Microclimate Manipulation for Improved Plant Growth©

Pat McCracken
Taylor's Nursery, Inc., 3705 New Bern Ave., Raleigh, North Carolina 27610

INTRODUCTION

Historically we have had to accept whatever climate nature has thrown at us unless we were willing to build expensive climate-controlled structures. With careful evaluation and a little ingenuity we can take advantage of microclimates to avoid some of the challenges that confront us.

Microclimates are small, relatively uniform climatic conditions that are restricted to a local area. Microclimates can be found in both soil and air. Examples are: soil and air temperature (both high and low temperatures), light levels, the amount of water in the soil, and air space in the soil. Soil microclimates in containers are much more extreme than in field production. Soil temperature in containers is often a major limiting factor for plant growth. Extreme high or low temperatures are detrimental to a healthy root system.

There are many ways to moderate the soil temperature in containers. Growing container plants in shade or with tight container spacing to reduce the amount of direct sunlight on the containers will help reduce soil temperature. Covering containers and/or placing containers can-tight in the winter will protect against extreme low temperatures. Air temperatures are easiest to moderate inside greenhouse structures. The use of evaporative coolers, fans, or heaters can be used to control temperature. Other methods of moderating air temperatures will be discussed later in this paper. Light levels can be modified easily with the use of either natural shade (under trees, etc.) or with the use of shade cloth. Water and air space in soils vary inversely with each other. As the amount of water in the soil increases the amount of air decreases and vice versa. By varying soil components and particle size of components it is possible to obtain optimal levels of both water and air. Soil components can be manipulated to allow for temperature management in container production as well. By increasing soil porosity (allowing faster drainage) it is possible to increase the irrigation frequency which can be used to cool plants down during the hotter time of the day.

BE OBSERVANT AND TAKE ADVANTAGE OF EXISTING MICROCLIMATES

Take the time to map out the microclimates on your nursery and then match crop needs with the available climates. Examples: low, poorly drained areas could be used for growing bald cypress,willows, or river birch. Windy areas should not be used for growing tall container trees – use these areas for low growing shrubs. Grow shade-requiring plants under natural shade from trees. Cold pockets might be used to keep B&B trees dormant longer which could extend the shipping season later into the spring. Careful management of microclimates can be used to improve crop quality and can reduce crop cycle time.

LEARN FROM YOUR MISTAKES

If you make a mistake, evaluate the effects. Mistakes can often lead to improvements in crop production. Following are two good examples of beneficial mistakes that we made at Taylor's Nursery. We had a crop of direct stuck 3.8-liter (1-gal) dwarf *Nandina* that had a mist cycle of 1-min every 20 min (we use low-volume spinners in this propagation house for "mist"). The cuttings had rooted and we switched the young plants to a once-a-day irrigation schedule (using the same low-volume spinners). The only problem is that we forgot to discontinue the mist cycle so that both cycles were running simultaneously! After several months of this "mistake" we noticed that the young plants were growing faster than they ever had before. We started looking for the cause and at this point realized the irrigation mistake. We also noted that the soil and air temperature in this greenhouse was much cooler than normal and the *Nandina* thrived. It appears that *Nandina* basically stop growing in high summer heat and generally put the best growth on during the fall and spring. We managed to achieve much faster than normal growth rates during the summer with this double irrigation system (we now continue this practice as a routine production tool). For this system to work it is critical to have a well-drained medium in the containers. We use pine bark and coarse perlite (3 : 1, v/v). Another mistake we have benefited from was on a crop of 3-gal *Acer rubrum* PNI 0268, October Glory® PP red maple. We had planted liners into 11-liter (3-gal) containers, and we then decided that we were not happy with the quality of the bark medium. It was difficult to keep it watered as well as we wanted; so, we decided to install some temporary low-volume sprinklers over the top of the new crop to help wet the medium and to supplement the normal irrigation cycle. We didn't have the ability at that time to install the low volume sprinklers over more than half the crop. We ran the temporary sprinklers for 1 min each hour. We intended to use this system for about 1 month. Once again, we accidentally left both systems running through the growing season. The results were incredible! The plants with only daily irrigation averaged 1.2 to 1.5 m (4 to 5 ft) tall and the plants with the supplemental cyclic irrigation averaged over 2.4 m (8 ft) tall! An interesting thing we noticed was how cool the air was around the block of supplementally watered plants. Walking past the block during the heat of the summer felt like walking past an open refrigerator. The supplemental water was keeping a thin film of water on the foliage of the maples, and the enormous surface area of the leaves was acting like a giant evaporative cooler. Since this mistake was so successful we decided to conduct an experiment to study this cooling effect with Dr. Ted Bilderback at North Carolina State University, Raleigh, North Carolina.

MATERIALS AND METHODS

The experiment began in June 1999 and concluded in late October 1999. We wanted to evaluate the effects of both shade and supplemental cyclic irrigation on growth of several species of trees. We decided that applying mist over the top of the plants would be the most effective method of cooling with supplemental irrigation. We selected *A. rubrum* PNI 0268, October Glory® PP red maple, *Quercus phellos*, *Cornus florida*, and *Magnolia grandiflora* 'Little Gem' for this study for their potential wide response range. Treatments consisted of full sun, full sun plus mist, shade, and shade plus mist. Mist was applied over the top of the trees with a series of mist nozzles. The nozzle height was raised as the trees grew. Mist was used from about 9:00 until 17:00 with a frequency of 1 min every 30 minutes. The experimental design was a randomized complete block with four environmental factor treatments and four species with four samples per treatment. Data collected were increase in height (recorded monthly), beginning and ending stem caliper, ambient air temperature (average, minimum, and maximum daily). Also recorded were soil temperature (daily average, minimum, and maximum), foliar temperature, relative humidity, light intensity, and vapor pressure deficit; however, these are not discussed in this paper.

RESULTS AND DISCUSSION

Results varied by species and will be discussed by species.

***Acer rubrum* PNI 0268, October Glory® PP red maple.** October Glory® PP red maple did not respond as dramatically during this experiment as they had done in the past. This was partly due to a problem with bud mites that slowed the plants down toward the middle of the experiment. Initially the best growth (height increase) was observed with sun and no mist treatment (Fig.1). This was most likely due to an unusually cool period we experienced during this time. By late July and August it was very hot and the best growth was observed with sun plus mist. Past this point we had very little growth due to mite damage. Caliper increase was basically the same under all environmental conditions with the exception of being less with shade plus mist (Fig. 3). These results suggest that October Glory® PP red maple grows best under full sun conditions with supplemental mist during the hottest months.

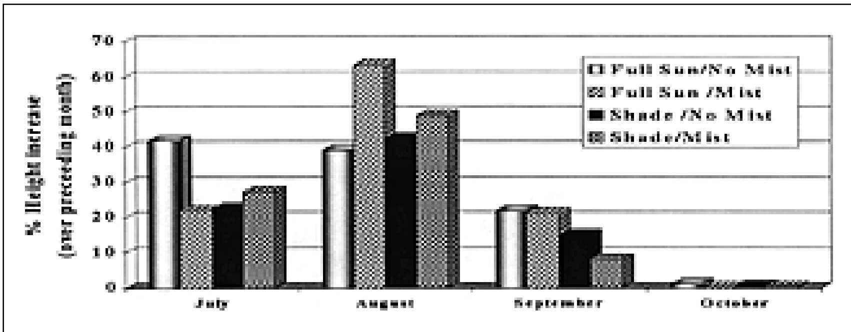


Figure 1. Effects of sun/shade and mist on growth of October Glory®PP maple.

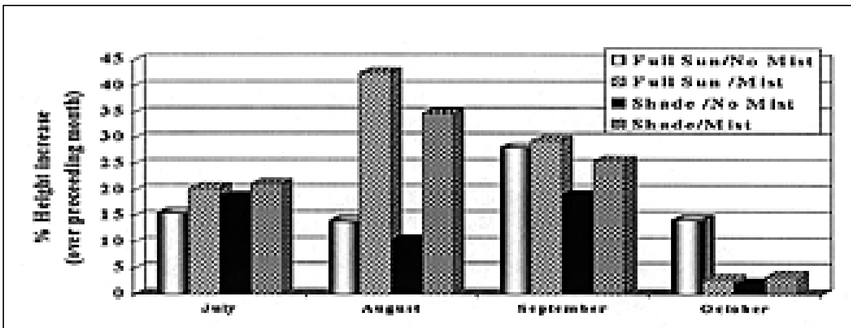


Figure 2. Effects of shade and mist on *Quercus phellos* (willow oak).

Quercus phellos. This species showed little response to environmental treatments initially, but with the onset of hot temperatures there was a dramatic increase in growth with both sun plus mist and shade plus mist (Fig. 1). As temperatures decreased later in the season there was very little effect from environmental treatments. During October, full sun treatment was most effective. Caliper increase was slightly greater with full sun plus mist (Fig. 5). It appears that *Q. phellos* grows best in either sun or shade with mist during the hottest months of the year, but the mist should be discontinued when the weather becomes cooler, and trees should be grown in full sun during the end of the growing season.

Cornus florida. *Cornus florida* had a substantial increase in growth initially under all environmental conditions other than full sun. As the summer heat increased the growth under sun plus mist and shade plus mist was dramatically greater than without mist (Fig. 3). As the temperatures began to cool down slightly into September the best growth was observed under shade or shade plus mist. By October the best growth was observed under full sun treatment. Caliper increase was lowest under full sun (Fig. 3). Something occurred during this study that we didn't expect. The *C. florida* grown under mist conditions in either sun or shade had little if any powdery mildew problems. The plants without mist had moderate to severe mildew problems. This lack of disease may account for the increased growth

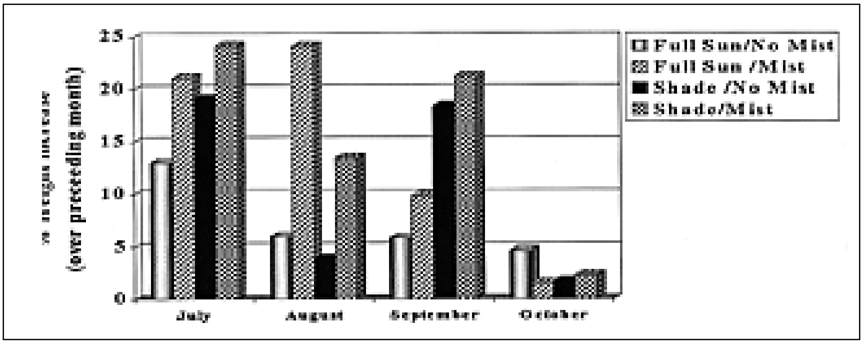


Figure 3. Effects of sun/shade and mist on growth of *Cornus florida* dogwood.

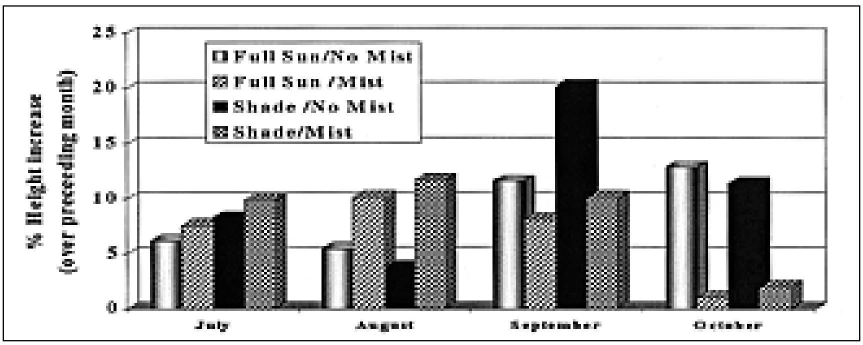
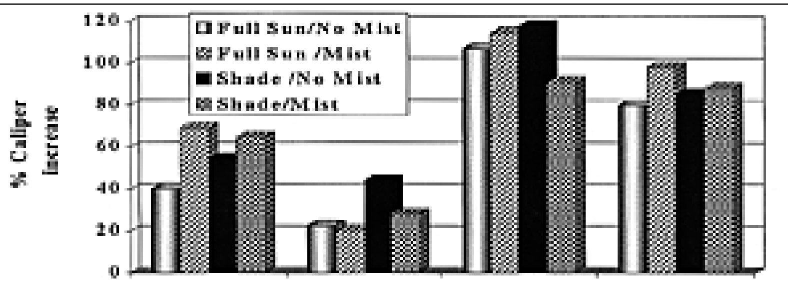


Figure 4. Effects of shade and mist on *Magnolia* 'Little Gem' magnolia.

we observed with mist treatments; however, we suspect that the *C. florida* grew best in October under full sun conditions without mist because the shade and mist treatments may have been too cool for optimal growth. It appears that *C. florida* grows best during the hottest times of the year in sun plus mist and would then benefit from shade, with or without mist, later in the season and then full sun without mist at the end of the season.

Magnolia grandiflora 'Little Gem' had a wide response to environmental factors depending on the time of the year (Fig.2). Initially there was a slight increase in growth with shade plus mist. During the hottest time of the year it appears that mist under sun or shade was beneficial. As the temperatures cooled off, the best growth response was found in shade and with the onset of cool temperatures in October the best response was found in either sun or shade without mist. Caliper increase was greatest with shade (Fig. 3). This caliper increase most likely occurred during September and October when we also observed the greatest height increase with shade. It appears that *Magnolia* 'Little Gem' benefits from cooler summer temperatures by using either sun plus mist or shade plus mist. As temperatures



Cornus florida | *Magnolia guandiflora* 'Little Gem' | *Acer vubrum* RNI 0268 October Glory® PP red maple | *Quencus phellos*

Figure 5. Effects of sun/shade and mist on caliper.

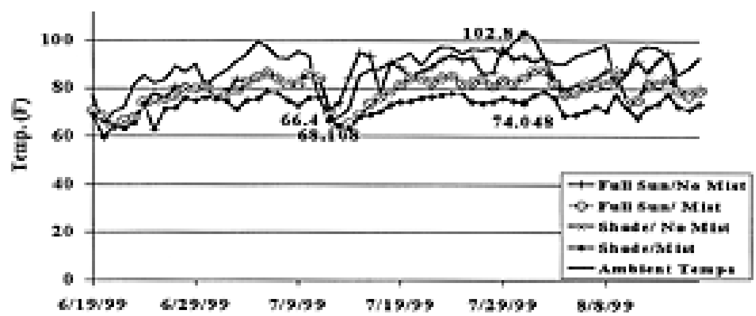


Figure 6. Canopy average temperatures micrologger data.

decrease, shade is beneficial, and late in the season, full sun without mist or shade without mist will increase growth.

CONCLUSIONS

By carefully observing responses of various species to microclimate, we can manipulate these microclimates to maximize the growth potential of each species. A combination of shade and or mist may be useful and needs to be modified throughout the growing season to achieve maximum benefit. Microclimate manipulation can be done easily and cost effectively and should become an integral part of your production strategy. The benefits of microclimate manipulation can be as important as fertilization and weed control.

The summer growing season of 2000 was very wet and cool for us in eastern North Carolina. The conditions that we created during the experiment in 1999 were basically duplicated naturally for us across the entire nursery. There were dramatic growth increases in many crops than what we normally expect. The responses were observed in both trees and shrubs. It was encouraging that responses observed experimentally were also confirmed this season with similar environmental factors.

Microclimate manipulation can be used to increase plant growth and in some cases to control diseases; however, we can't simply mark a calendar and say that on a set date each year we will do a certain manipulation. A good example of this was observed during our experiment in 1999. During July we had an exceptionally cool and overcast week (Fig. 3). The maximum ambient air temperature was 19°C (66°F) on 12 July 1999, and at the same time the shade plus mist maximum canopy temperate was 20°C (68°F). It appears that the shade cloth actually helped retain some heat. However, if the natural environmental conditions are cool and overcast, there is no benefit of mist to cool plants. Conversely, if the conditions are hot and dry, significant cooling can be achieved with mist. On 31 July 1999, there was a maximum ambient air temperature of 39°C (103°F) and at the same time a maximum canopy temperature of only 23°C (74°F) with shade plus mist. This was a 16°C (29°F) temperature difference! Factors change continually and will likely never be exactly the same from one year to the next. Be observant and prepared to rapidly adapt to environmental changes.