COOPERATIVE EXTENSION SERVICE
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Measurement of Temperature Extremes in Tobacco Float Systems

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Outside Beds

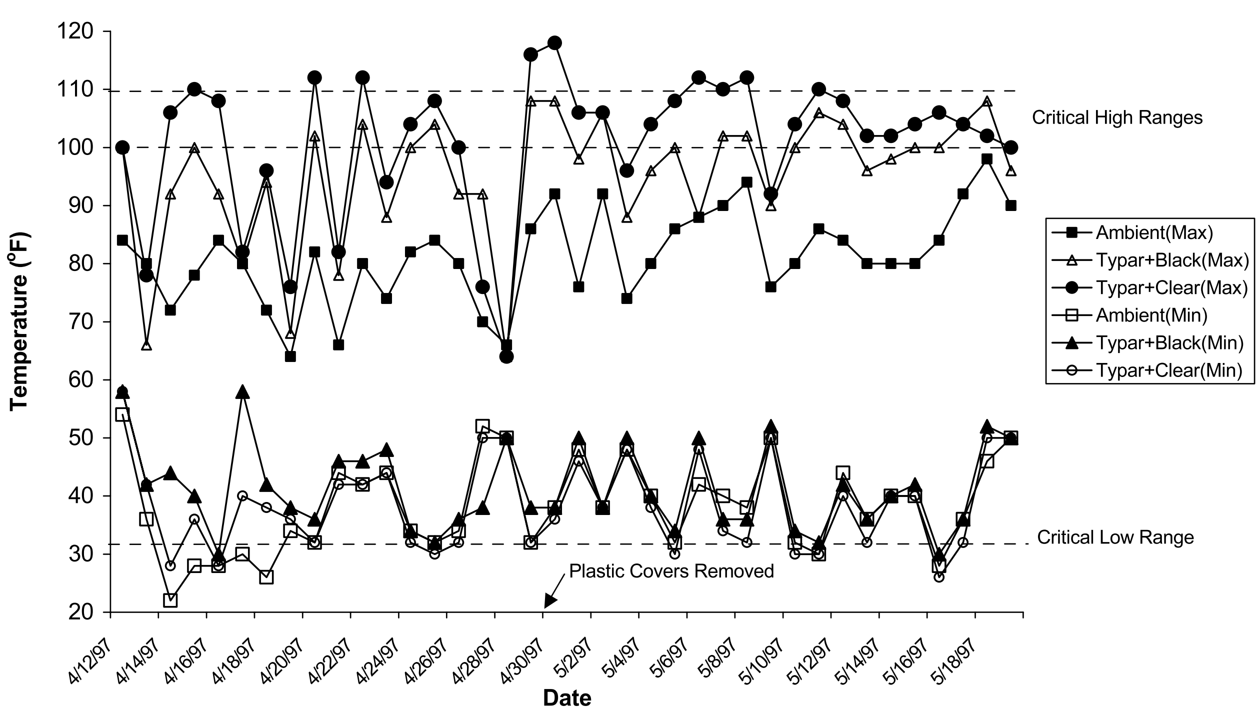
Temperature Evaluation under Clear and Black Plastic Covers in a Tobacco Float System

Wayne County—Ray Adams Farm—1997
Coordinated by Glen Roberts and Danny Adams

Since the first float system was used for tobacco transplant production in Kentucky, there has been debate concerning the merits of clear versus black plastic as an additional covering over traditional plant bed covers for rain and freeze protection. An experiment was designed to compare temperature differences under two plastic covers on outside float beds at the Ray Adams farm in Wayne County. Two float beds were seeded on March 27 and covered with Typar. One bed was covered with an additional layer of black plastic and the other with clear plastic. A ceramic heater was placed in each bed and set to operate at temperatures below 40ºF. Two maximum/minimum thermometers were placed in each of two outside float beds on April 12. Each bed had a thermometer placed at the end and center of the bed. A shielded thermometer was located outside of the beds for an ambient reading. Maximum and minimum temperature readings were recorded daily from April 12 to May 19. The clear cover was left on for the first five weeks, but ventilated on each end every day. The black plastic was taken off during the daytime except for rainy days. Maximum/minimum temperatures were recorded for 18 days before and 18 days after the plastic covers were removed.

The lowest maximum daily temperature was 64ºF recorded by all of the thermometers at some point during the initial 18-day recording period (Figure 1). The highest maximum temperature was recorded on April 30 in the center of the bed covered with Typar and a clear plastic cover. On that day the clear plastic was removed for the duration of the test. The temperature was 26ºF hotter than ambient, while the black cover surpassed ambient by 18ºF. Since the black plastic cover was removed during the day, the maximum temperatures in those beds may represent heat retention by the Typar cover alone. The value compares with temperatures taken after the plastic was removed. Minimum temperatures for the two covers were comparable at 28º to 30ºF

Figure 1: Critical Temperature Ranges under Plastic Covers in an Outside Float System—Wayne County—1997



and high enough to avoid freeze damage. The ambient temperature dropped to 22ºF during the early stages of the study.

The clear plastic cover retained heat in excess of 110ºF in the middle of the beds on four different days. The clear cover, although vented, was not removed during the day. This is a practice that should be reconsidered. Plastic covers provided little help at night with retention of the heat generated during the day. An additional heat source is necessary to maintain temperatures at an acceptable level.

After the plastic covers were removed, Typar covers retained temperatures that surpassed critical levels, although ambient stayed below 90ºF. Maximum temperatures indicated a need to ventilate beds with synthetic covers. Temperatures average 13° to 20ºF higher than ambient temperatures. The Typar covers reached critical temperatures beyond 100ºF on several days and in one case beyond 110ºF. Typar covers alone did not maintain nighttime temperatures above ambient.

Temperature Evaluation under Different Float Bed Covers

Pulaski County—Terry Barker Farm—1997 and 1998
Coordinated by Keenan Turner

A preliminary outside float bed cover evaluation was conducted at the Terry Barker farm in Pulaski County in 1997 and repeated in 1998. Electronic Optic Stowaway Temperature sensors were placed in outside float beds covered with one of three types of float bed covers, Continental, Typar, and Vispore. In 1998, these were compared to an ambient temperature sensor set up near the beds in a protective housing that reduced solar heating while still providing air movement. Sensors located inside float beds were set up in the same fashion. The recordable range of temperature sensors in the preliminary test was from 24° to 100.6ºF. Temperatures in excess of 100ºF were not anticipated. In 1998, a switch to sensors with a recordable range of –32° to 167ºF provided a more accurate picture of temperature extremes in float beds. These sensors were used in all subsequent studies. Taking measurements every ten minutes is excessive and does not add to the conclusions. Intervals of one hour are sufficient.

In 1997, sensors were placed in beds on April 15, and left for 13 days. Temperature readings were taken every 10 minutes for a total of 1,822 readings for each sensor. In 1998, sensors were placed in beds on April 10, and left for 35 days. Temperature readings were taken hourly for a total of 840 readings for each sensor.

In 1997, all sensors reached their maximum recordable high temperature at some time during the study (Figure 2). This indicated a need for sensors with a higher maximum temperature level. However, by evaluating the number of times that the temperature exceeded 100ºF, plant exposure to high temperature under different covers is evident. The Vispore cover reached temperatures in excess of 100ºF 72 times compared to 62 for the Continental. The Typar stayed the coolest, surpassing 100ºF only seven times.

Figure 2: Critical Temperature Ranges under Different Float Bed Covers—Pulaski County—1997

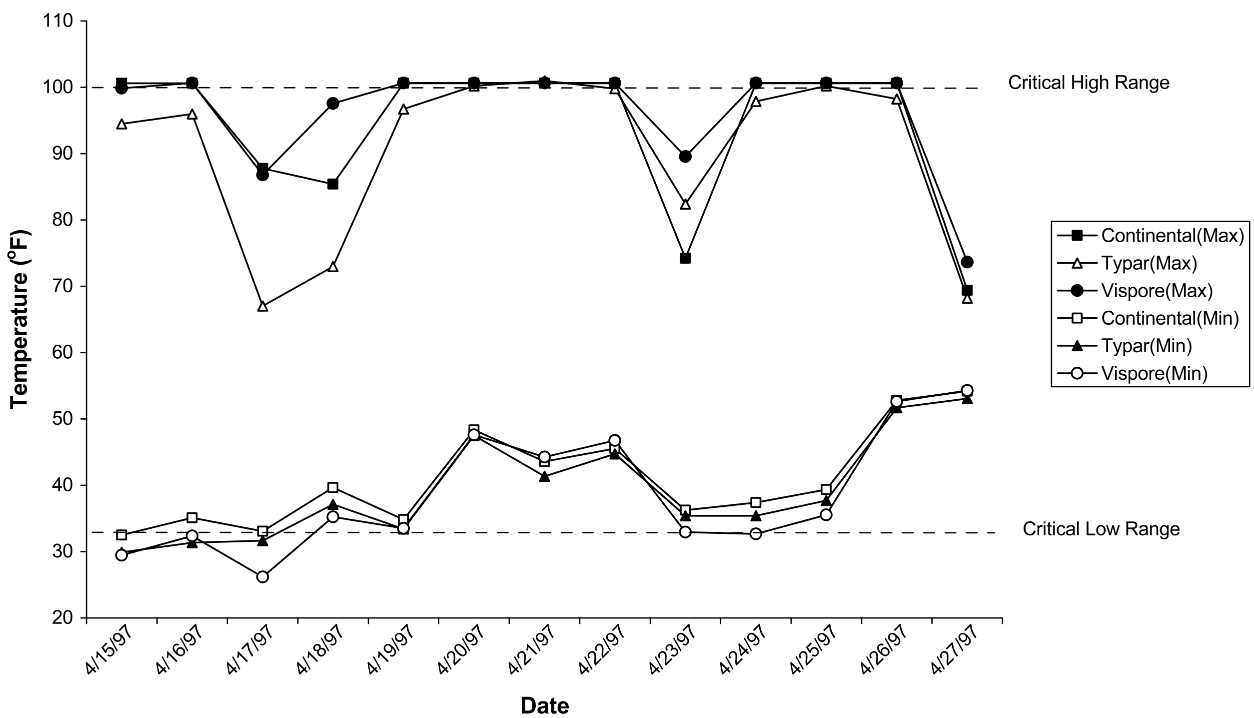
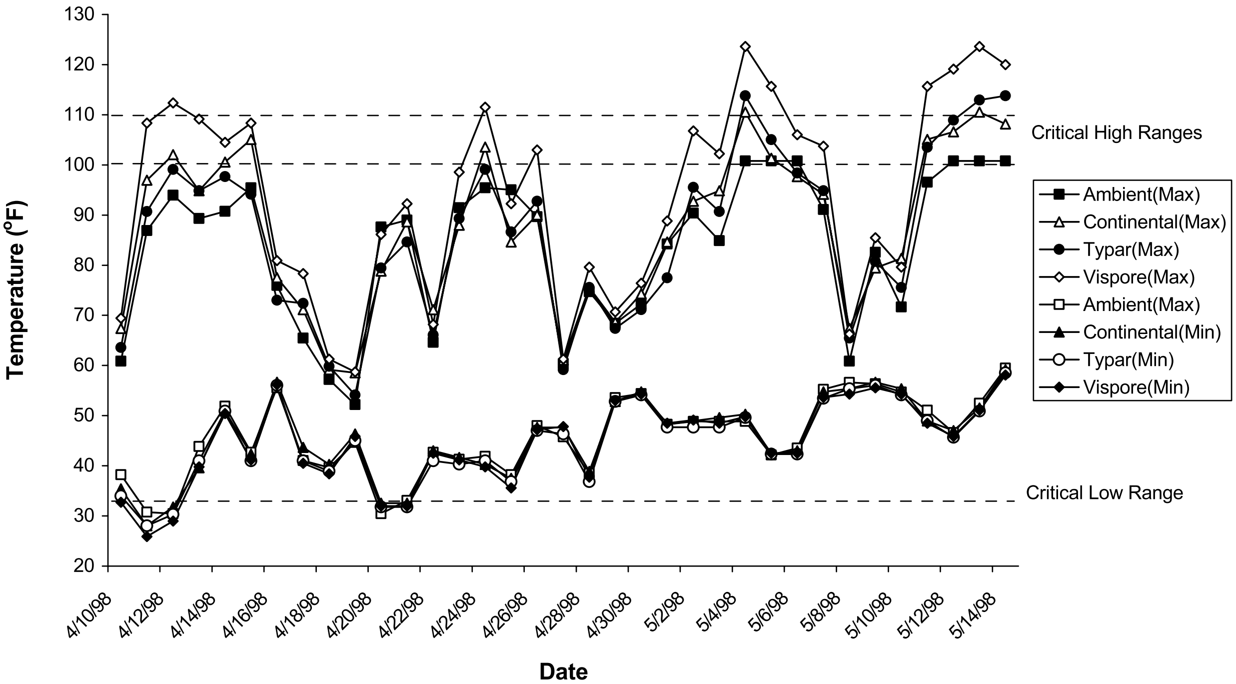


Figure 3: Critical Temperature Ranges under Different Float Bed Covers—Pulaski County—1998



The Continental maintained nighttime temperatures above 32°F better than the other two covers. It did not allow bed temperatures to drop below freezing. The Continental reached a minimum of 32.5°F, or 2.6°F warmer than the Typar and 6.3°F warmer than the Vispore. The Typar dropped below freezing for 15 measurements, while the Vispore dropped below freezing for 34 readings. Vispore, a plastic cover with tiny holes for moisture movement, appears to dissipate stored heat energy rapidly. A difference of a few degrees below the freezing mark can mean the difference between seedling survival and death. Ambient temperatures were not recorded for 1997, an oversight that was rectified in 1998 and subsequent tests.

In 1998, all covers reached a minimum temperature that was lower than any recorded for the ambient temperature (Figure 3). Moisture levels in the float beds may have created evaporative cooling under windy conditions that could have accounted for lower temperatures than those seen under ambient conditions. The Vispore cover reached a minimum of 25.9°F, or more than 2°F lower than the other two covers. This can mean the difference between plant survival and plant loss due to freeze damage. Ambient maximum temperature was just below 101°F. All covers retained heat energy with maximum temperatures reaching above critical levels. The temperature sensor under the Vispore cover reached a level of 123.6°F, which could potentially damage plants.

The amount of time that plants were subjected to critical temperatures was calculated. Ambient temperatures were in the critical range fewer hours than under any cover. However, neither the Continental nor the Typar covers were significantly different from the ambient in number of hours above the critical range. The Vispore cover reached critical temperatures for 49 hours, almost triple that of the ambient and more than double that of the Continental cover. Both the Typar and the Vispore hit critical lows more often than the Continental cover or the ambient temperatures.

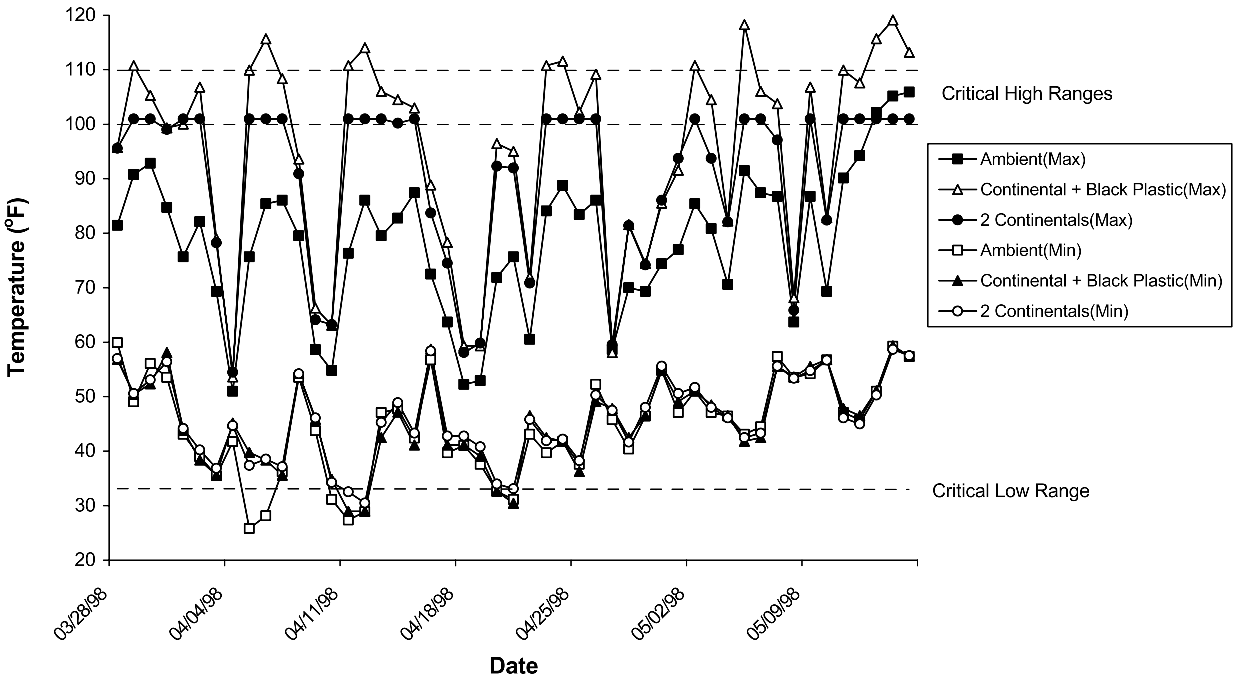
Temperature Evaluation under Two Float Bed Cover Arrangements

Wayne County—Ray Adams Farm—1998
Coordinated by Glen Roberts and Danny Adams

Outside float bed covers were evaluated at the Ray Adams farm in Wayne County. Electronic temperature sensors were placed in outside float beds covered with either two Continental covers or one Continental cover and black plastic. These were compared to an ambient temperature sensor set up near the beds in a protective housing that reduced solar heating while still providing air movement. Sensors located inside float beds were set up in the same fashion. Sensors were placed in beds on March 27, 1998, and left for 49 days. Temperature readings were taken every half-hour for a total of 2,352 readings for each sensor.

Both covers provided some safety from freezing temperatures compared to ambient, with two Continental covers recording a slight edge at 30.5°F (Figure 4). Under conditions in which the black plastic cover was removed, leaving a single Continental cover, heat buildup during the day was excessive, reaching 119.1°F. Two Continental covers may provide some shading

Figure 4: Critical Temperature Ranges under Different Float Bed Cover—Wayne County—1998



effect. The maximum temperature recorded under two Continental covers was 105.9°F, or 13.2°F lower.

The amount of time that plants were subjected to critical temperatures was calculated. Ambient temperatures were in the high critical range less time than under any cover. The Continental with black plastic generated temperature in excess of 110°F for 41 measurements. Neither ambient nor two Continental covers allowed temperatures to reach this level. The Continental with black plastic reached 100°F during 180 measurements compared to 165 for the two Continental covers. The ambient temperature reached critical lows 59 times over the course of the study, while the Continental with an assist from the black plastic reduced critical exposure to 27 times. Under the two Continental covers, the critical temperature was reached only five times over the course of five consecutive readings on a single day, April 12.

Black plastic may offer some benefits over clear plastic in terms of extreme temperatures, but black plastic also may elevate temperatures into critical zones. It does not afford much protection from freeze damage. Two Continental covers may provide enough rainfall protection to reduce damage from that concern, but this arrangement also has definite advantages for heat retention at night while preventing excessive heat buildup during the day.

Temperature Evaluation in an Outside Float Bed

Wayne County—John Cooper II Farm—1999
Coordinated by Glen Roberts and Danny Adams

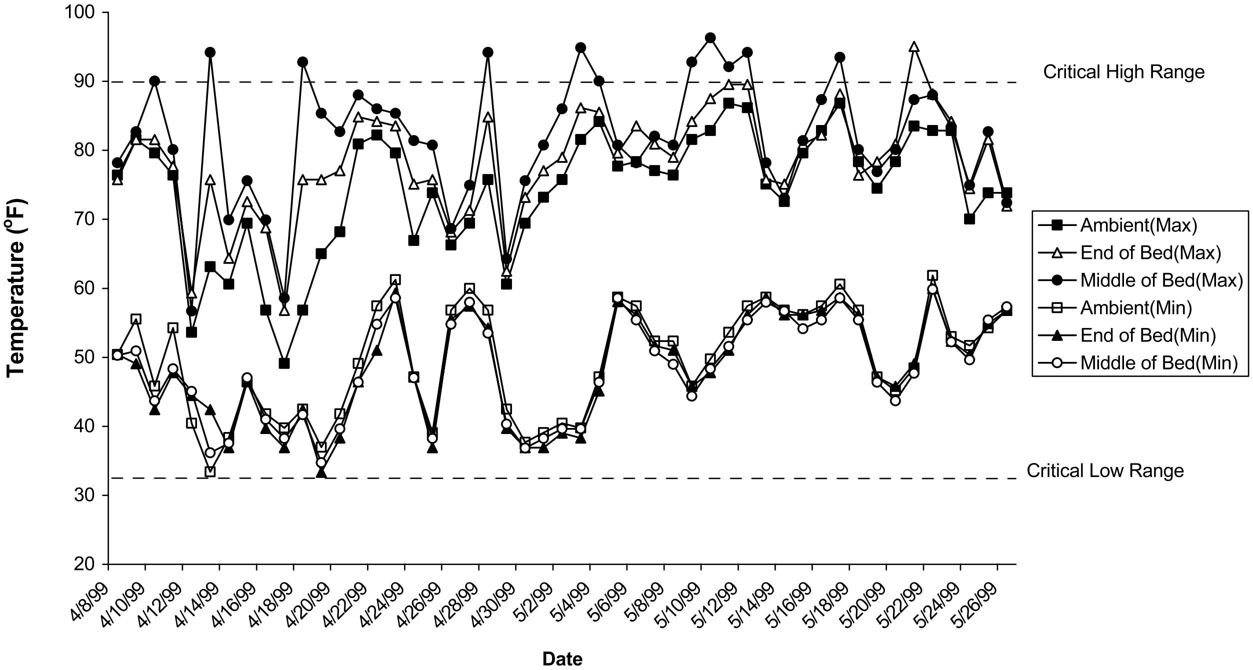
An outside float bed was evaluated at the John Cooper II farm in Wayne County. Electronic temperature sensors were placed in the bed at two locations, the end of the bed and in the center. These were compared to an ambient temperature sensor set up near the bed. All sensors were housed in a protective cover that was aspirated using an electric fan for a more accurate reading. Sensors were placed in the bed on April 8, 1999, and left for 49 days. Temperature readings were taken every hour for a total of 1,176 readings for each sensor. The bed was covered with two Continental covers.

Minimum temperatures varied little from ambient at either location in the bed with the sensors in the middle of the bed recording slightly more than a degree warmer than ambient (Figure 5). Ambient and the end of the bed were essentially equal. The end of the bed reached a maximum temperature that was approximately 8 degrees hotter than ambient, with the middle of the bed only a degree warmer. The Continental covers performed as expected, based on the previous year's research.

No reading exceeded 100°F. However, the middle of the bed rose above 90°F 23 times compared to three times for the end of the bed. Ambient, as was stated previously, did not exceed 90°F. No readings dropped below 32°F. Both measurements in the bed dropped below 40°F more times than the ambient temperature, a phenomenon that has been observed before. Evaporative cooling is suspected as a cause of the lower-than-ambient readings inside the float bed.

Daily temperature variations inside the float beds were greater than for the ambient temperatures. This was especially true for readings taken in the middle of the bed. Temperatures fluctuated more than 50°F on four different days in the middle of the

Figure 5: Critical Temperature Ranges in an Outside Float Bed—Wayne County—1999



bed, reaching a 58°F fluctuation on April 13. Temperatures fluctuated more than 40°F on 15 of the 49 days in the middle of the bed compared to five for the end of the bed and only one day for ambient temperatures. The number of days in which the temperature range was greater than 30°F rose to 13 for the ambient temperature, 23 for the end of the bed, and 30 for the middle.

Greenhouse

Temperature Evaluation in a Mini-Greenhouse

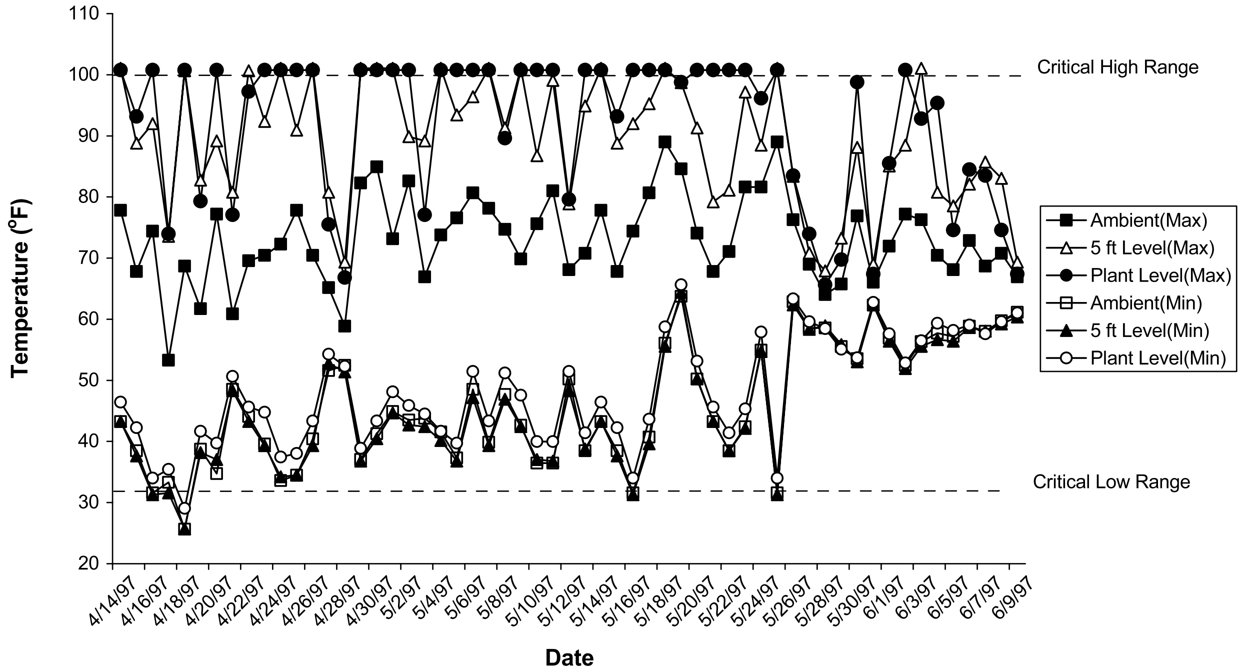
Adair County—1997
Coordinated by David Herbst

Mini-greenhouses have become popular in some areas of Kentucky. There are major concerns about temperature control in some of the designs being used. A mini-greenhouse was built at the Adair County Extension Office to evaluate temperature control. Optic Stowaway temperature sensors were placed at three locations inside the mini-greenhouse—at plant level, 5 feet above plant level, and in the float water—plus one outside to record ambient temperatures. Sensors recorded temperature every 30 minutes from April 14 to June 9 for a total of 2,648 readings per sensor.

Sensors at the 5-ft level and plant level reached their maximum recordable high temperature (100.6°F) at some time during the study (Figure 6). This study, as did other studies in 1997, indicated a need for sensors with a higher maximum temperature level. However, by evaluating the number of times that the temperature exceeded 100°F, plant exposure to high temperature is evident. Ambient temperatures did not exceed 100°F at any time. Plant level temperatures exceeded 100°F on 217 readings, or 8.2 percent of the time. Ventilators located closer to the 5-ft level helped prevent high temperatures at that level but did not help as much at plant level. Temperatures exceeded 90°F only at the 5-ft and plant levels, with more than twice the number of high recordings at the plant level than at the 5-ft level. The mini-greenhouse offered little protection from cold temperatures, with the 5-ft level minimum temperature being essentially identical to the ambient temperature. The amount of time the temperature was below freezing was 14 times for ambient and 15 for the 5-ft level. The plant-level minimum temperature was 3.4° higher than ambient and dropped below freezing only seven times.

Float water temperatures remained relatively stable and did not reach critical levels. Float water temperatures tend to run slightly higher than soil temperatures.

Figure 6: Critical Temperature Ranges in a Mini-greenhouse—Adiar County—1997



Temperature Evaluation under a Greenhouse Environment

Oldham County—Les Snyder Farm—1998 and 1999
Coordinated by Ron Thomas

A greenhouse environment was evaluated at the Les Snyder farm in Oldham County in 1998 and 1999. Electronic temperature and humidity sensors were placed at various points inside the greenhouse. These sensor readings were compared to an ambient temperature sensor placed outside in a protective housing to reduce solar heating while still providing air movement to achieve a more accurate reading. Sensors were located inside at plant level and 5 ft from ground level in the middle of the greenhouse, a location similar to that used for placement of thermostats in many greenhouses in Kentucky. Sensors were placed in beds on March 26, 1998, and left for 49 days and on April 14, 1999, and left for 67 days. Temperature readings were taken every half-hour initially but were later changed to register every hour. Initial half-hour readings were dropped to standardize the data, leaving 1,185 readings for each sensor in 1998 and 1,628 in 1999. The plant-level sensor also recorded plant-level humidity every hour and calculated dew point temperatures.

Temperature readings in 1998 suggested that the Snyder greenhouse environment was maintained at a relatively stable temperature throughout the time plants were germinating and growing (Figure 7). Although the ambient temperature dropped to 30.3ºF, greenhouse temperatures did not drop below 55ºF. No damage from cold was expected at such high temperatures. However, typical "cold injury" symptoms occurred. The readings at the 5-ft level, where many thermostats are placed, reached 111.3ºF on April 16 and coincided with a power outage. However, at plant level the temperature reached only 102.6ºF. This temperature was the only time plant-level temperatures exceeded 100ºF. Plant-level temperatures exceeded 90ºF 18 times compared to 26 times for ambient and 65 times for the 5-ft level.

In 1999, greenhouse temperatures were maintained at more stable levels than in 1998 (Figure 8). Ambient temperatures dropped to a low of 36.9ºF. Greenhouse temperatures dropped to lows of 42.6ºF at the 5-ft level and 43.2ºF at plant level. Neither outside nor inside temperatures exceeded 100ºF. Ambient temperatures exceeded 90ºF 12 times compared to 65 times for the 5-ft level and 18 for the plant level. However, "cold injury" symptoms, such as cupping of leaves, white buds, and ground suckers, still occurred.

Humidity is always a challenge and was no exception in this house. Humidity reached saturation (plant-level temperature within 4 degrees of dew point temperature) 37.2 percent of the time in 1998 and 44.4 percent of the time in 1999 (Figure 9). Although the producer has been successful at heat control, improvement in ventilation for moisture control is needed.

Figure 7: Critical Temperature Ranges in a Float Greenhouse—Oldham County—1998

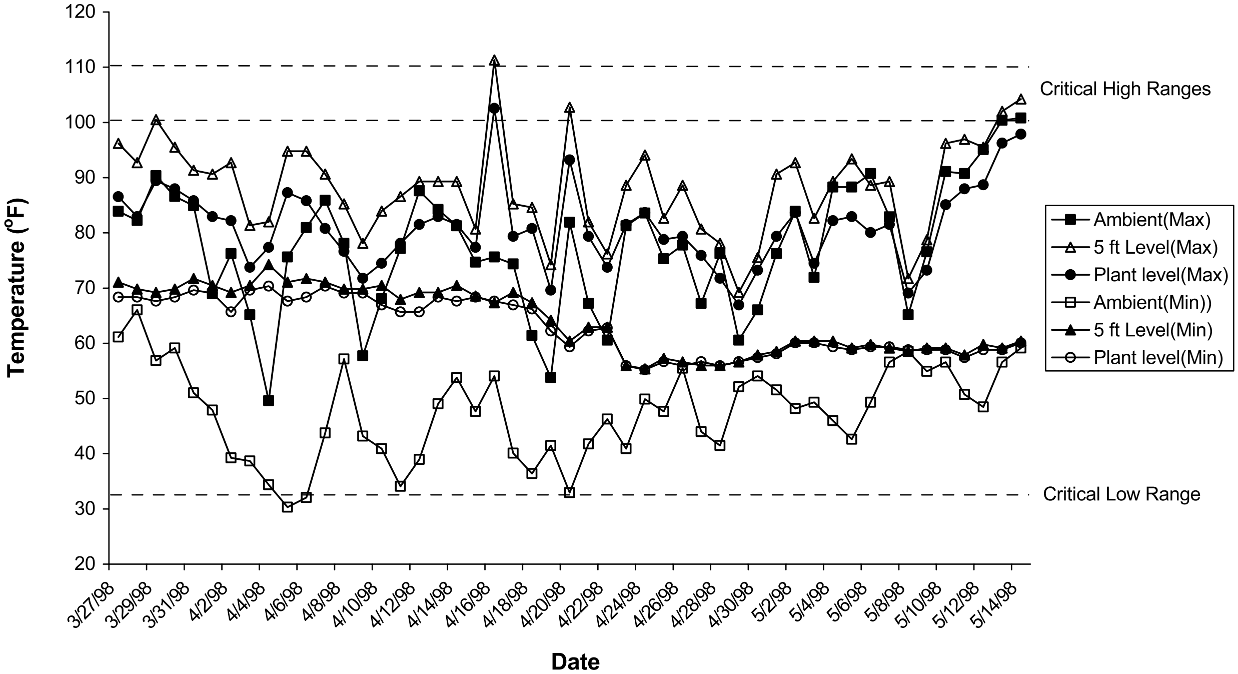


Figure 8: Critical Temperature Ranges in a Float Greenhouse—Oldham County—1999

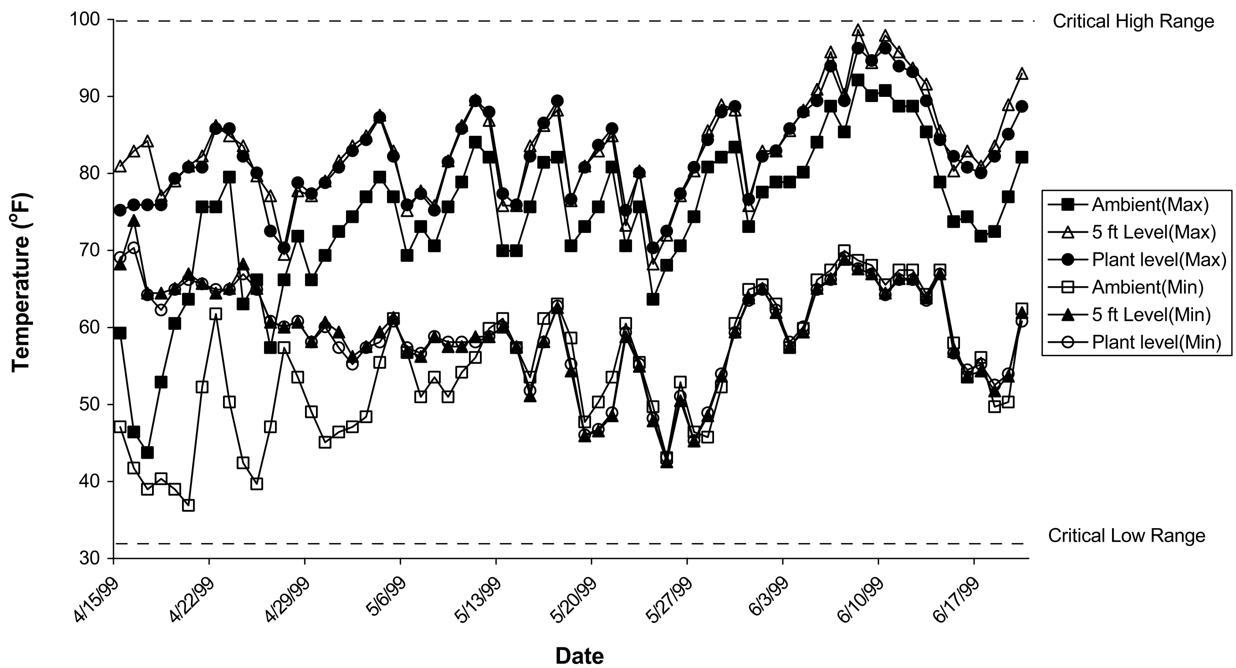
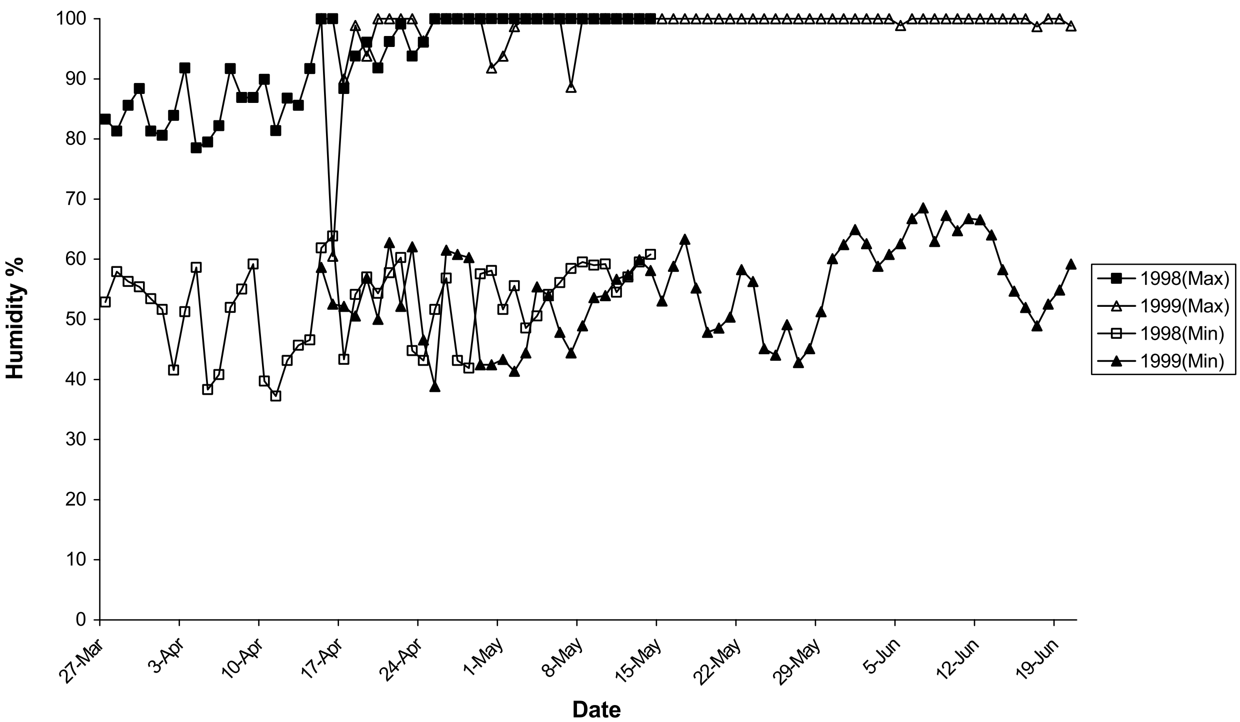


Figure 9: Humidity Levels in a Float Greenhouse—Oldham County—1998 and 1999



Summary

Outside Float Beds

Temperatures in outside float beds were found to vary considerably during the course of a 24-hour period, regardless of the type of covering material used. Temperatures exceeded critical high temperatures more often than they fell below critical low temperatures. This suggests that heat buildup in outside float beds is of greater concern than freeze damage. Transplants often survive temperature extremes; however, other tests and observations indicate that these extremes may enhance ground sucker development. Growers using outside beds must recognize the need to provide ventilation by raising the sides or ends of the beds to provide some cooling on sunny days when the ambient temperatures are relatively mild.

Some producers are using clear and black plastic believing that they provide heat retention and rainfall protection. These results indicate that plastic does little to aid in nighttime heat retention where an external heat source is not provided and verify concerns about high heat buildup under sunny conditions. Producers who use plastic for rain protection must take care to remove plastic covers soon after the cloud cover clears or they risk heat damage to plants. Preliminary results suggest that two spun-bonded covers on a bed may provide rain protection benefits without increasing heat buildup. Further research is needed to verify the feasibility of using a double cover. Preliminary results with white plastic covers not reported in this paper are encouraging.

Greenhouse

The greenhouse results confirm the need for good temperature monitoring and control in greenhouses. Thermostats or other control devices should be located to provide an accurate reading of the temperature at or near plant level. Measurements well above plant level or near doorways may provide misleading temperature information.

Ground suckers still remain a major problem in float plant production. However, good greenhouse temperature control did not eliminate this problem. Other potential influences on this phenomenon need to be explored.

Acknowledgments

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