacks shading the plants in the bottom pots. We are experimenting with LED to provide light to the bottom pots along with light between the stacks. Our strawberries late in the season (November and December) have white tops due to lack of sunlight. The individual berries are also hard, though they are the sweetest of the entire season. We are experimenting using LED to extend the beginning and end of the growing season. We need to look at the economics of using LED—cost trade offs of increased production due to LEDs compared to the costs of installing and operating LEDs.

7. *Plant maintenance. planting, and picking*: We found that less maintenance is required for tasks such as weeding and runner removal for VGSP compared to in-ground crops. The VGSP allows us to stand while harvesting rather than crawl on our hands and knees to perform plant maintenance. For weed control we are experimenting with wood mulch and plastic placed between plants. So far we found wood mulch easier to incorporate.

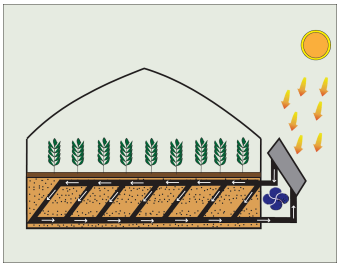
In 2025 we monitored the labor hours in a high tunnel needed to plant the VGSP compared to in-ground planting: to plant the same number of plants for each, labor hours were virtually the same. In preparing the pots and planting, we used an assembly line process outside the tunnel before moving inside the tunnels to place the pots on the rack. For Phase 2 we will research more efficient methods to transfer the pots to/from the racks.

As noted above, standing to pick berries from the VGSP requires less exertion than crawling around to pick in-ground. The vast majority of strawberry farms are already small, and these farms account for the largest share of direct sales; in addition, small and midsized "U-pick" strawberry farms are popular seasonal destinations for agritourists. According to Shelby Vittek, U-pick farms now exist in every state of the Union, and for good reason: "Agritourism has boomed over the last two decades," Vittek notes, "with revenue more than tripling from 2002 to 2017. According to the USDA, agritourism revenue grew from $704 million in 2012 to $950 million in 2017. Pick-your-own (PYO) farms achieve growth by meeting consumer demand for direct farm-to-table connections, offering fresh, affordable, and high-quality products. (See Biblio 21).

Would these "DIY" consumers rather pick standing up or on their hands and knees? Anecdotally, older people who visit SVF certainly enjoy picking berries from a VGSP system.

For the same reason, the VGSP will be more accommodating to technology that develops robotic pickers than inground will.

8. *Extending growing season*: In 2018 we installed Phillips LED lighting in between the stacks. We did not record the yield data but we did notice improved berry production. For the Phase 2 project we again set up stacks with LED lighting and record yield data.

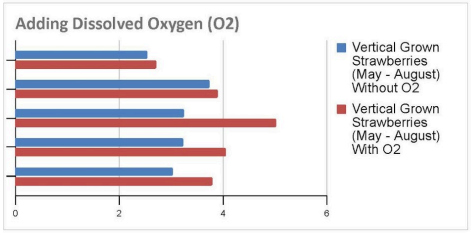


During our prototype experimentation we have not tried placing the VGSP stacks in any of our three solar thermal heated tunnels. Two of the three solar heated tunnels were developed from a SBIR Phase 2 grant. In February, November, and December, day and night, the solar thermal will warm the soil to temperatures in the 70Fs and the air to temperatures to the 50Fs. The ideal growing temperatures for strawberries is 60F-80F with cooler nighttime temperatures for optimal fruit development. We might need to add some heat during the day using our heaters when the outside temperature is below freezing. For Phase 2 prototype experimentation, we plan to use air for heat transfer and soil for thermal mass in Tunnel 11, our primary solar thermal.

9. *Improve production*: As noted above, more direct sunlight to all plants in the VGSP system will naturally improve yields. Adding dissolved oxygen to irrigation water also improves berry yields, specifically, by 20%. In 2018, SVF used the prototype O2Grow system to add dissolved oxygen to irrigation water. (See pic for results.) Because strawberries yield best in the cooler weather of spring and fall, we sought to duplicate this climate in the summer. In the late summer of 2019 we cooled a high tunnel using an air/water cooling unit. (See pic.) We also used 50% shade cloth covering. We managed to cool

O2 Grow on strawberries (May-Sept)

| Without O2 | With O2 | % |
|---|---|---|
| 3.03 | 3.79 | 25.08% |
| 3.238 | 4.05 | 25.08% |
| 3.25 | 5.03 | 54.77% |
| 3.744 | 3.904 | 4.27% |
| 2.542 | 2.712 | 6.69% |




the tunnel several degrees from the outside but did not collect berry production data. We plan to resume the experimentation in Phase 2. Admittedly, cooling a plastic-covered high tunnel is a challenge since it is a passive solar collector.

10. *ROI and commercialization*: The current VGSP present cost is $275 per a four-pot stack of 83 plants (all cost including plants). We estimate the yearly operating cost of $175. with a projected VGSP per stack selling price of $1000. If each plant produces 0.75lb (the current yield) at retail price for organic berries of $7.50/pound, we project VGSP per stack revenue to be $467 (83 plants x 0.75#/plant x $7.50/#). Resulting in a yearly profit of $292 ($467 revenue-$175 operating cost). The ROI would be less than 4 years If we increase the yield to 1.5 lbs per plant, the ROI would be less than two years.

The VGSP will be manufactured at SVF in Readstown, WI, and at Little Hill Berry Farm in Northfield, MN. The VGSP racking system will be manufactured at Poly-Tex in Castle Rock, MN. We expect the first VGSP unit will be ready for sale in 2028 or sooner.

11. *Marketing*: In 2019 we set up a booth at the Wisconsin Fruit and Vegetable Growers Conference, where we featured an early prototype of the four-pot stack system. We received interest from 20+ growers. We also received interest from consumers interested in placing a stack on their backyard patio. Erik Gundacker gave a presentation about the state of the VGSP system at the same conference in 2024. (See Presentation.) In addition to being an official presenter at the conference, Gundacker welcomed growers interested in participating in the SBIR Phase 2 proposal. From the list of 15 growers available, I selected four, including Aaron Wills of Little Hill Berry Farm (See support letter.) who in 2025 set up a two stack VGSP system. For 2026, I have received an invitation from Terry Nennich to present at the 2026 MN Fruit and Vegetable Growers conference. In addition, we have allied with Poly-Tex to build the steel racking system to assist in commercialization. (See support letter). For other marketing and commercialization assistance see paragraph j. Potential Post Application.

**Technical Objectives:**

1. Improving strawberry yield to 1.5 lbs per plant
2. Developed a metal racking racking system

Can berry production increase by optimizing VGSP stack spacing, installing LED lighting, solar thermal, adding dissolved oxygen to the irrigation water, and cooling the tunnel? Furthermore,

along with potential yield improvements, how much does each unit cost and what is its worth relative to ROI?

**Work Plan:**

1. Improved yield to 1.5 lbs per plant
    a. Optimize VGSP stack spacing—with little cost to implement and greatest probability to increase yields
    b. Install LED—high cost to implement but with ability to perform economic tradeoffs
    c. Use solar thermal to extend season—high cost to implement but with ability to perform economic tradeoffs
    d. Add dissolved oxygen to irrigation water—lower cost to implement with an increase yields of 20%
    e. Examine and test methods to reduce temperatures on hot days in the tunnel—cost could be a factor
    f. Weed control—test mulching methods but at low cost whatever method to implement
2. Develop a metal racking racking system

The project includes three existing strawberry growers:

1. Little Hill Berry Farms, Northfield, MN
2. Govin's Farm, Menomonie, WI
3. Flyte Family Farms and Fieldstones, Coloma, WI

These farms have been added to the project along with SVF,  Readstown, WI. All are performing different tasks pertinent to the VGSP proposal: Little Hill Berry Farm is testing the current prototype VGSP. Each of the three growers will be supplied a 20-foot long by 30-foot wide high tunnel with 6-foot side walls. The tunnels are made by Poly-Tex. The roof and side and end walls will be covered with 6 mil UV AC/IR plastic fixed in place by wiggle wire and u-channel/wiggle wire. All materials for the VGSP will be supplied to each grower including the pots, racks, irrigation line, irrigation controller, substrate, insect netting, weed guard, strawberry plants. Funds will be provided to construct the tunnel, construct the VGSP, and perform recorded tests.

Since the project start date is expected to be 4/1/26, most of 2026 will be setting up the VGSP at SVF and the three other growers. Depending on how the setup progresses, we might be able to do minimal growing/testing in Fall 2026. Availability of strawberry plants could have an impact on growing in the fall of 2026. The following is a schedule, including the tasks with linkage to the technical objectives. Recording of results will be specified, if applicable.

**Work Plan by Week:** After receipt of order expected 4/1/26: each grower, including SVF, will record observations during planting and results during picking season. (SVF will coordinate each part of the plan with the other growers involved in the project.) The following information, to be called The Grower Report, was recorded during and after Phase 1: Date each stack was picked, berry variety, weight of fruit picked, presence of insects/diseases, berry sizes, integration interval, weekly and monthly summary.

*Week 1*: Conduct a conference call (via Zoom) with members of the team (SVF, growers and Poly-Tex) to discuss the schedule and tasks, and the current state of prototype development.

*Week 2 -Week 8*: Prepare purchase orders for material needed, such as high tunnels and VGSP components. Place orders and deliver to the three farms, including SVF. Each of the three farms will have a 20’ long x 30’ wide high tunnel, 16 or 20 four- pot VGSP, 2x2 wood temporary rack system, and irrigation supplies.

*Week 4*: Have a Zoom meeting concerning the design and schedule of the **metal racking system (Objective 2 task)** with Poly-Tex and Little Hill Berry Farm. The rack design will be based on the current rack, which is made using 2x2 wood and steel purlins for the pot support. The rack prototype will be available ideally when the VGSP is ready for installation at the various farms. The design will include a single stack racking system along with a four-stack racking system that can be daisy chained together.

*Week 6-14:* Prepare the stacks for the growers including SVF. The VGSP for each grower and SVF is as follows:

1. Little Hill Berry Farms: four rows of four stacks with 8’ rows spacing, test adding oxygen with prototype O2Grow System
2. Govin’s Farm: four rows of four stacks with 8’ row spacing
3. Flyte Family Farms and Fieldstones: five rows of four stacks with 6’ row spacing

4. Scenic Valley Farm: two 30’x96’ and one 30’x20’ high tunnels. 1) one tunnel with 80 stacks with four rows of 20 stacks with 8’ row spacing; 2) second tunnel with 100 stacks with five rows of 20 stacks with 6’ row spacing; 3) third tunnel with 16 stacks with four rows of four stacks with 8’ row spacing. This tunnel is in present use for this purpose at SVF. Tunnels 1 & 2 will test row spacing, stack spacing, solar thermal heating, adding oxygen with prototype O2Grow and LED. (See Work Plan for additional information.)

*Week 7:* Prepare The Growers Report on Google Drive and share the report with growers. All growers can see reports of other growers

*Week 6-12:* The substrate and other VGSP material will be produced at SVF, all to be delivered to the three other farms

*Week 8-14:* At SVF prepare the existing solar thermal 30x96 high tunnel

*Week 10-14:* At SVF prepare a second 30 x 96 high tunnel and the third 30 x 20 high tunnel.

*Week 10-12:* Assign to SVF and growers the following **objective #1 task** to improve yield per plant. Grower task assignments are listed.

a. Optimize VGSP stack spacing (all four farms)
b. Install LED (SVF)
c. Use solar thermal to extend season (SVF)
d. Add dissolved oxygen to irrigation water (SVF and one grower, TBD)
e. Examine and test methods to reduce temperatures on hot days in the tunnel (SVF)
f. Weed control—test mulching methods (all four farms)

*Week 13:* Review these tasks with the growers along with The Growers Report.

*Week 13-24:* Install high tunnels and VGSP at all four farms.. If needed, SVF personnel will travel to the other farms to help with installation. The metal racking system will be used when available. If not 2x2 wood will be used. The goal for the metal racking system is to have it ready for the grower’s VGSP setup. SVF’s two high tunnel configuration is as follows: Partitioning sections/rows for testing: High tunnel 1 Solar Thermal:

-Section 1 with four rows with eight stacks per row, testing LED.

-Section 2 with four rows with eight stacks, testing space between rows.

-Section 3 with four rows with four stacks, testing dissolved oxygen using the prototype O2Grow System

The entire tunnel will test extending the season using Solar Thermal. Partitioning sections/rows for testing: High tunnel 2:

-Section 1 with four rows with eight stacks per row, testing cooling tunnel using air/water exchanger cooler and shade cloth

-Section 2 with four rows with eight stacks testing dissolved oxygen using the prototype O2Grow System,

-Section 3 with five rows with three stacks, testing space between rows and stacks.

Partitioning sections/rows for testing: High tunnel 3:

-Section 1 with four rows with four stacks, 8’ row spacing. This tunnel will test cooling the tunnel using forced air/water-filled exchanger copper tubing and shade cloth. The pots will not be filled with soil until ready to plant.

*Week 20-28:* If time/weather permits, plant strawberries. From the time of planting strawberries will produce and ripen in 45 days. Record all data for The Growers Report.

*Week 24:* Approximately Sept. 1 order strawberry plants for 2027 spring planting.

*Week 52-56*: April 1, 2027, growers receive strawberry plants, prepare pots for plants

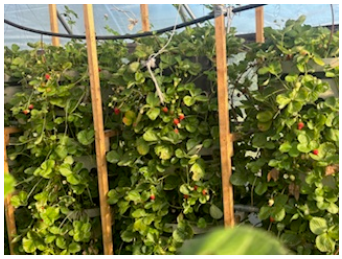
*Week 52-90*: Record all data via grower reporting on Google Drive accessible by all growers. (See The Growers Report.)

*Week N*; As appropriate, prepare and send 1) Interim Technical Progress Report, 2) Comprehensive Final Technical Report, 3) schedule an out-briefing with SBIR/STTR staff to discuss project results and impacts. The reports will be submitted via the REEport system and contain initial project information, annual reports, and summary reports.

**Related Research or Research and Development:** Since 2009, SVF has been growing organic strawberries, raspberries, blackberries and various vegetables expanding to 15 automated high tunnels. We grow in plastic culture with drip irrigation and moisture sensors, using environment controlling features such as fans and rollup sidewalls, and heaters to extend the season. All tasks are monitored/managed remotely via a plc based controller. We’ve also added solar thermal heating in some of the tunnels run by the same plc based controller. As stated in previous paragraphs, much of this was funded through USDA SBIR Phase 1&2, NRCS EQIP high tunnel and MN & WI state grants

The strawberries were planted in the ground in the tunnels. We wanted a way for easier maintenance and harvesting ( walk and pick vs crawl and pick), more efficient use of valuable high tunnel footprint space, better air flow for IPM and disease management and to keep the berries off the ground while still maintaining the quality of soil-grown berries. We also wanted a system that was affordable to the small and midsize farm but easily scalable for growth.

We researched, designed, and developed and are now testing the VGSP prototype. These pics are from August 2025.

Here is a video taken in September 2025 of four rows of vertical stacks along the side of a raised bed of strawberries. For the last three years we have generated income while working  on increasing the yield. Phase 2 goals are to increase pounds of berries per plant and build a metal rack to support the pots. This pic are strawberries picked from the VGSP (right bowl) and strawberries from one of our in ground tunnels (left bowl). Yields per plant are less in the VGSP but the berries are larger and juicier.

**Potential Post Application:** SVF sees market potential for the VGSP among small and medium size strawberry growers—part of 9,000 strawberry farms in the US, according to the USDA NASS 2017 Census (see Bibl #10).. Among these small and medium farms, many U-pick farms have shown interest in vertical grown strawberries. One of the best methods to locate these farms is to Google search by state for “U-pick” or “pick-your-own” strawberries farms. We will join and use agriculture organizations—and especially strawberry and fruit growers associations—to assist in identifying customers and growers. Many of the berry associations are listed on the Nourse Farms associations website.

We have presented and plan to continue presenting VGSP at growers conferences in the Upper Midwest including WI Fruit and Vegetable Grower Conference, WI Growing Conference,

MN Fruit and Vegetable Growers Conference, Mappleseed formerly known as MOSES Organic Conference. With the broadcast exposure of the VGSP, two years (2019 & 2025) presenting at the WI Growers and our website, we have had many contacts. As noted above, we have also formed strategic alliances with companies such as Poly-Tex

Although not within the parameters of this Phase 2 project, there is a market for the VGSP with consumers. We had a booth displaying a single stack VGSP at the 2019 WI Fruit and Vegetable Conference and maintained a list of interested parties: half of the contacts on the list were consumers placing a single stack VGSP on their back yard patio, businesses placing stack(s) on their entry foyer, school foyers and schools offering agriculture-related courses. With urban farming continuing to blossom, the VGSP also has a potential with the urban farmer.

The VGSP present cost is $275 per a 4 pot stack of 83 plants (all cost including plants). The projected price per stack is $1000 or $12 per plant. The gross profit is 72%. If each plant produces 0.75#, which is the current yield, selling at a retail price of $7.50/pound for organic strawberries, the ROI is less than 4 years. We estimate the yearly operating cost per stack to be $175, which we will verify during this project. If as part of this phase 2 project the yields would increase to 1.5#s or even 2#s per plant, the ROI would be less than two years.