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# PROTECTED WINTER PRODUCTION OF 'GALIA' MUSKMELONS

Eric A. Waldo, George J. Hochmuth, Daniel J. Cantliffe
and Steven A. Sargent
*Horticultural Sciences Department*
*University of Florida, IFAS*
*Gainesville, FL 32611*

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*Abstract.* **'Galia' muskmelons (*Cucumis melo* var. *reticulatus* (L.)) were grown under walk-in tunnels (quonset style structures covered with a single layer of polyethylene film and heated and cooled without powered heating or cooling equipment) and low-tunnels (row-covers) during the winter/spring of 1997. Half of the walk-in tunnels contained thermal tubes (tubes twelve inches in diameter that hold water which acts as a solar collector during the day and releases the energy as heat during the night). The objective of the project was to compare the effectiveness of walk-in tunnels and low-tunnels for protecting crops from cold, winter and early spring temperatures. Walk-in tunnel plots were planted 17 Feb. and 3 and 22 March. Low-tunnel plots were planted 3, 22, and 28 March. Harvesting began on 8 May and continued until 18 June. Early yields, total marketable yields, soluble solids concentration of fruits, and individual fruit weights were greater in walk-in tunnels with and without thermal tubes than in low-tunnels.**

## Introduction

Farmers in Florida have produced winter vegetables for many years and have generally received high prices for their crops because few other regions in the United States are capable of producing vegetables outdoors during the winter months. Winter vegetable production in Florida has been located primarily in the southern part of the state due to the warmer temperatures found there. Farmers in the northern part of the state have used various means of crop production to take advantage of early or out-of-season prices, but there are limitations to each production method. Transplanting rather than direct-seeding results in earlier yields, but transplanting alone does not protect plants from frosts or freezes. Plastic mulches and row-covers have been used to increase early yields by several weeks (Hochmuth, 1987), but results are often inconsistent because of the limited freeze protection provided. Generally temperatures under the covers are 2 to 4 F warmer than outside air (Wells and Loy, 1993).

Another crop production option which can be used in Florida is greenhouse crop culture. Heated greenhouses ensure protection from freezing temperatures but are very expensive to build and operate. A typical 110 × 35 foot greenhouse including fans, heaters, etc., can cost as much as $30,000. In addition to the fixed costs is the annual expense of operating a greenhouse. In 1990, the cost for supplies and labor was estimated to be up to $14,000 per year (Hochmuth, 1990). This can eliminate greenhouse production as an option for growers who have limited cash flow or for growing crops that are not exceptionally high in value.

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There is however a possible solution to be found by using walk-in tunnels and thermal tubes. A walk-in tunnel has been defined as "a portable walk-in, greenhouse-like structure without a permanent electrically powered heating or ventilation system, covered with one layer of plastic, and sited on field soil" (Wells and Loy, 1993). For many years, walk-in tunnels have been widely used in the Middle East, Asia, and southern Europe for vegetable production (Wells and Loy, 1993), and recent studies demonstrated that the tunnels have great promise in the United States as well (Gent, 1991; Secker et al., 1996; Wells, 1991).

While the walk-in tunnel itself provides a warmer climate for the plants in cooler weather, other technologies have been investigated which add to the effectiveness of a walk-in tunnel's warming abilities, especially in offsetting freeze damage. One of these technologies is the use of thermal tubes. Thermal tubes are clear polyethylene tubes, 10 to 12 inches in diameter, filled with water which absorbs the sun's energy during the day and slowly releases the energy as heat throughout the night. The tubes are laid alongside the plants and have been shown to not only raise the soil and plant canopy temperatures during cold periods (Secker et al., 1995) but also to lower the soil and plant canopy temperatures during warmer periods (Storlie and Neary, 1994). Thermal tubes were developed and tested by Grafiadellis in 1986 in Greece, and much work was then done throughout the Mediterranean region to refine these systems (Grafiadellis, 1989; Pavlou, 1990; Secker et al., 1995). Although thermal tubes were originally created to offset heating costs in greenhouses (Pavlou, 1990), their usefulness in tunnel production was soon realized and pursued. Different types of plastic and sizes of tubes were tested, and polyethylene tubing with a diameter of 12.5 inches was deemed to be best (Grafiadellis, 1989).

The objectives of this study were to evaluate the effects of walk-in tunnels, low tunnels, and thermal tubes on winter muskmelon production in northern Florida.

## Materials and Methods

Muskmelons ('Galia') were grown in the Spring of 1997 at the Horticultural Research Unit of the University of Florida in Gainesville, Florida. Plants were grown in six walk-in tunnels (three with thermal tubes and three without thermal tubes) and in six low-tunnel plots. Each walk-in tunnel or low-tunnel plot had three raised (6 inches), plastic mulched beds extending 25 feet in length.

Each walk-in tunnel was 60 feet long, 30 feet wide, and 11 feet high. The tunnels were quonset-style frames covered with a single layer of 0.006 inch (6 mil), polyethylene, infrared-barrier, anti-condensation, UV-resistant film (Sunsaver, Green-tek Edgerton, WI). The tunnels were ventilated through a 68-inch wide insect barrier screen (Meteor Anti-virus, Green-tek Edgerton, WI) which ran the length of the tunnels on both sides. The bottom edge of these screens was about 1 foot off the ground. When temperatures were low (<50 F), a panel of plastic was rolled down over the insect screen. These panels were rolled down with "T" handles attached to a metal bar attached to the plastic. Doors were located on each end of the tunnels for easy access.

Three of the walk-in tunnels had thermal tubes lying beside each bed. The thermal tubes were 0.006 inch (6 mil) plastic sleeves, 50 feet long (not including 3 or 4 feet on each end used to tie the tubes up and attach them to a stake) and 12 inches in diameter. The tubes were filled with water, and approximately ⅕ gallon of chlorine bleach (5.25% sodium hypochlorite, Clorox) was added to each tube to inhibit algae growth.

The low-tunnels consisted of wire hoops every 5 feet which were covered with a fabric-like polypropylene row-cover material. This material was lightweight (0.6 oz per sq. yard) and allowed air to reach the crop. The covers were placed over the plants after transplanting and removed when the plants began to flower to allow bees and other insects to pollinate the crop.

Transplants (grown in a greenhouse by the researcher and generally 3 weeks old) were planted on various dates. The first planting in the walk-in tunnels was made on 17 Feb. The second planting in the walk-in tunnels and the first planting in the low-tunnel plots were made on 3 March. The third planting in the walk-in tunnels and the second planting in the low-tunnel plots were made on 22 March. The third planting in the low-tunnel plots and a control plot (no cold protection) were made on 28 March. In each plot, 18 plants were planted 16 inches apart on alternate sides of the drip tape.

Based on soil test results and recommendations from the Extension Soil Testing Lab at the University of Florida, crops were fertilized with approximately 150 lb of N and 120 lb of K. Approximately 40 lb of N was applied pre-plant broadcast in the beds. The remainder of the fertilizer was applied weekly in portions through fertigation using a peristaltic pump through an injection port.

Irrigation was scheduled by the use of tensiometers. Irrigation periods were increased when the tensiometer at a depth of 6 inches was drier than -10 cb prior to the first irrigation event of the day.

Bumble-bees (*Bombus impatiens*) (Koppert Biological Systems, Ann Arbor, MI) were used to pollinate the flowers. Three hives were used to pollinate all six tunnels by switching the hives every other evening from one tunnel to another. Standard, labeled pest management practices were followed. Pesticides were applied as needed.

Melons were harvested when yellow color could be seen in the background of the melon's skin all the way around the region near the peduncle. ('Galia' melons have poorly defined natural abscission (slip) stages, so slip stage could not be used to determine maturity of the fruit.) Melons were individually weighed and evaluated for grade. Those melons with netting on more than 50 percent of their surface were considered to be grade 1. Melons with netting on 50 percent or less of their surface were counted as grade 2. Melons which were deformed, cracked, rotten, or weighed less than 1.5 lb (700 g) were considered to be culls. Samplings of five grade 1 melons from each plot were analyzed for soluble solids concentration using a refractometer.

The data were analyzed using analysis of variance for a factorial, nested design. Media (soil or perlite), structures (heated or unheated walk-in tunnel or low tunnel), and planting date nested within structures were the factors for analysis of variance. Comparisons among treatments were made using least square means. Yields from plants in the control plot are included in figures as a reference only. They were not included in statistical analysis due to the nature of the experimental design. Also, while "media" was a part of the overall project and was included in the analysis of data, only data from the structure factor effects will be presented in this paper.

### Results and Discussion

Crops grown in both heated and unheated walk-in tunnels had greater total yields (Fig. 1), early yields (Fig. 2), and fruit quality (Figs. 3 and 4) than crops grown using low-tunnels. The greater total yields in the walk-in tunnels were due in part to the reduced cull percentage inside the walk-in tunnels and the protection they provided from pests and pathogens. The lower mean cull percentage in the walk-in tunnels (Fig. 5) was due to the protection the walk-in tunnels provided the fruit from the environment. The melons were observed to crack and rot quickly when mature if there was any moisture at the point where the melon touched the ground. The walk-in tunnels protected the melons from rain which added excess moisture to the outdoor crops leading to increased fruit rot. The percentage of culls for the low-tunnels might have been even greater than recorded because a num-

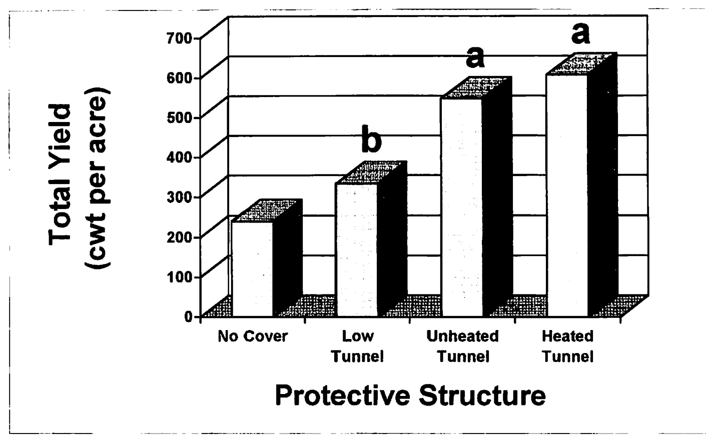


Figure 1. Total marketable yield means. Treatments with the same letter are not significantly different at the 5% level according to comparisons using least square means.

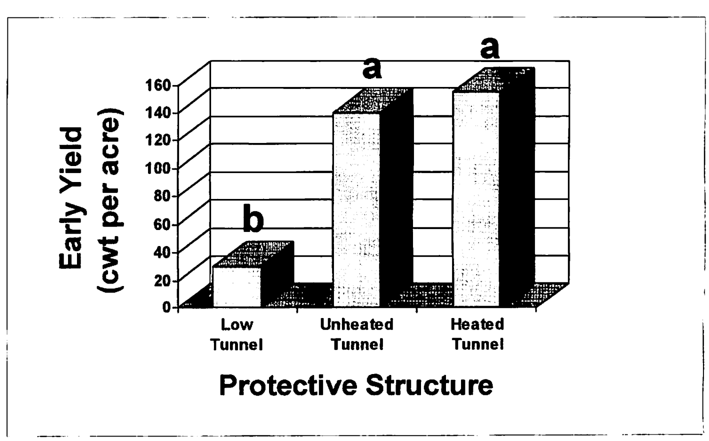


Figure 2. Comparison of early (first third of total number of harvests for plots planted on the same date) marketable yields for crops planted 3 March and harvested through 21 May. Treatments with the same letter are not significantly different at the 5% level according to comparisons using least square means.

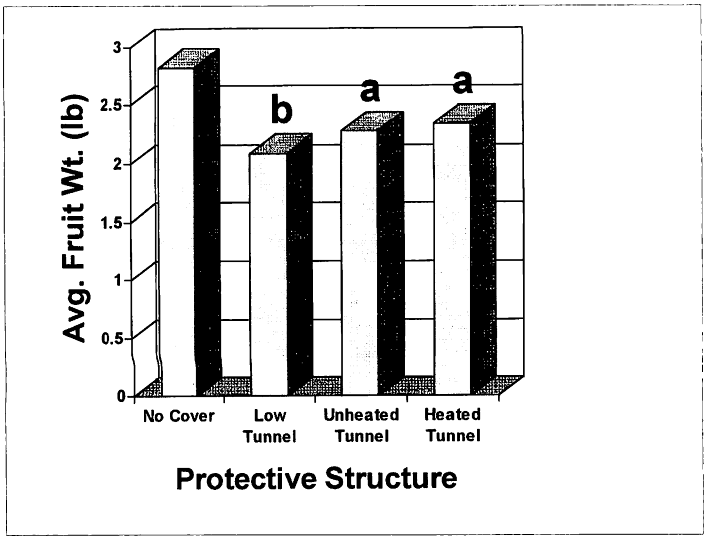


Figure 3. Comparisons of average marketable fruit weight. Treatments with the same letter are not significantly different at the 5% level according to comparisons using least square means.

ber of melons decayed in the field and could not be harvested.

Crops grown under row-cover were severely infected with downy mildew (*Pseudoperonospora cubensis*). The disease was severe even though a fungicide program was initiated soon after symptoms appeared. Only a small area of downy mildew was found inside the walk-in tunnels. The epidemic of downy mildew in the outdoor, low-tunnel plots was due to the rain and cooler outdoor temperatures which helped the fungus spread quickly (Agrios, 1988). The drier, warmer conditions inside the walk-in tunnels kept the disease from spreading.

The higher early (first third of total number of harvests for plots planted on the same date) yields in the walk-in tunnels for plots planted on the first coordinated planting date (3 March) (Fig. 2) were due to the walk-in tunnels' higher temperatures during cool weather and reduced pest pressure.

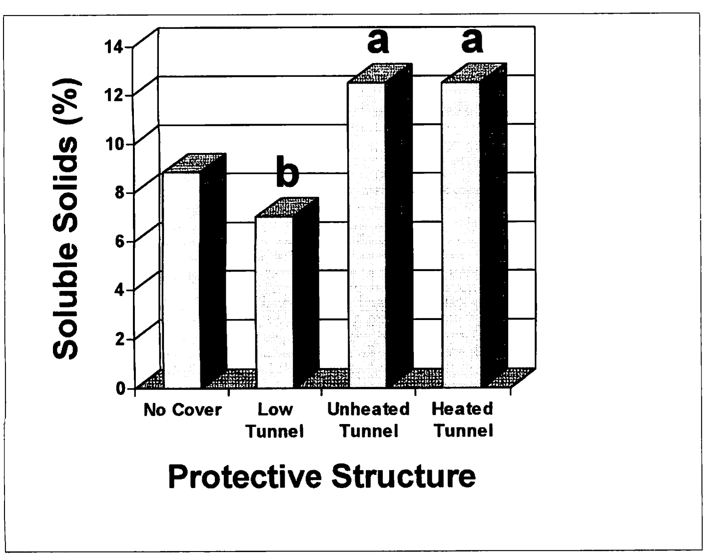


Figure 4. Comparison of Brix means. Treatments with the same letter are not significantly different at the 5% level according to comparisons using least square means.

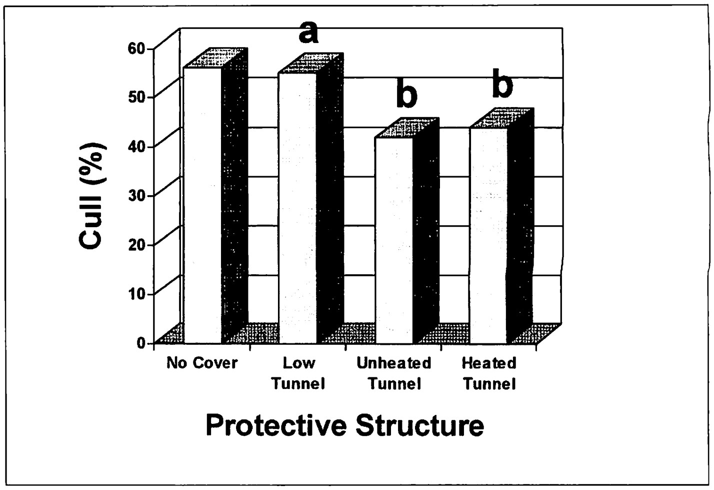


Figure 5. Comparison of cull percentages by count. Treatments with the same letter are not significantly different at the 5% level according to comparisons using least square means.

In one set of measurements taken on 19 April, the temperature inside one of the heated tunnels (47 F) was 8 degrees F higher than the outside air temperature (39 F). The temperature inside one of the unheated tunnels was 42 F on the same night. These cool temperatures occurred after the fabric was removed from the low-tunnels. Protecting crops from low temperatures during the spring has been shown to promote more vigorous growth and earlier yields in crops (Hodges, 1991). The reduction of disease (as noted above), and hence increased plant vigor inside the walk-in tunnels, probably also contributed to the increased early yields observed within the walk-in tunnels. The early yields for plots planted on the second coordinated planting date (22 March) were not significantly different at the 5% level.

The increase in quality of fruits grown in the walk-in tunnels is evidenced by both a higher individual fruit weight and a higher concentration of soluble solids in the fruits (Figs. 3 and 4). This increase in fruit quality was due, in part, to the reduced levels of downy mildew in the walk-in tunnels. Downy mildew reduces fruit quality (Kucharek 1984) by damaging leaf tissues and thereby reducing rates of photosynthesis and plant metabolism.

In conclusion, walk-in tunnels with and without thermal tubes are relatively inexpensive technologies which provide a protected environment for growing muskmelons during the cooler months of the year. Walk-in tunnels might provide a suitable means to produce vegetable crops in northern Florida under an otherwise excessively cool and wet winter and early spring climate. Further research should examine the seasonal limits, environmental monitoring and control, and potential profitability of these systems for production of muskmelons and other crops in northern Florida.

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# NITROGEN FERTILITY REQUIREMENT FOR ICEBERG LETTUCE GROWN ON SANDLAND WITH PLASTIC MULCH AND DRIP IRRIGATION

D. J. CANTLIFFE AND G. J. HOCHMUTH
*Horticultural Sciences Department*
*University of Florida, IFAS*
*PO Box 110690*
*Gainesville, Florida 32611-0690*

ZVI KARCHI
*PERI*
*PO Box 6*
*Bet-Dagan 50250 Israel*

ITZHAK SECKER
*34 Burla Street, Apt. 2*
*Tel-Aviv 69364 Israel*

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*Abstract.* **In order to insure a profitable industry and production of quality produce on the sandy soils of Florida, a series of experiments were conducted over four years to determine the response of iceberg lettuce (*Lactuca sativa* L.) grown with drip irrigation and plastic mulch to nitrogen (N). Beds were established with no preplant fertilizer, drip irrigation, and white-on-black co-extruded polyethylene film. Irrigation frequency was managed by tensiometers and was initiated as water tensions reached -10kPa. Nitrogen as $NH_4NO_3$ and $KNO_3$ was applied weekly via the drip tube at rates from 55 to 275 kg·ha$^{-1}$ N. Lettuce yields were improved by total N rates of 160 to 195 kg·ha$^{-1}$ N and thereafter decreased. Head firmness, head size, and (stem) butt diameter were generally largest with this same N fertility rate. Other quality factors such as core length and internal tip burn were minimized with the lowest N rate (55 kg·ha$^{-1}$ N). Profitable production of high-quality iceberg lettuce on sandland with drip irrigation, plastic mulch, and 160 to 195 kg·ha$^{-1}$ N in Florida is now possible.**

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## Introduction

Approximately 3,500 ha of lettuce are grown in Florida annually, mostly on organic soils around Lake Okeechobee and Zellwood. Very little lettuce has been grown commercially on the mineral soils of the state. Likewise, there are very few reports of lettuce production or experimentation on sandy soils (Seale and Cantliffe, 1985, 1986; Cantliffe and Karchi, 1992; Seale et al., 1994; Robles, 1997).

Expansion of lettuce production to the abundant sandy soils in Florida seems logical for several reasons. Closer proximity to the U.S. East Coast markets offers Florida lettuce a competitive advantage in transportation costs compared to California lettuce. Mild climatic conditions throughout the entire peninsula of the state offer the possibility of obtaining added revenues from earlier production. The use of adapted cultivars, specific climatic regions, and special production techniques might enable lettuce production 8 to 10 months of the year in Florida. Lastly, decline of agricultural land due to oxidation of Histosols, the closing to agricultural production and flooding of the Histosols around Lake Apopka, and competition with other crops such as sugar cane, limit lettuce production on the muck soils.

Several problems with producing lettuce on sandland in Florida have been identified by Robles (1997). They included the need for more adaptive cultivars for sandland production, improvements in transplant technology, and the need for fertilizer recommendations, especially N, for lettuce grown with plastic mulch and drip irrigation.

In a fertilizer trial using open ditch seepage irrigation, Everett (1980) reported advantages of polyethylene mulch for increasing yields and lettuce head weight. However, fertilizer rates ranging from 470 to 1031 kg·ha$^{-1}$ of 18-0-20 (N-P-K) above a standard rate of 560 kg·ha$^{-1}$ of 5-4-7 had no effect on yield or head weight. Cantliffe and Karchi (1992) grew several cultivars of iceberg lettuce on white plastic mulch and drip irrigation with 1200 kg·ha$^{-1}$ of 13-2-11 (N-P-K) fertilizer applied preplant and rotovated into the bed. Fertigation as weekly applications of 18 kg N, 12 kg P, and 6.7 kg K were also applied from planting until two weeks before harvest.