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Abstract
The researcher compared air and soil temperature dynamics, as well as growth and yield of crops in small hoop and large greenhouses, and evaluated the effects on temperature and crop performance of different row covers and row cover management.

Keywords
Fruit and vegetables, Organic production practices and comparisons

Disciplines
Horticulture

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Feasibility of unheated large gutter-connect greenhouses for winter organic vegetable production in Iowa

Is it practical to grow vegetables in the winter in an unheated one-acre greenhouse in Iowa and what type of row cover will provide the best protection for the crops?

Produce can be grown quite well through the winter in the large unheated greenhouse. Growth was slightly greater in the small unheated greenhouse than in the large greenhouse for some crops. Poly row covers provided more cold protection than fabric row covers, and in some cases crop quality and yield are better if the covers are off during the day and on at night. If covers are not removed during the day, fabric covers are better.

Background

The expense of heating a greenhouse makes it difficult to make money growing organic vegetables during an Iowa winter. Many growers have had success growing cold hardy vegetables in unheated greenhouses by adding a layer of plastic or fabric over the growing beds to provide an extra layer of protection. This had only been done in relatively small greenhouses and it was not known how well it would work in larger greenhouses, which have different rates of heating and cooling. This project tested whether it is a practical tactic to use in a large greenhouse.

The objectives of the project were to:
1. Determine whether it is practical to grow produce through the winter in Iowa in a large (one-acre) unheated gutter connect greenhouse,
2. Test different row cover treatments that provide extra protection to crops, and
3. Compare air and soil temperatures, crop growth and yield in large and small unheated greenhouses.

Approach and methods

The researcher established experimental plots in a large (one-acre) greenhouse, one hooped house and one small greenhouse. The large greenhouse and one small greenhouse were not heated, although the second small greenhouse was heated enough to keep it from freezing at night. Sheets of plastic or fabric row covers supported by wire hoops were placed over the experimental plots. Some of the plots were uncovered during the day and covered at night, while others were covered all of the time. Yield and growth of three crops were measured, air and soil temperatures were monitored, and savings in heating costs were estimated.

The plastic row covers used were old poly plastic from the greenhouse roof, saved from the last time the roof was replaced. These poly covers were compared to commercially available fabric row covers that are commonly used by growers to protect crops from cold. When compared to the fabric covers, the poly covers kept
the air and soil temperatures warmer at night. This enhanced the early growth of spinach and helped komatsuna, a green leafy vegetable popular in Asia, reach harvest size more quickly.

Results and discussion
Anyone who has worked in greenhouses of different sizes has noted that a small greenhouse will warm up faster and become hotter during the day than a large greenhouse. Most people who are knowledgeable about greenhouses have assumed that a small greenhouse will cool down faster and be colder at night because of a larger surface to volume ratio. This study found that this was not the case. The small unheated greenhouse and the unheated one-acre greenhouse showed nearly the same minimum temperatures at night.

Daytime high temperatures behaved as expected and were higher in the small greenhouse than the big greenhouse. Temperatures that were warmer during the day and the same at night made the small greenhouse more favorable for growing crops during the winter. Spinach and one variety of lettuce yielded more and komatsuna was ready to harvest sooner in the small greenhouse than in the one-acre greenhouse. However, the big greenhouse was acceptable and produced good crops. For example, yield of komatsuna was not consistently different between big and small greenhouses, but first harvest was about two weeks sooner in the small greenhouse.

The study also found that removing the covers during the day enhanced the growth of some crops, probably because the crops get more sunlight. Both spinach and komatsuna yielded more in the one-acre greenhouse when the row covers were removed during the day rather than being left on all the time. Fungal diseases were not measured but were observed to be reduced with row cover removal.

Conclusions
This research project found that cold hardy crops can be grown successfully in a large gutter-connect greenhouse in Iowa without heating the greenhouse, except to melt snow or ice on the roof. The minimum nighttime air temperatures in the big greenhouse and small unheated greenhouse were not much different and the maximum daytime temperatures were usually higher in the small greenhouse. This is probably why growth of spinach, komatsuna, and Ermosa lettuce was greater in the small greenhouse.

Poly row covers usually kept minimum air and soil temperatures higher than fabric row covers. This may be the reason for higher yield of spinach in the one-acre greenhouse and fewer days to harvest of komatsuna in both greenhouses when these crops were covered with poly. With some crops such as komatsuna, the type of row cover and whether it is left on all the time or removed during the day can make major
differences in yield, quality, and days to first harvest. With other crops, such as baby lettuce, differences among row cover treatments are small and mostly not significant. A thick fabric (2 oz. per square yard) row cover treatment gave results that were similar to poly row cover treatments. Labor hours were estimated for each system and can provide guidance for growers considering a system of row cover removal.

**Impact of results**

The project objectives were achieved. It was demonstrated that it is practical to grow vegetables in an unheated large gutter-connect greenhouse in Iowa. This information will help Iowa farmers who are new to high tunnel/greenhouse growing to decide on greenhouse size and row cover treatments for winter growing. It will inform the Iowa farmers who are already growing in small unheated high tunnels/greenhouses because it showed that small greenhouses are better than large greenhouses for some types of winter crop production. These findings should encourage them to try different row cover treatments to determine what will work best for greenhouse crops in their area.

What does this mean for an Iowa farmer? A farmer who has a large greenhouse should be able to grow vegetables through the winter successfully. There are extra labor costs for removing and replacing the row covers, but this is much less than the cost of heating the greenhouse. A farmer will have to evaluate whether the extra yield and quality from removing the covers justifies the extra labor needed to remove them. If a farmer is considering adding unheated greenhouse space to his or her operation, hoop houses may be a better choice than a large gutter connect greenhouse. In the hoop house, daytime temperatures were a little higher than in the one-acre greenhouse and crop growth was usually a little greater during the coldest part of the winter.

The project impacted the Maharishi University of Management Organic Farm. In previous years, the greenhouses were heated at night, just enough to keep the temperature above freezing. Not heating the greenhouses in this project reduced the farm’s total fossil fuel use by about 80 percent and the farm’s heating expense by about $16,000.

**Education and outreach**

A field day was held in April 2010 that attracted more than 60 people. Approximately half were area farmers and the remainder were gardeners or other interested observers. Brief reports appeared in the Cedar Rapids Gazette, on KTVO television, a local radio station, MUM Review, and several web sites including globalgoodnews.com, leeleffler.com, and insideawake.posterous.com. Results were posted on the Hightunnels listserv and website.

**Leveraged funds**

No additional funds were leveraged as a result of this grant.

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Experimental plots in 1 acre greenhouse.