

Evaluation of a Chlorophyll Meter to indicate Relative Growth Rates of Similar Plant Material

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INTRODUCTION

Technological advances in electronics have provided us with new equipment to enhance our ability to quantify treatment differences in plant material. One such instrument provides a non-destructive evaluation of leaf chlorophyll levels. Early testing and present use of this instrument focuses on nitrogen fertility of grasses (usually grain crops). The work has resulted in a rapid determination of nitrogen crop fertility levels that identifies fertilization needs for the crop.

This study was initiated to determine if a chlorophyll meter could be a useful tool for production of woody nursery stock. Preliminary information indicated a possible relationship between perceived growth and chlorophyll readings within species. Verification of a correlation between chlorophyll levels and growth of related plant material could allow plant breeders to use information as early indicators of plant performance.

This report is the result of 2-years' data that measured chlorophyll levels in leaves of similar plant material. Initial work during 1992 monitored 12 types of deciduous trees. Data was collected from at least two cultivars within each species of four genera to allow for comparison. During the summer of 1993, a database was developed for six cultivars of *Cornus kousa* × *C. florida* cultivars bred by Dr. Elwin Orton and grown under nursery conditions. A comparison of chlorophyll readings and evaluations by growers of the relative growth rates was also completed.

MATERIALS AND METHODS

During this experiment, chlorophyll levels were determined with the use of a Minolta SPAD-502 chlorophyll meter. Calculations of relative values are based on the amount of light transmitted by the leaf in two-wavelength regions in which the absorption of chlorophyll is different. These correspond to the red area where absorption is high and unaffected by carotene, and the infrared area where absorption is extremely low. Two light-emitting diodes (LEDs) provide illumination in the 650 and 940 nm wavelength areas, which are transmitted through the leaf to a silicon photodiode (SPD) receptor. A ratio between the two light intensities is calculated and is compared to a calibrated value which results in a value that is displayed.

Twelve cultivars of shade trees were evaluated during the summer of 1992. Those evaluated included *Acer platanoides* 'Crimson King', *A. platanoides* 'Summershade', *A. rubrum* 'Red Sunset', *A. rubrum* 'Northwood', *A. rubrum* 'Autumn Flame', *Fraxinus americana* 'Autumn Purple', *F. americana* 'Rose Hill', *F. americana* 'Skyline', *Tilia cordata* 'Greenspire', *T. cordata* 'Olympic', and *Zelkova serrata* 'Green Vase' and 'Village Green'. During the summer of 1993, six cultivars of *C. kousa* × *C. florida* hybrids were evaluated. The cultivars tested were 'Rutgan'

Stellar Pink[®], 'Rutban' Aurora[®], 'Rutdan' Celestial[™], 'Rutcan' Constellation[®], 'Rutfan' Stardust[®], and 'Rutlan' Ruth Ellen[®].

All readings were taken from intact mature leaves. Shade trees were randomized within five complete blocks and planted in the spring of 1991. Five treatment plants of each variety were included in each block. Readings were taken from five leaves on each of the treatment plants. Chlorophyll level evaluation took place on 1 June, 15 June, 1 July, 14 July, 31 July, 18 August, 1 September, 15 September, and 1 October 1992. Dogwood selections were planted in block form, with data taken from plants in complete rows. Seven replications of each variety were evaluated, with five leaves from each plant being averaged. Dogwood data was recorded on 16 July, 17 August, and 17 September 1993. Data was statistically analyzed using the Fisher's PLSD test. Separations were at the .05% level (95% probability).

RESULTS

Overall shade tree leaf chlorophyll levels increased as the season progressed from the first test date on 1 June through 18 August (Fig. 1). After that date, chlorophyll levels gradually decreased through the last test date on 1 October. By 1 October, some species exhibited early fall leaf coloration so data was recorded from leaves representative of the total tree leaf area.

Trees were evaluated within species to determine if differences in chlorophyll levels existed. There were significant differences in mean chlorophyll ratings for all but the *Tilia* species (Table 1). Also indicated in Table 1 were the peak mean chlorophyll levels recorded by species and the date on which the peak levels occurred. The species with the highest annual mean chlorophyll reading was consistent with the latest date for the peak mean chlorophyll reading for *Acer*, but that relationship did not exist for the other genera tested.

Acer platanoides 'Summershade' was observed by growers to gain in size faster than *A. platanoides* 'Crimson King'. Data from this study indicated 'Crimson King' had significantly higher rates of chlorophyll than 'Summershade'. Grower ob-

Chart 1: The Effect of Date on Leaf Chlorophyll Levels (1992)

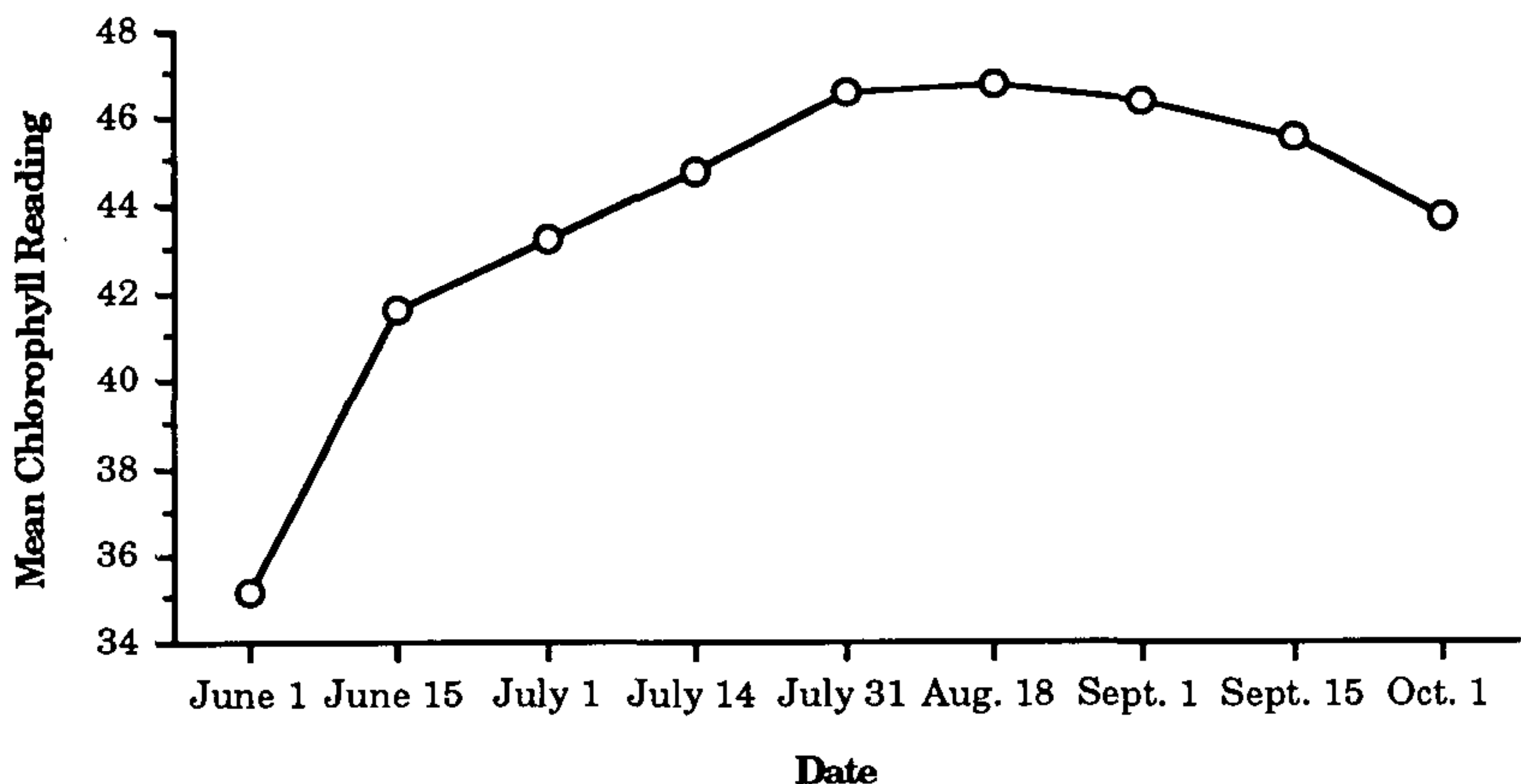


Figure 1. The effect of date on leaf chlorophyll levels (1992).

served growth rates for *F. americana* species indicated the greatest growth for 'Skyline' and the least in the 'Autumn Purple'. The highest indicated chlorophyll levels were found in 'Skyline' and the least in 'Rose Hill'.

Table 1. Shade tree chlorophyll ratings.

Variety	Annual mean ¹	Peak mean ²	Peak date
<i>Acer plataniodes</i> 'Crimson King'	52.3 a	58.9	10/1
<i>A. plataniodes</i> 'Summeshade'	41.0 b	44.3	9/1
<i>A. rubrum</i> 'Autumn Flame'	40.8 b	45.5	8/18
<i>A. rubrum</i> 'Northwood'	40.2 b	43.4	7/31
<i>A. rubrum</i> 'Red Sunset'	45.9 a	50.0	9/15
<i>Fraxinus americana</i> 'Autumn Purple'	46.5 b	50.3	7/31
<i>F. americana</i> 'Rose Hill'	43.7 c	46.8	8/18
<i>F. americana</i> 'Skyline'	47.9 a	52.2	7/31
<i>Tilia cordata</i> 'Greenspire'	44.3	44.9	8/18
<i>T. cordata</i> 'Olympic'	43.8	46.9	10/1
<i>Zelkova serrata</i> 'Green Vase'	39.6 b	43.4	8/18
<i>Z. serrata</i> 'Village Green'	40.8 a	44.7	8/18

¹ Letters indicate significance within species at 95% probability.
² Significance not evaluated.

Dogwood cultivars were also evaluated for mean chlorophyll ratings. Significant differences in chlorophyll were indicated, with Celestial™ having the highest levels and Ruth Ellen®, the lowest levels (Table 2). Six of seven growers propagating these dogwood cultivars responded when asked to indicate the ease of propa-

Chart 2: The Interaction of Cultivar and Date on Leaf Chlorophyll (1993)

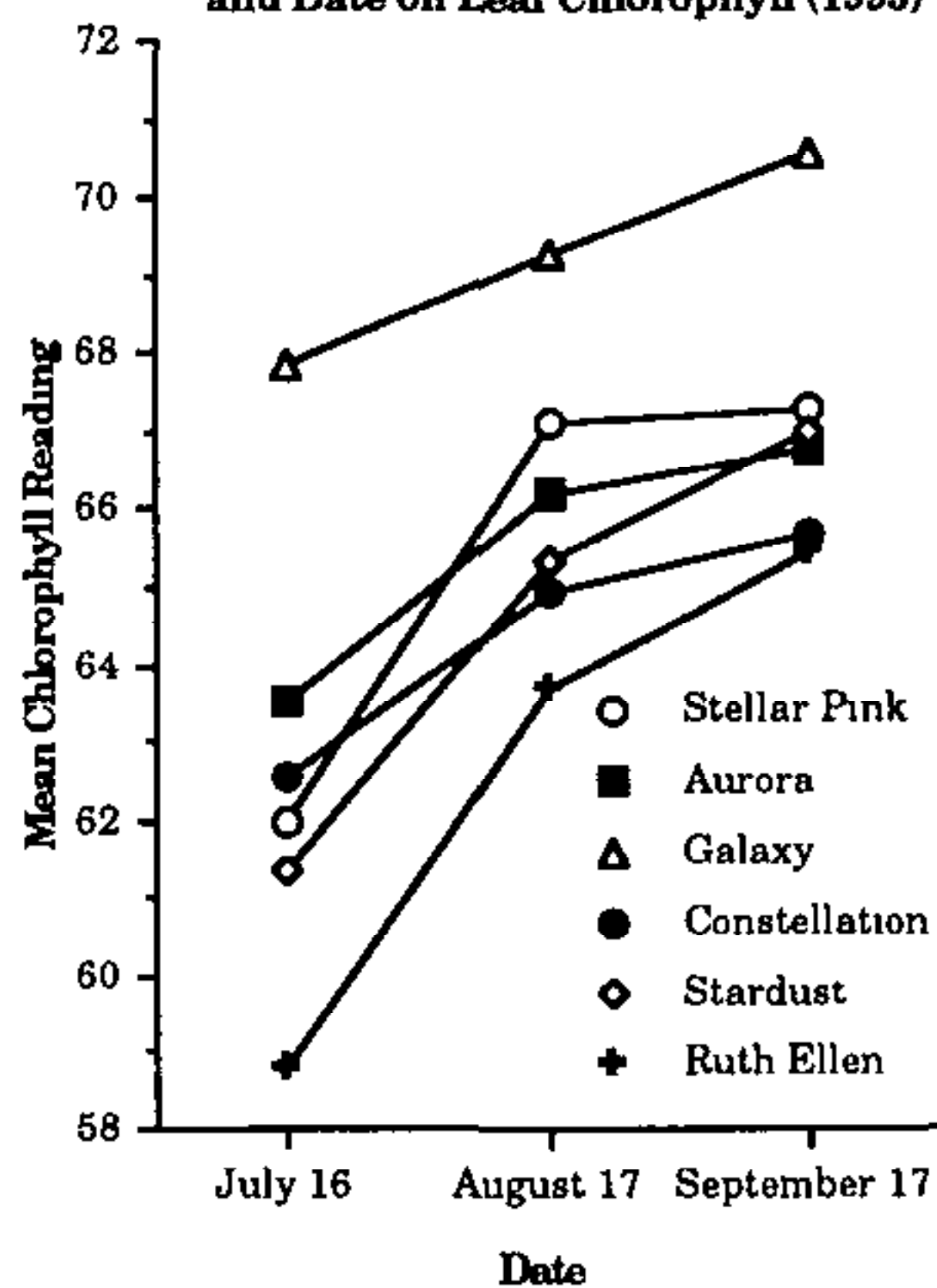


Figure 2. The interaction of cultivar and date on leaf chlorophyll (1992).

Chart 3: The Interaction of Mature Cultivars and Date on Leaf Chlorophyll (1993)

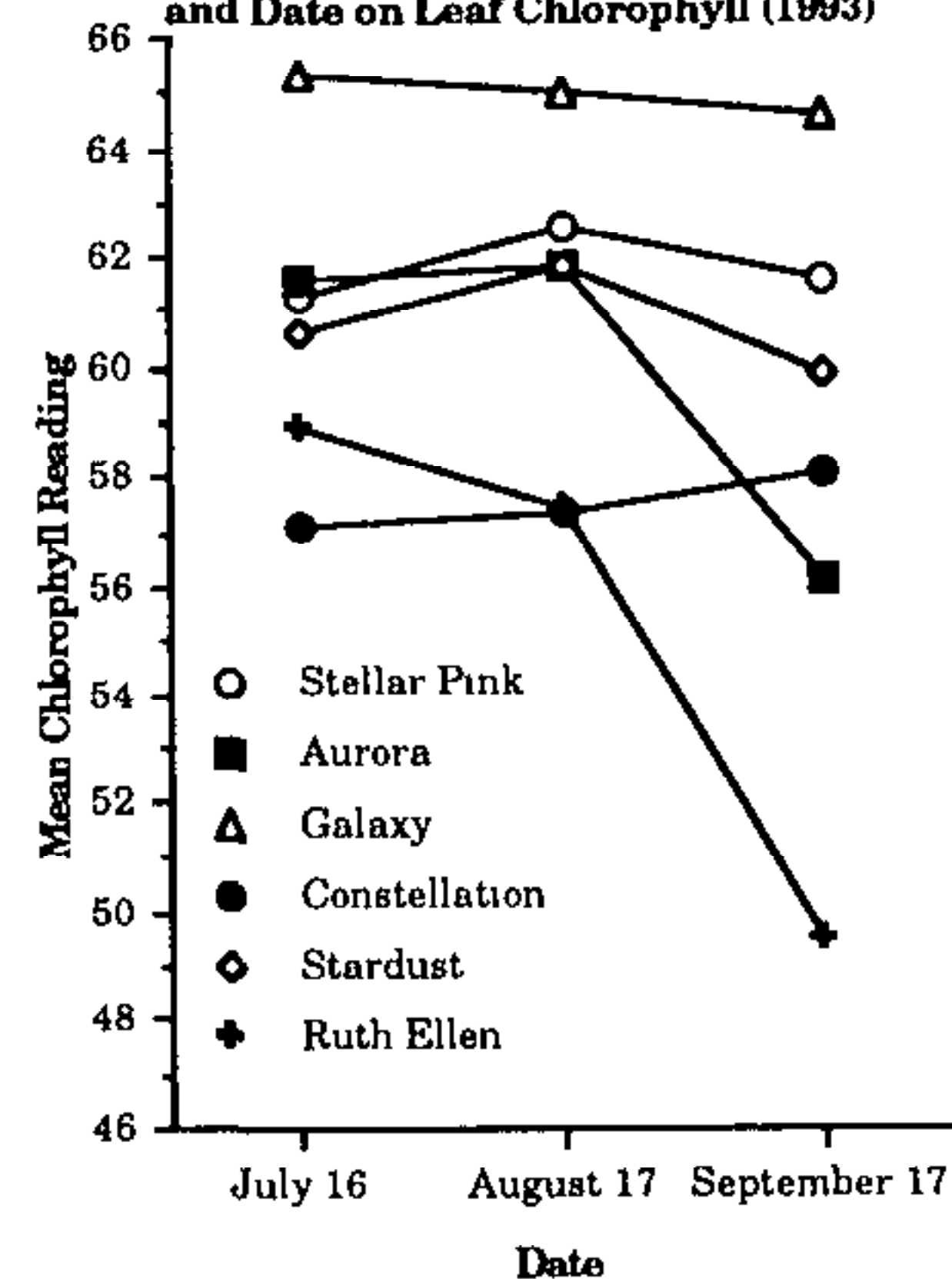


Figure 3. The interaction of mature cultivars and date on leaf chlorophyll (1992).

gation and the relative vigor of this plant material. This information is recorded in Table 3. With the exception of Stardust[®], cultivars were rated as easy to propagate. Stardust[®] is more dwarfed in size as compared to the other cultivars, which may have an impact on propagation. A comparison of relative vigor indicated Aurora[®] and Ruth Ellen[®] as being the most vigorous cultivars. Only Stardust[®] was significantly poorer in vigor than the other cultivars, which is probably related to its genetic potential. Stellar Pink[®] was intermediate in vigor.

Table 2. Dogwood chlorophyll ratings.

Variety	Annual mean ¹	Peak mean ²	Peak date
<i>Cornus</i> Stellar Pink [®]	65.5 b	67.3	9/17
<i>Cornus</i> Aurora [®]	65.5 b	66.7	9/17
<i>Cornus</i> Celestial [™]	69.2 a	70.6	9/17
<i>Cornus</i> Constellation [®]	64.4 bc	65.7	9/17
<i>Cornus</i> Stardust [®]	64.6 bc	67.0	9/17
<i>Cornus</i> Ruth Ellen [®]	62.6 c	65.5	9/17

¹ Letters indicate significance within species at 95% probability.

² Significance not evaluated.

Table 3. Dogwood grower evaluation.

Variety	Ease of propagation ¹	Vigor
<i>Cornus</i> Stellar Pink [®]	6.3 a	7.7 ab
<i>Cornus</i> Aurora [®]	8.7 a	8.2 a
<i>Cornus</i> Celestial [™]	8.0 a	7.8 a
<i>Cornus</i> Constellation [®]	8.5 a	8.0 a
<i>Cornus</i> Stardust [®]	4.5 b	3.5 b
<i>Cornus</i> Ruth Ellen [®]	7.8 a	8.2 a

¹ Evaluated on a 1 to 9 scale with 9 being the best cultivar.

As a validation of the chlorophyll levels recorded in the block of young dogwood, mature trees of the cultivars were also measured for chlorophyll levels (Table 4). Celestial[™] again recorded the highest chlorophyll levels, while Ruth Ellen[®] had the lowest levels, as was the case with the younger material. Overall, the position of the relative chlorophyll levels were similar to those recorded on younger material. The actual recorded chlorophyll levels were somewhat lower than those recorded on younger material. For younger plants, the highest mean chlorophyll levels each occurred on the latest test date. On the mature material, the highest levels did not correspond to an individual test date.

Table 4. Mature dogwood chlorophyll ratings.

Variety	Annual mean ¹	Peak mean ²	Peak date
<i>Cornus Stellar Pink</i> [®]	61.8 b	62.6	8/17
<i>Cornus Aurora</i> [®]	59.9 bc	61.9	8/17
<i>Cornus Celestial</i> [™]	65.0 a	65.4	7/16
<i>Cornus Constellation</i> [®]	57.6 cd	58.1	9/17
<i>Cornus Stardust</i> [®]	60.8 b	61.8	8/17
<i>Cornus Ruth Ellen</i> [®]	55.3 d	58.9	7/16

¹ Letters indicate significance within species at 95% probability.

² Significance not evaluated.

Data developed regarding the interaction between young dogwood cultivars and the date as they relate to leaf chlorophyll levels is shown in Fig. 2. *Celestial*[™] had the highest chlorophyll levels consistently through the year, *Ruth Ellen*[®] consistently had the lowest, and other cultivars varied with the time of year. Observation of other nursery plant material indicates that, for many plants, early growth is an indicator of overall performance. *Aurora*[®], which was rated highest in vigor by growers, was second highest in early season chlorophyll levels. *Constellation*[®] was rated just behind *Aurora*[®], followed by *Stellar Pink*[®] and *Stardust*[®]. Each is rated in the same position for early season chlorophyll levels and for grower vigor ratings.

Chlorophyll levels in mature plant material had relationships that were similar to those found with less mature material (Fig. 3). *Celestial*[™] again was found to have the highest levels of chlorophyll throughout the season, while the cultivar *Ruth Ellen*[®] was near the lowest all season. Although *Constellation*[®] recorded the lowest overall chlorophyll rating, it was the only mature tree cultivar to increase in chlorophyll level throughout the season.

DISCUSSION

The use of chlorophyll meters as an indicator of plant performance has occurred primarily with small grains. These rapidly growing annual crops are subject to nutritional deficiencies. Because of the perennial nature of woody plants, they are usually more tolerant of nutritional variations.

Information developed over three years has not resulted in a development of a reliable testing procedure where one would benefit from the use of a chlorophyll meter as a diagnostic tool in woody ornamental plant material. While some relationships appear to exist within species, there seems to be little consistent correlation between leaf chlorophyll levels and growth or ease of propagation. A factor that was not documented was that of plant canopy size. Since the total leaf area can compensate for individual leaf chlorophyll levels, a measurement would be useful to further clarify the information developed in this study. Although actual levels were lower, validation of chlorophyll levels was achieved through the measurement of chlorophyll in mature trees.

There is much work left to do. While leaf chlorophyll level may be involved in plant performance, information from other factors related to plant performance must be developed. Whether we look for ways to evaluate vigor, cold hardiness, nutrition, or other possibilities, databases must be developed. With additional performance factors, it may be possible to develop useful models that can serve as early indicators of plant performance. It is up to us, however, to identify which electronic devices are tools, and which are toys.

BRIAN MAYNARD: With *Acer platanoides* 'Crimson King' do you have to calibrate your meter for other pigments in the leaves?

JAMES JOHNSON: No you don't.