Integrated Salad Green and Dairy Production

Final Report for FNE04-512

Project Type: Farmer
Funds awarded in 2004: $5,824.00
Projected End Date: 12/31/2004
Region: Northeast
State: Vermont
Project Leader:

Ben Dykema

Project Information

Summary:

Note to readers, attached is the complete final report for FNE04-512

As stated before, 234 sq. ft. of growing space was constructed in suspended growing beds on the south side of the solar barn. The actual space consisted of three parallel rows of 8 inch diameter pipe joined end to end and sealed. Four rows had been planned, but it was determined that the structural members of the barn could not hold the cumulative weight when visual stress was observed after the first watering. Roughly 224 sq. ft. was planted with mixed salad greens, the majority of which were a mild mesculin mix. The front (south most) row broke on its east end due to excess weight from a water leak in the trickle tape irrigation, and 13 feet of pipe was not planted. The grow beds were planted successively, with an average of 25 sq.ft. of bed space being planted every week.

Actual harvested space was significantly less than the total space. This is attributed to several factors: Firstly the irrigation system was late on delivery and it set back the initial planting date. The first 30 sq. ft. of bed was planted before the trickle tape arrived and was initially hand watered. After the irrigation was set up, the tape had to sit above the soil of the first 13 feet of each row. It did not water adequately, and the first 30 sq. ft. experienced stunted growth for the entire growing period. The next 50 square feet was planted after the irrigation installation and it grew normally. It is interesting to note that accelerated growth was not observed despite the elevated CO_2 levels in the greenhouse. However, during this period of growth (mid Sept. to mid Oct.), the barn walls were being raised often to shed excess heat on warm days, and this could have lowered CO_2 accordingly. A second reason for lack of growth may have been due to the side walls themselves. The side wall curtains were scheduled to be changed during the start of the grant. They were fairly worn, ripped, and had limited transparency (roughly 50%). It was not replaced until mid-November. The crops that did well were grown in a period when the side wall was raised consistently and there was exposure to direct sunlight. Later crops were grown behind the side wall for the majority of their time, and their growth was noticeably stunted. Lastly, 154 sq. ft. of bed space had either close to mature or adolescent greens in them when a killing frost hit the barn. Harvest was planned for three days after the date that the frost occurred on. In short, a lot of potential

harvestable crop was killed. However, tip frosting was observed on the greens as early as December 3rd, and was gradually lowering the quality of harvestable product. (see appendix for frost evidence) The high infiltration rate and susceptibility to frost was also caused by a malfunction of two main bay doors. The two south-most bay doors on the east side of the barn were broken, and the repair company was behind schedule fixing them. They were unfortunately still in disrepair the day of the hard frost. It should be noted that the southern side curtain has been replace with new, highly transparent poly-glazing, and the bay doors have been repaired.

The spring crop was able to be planted as early as the beginning of March based on daily low inside barn temperatures. The new sidewall and repaired doors allowed the barn to maintain more elevated temperatures. Crop growth was on schedule with the reported growth periods form the seed company. However, by the beginning of May the sun angle had become too high and the grow beds only received light through the opaque ceiling of the solar barn. This stunted further crop growth, but later harvests were still made. The crops seemed to grow slowly but steadily under the diffuse light.

On average, the barn stayed 20 degrees warmer than the outside, except for days where high winds were recorded (except for south winds). This was due to the lack of solid membranes on the east and west sides of the barn (only mesh is in place for walls) and the intentional (cracks in the overlap of the side walls) and unintentional (tears and rips) air leaks in the plastic glazing of the barn.

The barn had elevated CO_2 levels at all samples, and this included a sample taken while the barn had raised walls and open soffit vents, i.e. full natural ventilation. It should be noted that directly outside the barn was sampled as well, and 15% lower levels (380 ppm) were detected. This sample was also taken during a day with slight winds coming from the north. This meant that all of the interior air was likely being pushed out towards the south wall as well as through the soffit vents, so the monitors were likely being exposed to the CO_2 laden interior air On days with south winds, the beds may have not been getting the CO_2 enriched air. In the spring trials, a south wind day with ventilation will be attempted to see the effect on the grow bed CO_2 levels. This effect is less important when the weather dictates that the side walls remain closed (mid-October through mid-April). The barn was also sampled on a day with closed walls, and the CO_2 levels inside were 11% higher (500ppm) than the ventilated barn sample. The exterior CO_2 sample for that day was faulty, but the sample was 34.5% higher than the exterior sample from the first sampling round.

Ammonia never registered greater than 1 ppm, and was sampled on days with the curtain walls closed at suspected peak times. The samples were taken at plant level and also in the south soffit peak of the barn. This was done due to ammonia vapor's property as a light gas. In stratified air conditions, the ammonia could have been settling above the air, trapped in the soffit. However, measurements indicate that this was not the case. The low ammonia levels are attributed to the infiltration rates of the greenhouse and the frequency of the barn floor cleaning. This particular barn is cleaned three times a day and prevents large waste buildup on the floors. This is a consideration that needs to be applied to other barns of different operational conditions, especially interested parties who have deep-pack solar barns. This also needs to be considered if the floors are not cleaned regularly, e.g. a cleaning machinery malfunction. There was one period of two days in which the skid steer was down for maintenance, but testing was possible. However, the sheer fact that the plants did not display any signs of ammonia toxicity could be considered proof that the levels were not high enough. However, this cannot be validated as other factors such as infiltration, sun exposure, and temperature could not be specifically determined.

The biothermally or compost heated irrigation system has worked as expected. Water is injected into the tube imbedded in the pile, and after a half hour is allowed to pass on to the crops. The water is superheated to 120oF, but by the time it travels across the barn to the beds, it cools to 75-80oF. When the water is shut off, the tube imbedded in the pile remains filled with water. When irrigation is turned on again, the water is at the same temperature as the pile (normally 140oF) and is fed to the beds. This simple system is relevant to many irrigated crops of smaller scale and should be considered by farmers with the access to composting materials (it is in fact being used on some farms for radiant floor heating and other applications). Care was not taken to set up the pile for easy management however. A system that allows for easy construction and removal of the compost and water coil should be developed for a system like this. This could have been accomplished by putting the tubing in a vessel or structure for easy removal (such as a welded rebar frame or steel drums), but it was not of great concern considering the budget and time allotted for the grant.

Unexpected factors have became the main concerns of the grant. These concerns center around crop quality and maintenance issues. Scaffolding is not a long term solution to bed access as it is possibly dangerous for humans and cows. Any object in a cows reach will normally be disturbed and the scaffolding has not been an exception. There was observed damage due to chewing, and also breakage. Future projects will have to address this issue. Ideally, a deck or walkway would be established for a growing system like this. However, this would affect the input cost and therefore rates of return and profit. Irrigation has been an ongoing problem of the grant. The irrigation system has been inconsistent, leaving dry areas in some of the beds. The rows did not completely cure during construction due to humidity and wind moving the then empty beds. Leaks have occurred in some of the joints and have spilled water on the stalls below. This has caused concerns for cow safety, and watering has been limited to half hour intervals to minimize spills. However, it is still occurring to a limited extent due to lack of absorbency in the soil mix, established pathways in the soil, and an inability to patch the areas completely from under the rows. Harvested crops have also created concerns. During harvest, a thin film of fine sawdust, and sometimes fly spots and pigeon feces were observed on the product. This was removed with typical washing and spin-drying common to green preparation however. While post-preparation of greens led to a visually acceptable and even above average product, odor and taste were concerns of market managers. Parties complained of a faint barn-like smell and off-taste. It is unclear how valid the complaints were, as no tests can be run to check content and odor profiles. The parties were informed of the growing conditions beforehand, and this knowledge may have affected their judgment. It is feasible however that some of the volatile organic compounds common in barns from silage and waste have affected the crop. This should be examined further in future projects.

Considering the above factors, it is recommended that a similar but disparate system be established. It is possible to add an entire south bay onto the solar barn because the multi-bay design allows for expansion. We suggest that an entire bay could be established that could be devoted to crop growth. The bay would be separated from the main barn by the already existing stalls on what is now the south wall. The floor to this bay could be soil, and the walls an ceiling of the bay could be clear poly. Since the bay would not be isolated from the shared airspace of the barn, the CO_2 and heat benefit would remain relatively unaffected. Also, simple air handling vents and fans could move air from the middle of the barn to the south side for added affect. This system would hopefully solve the aforementioned worker safety and productivity issues but maintain all of the integration benefits. The costs will have to be considered against the costs of the previous system and the possible benefits. However, the system may not be a financial loss if in the future it becomes obsolete. The extra bay could be paved and easily converted into another barn bay to accommodate a growing herd. This system should be considered for a future project on a willing farm.

Overall, the project was relatively successful. This pilot scale project is proof of concept that crops can be grown in livestock barns for integrated food production. The interior conditions, while not optimal, are acceptable for indoor cultivation. The benefits are of course season extension of cropping without the use of any fossil fuels for heating and CO_2 enrichment. As was shown, the growing season can be extended up to two months for cold hardy crops. More importantly, these crops can be marketed at a time when markets are paying a premium for product due to lack of availability. It was found that the local production of mixed greens for most of Burlington's market ceases in late October (or directly after the season's first killing frost) and begins in mid-May.

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Research

Participation Summary

US Department of Agriculture

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