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de Soyza, Amrita Giles, Ph.D.

City University of New York, 1989

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PHOTOSYNTHETIC RESPONSES AND LEAF VARIABILITY IN SASSAFRAS

by

AMRITA G. DE SOYZA

A dissertation submitted to the Graduate Faculty in Biology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, City University of New York.

1989

This manuscript has been read and accepted for the Graduate Faculty in Biology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

PHOTOSYNTHETIC RESPONSES AND LEAF VARIABILITY IN SASSAFRAS

by

Amrita G. de Soyza

Adviser: Dr. Dwight T. Kincaid

A field study was carried out to investigate whether spatial and temporal variability in leaf form has functional and adaptive meaning in terms of net photosynthesis in Sassafras albidum. Leaves with entire margins predominated at the proximal and distal nodes of shoots while lobed leaves were most common at the intermediate nodes and had the greatest surface area.

Greatest chlorophyll content (mg g^{-1} and g m^{-2}) occurred in leaves of the intermediate nodes except during the latter part of the growing season, when leaves of the distal nodes had the greatest chlorophyll contents. A similar pattern was seen with leaf nitrogen content.

Greatest net photosynthetic rates occurred in leaves of the intermediate nodes (nodes 6 - 9; maximum of 14.53 μmol m^{-2} s^{-1}). Statistically significant differences in net photosynthesis were rarely found between leaves with entire margins and leaves with lobes. I conclude that the nodal position of a leaf is more important than leaf shape in determining the photosynthetic capacity of a leaf. Similarly, significant differences were rarely found in stomatal conductance, transpiration or water use efficiency among leaf shapes. Midday xylem water potential (which ranged from -0.95 mPa on June 10 to -1.68 mPa on August 18) also showed no statistically significant differences among leaf shapes.

A study of the effect of leaf size and shape on convectional heat loss using illuminated leaf models with integrated thermocouples, showed that lobed leaves had lower temperatures and shorter time constants than leaves with entire margins of the same surface area. While direct relationships between leaf form and leaf function were not to established, the predominance of lobed leaves at the intermediate nodes which have the greatest capacity for photosynthesis and the greatest surface area, suggested that leaf lobing plays a role in maintaining these leaves at temperatures conducive to favourable water relations and high net photosynthetic rates.

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1. INTRODUCTION

Photosynthesis is one of the most important biochemical processes for life on earth. In terrestrial plants, the photosynthetic mechanism is largely concentrated in specialized organs - the leaves. Leaves are variable in morphology[1] and anatomy[2], with much of this variation thought to be adaptation to the environment; for example the gross anatomical differences in leaf structure between C_3 and C_4 plants, and the gross morphological differences between leaves of deciduous trees and leaves of coniferous trees. While leaves vary among taxa, there is also variation in leaf morphology within species and, most interestingly, variation in leaf morphology within individual plants of a species. However, little is understood about the basis, if any, of this variation, whether it is of functional importance to the plant, or whether it is indicative of multiple adaptive peaks, or of phylogenetic inertia (Cronquist 1988). Considering that leaves house the photosynthetic machinery that produces the trophic energy for sustaining all terrestrial biota, it is interesting that the meaning of variability in leaf form, in my view, eludes satisfactory explanation.

Probably least understood of all forms of variability in leaf morphology is two-dimensional shape, and this is partly due to difficulty in quantifying leaf shape. In order to investigate leaf shape in relation to function I studied Sassafras albidum[3] (Nuttal) Nees., a small to moderately large tree of the deciduous forests of the eastern U.S.. Sassafras was chosen because, instead of having leaves lying along a baffling continuum of form, as one might find in an oak tree, its leaves are displayed in discrete categories of shape. Trees (genets) of Sassafras were chosen from a population growing

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[1] by morphology I mean Form = size (surface area of one side of leaf, in mm^2) and shape.
[2] Cross sectional and other microscopic details.
[3] Family: Lauraceae, Common name: Sassafras

in the floodplain along the Bronx River at Bronxville, N.Y. These trees exhibit several different categories of shape (leaf sinus patterns) on a single shoot, usually entire (0 sinuses), one sinus (left or right) and two sinuses. Occasionally three and four sinus leaves have been observed but of the approximately 15,000 leaves that have been scored for form category since 1983, only a handful have had 3 or 4 sinuses (Kincaid, 1988 personal communication).

Leaf lobes (sinuses) increase the perimeter of the leaf, thereby decreasing leaf boundary layer thickness and affecting heat exchange between the leaf and its microclimate. Variation in leaf shape may therefore play an important role in the ecology and physiology of a plant by enabling it to survive in a range of environments which would otherwise be difficult given a single, unchanging leaf. Furthermore, the variation in leaf form along a shoot may represent the changing requirements of a plant at different stages during its growing season. From work begun in 1983, we have a partial understanding of how leaf surface area and leaf shape category vary with position on a tree, nodal sequence on a shoot, among genets and, among local populations of Sassafras. Ramirez and Kincaid (1986, abstract) have reported that different genotypes of Sassafras produce different proportions of leaf form categories and that leaves at the intermediate nodes have the largest surface area. Since these are not the oldest leaves, leaves at different nodes must have different rates and/or durations of active growth. It has also been shown that leaves at these intermediate nodes have the greatest proportion of two lobed leaves (Kincaid et al., 1985, abstract).

However, with the exception of a study by Bazzaz et al. (1972) which did not consider the patterns of photosynthesis within plants, we do not have a field characterization of the photosynthetic responses of Sassafrass and this characterization is a broad objective of my study. More specifically, does spatial and temporal variability in leaf form have functional and adaptive meaning in terms of net photosynthesis? This is a question of major botanical import which I can begin to address using the simple and easily quantifiable leaf form of Sassafras.

Given what is informally known in our laboratory about leaf form and leaf area distribution along shoots of Sassafras, the prediction is that leaves at the intermediate nodes are the most photosynthetically productive. If there is a gradient in photosynthetic productivity along a shoot, one would expect that there is a similar gradient in the distribution of the photosynthetic mechanism along a shoot. Leaf chlorophyll is an essential, rate determining factor in the photosynthetic machinery, and is relatively easy to measure. In order to test if lobed leaves and/or leaves at the intermediate nodes do indeed have an enhanced light harvesting capacity, in the summer of 1986 I measured chlorophyll content, using methanol to extract chlorophyll from leaf discs, in eight genets of Sassafras. In this study I kept track of leaf nodal position, leaf shape category and also considered differences between leaves from sun and shade positions in the canopy.

While measurement of chlorophyll content may yield information on the pattern of photosynthetic capacity, it is also necessary to measure leaf performance in the field. In 1987, I measured photosynthesis in 999 leaves on four genets of Sassafras, using a LI - 6200 Portable Photosynthesis System (LI-COR Inc., Lincoln, Nebraska); always keeping track of leaf nodal position and shape category.

Since any age dependent variability in the intrinsic photosynthetic capacity of a leaf may confound the interpretation of measured photosynthesis data, I performed a demographic study of leaf area and shape on the very leaves for which photosynthesis was measured. To further unravel the effect of leaf age on the photosynthetic machinery, I also measured chlorophyll content in all leaves along a shoot from each of the four genets of Sassafras, on four occasions during the growing season.

I have relied heavily on leaf chlorophyll content as an estimator of intrinsic photosynthetic capacity, but it is just one component of photosynthesis. An alternate would be to measure the amount of the enzyme Ribulose bisphosphate carboxylase-oxygenase (RUBISCO) which is essential to the photosynthetic process. A large amount of the total leaf nitrogen is closely related to photosynthesis - chlorophyll itself accounts for about 6 % of leaf nitrogen, but is dwarfed by Rubisco which may account for up to 50% of leaf nitrogen (Field and Mooney, 1986). While an analysis of Rubisco was not part of this thesis, whole leaf nitrogen was measured using the Kjeldahl method to determine if the patterns observed for chlorophyll content would be repeated with nitrogen content.

Plant water status also has a role in the photosynthetic response of a leaf, particularly through its action on stomatal aperture. While it is impractical to measure Xylem Water Potential (XWP) for leaves at all nodal positions (since only one leaf may be removed for measurement, per shoot), I measured XWP in several lobed and unlobed leaves, to determine if there is any difference in the intrinsic water handling mechanisms between leaves with different shapes, which would then affect the photosynthetic response.

Finally, I considered the thermal characteristics of lobed and unlobed leaves. This is difficult to do in the field or in the laboratory, with real leaves of Sassafras, and so I relied on information gathered using leaf models in the laboratory. Leaves were reconstructed from digitized images of real leaves stored on computer using the Fourier transform based Leaf Boundary Method of Kincaid and Schneider (1984). This method allows images of real leaves to be magnified or reduced so that leaf models may be constructed to any size, or constructed having identical area but of different shape categories. This flexibility allowed me to investigate thermal behavior independently of leaf size.

In describing this research, the Materials & Methods and Results sections have been separated into chapters for each aspect of this study. In the Discussion, however, I have drawn from these chapters for my conclusions on the photosynthetic response and leaf variability in Sassafras.

2. LITERATURE SURVEY

Leaves, with their tremendous variety of shape and size, have an estimated total surface area of about 65 x 10^7 km^2 and are the major site for the light harvesting and metabolic processes of photosynthesis in terrestrial plants (Sestak, 1985). For a century, there has been interest in determining the relationships between leaf form and function, particularly in how leaf morphology and anatomy are involved as adaptations to specific environments (Ehleringer & Werk, 1986). While early studies by Haberlandt (1884), Schimper (1903) and Warming (1904) had no experimental basis, they did establish probable relationships among certain leaf characteristics and environmental factors. Only in recent years has the functional significance of leaf form been investigated experimentally.

The theoretical and empirical basis for leaf energy balance linking the microclimate with water loss, leaf temperature and other leaf characteristics was provided by Raschke (1956) and Gates (1962) while others provided a linkage between water, energy transfer, form, and photosynthesis (Mooney 1972, Parkhurst & Loucks 1972, Givnish & Vermeij 1976, Cowan & Farquar 1977 and Mooney & Gulmon 1979). It has been noticed that in some species, a succession of leaves is produced with each set apparently adapted to specific environmental conditions (Hicks & Chabot 1985). Such adaptation may include the photosynthetic machinery, leaf area, leaf thickness or leaf shape. While variation in leaf shape may occur in one or more dimensions[1], the effect of intraspecific variation in leaf form in a single plane, on leaf function, has been little studied.

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[1] As in leaves with tortuous margins, e.g. <u>Circium</u> <u>vulgare</u> (Gleason & Cronquist, 1963)

In order to investigate the effect of two dimensional variation in leaf shape on leaf function, it is first necessary to select a plant species with a limited number of easily quantifiable and discrete leaf shapes. Sassafras albidum grows in moist, well drained soils of the open woodlands from sea level to a high of 1,350 m in the southern Appalachian Mountains (Elias, 1980). Sassafras has a distribution from southern Maine to Ontario and south over the Mississippi Valley to east Texas and central Florida with the largest trees reported on the deeper soils of the Great Smokey Mountains of North Carolina and Tennessee (Collingwood & Brush, 1964). Sassafras has heteromorphic leaves which may have an entire lamina; or they may have one sinus (lobe) on the left or right side of the midrib; or they may have two sinuses (lobes), one on each side of the midrib; or, occasionally, they may have more than two sinuses (lobes). However, there are no forms intermediate to these categories. The leaves are flat with smooth margins. Sassafras has a flat, unsymmetrical crown of twisted branches which spread almost at right angles from the trunk to support upward reaching branchlets (Collingwood & Brush, 1964). While S. albidum is endemic to the eastern United States, it has a close relative in China and Taiwan, Sassafras tzumu, Hemsl., which bears a close resemblance to S. albidum, and which also has heteromorphic leaves (Hemsley, 1907).

Bazzaz et al. (1972) measured photosynthesis of Sassafras growing under shade and in open field conditions and concluded that this species could maintain relatively high rates of net photosynthesis in both environments. However, leaf age, area, shape and nodal position were not considered. Ghent (1973) reported in a study of four Sassafras trees[1] in Illinois, that leaves with entire margins predominate at the proximal nodes and at the distal nodes of the shoots while lobed leaves predominate at the intermediate nodes. He also reported that the proportions of leaf shape categories

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[1] ca. 2954 leaves in a statistical, frequency analysis of form categories.

differ from tree to tree and with position on a single tree. A study by Ramirez and Kincaid (1986, abstract) also showed this and that leaves of the intermediate nodes had the largest surface area at the Bronx River population. It has also been shown that leaves of these intermediate nodes show the greatest proportion of two lobed leaves (Kincaid et al., 1985, abstract).

Sestak (1985) identifies three phases of leaf development. During phase 1, leaves are formed and leaf area increases. During phase 2, leaves reach maturity (after reaching maximum leaf area). During phase 3, leaves senesce and leaf area decreases. Increases in leaf area during leaf ontogeny follow a sigmoid curve as demonstrated in Cucumis (Hopkinson, 1964), Capsicum (Schoch, 1972a), Vigna (Schoch & Candelario, 1973), Phaseolus (Catsky et al., 1976, Ticha & Catsky, 1977, Verbeten & de Greef, 1979) and Malus (Kennedy & Johnson, 1981). However, various parts of a leaf expand at different rates and for different periods (Sestak, 1985). Leaf growth rate is greatest in young leaves and this rate declines until leaves reach maturity. However, there are at least three patterns of leaf area distribution along the growing axis of a plant. In the first type, leaf area progressively decreases with nodal position from the base to the apex, typical of Ipomoea (Ashby, 1948) and Arabidopsis (Hoffmann, 1968). In the second type, leaf area increases with nodal position from the base to the apex of the growing axis, as shown in Lolium (Sant, 1969), Capsicum (Schoch, 1971) and Nicotiana (Hackett & Rawson, 1974). In the final type, leaf area progressively increases in area with nodal position, from the base to the apex of the growing axis, reaches a maximum at a group of leaves in the middle region of the growing axis, and then decreases with nodal position toward the apex. This latter pattern is present in Malus (Cowant, 1936), Callistephus (Cockshull, 1966), Sinapsis (Humphries, 1967), Plectranthus (Ticha, 1968), Mangifera (Taylor, 1970), Filipendula (Morzov, 1978), Vigna (Littleton et al., 1979), Gossypium (Radin & Parker, 1979), Vicia (Dennett et al., 1979) and Helianthus (Rawson et al., 1980).

In addition to these patterns of leaf growth potential, growth in leaf area may be strongly modified by environmental factors such as temperature, as shown for Phaseolus (Wilson & Ludlow, 1968), Vicia (Dennett et al. 1979, Dennett & Auld, 1980), Glycine, Gossypium (Jones & Hesketh, 1980) and Helianthus (Rawson & Hindmarsh, 1982); radiation, as shown for Tropaeolum (Rummi & Carpinetti, 1977), Vicia (Dennett et al., 1979) and Sinapsis (Wild & Wolf, 1980); and water supply, as shown for Ipomoea (Ashby, 1948), Sorghum (McCree & Davis, 1974), Zea, Glycine (Boyer, 1970), and Helianthus (Rawson et al., 1980, Takami et al., 1981, and Rawson & Turner, 1982). Other environmental factors which have been shown to affect leaf area include photoperiod in Nicotiana (Hackett & Rawson, 1974), humidity in Capsicum (Schoch, 1971), salinity in Phaseolus (Wignarajah et al., 1975) and nitrogen nutrition in Lolium (Robson & Deacon, 1978), Gossypium (Radin & Parker, 1979) and Hordeum (Mader et al., 1981).

Leaf chlorophyll content has been used to compare species characteristics of ecotonal communities, to estimate photosynthetic productivity, predict energy absorption phenomena and to evaluate the development of herbaceous species during canopy closure (Randall ,1953; Bray, 1960; Ovington & Lawrence, 1967; Bazzaz & Bliss 1971). Leaf chlorophyll content has been shown to change with leaf age, in most cases reaching a maximum at about the time leaves reach maturity (completion of expansion growth) as shown for Citrus sinensis (Wallihan et al., 1976), Poplar populus (Ceulemans & Impens, 1979) and Carica papaya (Lin & Ehleringer, 1982); followed by a decline in leaf chlorophyll content as the leaf further matures, together with a parallel decline in maximum net photosynthesis (Lin & Ehleringer, 1982). Interestingly, Silvius (1978) showed that in Glycine max, leaf chlorophyll content increased beyond full leaf expansion, but without a corresponding increase in net photosynthesis. Floyd and Noble (1979) reported that the chlorophyll a/b ratio reached a peak at canopy closure and that total chlorophyll content reached a maximum 1 - 3 weeks later, in a study correlating leaf chlorophyll content with environmental and physiological factors on Quercus alba, Liriodendron tulipifera, Acer rubrum, Cornus florida, Desmodium nudiflorum and Sassafras albidum.

Leaf chlorophyll may account for about 6% of total leaf nitrogen; and RUBISCO, the primary enzyme of photosynthesis may account for 50% of total leaf nitrogen (Field & Mooney, 1987). A large portion of nitrogen occuring in the leaf is thus involved in the photosynthetic reactions, and leaf nitrogen content may be considered an indicator of the photosynthetic potential of a leaf. Diepenbrock and Geisler (1978) found that leaf nitrogen content influenced leaf chlorophyll content, especially in older leaves of Glycine max. Field and Mooney (1983) found that in Lepechinia calycina, leaf nitrogen content decreased with increasing leaf age, but that nitrogen use efficiency (μ mol CO_2 mol N^{-1}) did not decrease at the same time. It has been shown that over periods of days to weeks, leaf nitrogen contents are adjusted, presumably to maximize the difference between consequent photosynthetic benefits and the cost of nutrient aquisition (Mooney & Gulmon, 1979; Gulmon & Chu, 1981; Mooney & Chiariello, 1984. Field (1983) has shown that leaf nitrogen is retranslocated from older (shaded) leaves to younger (unshaded) leaves in such a way as to maximize net canopy carbon gain. This suggests that at the later stages of a growing season, there is less investment of nitrogen in the more permanent segments of the photosynthetic machinery (structural components of the leaf lamina) and considerably more investment in those segments giving quick returns in the investment (Field & Mooney, 1986). While Bjorkman (1981) found a strong correlation between maximum net photosynthesis and RUBISCO activity, there is evidence that RUBISCO levels alone are not responsible for the maximum net photosynthesis versus nitrogen relationship (Field & Mooney, 1986).

The effect of leaf age on photosynthesis has been studied in a wide variety of plant species. Rasulov et al. (1983) in a study on Gossypium hirsutum observed that net maximum photosynthesis increased from leaf age 5 to 20 days, but decreased thereafter. Joggi et al. (1983) observed that in Trifolium pratense, net photosynthesis increased linearly with leaf area index (LAI) to a LAI of 3.5 and then declined, and that the position of leaf age categories in the canopy are more important than the vertical distribution of leaf area.

The nodal position of a leaf along a shoot is representative of the age of a leaf, and studies on the effects of leaf age on photosynthesis have largely concentrated on individual leaves, with little attention paid to their photosynthetic response relative to other leaves on the same shoot or plant. Recent research on Solanum tuberosa (Vos & Oyarzun,1986), Glycine max (Latche et al. 1986), Albizzia and Semanea (Mutchachelian et al. 1986), and Trifolium repens (Boller & Nosberger, 1985) have shown greatest net photosynthetic rates when leaves reach full expansion, followed by a decrease in photosynthetic rates as the leaves matured further. This general pattern has been observed in several taxa of trees including Hevea (Samsudin & Impens, 1979a, b), Malus (Kennedy & Johnson, 1981), Pinus (Coyne & Bingham, 1982), and Prunus (Sams & Flore, 1982). Roper and Kennedy (1986) observed highest photosynthetic rates at 80% full leaf expansion in Prunus avium and Bozarth et al. (1982) observed maximum net photosynthesis shortly before full leaf expansion in Rosa hybrida L. cultivar Samantha. Similar patterns have been found in monocots (Dwyer & Stewart, 1986; Suzuki et al., 1987; Williams, 1985). It has been shown that, in Helianthus annus, all leaves, regardless of position on the plant have the same age determined pattern of gas exchange per unit leaf area (Rawson & Constable 1980). It has also been shown that Ultra-violet radiation can affect the rate and duration of leaf expansion and bring about a shift in the ontogenetic sequence of photosynthetic capacity as a function of leaf age in Glycine max, so that leaves of similar chronological age are at different stages of maturity (Teramura & Caldwell, 1981). On the other hand, leaf age has a negligible effect on photosynthesis in several species including Agropyron intermedium, A. desertorum, Phalaris arundinacea (Frank, 1981) and Larrea tridentata (Syversten & Cunningham, 1977). While ontogenetic trends and even maximum photosynthesis may not differ much in the broad view between species of the same genus, between cultivars, or between hybrids of the same species, growth environment and conditions of determination, in the short run, may strongly alter the values of absolute net photosynthesis (Sestak, 1985). Morinaga et al. (1985), in a rare comparative study of leaf photosynthesis along shoots reported maximum net photosynthetic rates in the one to four leaves positioned near the shoot apex in Citrus unshiu. Sato et al. (1978), working on Colocasia esculenta reported that greatest leaf area occurred at the intermediate nodes and that net photosynthesis increased with leaf expansion and reached a maximum 14 to 15 days after full leaf expansion.

The photosynthetic response of a leaf to incident PAR could be determined by the physiological age of the leaf, where leaves approaching full expansion (maturity) have greatest net photosynthesis at a given PAR, and have a higher light saturation point; and senescing leaves have lowest net photosynthesis and are light saturated at lower PAR ; and young, expanding leaves are intermediate in their response to incident PAR (Sestak, 1985). This pattern has been demonstrated in several species, including Helianthus (Hiroi and Monsi, 1966), Glycine (Kumara, 1969), Vigna (Bonhomme et al., 1977) and Coffea (Yamaguchi and Friend, 1979). There also is evidence of leaf adaptation to light habitat, where shading early in the development of a leaf may lead to lower light compensation point, lower light saturation point, and lower net photosynthesis (Sestak, 1985). Furthermore, Boardman (1977), Wild (1979) and Bjorkman (1981) have shown that the net photosynthesis versus irradiance curves decrease with leaf age. Pavlova (1983) showed that increased shading caused the decrease of photosynthetic activity in Vicia faba and Fraximus viridis, especially in older leaves. An effect on photosynthesis of the environment in which leaves are formed has also been demonstrated by Singh et al. (1984) in Citrus limon, where leaves of the spring flush have greater photosynthetic capacity than do leaves of the rainy season flush at all stages of their growth and development.

Most of the above studies are on commercially important species and in most cases, species having simple (undissected) leaves. White (1983) in a study on 48 eastern deciduous trees reported that as leaf size (area) increased, the percentage of trees with lobed, and then compound leaves increased, but that simple, unlobed leaves ranged throughout. A recent study by Gurevitch (1988) has shown that leaf dissection in Achillea millefolium differs dramatically along an altitudinal gradient; dissection decreases with increase in altitude and leaves with greater dissection maintained temperatures close to air temperature while less dissected leaves reached temperatures substantially above air temperatures. Baker and Myhre (1969) found that leaves of the mutant lines of cotton (Gossypium hirsutum) with 'okra' (lobed) leaves had thinner boundary layers than their normal analogues, but that carbon fixation was not enhanced under field conditions. However, Shanmugam et al. (1980) found that 'okra' (lobed) leaves of lines of cotton had a lower leaf area index and yet produced more dry matter than 'normal' leaf lines, while Karami and Weaver (1980) found that plants of American Upland Cotton (G. hirsutum) with the 'okra' (lobed) leaf shape had a higher photosynthetic rate than plants with 'normal' (entire) leaves. Studies such as that by Iordanov & Jordanov (1970) on Vicia have shown that leaves of different shapes, but on the same plant, are associated with differences in maximum net photosynthetic rates; but since these shapes are associated with different physiological states of the plant, their usefulness in investigating form / function relationships is limited. Wind tunnel experiments by Vogel (1968, 1970) have shown that deeply lobed leaves, with their thinner boundary layers, have higher convection coefficients than do less deeply lobed leaves with their thicker boundary layers; and, in the broader view, we think that variation in the convective abilities of leaves influence leaf temperature and thus photosynthesis and transpiration (Gates 1980).

3. LEAF AREA AND FORM

METHODS AND MATERIALS

In 1986, eight genets (numbers 585, 586, 589, 590, 591, 595, 597 & 598; Table 3.1) of Sassafras albidum. from a population growing along the floodplain of the Bronx River at Bronxville, N. Y. were used in a study of chlorophyll contents (Chapter 4). All the leaves from five sun shoots and five shade shoots were analyzed per genet. Leaf form at each node was recorded. In 1987, four genets (numbers 99, 100, 590 & 591, Table 3.2) were selected from the same population for a demographic study of leaf growth. On May 7, 1987, when the leaves had just begun to emerge, twenty shoots of each of the four plants above were "tagged" non-restrictively, using numbered bird-bands (National Band and Tab Co., Newport, Kentucky). At intervals over the growing season, leaves on these shoots were scored for nodal position and for shape category (entire margin; one sinus on the left or right side of the midrib; two sinuses, one on each side of the midrib); and the blade lengths and widthswere measured. During each of the above measurements, leaf nodal position was recorded.

While leaves were easy to score for the form categories, leaf area was predicted using the product of leaf length and width regressed[1] onto area. Leaf length and width were measured for each leaf of five of the 20 tagged shoots, at intervals during the growing season and the leaves on all 20 shoots were measured once, when leaf expansion ceased in late August to early September. Separate regression models were calculated for entire margined, one lobed and two lobed leaves from a data base of 993

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[1] In a least squares sense.

leaves (not part of this experimental system) that were sampled destructively in 1986, digitized and processed using the Fourier transform-based Leaf Boundary Method of Kincaid and Schneider (1983) on an Apple IIe computer. This database was installed on an IBM XT computer using the program Reflex (Borland /Analytica Inc., Scotts Valley, California) and regression curves obtained using programs written in BASIC following Sokal and Rholf (1981). These regression curves were used to estimate leaf area (in mm^2 one leaf surface).

Regression equations used to predict leaf area:

1. Entire leaves -

$$Y = -302.51637 \text{ x } 1.54773 \text{ (length x width) in } mm^2$$

$$(F = 11996.9\ (1,587),\ r^2 = 0.953,\ p < .001)$$

2. One Sinus leaves-

$$Y = -21.81613 \text{ x } 1.59676 \text{ (length x width) in } mm^2$$

$$(F = 1636.5\ (1,104),\ r^2 = 0.940,\ p < .001)$$

3. Two Sinus leaves-

$$Y = 192.3123 \text{ x } 1.84537 \text{ (length x width) in } mm^2$$

$$(F = 3783.4\ (1,239),\ r^2 = 0.941,\ p < .001)$$

Table 3.1. The genotypes of Sassafras that were measured in 1986 for leaf form and chlorophyll content are listed in order of decreasing tree diameter at breast height (DBH). The frequency distributions for leaf form category are given as percentages of the total number of leaves measured for five sun shoots and five shade shoots collected per tree.

			Leaf Form Categories (percentages)			Canopy Position (frequencies)		
Genet #	DBH (mm)	Height (m)	Entire Margin	One Lobed	Two Lobed	Sun	Shade	Total Leaves
590	592	15.55	50%	12	38	68	46	114
597	487	8.53	39	10	50	62	49	111
598	369	16.46	87	9	5	55	51	106
591	292	10.15	62	8	30	60	55	115
586	185	9.02	57	15	28	47	42	89
585	131	7.61	81	10	8	52	44	96
589	129	8.14	85	5	9	49	37	86
595	93	7.38	50	6	44	62	41	103
Overall			63%	9%	28%	455	365	820

Table 3.2. The genotypes of Sassafras that were measured in 1987 for area, leaf form, chlorophyll content, nitrogen content and photosynthesis are listed in order of decreasing tree diameter at breast height (DBH). The frequency distributions for leaf form category are given as percentages of the total number of leaves measured for twenty shoots per tree.

			Leaf Form Categories (percentages)			
Genet #	DBH (mm)	Height (m)	Entire Margin	One Lobed	Two Lobed	Total Leaves
590	596	15.25	43.7	12.2	44.1	272
591	301	12.11	39.0	10.5	50.5	200
99	120	4.80	98.0	1.0	1.0	196
100	103	3.62	81.2	10.6	8.2	170
Overall			63.0%	8.7%	28.3%	836

RESULTS

1986

A sample of 10 shoots (five from "sun" positions and five from "shade" positions) from each of the eight genets yielded an overall pattern for the nodal distribution of leaves with two lobes is shown in Figure 3.1. Leaves with entire margins predominate at the proximal and distal nodes while leaves with two lobes are most common at the middle nodes. The highest frequency of leaves with two lobes (85%) occurs at node 10 on shade shoots. Leaves with one lobe occur along the shoots most frequently at the interfaces between entire margin and two lobed leaves (Figure 3.2), resulting in a bimodal distribution by node.

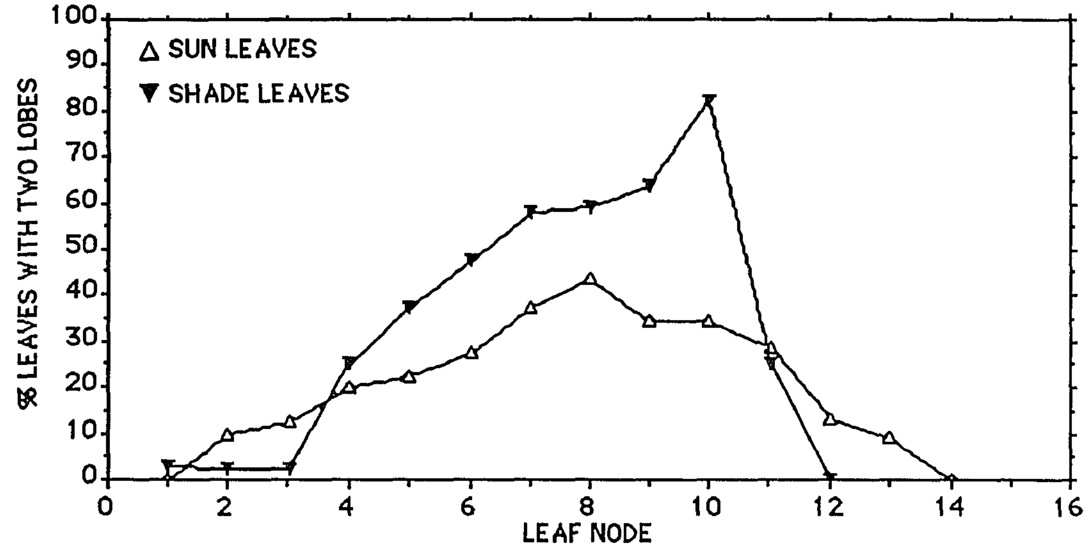

Figure 3.1. Frequency of occurrence of leaves with two lobes, expressed as a percentage of all leaves at each node along shoots from "sun" and "shade" positions. Data from 10 shoots from each of the eight genets used in this study have been merged.

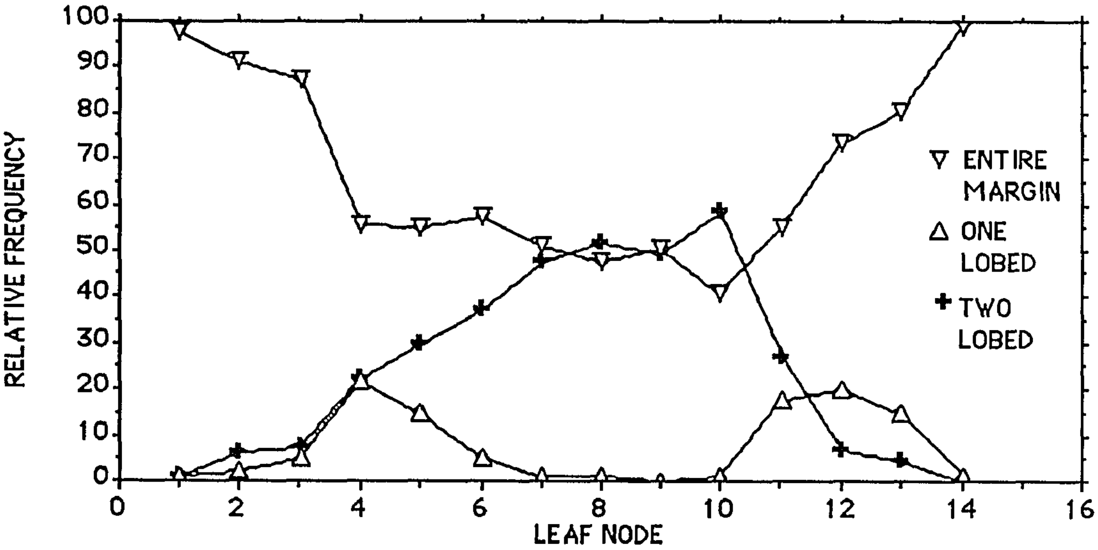

Figure 3.2. Relative frequency of leaf form categories at each node for 10 shoots from eight genets of Sassafras in 1986. See Table 3.1 for sample sizes.

1987

Genet 99

Leaf Shape

Newly emerged leaves were first large enough to be scored for shape on May 11, 1987, at which time there was a maximum of 10 leaves on a shoot. Leaves with entire margins predominated throughout the length of all 20 shoots sampled (Figure 3.3). There were, however, a few lobed leaves at distal nodes 8 and 9. This pattern of mostly entire margined leaves and few lobed leaves did not change during the rest of the growing season and the final measurement of leaf form by node is shown in Figure 3.4

Leaf Area

The least squares second degree polynomial regression curves for leaf area, for each node for each of four measurements (May 11, May 26, July 1, and July 21) are shown in Figure 3.5. In each case the regression is very highly significant with r^2 values of 0.54, 0.597, 0.568 and 0.377 respectively. The youngest leaves were usually so small that they could not be measured accurately without risking damage to the leaf; they were excluded. On each of the days when leaf area was measured, there is a definite curvilinear pattern, and leaves of the middle nodes - be they node four on May 11, node five on May 26, or node seven on July 1 and July 21- always had the greatest surface area relative to the other leaves on these shoots. Using the regression, the greatest predicted single leaf surface area was approximately 18,000 mm^2, on July 21, 1988.

Leaf Expansion

The rate of expansion for leaves at each node is shown in Figure 3.6. Most growth occurs between May 11 and May 26, with the youngest leaves expanding the most. Between May 26 and July 1, there is little growth and most of it is restricted to the youngest leaves (nodes 7 - 9). Between July 1 and July 21, there is virtually no expansion growth.

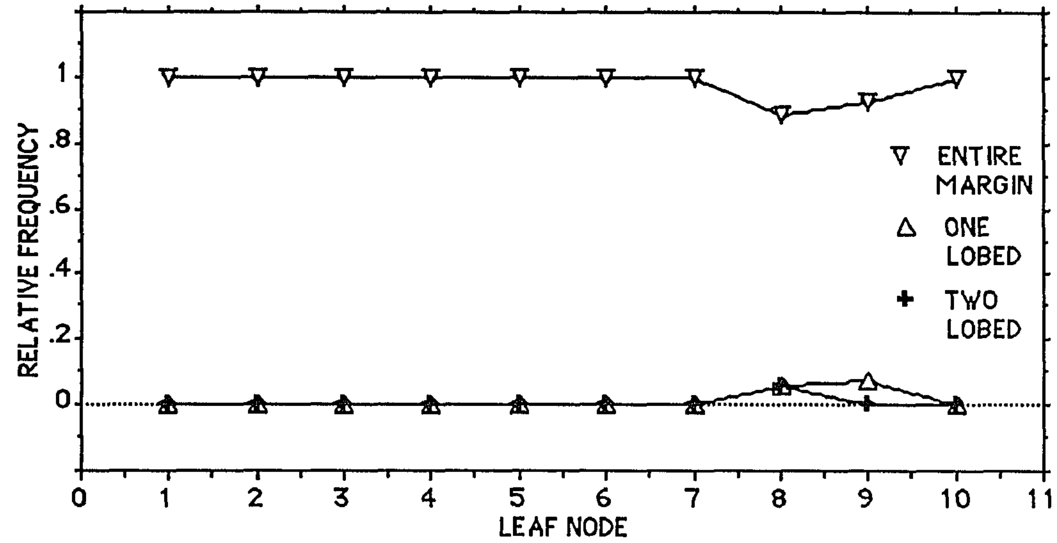

Figure 3.3. Relative frequency of leaf form categories at each node for 20 shoots of genet 99 on May 11, 1987.

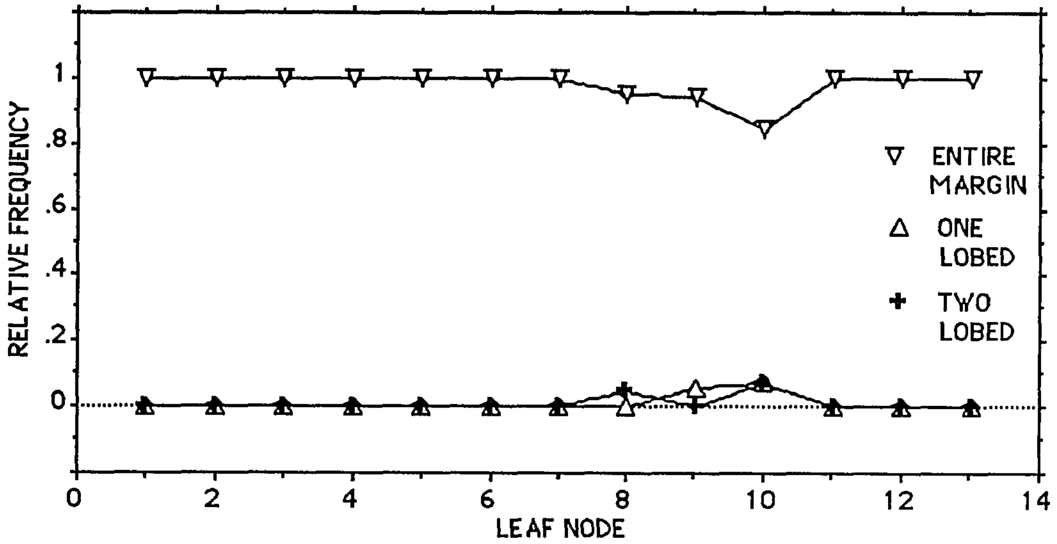

Figure 3.4. Relative frequency of leaf form categories at each node for 20 shoots of genet 99 on August 18, 1987.

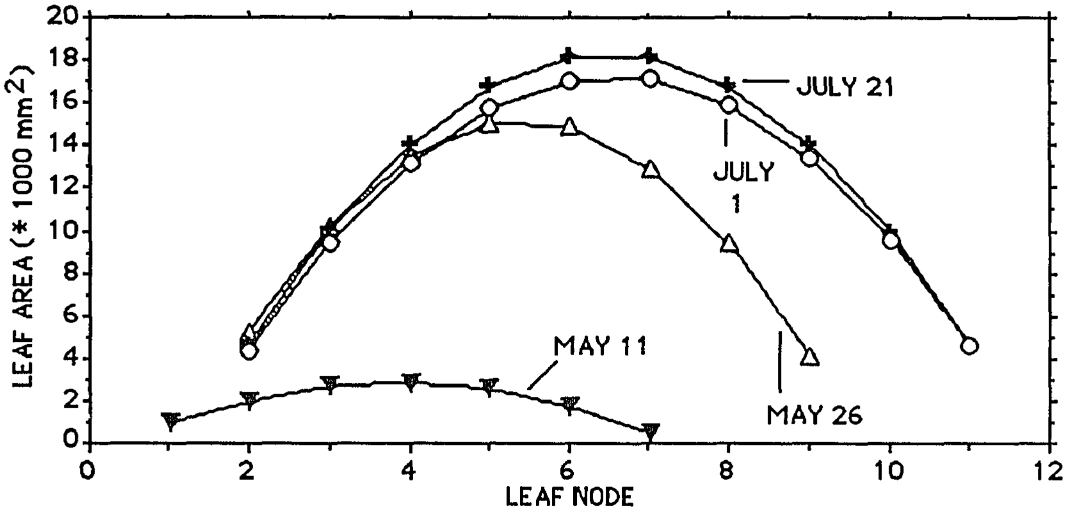

Figure 3.5. Regression curves of average leaf area per node for five shoots of genet 99 on four measurement days. In each case the regressions are statistically significant ($p < .001$) and have r^2 values of 0.540 (May 11), 0.597 (May 26), 0.568 (July 1), and 0.377 (July 21).

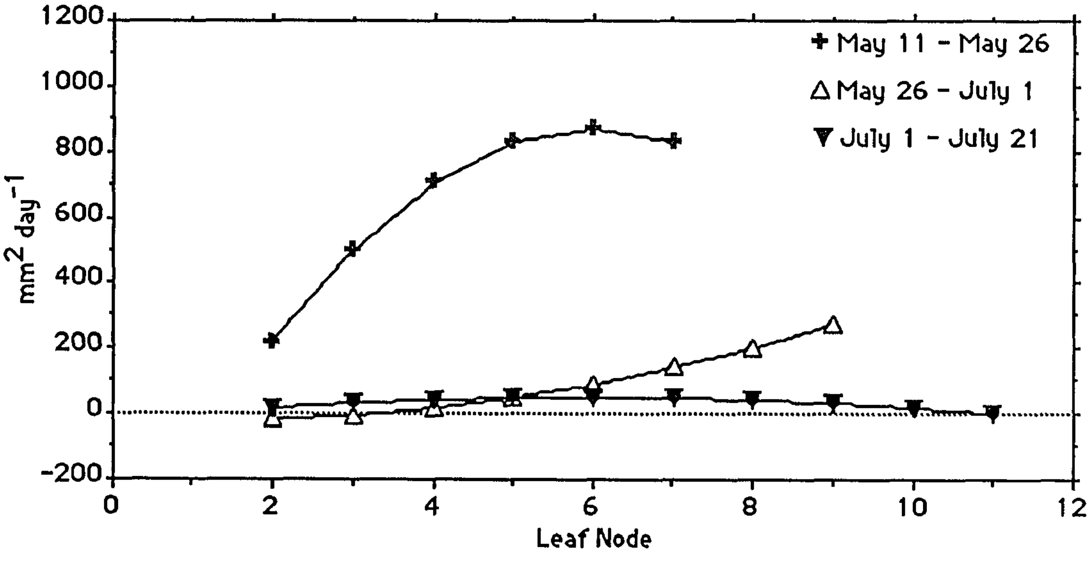

Figure 3.6. Rate of expansion growth (mm^2 day^{-1}) for leaves at each leaf node on genet 99.

Genet 100

Leaf Shape

On this genet, the first leaves to emerge have entire margins, but by node five the first lobed leaves can be seen. When leaf form was scored on May 11, 1987 leaves with two lobes were predominant among the most recently emerged leaves at node eight (Figure 3.7). Leaves with single lobes are most common at node seven but decrease in frequency of occurrence by node eight. By the time of the next measurement on May 26 only two new leaf nodes had been added (Figure 3.8) and none of these leaves had lobes. At node nine, leaves with two lobes and leaves with entire margins occur with equal frequency, but by node ten, only leaves with entire margins leaves can be seen. However, these youngest leaves are present on only some shoots and by the next measurement on, June 16, leaves with two lobes are more frequent than are leaves with entire margins, at node ten (Figure 3.9), and leaves with entire margins predominate at node eleven. This pattern is stable until the latter part of the growing season when leaf damage[1] and senescence occur (Figure 3.10).

Leaf Area

The regression curves for average leaf area per node, for each of four measurements during the growing season (May11, May 26, July 1, and July 21) are shown in Figure 3.11. In each case the regression is very highly significant with r^2 values of 0.497, 0.682, 0.632 and 0.601 respectively. The youngest leaves were usually so small that they could not be measured accurately and without risking damage to the

---

[1] mechanical and herbivore

leaf, so they were excluded. On each of the days when leaf area was measured, there is a definite curvilinear pattern, less visible on May 11 when leaves at nodes three and four had the largest surface area, but highly visible subsequently when leaves at node five (May 26) and then node five and six (July1 & 21) have the largest surface area on these shoots. Most increase in leaf surface area occurred between May 11 and May 26, and some increase (especially in leaves of the distal nodes) occurred between May 26 and July 1, but very little growth was observed between July 1 and July 21. Using the regression, the greatest predicted surface area reached was approximately 25,000 mm^2, on July 21

Leaf Expansion

The rate of expansion growth at each node is shown in Figure 3.12. Most growth occurs between May 11 and May 26, with the leaves of intermediate age (nodes 4 - 6) expanding the most. Between May 26 and July 1, growth is greatest at the youngest leaves (nodes 6 - 8). Between July 1 and July 21, there is virtually no expansion growth and, indeed, there appears to be a decrease in leaf area.

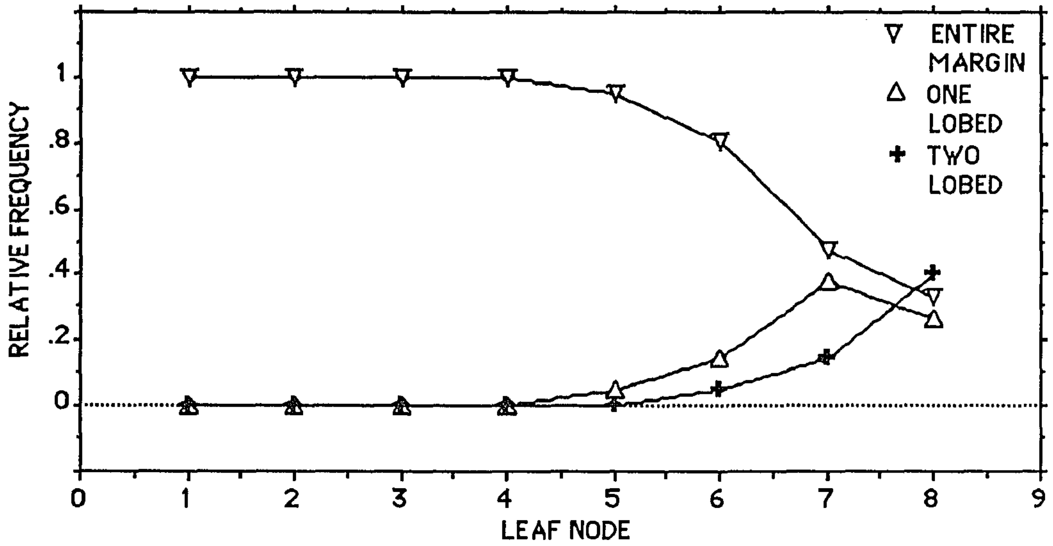

Figure 3.7. Relative frequency of leaf form categories at each node for 20 shoots of genet 100 on May 11, 1987. Lobed leaves occur first at node five and by node eight all three forms occur at approximately equal frequencies.

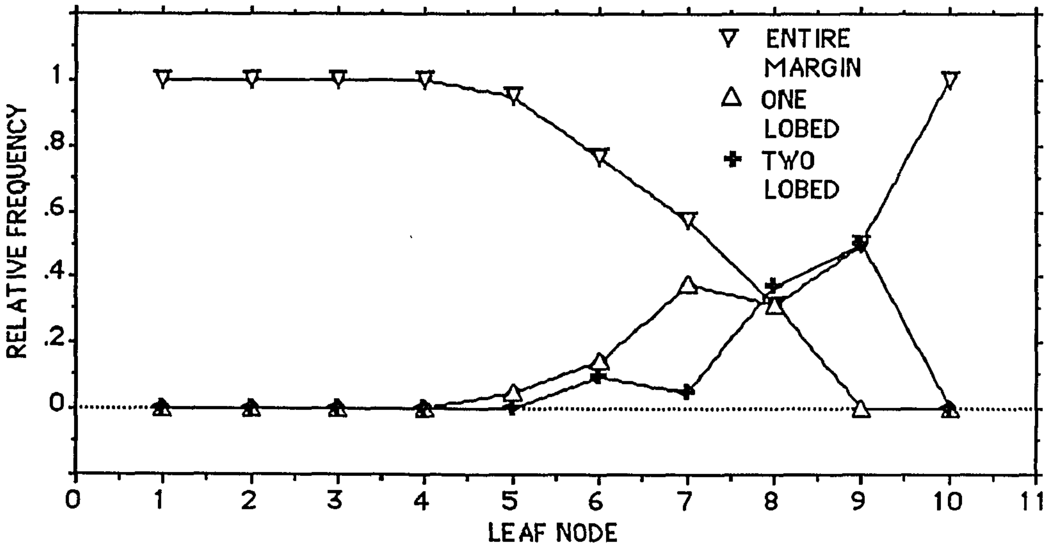

Figure 3.8. Relative frequency of leaf form categories at each node for 20 shoots of genet 100 on May 26, 1987. Lobed leaves occur first at node five and by node eight all three forms occur at approximately equal frequencies. By node ten, only entire leaves are present.

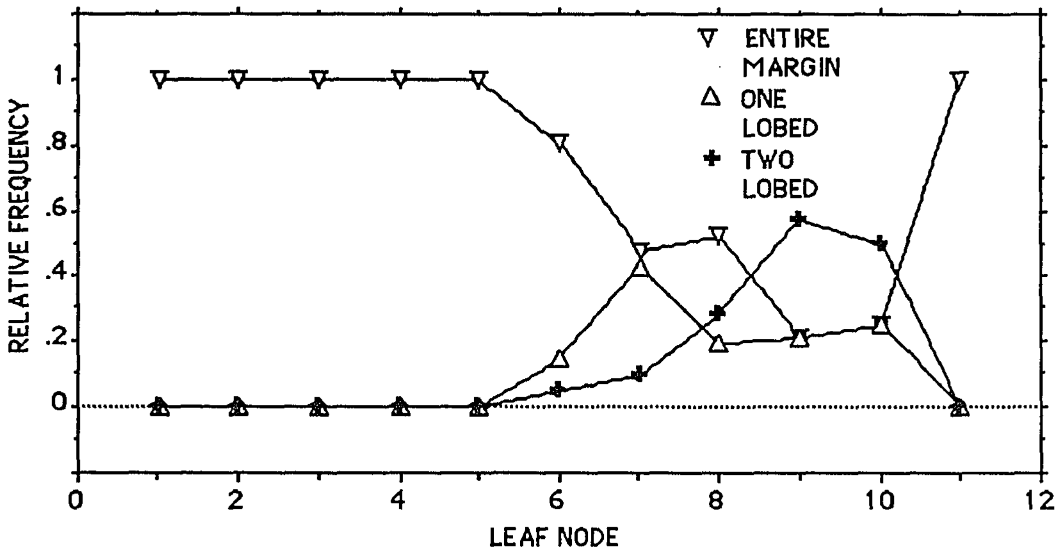

Figure 3.9. Relative frequency of leaf form categories at each node for 20 shoots of genet 100 on June 16, 1987. Recently emerged leaves at node ten are mostly with two or one lobe, but at node 11 are largely with entire margins.

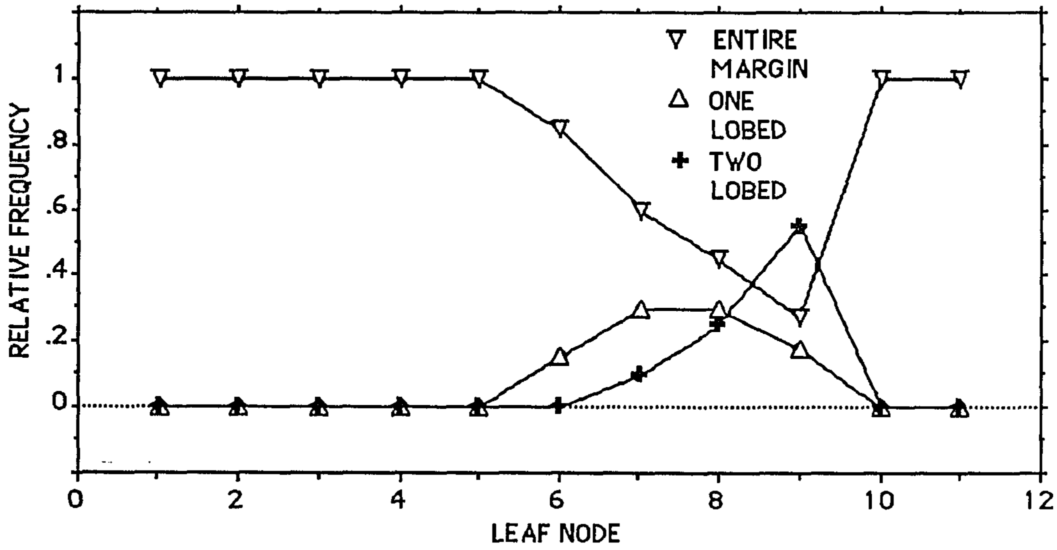

Figure 3.10. Relative frequency of leaf form categories at each node for 20 shoots of genet 100 on August 18, 1987. The patterns established in June are maintained and the most recently emerged leaves (node 12) have entire margins.

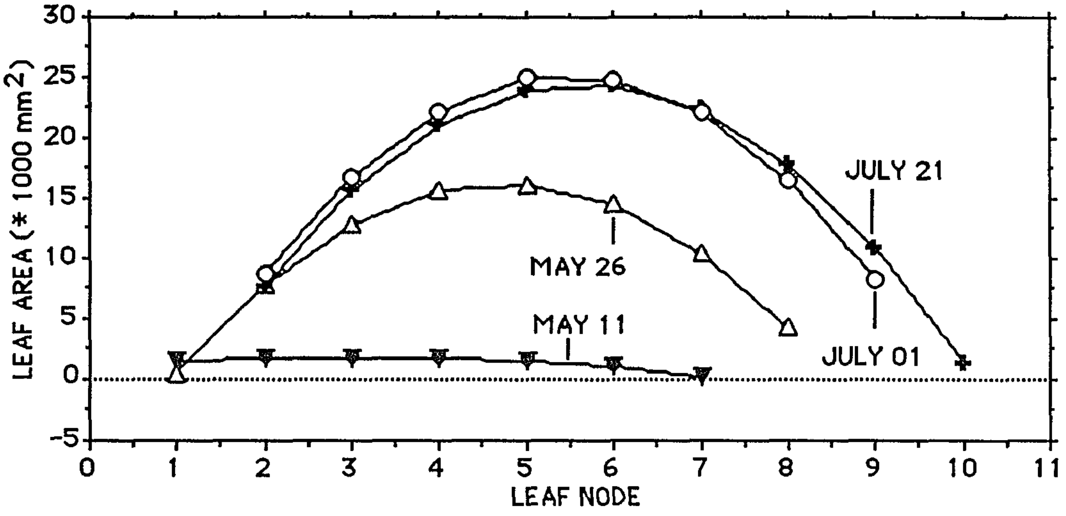

Figure 3.11. Regressions of average leaf area per node for five shoots of genet 100 on four measurement days. In each case the regressions are statistically significant ($p < .001$) and have r^2 values of 0.497 (May 11), 0.682 (May 26), 0.632 (July 1), and 0.601 (July 21).

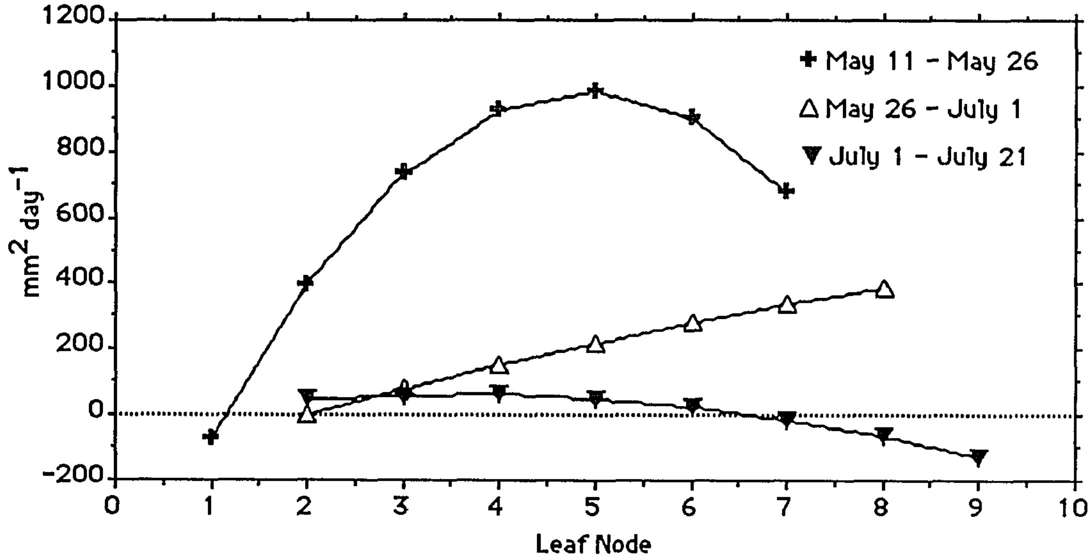

Figure 3.12. Rate of expansion growth (mm^2 day^{-1}) for leaves at each node on genet 100.

Genet 590

Leaf Shape

Newly emerged leaves of genet 590 were first scored on May 7, 1987 when there was a maximum of six leaves on a shoot. Lobed leaves occur first at node four and by node six they are the predominant type (Figure 3.13). By May 11, as many as ten leaves were present, per shoot, and in the most recently emerged leaves (nodes seven through ten) two lobed leaves were the dominant form (Figure 3.14). Leaves with one lobe occur mostly at nodes four and five. By June 20, I found up to 18 leaves per shoot, and the youngest leaves all had entire margins (Figure 3.15). The three leaf shapes exhibit three different patterns of distribution by node. Entire margin leaves occur most frequently at the proximal and distal nodes (the oldest and youngest leaves respectively) and there are few of these leaves at the intermediate (medium age) nodes. Two lobed leaves are absent at the proximal (1 - 3) and distal (16 - 18) nodes but are the most common type at the intermediate nodes (5 - 12). The frequency of occurence of one lobed leaves is bimodal, peaking at nodes 4-5 and 12-13. This pattern changes very little by the end of the growing season (Figure 3.16)

Leaf Area

The regression for average leaf area per node, for each of five measurements during the growing season (May 11, May 26, June 20, July 15 and August 18) are shown in Figure 3.17. In each case the regression is very highly significant with r^2 values of 0. 447, 0.664, 0.558, 0.532 and 0.519 respectively. The youngest leaves were usually so small that they could not be measured accurately and without risking damage to the leaf; they were excluded. On each of the days when leaf area was measured, there is a definite curvilinear pattern, that is apparent from May 11 when leaves at nodes five had the largest surface area, through May 26 (node 7), June 20 (node 9), July 15 (node 9) and August 15 (node 9-10). Little increase in leaf surface area occurred between June 20 and July 15. Using the regression, the greatest predicted average single leaf surface area reached was approximately 39,000 mm^2, on August 18.

Leaf Expansion

The rates of expansion growth for leaves at each nodal position are shown in Figure 3.18. Most growth occurs between May 11 and May 26, with the youngest leaves (nodes 6 - 8) expanding the most. Between May 26 and June 20, growth is greatest at the youngest leaves (nodes 8 - 10). Between June 20 and July 15, there is virtually no expansion growth but there is a flush of growth at the intermediate nodes, between July 15 and August 18.

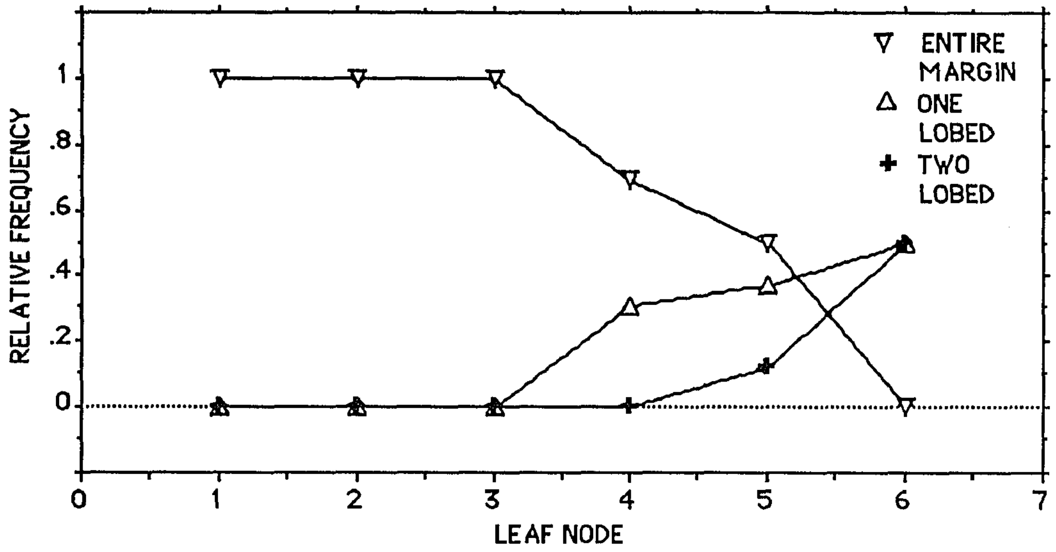

Figure 3.13. Relative frequency of leaf form categories at each node for 20 shoots of genet 590 on May 7, 1987.

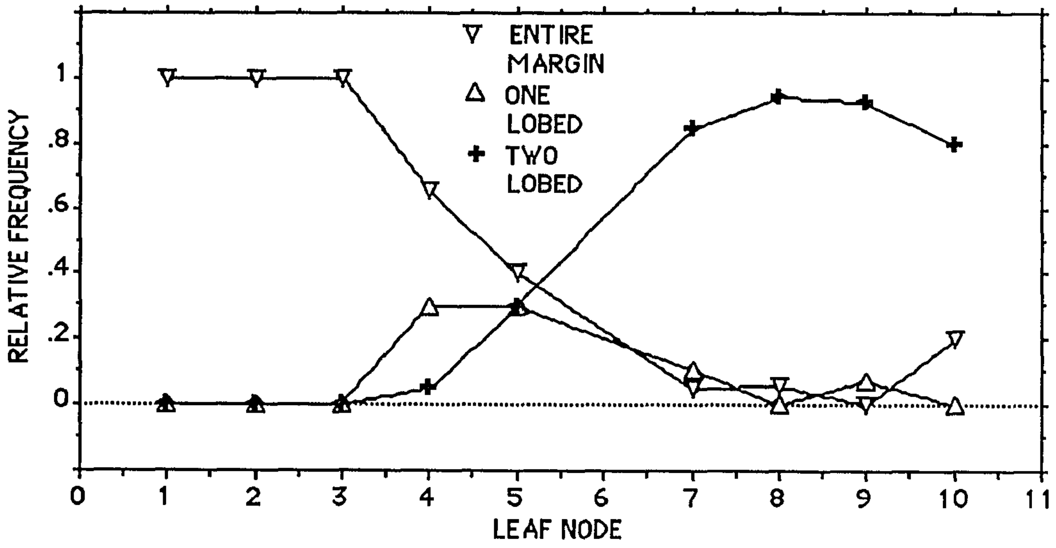

Figure 3.14. Relative frequency of leaf form categories at each node for 20 shoots of genet 590 on May 11, 1987.

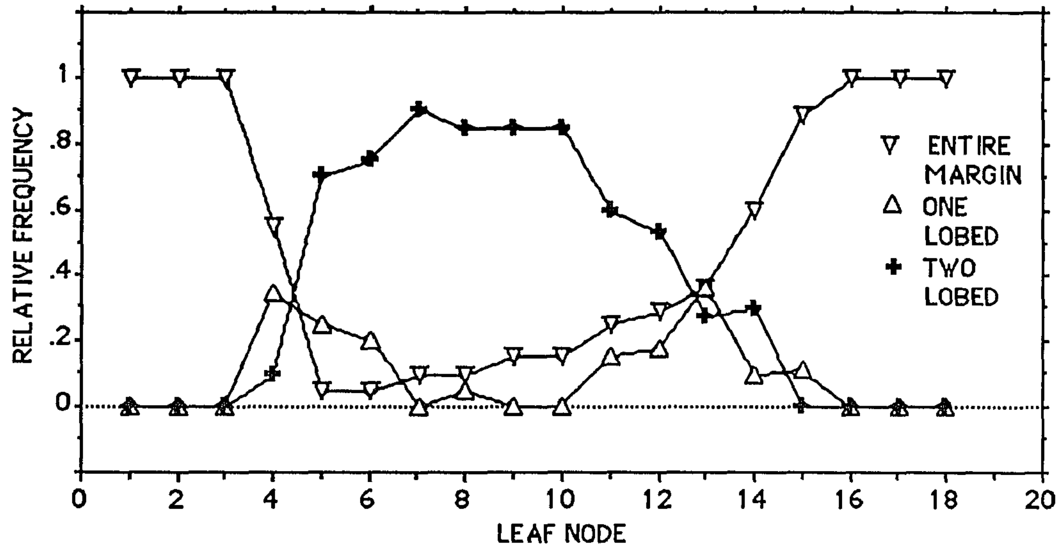

Figure 3.15. Relative frequency of leaf form categories at each node for 20 shoots of genet 590 on June 20, 1987.

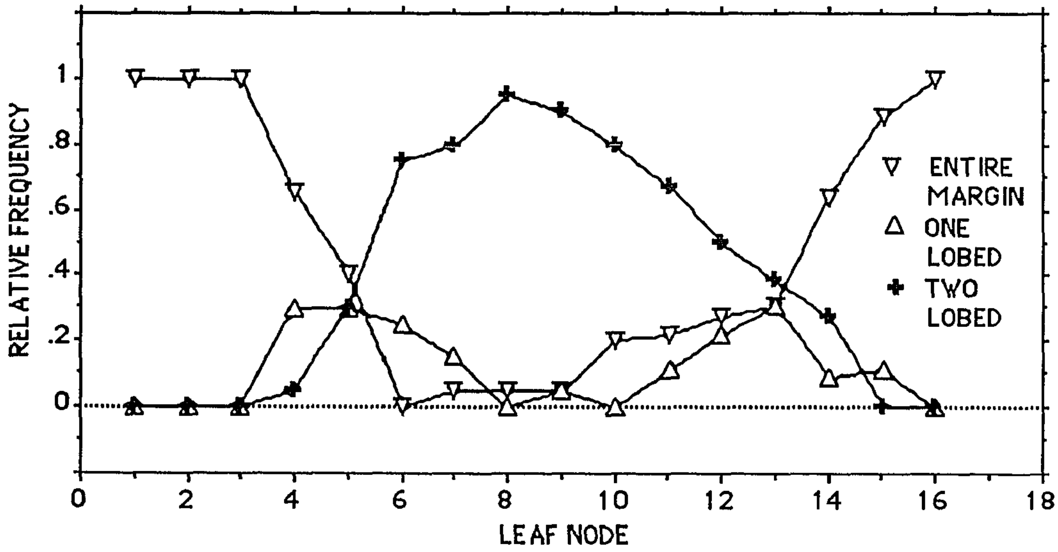

Figure 3.16. Relative frequency of leaf form categories at each node for 20 shoots of genet 590 on August 18, 1987.

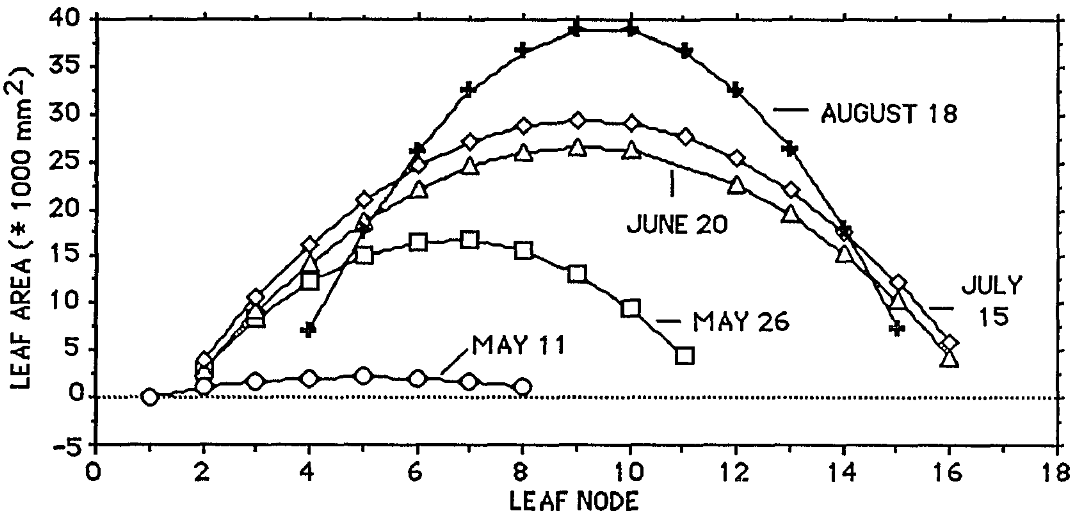

Figure 3.17. Regressions of average leaf area per node for five shoots of genet 590 on five measurement days. In each case the regressions are statistically significant ($p < .001$) and have r^2 values of 0.447 (May 11), 0.664 (May 26), 0.558 (June 20), 0.532 (July 15) and 0.519 (August 18).

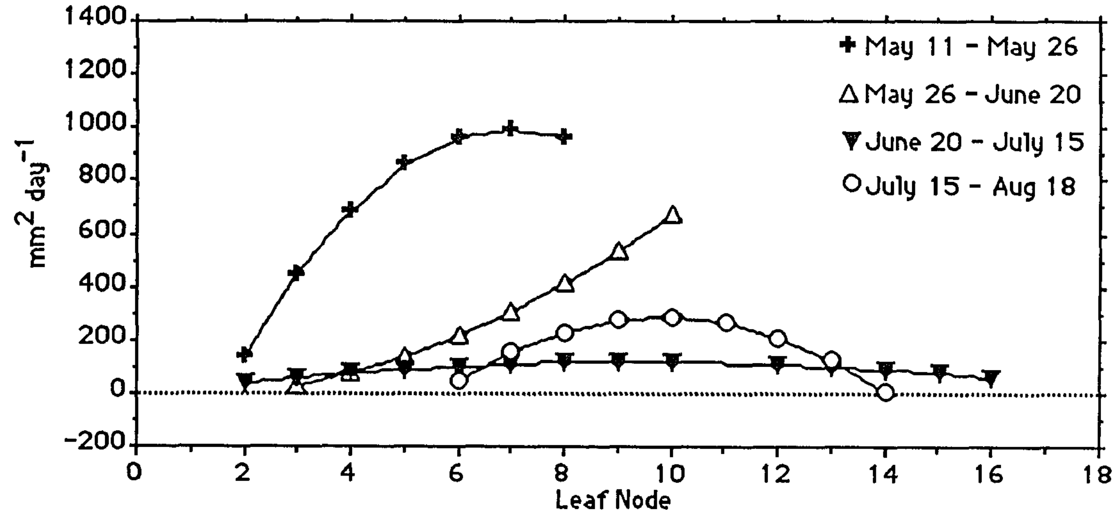

Figure 3.18. Rate of expansion growth (mm^2 day^{-1}) for leaves at each node on genet 590.

Genet 591

Leaf Shape

Newly emerged leaves of genet 591 were first scored on May 11, 1987 (Figure 3.19). The pattern of distribution of leaf shapes is similar to that for genet 590. Only entire margin leaves occur at the proximal nodes (nodes 1-3), but the proportion of lobed leaves, first with one lobe and then with two lobes, increases from node four onward. By node six, leaves with two lobes are the predominant form. By May 26, two additional leaf nodes were observed, consisting mainly of leaves with two lobes (Figure 3.20). By June 16, another five nodes had been added, mostly leaves with two lobes, but with an increasing presence of leaves with entire margins (Figure 3.21). There was little change in this distribution by July 15 (Figure 3.22) but a second flush of growth occurred between this date and August 25 when several newly formed leaves at the most distal nodes (13-14), mostly with entire margins, cause the pattern of the distribution to change so that entire margin leaves predominate at these distal nodes (Figure 3.23).

Leaf Area

The regressions for average leaf area per node, for each of four measurements during the growing season (May 11, May 26, July 15 and August 25) are shown in Figure 3.24. In each case the regression is very highly significant with r^2 values of 0.555, 0.717, 0.445, and 0.524 respectively. The youngest leaves were usually so small that they could not be measured accurately and without risking damage to the leaf; they were excluded. On each of the days when leaf area was measured, there is a definite curvilinear pattern, from May 11 when leaves at nodes five had the largest surface area, through May 26 (node 7), July 15 (node 8) and August 25 (node 8). Most increase in leaf surface area occurred between May 11 and May 26, May 26 and July 15 but little increase occurred between July 15 and August 25. Using the regression, the greatest predicted surface area for the average leaf reached was approximately 40,000 mm^2, on August 18.

Leaf Expansion

The rates of expansion growth for leaves at each nodal position are shown in Figure 3.25. Most growth occurs between May 11 and May 26, with the leaves of intermediate age (nodes 6 - 8) expanding the most. Between May 26 and July 15, growth is greatest in the younger leaves (nodes 9 - 11). Between July 1 and July 21, there is virtually no expansion growth.

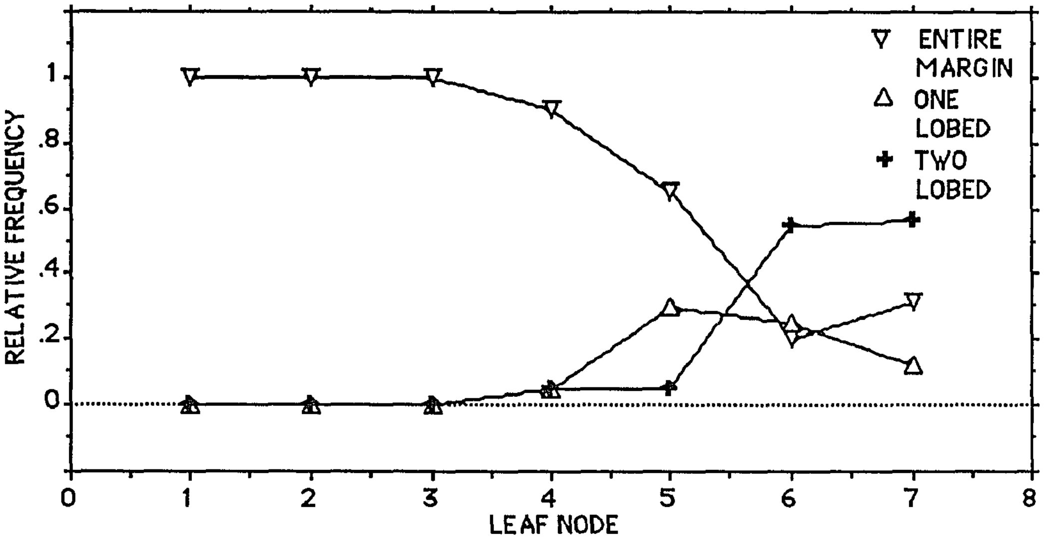

Figure 3.19. Relative frequency of leaf form categories at each node for 20 shoots of genet 591 on May 11, 1987.

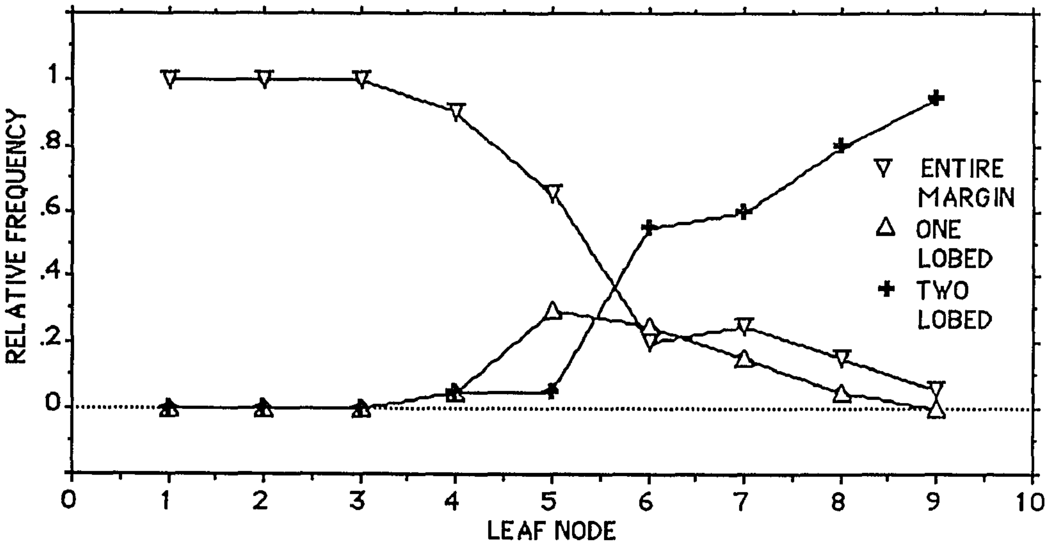

Figure 3.20. Relative frequency of leaf form categories at each node for 20 shoots of genet 591 on May 26, 1987.

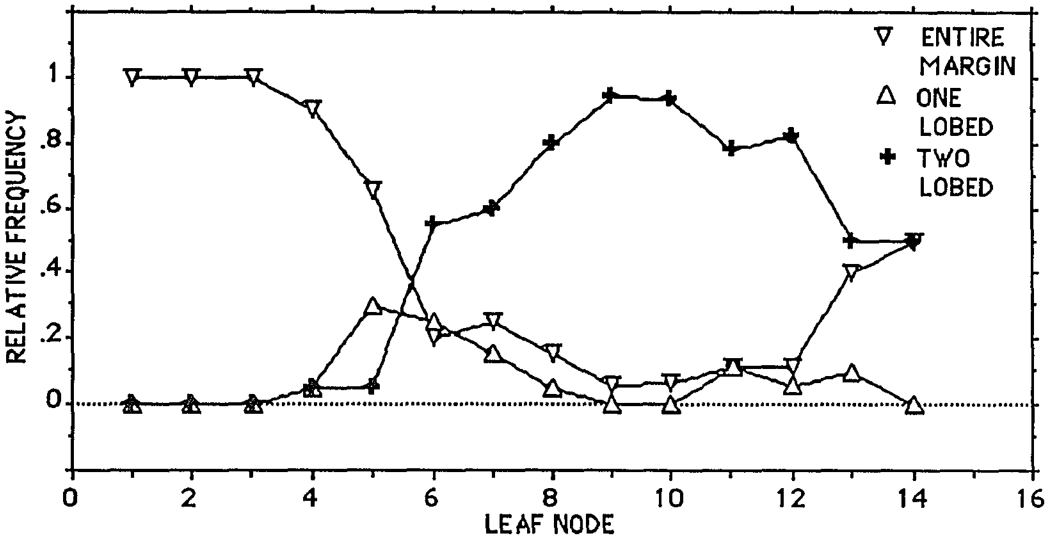

Figure 3.21. Relative frequency of leaf form categories at each node for 20 shoots of genet 591 on June 16, 1987.

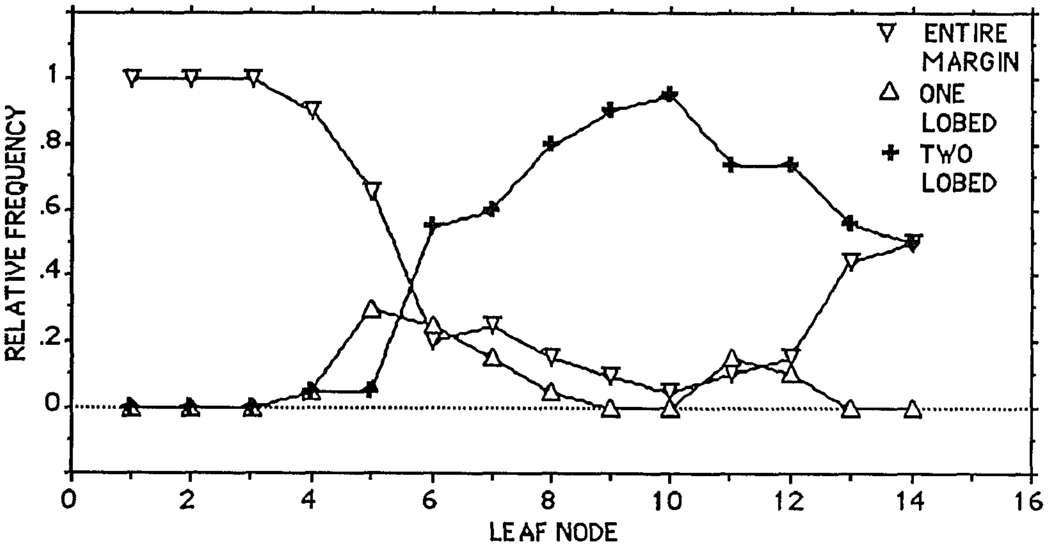

Figure 3.22. Relative frequency of leaf form categories at each node for 20 shoots of genet 591 on July 16, 1987.

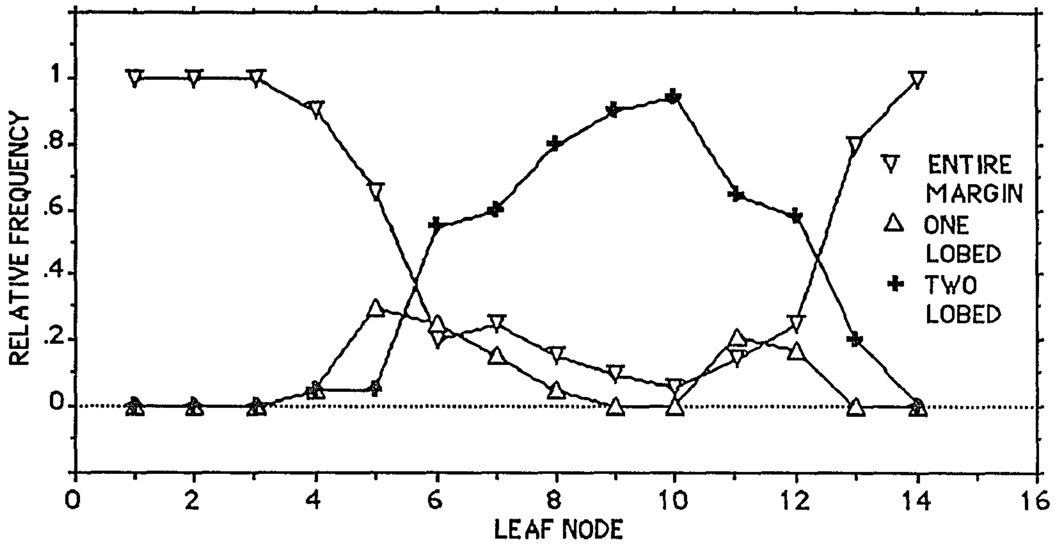

Figure 3.23. Relative frequency of leaf form categories at each node for 20 shoots of genet 591 on August 25, 1987.

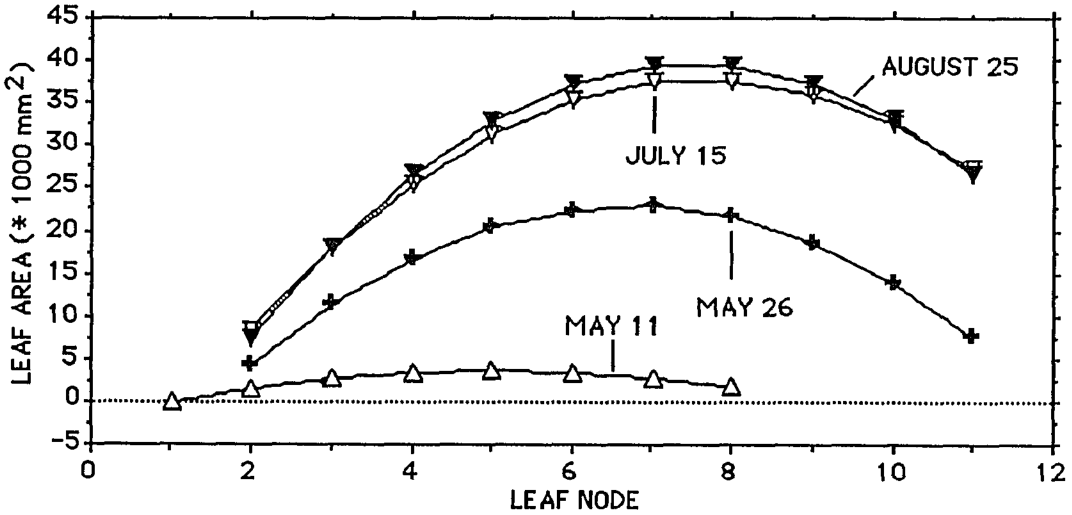

Figure 3.24. Regressions of average leaf area per node for five shoots of genet 591 on four measurement days. In each case the regressions are statistically significant ($p < .001$) and have r^2 values of 0.555 (May 11), 0.717 (May 26), 0.445 (July 15), and 0.524 (August 25).

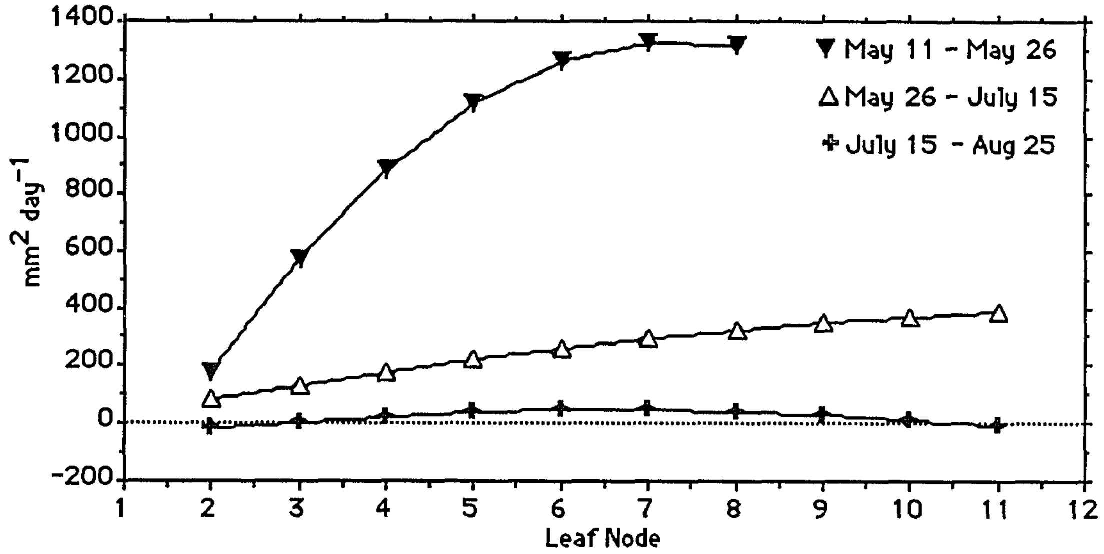

Figure 3.25. Rate of expansion growth (mm^2 day^{-1}) for leaves at each node on genet 591.

4. CHLOROPHYLL CONTENT

1986

Leaf chlorophyll content is often measured in ecological studies but it is seldom measured at high degrees of freedom in natural populations. Consequently, little is known about any statistically significant patterns in leaf chlorophyll content which might exist among the leaf nodes, leaf shapes, shoots, and genets (genotypes) in a plant population. Chlorophyll and the other compounds of photosynthesis are a major investment in nitrogen; and the economy of nitrogen use has become important in evaluating trends in plant form (Field and Mooney, 1986).

From work begun in 1985 we have a database of 933 leaves analyzed for leaf form from eight genets of Sassafras. During the summer of 1986, I measured leaf chlorophyll content (expressed as mg g^{-1} wet leaf weight; g m^{-2}; and chlorophyll a / chlorophyll b ratio) for these eight genets. The object was to statistically test the hypotheses below.

NULL HYPOTHESES

Chlorophyll content is homogeneous between sun and shade leaves.
Chlorophyll content is not predictable given leaf node number.
Chlorophyll content is homogeneous among leaf shapes.
Chlorophyll content is homogeneous among shoots.
Chlorophyll content is homogeneous among genets.
Chlorophyll content is homogeneous across the 1987 growing season.

MATERIALS AND METHODS

In 1986, eight genets of Sassafras (#s 585, 586, 589, 590, 591, 595, 597 & 598; Table 3.1) were chosen along the floodplain of the Bronx River in Bronxville, New York. Five sun shoots and five shade shoots were collected from each genet from June to July 1986. "Sun" refers to the outermost, sunlit shell of foliage and "shade" refers to foliage nearer the primary trunk. Trees were chosen which displayed their leaves along an apparent gradient of light exposure that most ecologists would categorize as "sun" versus "shade." The leaves of Sassafras are alternate. Leaves were numbered sequentially from the most mature (first initiated) to the youngest node, and the shape category of the leaf at each node recorded. Chlorophyll content of each leaf was then measured.

Leaf discs of constant size (31.72 mm^2) were cut using a hole punch and avoiding the midrib and larger veins. Depending on the size of the leaf, about 10 discs were removed from each blade and the number of discs was recorded. The fresh discs from each leaf were pooled and weighed on an analytical balance and placed in tubes containing about 6 ml of absolute Methanol. The tubes were incubated in a convection oven for 2 hours at 55 degrees, by which time the discs were white, completely leached of chlorophyll. (This was confirmed by repeating the above procedure on discs which had already been through the extraction procedure, using fresh methanol, with no absorbance being detected by the methods below.)

The tubes were cooled to room temperature and the methanol solution transferred into centrifuge tubes and spun at 5000 rpm for 10 minutes. Since the leaf tissue was not macerated, sediments were minimal. The volume of the clear, green supernatant was measured in ml and absorbance at wavelengths 650, 665 and 720 nm determined against a methanol reference standard using a spectrophotometer (Macpherson model EU 700-Series). These absorbance values were applied to the following equations (provided by R. Glick as derived from Mackinney, 1941) to calculate chlorophyll content in solution:

$$\text{Total Chlorophyll (mg l}^{-1}\text{)} = 25.5(A_{650} - A_{720}) + 4.0(A_{665} - A_{720})$$

$$\text{Chlorophyll a (mg l}^{-1}\text{)} = 16.5(A_{665} - A_{720}) - 8.3(A_{650} - A_{720})$$

$$\text{Chlorophyll b (mg l}^{-1}\text{)} = 33.8(A_{650} - A_{720}) - 12.5(A_{665} - A_{720})$$

Chlorophyll in mg per sample was calculated using a correction for dilution. Since I knew the wet weight and surface area of leaf tissue used, I was able to calculate the weight of chlorophyll (in mg) per gram and per square meter of the leaf tissue.

To analyze how well 10 leaf discs taken from a leaf provide an estimate of total leaf chlorophyll, I selected 20 large leaves and from each took multiple samples of 10 discs and processed them as above. Of these 20 leaves there were no significant differences in chlorophyll content among samples from the same leaf (ANOVA $p>.05$). Therefore, regarding chlorophyll content, 10 discs are a satisfactory estimate of the whole leaf.

In this study of leaf chlorophyll content, the variates are ratios (mg g^{-1}; mg m^{-2}; chlorophyll a/chlorophyll b). Some samples were not normally distributed (Kolmogorov-Smirnov goodness-of-fit test) and groups of samples often showed heteroscedasticity (Bartlett's test) with neither condition "cured" by transformations. Nevertheless, I analyzed the raw ratios by analysis of variance (ANOVA), because at high degrees of freedom the results of ANOVA remain reliable in the face of violated assumptions (Green 1979). This was convenient since sample sizes were large and the various designs of ANOVA allowed me to answer questions about chlorophyll variability in Sassafras. A Type I error of 0.05 was used.

The Kolmogorov-Smirnov Two-Sample test, a powerful method for comparing the frequency distributions of two samples, was performed on data sets for which two-group, one way ANOVA was performed. Here, congruence was found in the results (significant or non-significant) of the two methods, thus bolstering confidence in the analysis.

1987

In 1987, chlorophyll concentration was measured in leaves of four genets, #s 99, 100, 590 and 591 (Table 3.2). Four shoots from each genet were used in this study, one shoot from each genet at intervals during the growing season. This study was carried out to investigate changes in the pattern of distribution of chlorophyll in leaves along shoots, in a time course over the growing season.

RESULTS

1986

Homogeneity of Chlorophyll Content Between Sun and Shade Leaves

Chlorophyll content on the basis of sun or shade positions is presented in Table 4.1. Although significant differences were found in the a/b ratio of sun versus shade leaves in two genets (591 and 590) out of eight genets, this difference is not found in the sample at large (mean a/b ratios of 3.31 vs. 3.17; $p > .05$). When measured in terms of mg g^{-1} wet weight, there are significant differences in chlorophyll content between leaves from sun and shade positions in six genets. Overall, for the lumped data, mean chlorophyll content is higher in shade leaves than in sun leaves, on the basis of leaf mass (7.12 vs. 5.6 mg g^{-1}; $p < .001$). However, mean chlorophyll content is greater in sun leaves than in shade leaves when measured in g m^{-2} but, in this case, only four genets show differences between leaves from sun and shade positions. The two genets that show no significant difference between chlorophyll content in sun and shade position leaves when measured as mg g^{-1} also do not show any differences when measured as g m^{-2}.

Table 4.1. Mean chlorophyll content in mg g^{-1}, g m^{-2} and chlorophyll a/b ratio for 365 shade leaves and 455 sun leaves from eight genets of Sassafras. Sample sizes for each ANOVA are in Table 3.1. Single-classification ANOVA was done for each genet and for the data merged down the eight genets.

	LEAF CHLOROPHYLL CONTENT								
	mg g^{-1}			g m^{-2}			a/b ratio		
Genet	Shade	Sun	ANOVA	Shade	Sun	ANOVA	Shade	Sun	ANOVA
585	8.24	5.59	***	.4513	.4047	ns	3.05	3.15	ns
586	7.33	4.16	***	.4205	.5395	***	3.35	3.41	ns
589	4.96	4.29	ns	.4358	.4358	ns	3.43	3.13	ns
590	8.87	5.04	***	.3247	.3836	***	2.89	2.27	*
591	10.6	8.23	*	.3149	.4011	***	3.05	3.33	**
595	6.63	4.29	***	.3655	.3680	ns	3.14	3.22	ns
597	5.04	6.84	***	.3091	.4009	***	3.13	3.38	ns
598	4.63	4.82	ns	.3295	.3413	ns	3.36	3.58	ns
ALL	7.12	5.6	***	.3605	.4052	***	3.17	3.31	*

ns = not significant; * = $0.01 < p \leq 0.05$; ** = $0.001 < p \leq 0.01$; *** = $p \leq 0.001$

Predictability of Chlorophyll Content given Node Number

Least-squares regression was used to investigate nodal trends in chlorophyll content. A significant curvilinear trend in leaf chlorophyll with nodal position was observed in seven of the eight genets when chlorophyll content was measured in mg g^{-1}, and in all eight genets when measured in g m^{-2}; and the following descriptions of greatest chlorophyll content are based on these regressions. In genet BR 585, measured on July 3, 1986, greatest chlorophyll content (mg g^{-1}) was observed in leaves at node six in both shade leaves (Figure 4.1) and sun leaves (Figure 4.2). In the same leaves, greatest chlorophyll content per leaf surface area (g m^{-2}) was observed in shade leaves at nodes five and six (Figure 3.3) and in sun leaves at nodes six and seven (Figure 4.4). In genet 586, measured on June 20, 1986, greatest chlorophyll content (mg g^{-1}) was observed in leaves at node five in shade leaves (Figure 4.5) and node eight and nine in sun leaves (Figure 4.6). In the same leaves, chlorophyll content on the basis of leaf area (g m^{-2}) is greatest at node five in shade leaves (Figure 4.7) and nodes seven and eight in sun leaves (Figure 4.8). In genet 589, measured on June 30, 1986, greatest chlorophyll content (mg g^{-1}) was observed in leaves at nodes five and seven in both shade leaves (Figure 4.9) and sun leaves (Figure 4.10). When chlorophyll content was measured on the basis of leaf surface area (g m^{-2}) for these same leaves, greatest chlorophyll content was observed in leaves at nodes six and seven in shade leaves (Figure 4.11) and in sun leaves (Figure 3.12). In genet 590, measured on July 8, 1986, greatest chlorophyll content on the basis of leaf fresh weight was observed in shade leaves at node seven (Figure 4.13) and nodes seven and eight in sun leaves (Figure 4.14). When chlorophyll content was measured on the basis of leaf surface area (g m^{-2}), greatest chlorophyll content was observed in leaves at node 10 in shade leaves (Figure 4.15) and nodes eight and nine in sun leaves (Figure 4.16). Leaves of genet 591 were measured for chlorophyll content on July 17 (two shoots each, sun and shade positions) and July 22 (three shoots each, sun and shade positions). Possibly as a result of this fragmentation of sampling dates, no significant curvilinear pattern was observed in shade leaves of this genet when measured in either mg g^{-1} (Figure 4.17) or g m^{-2} (Figure 4.19); while in sun leaves a significant curvilinear pattern was observed when chlorophyll content was measured on the basis of leaf fresh weight, with greatest chlorophyll content in leaves at nodes six and seven (Figure 3.18) and when measured on the basis of leaf surface area, with greatest chlorophyll content in leaves at nodes seven and eight (Figure 4.20). In genet 595, measured on July 25, 1986, greatest chlorophyll content (mg g^{-1}) was observed in leaves at node eight in shade leaves (Figure 4.21) and at nodes three and four in sun leaves (Figure 4.22). In these same leaves, chlorophyll content, when measured on the basis of leaf surface area (g m^{-2}) resulted in highest concentrations in leaves at node seven in shade leaves (Figure 4.23) and in leaves at node seven in sun leaves (Figure 4.24). In genet 597, measured on July 15, 1986, greatest chlorophyll content on the basis of leaf fresh weight (mg g^{-1}) was observed at node 11 in shade leaves (Figure 4.25) and in leaves at nodes six and seven in sun leaves (Figure 4.26); and on the basis of leaf surface area (g m^{-2}), greatest chlorophyll content was observed in leaves at node 11 in shade leaves (Figure 4.27) and at node nine in sun leaves (Figure 4.28). In the final genet, #598, measured on June 25, 1986, greatest chlorophyll content (mg g^{-1}) was observed in leaves at node five and six in shade leaves (Figure 4.29) and in sun leaves (Figure 3.30); while on the basis of leaf surface area (g m^{-2}) greatest chlorophyll content was observed in leaves at nodes five and six in shade shoots (Figure 4.31) and node six in sun shoots (Figure 4.32).

When data for the eight genets were merged, the patterns observed in individual genets in both sun and shade positions were generally maintained. In this analysis, since there was a fair degree of variability in chlorophyll content among genets and since I was interested in nodal patterns of chlorophyll content, not actual chlorophyll contents, the variables were transformed to standard normal deviates (+3) to place them on a uniform scale of measurement. In this fashion, overall chlorophyll contents for sun and shade leaves, whether measured on the basis of leaf fresh weight or leaf area follow a statistically significant curvilinear pattern. Greatest chlorophyll content in mg g^{-1}, for shade leaves (Figure 4.33) and sun leaves (Figure 4.34) occurs in leaves at nodes six and seven, and on the basis of leaf area (g m^{-2}) for shade leaves (Figure 4.35) and sun leaves (Figure 4.36) in leaves at nodes six to seven, and eight respectively.

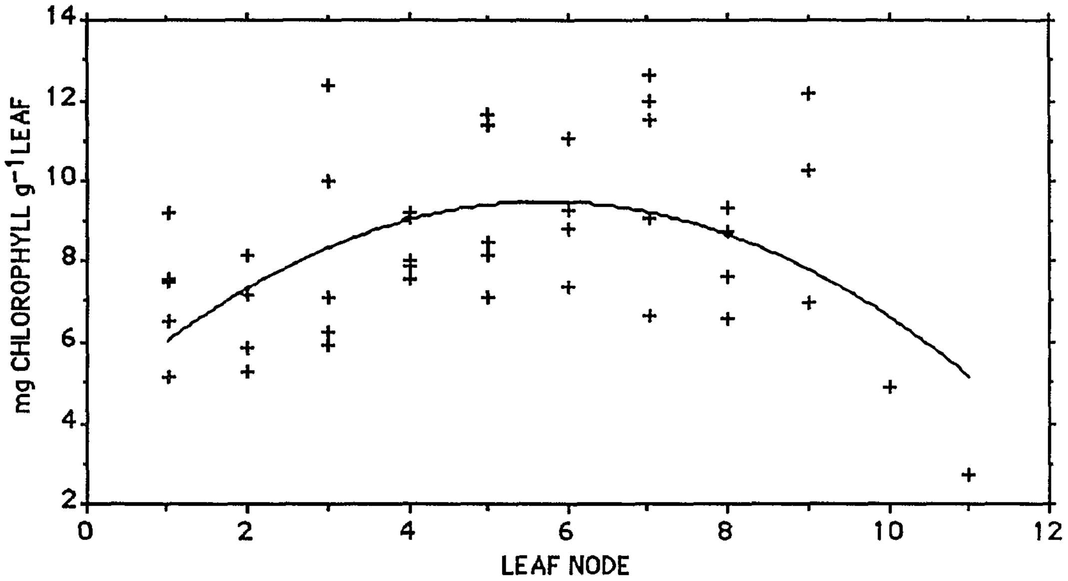

Figure 4.1. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 585, on July 3, 1986, with a second degree least squares regression (F = 7.879 (2,40 df), r^2 = 0.283, $p < .01$) superimposed.

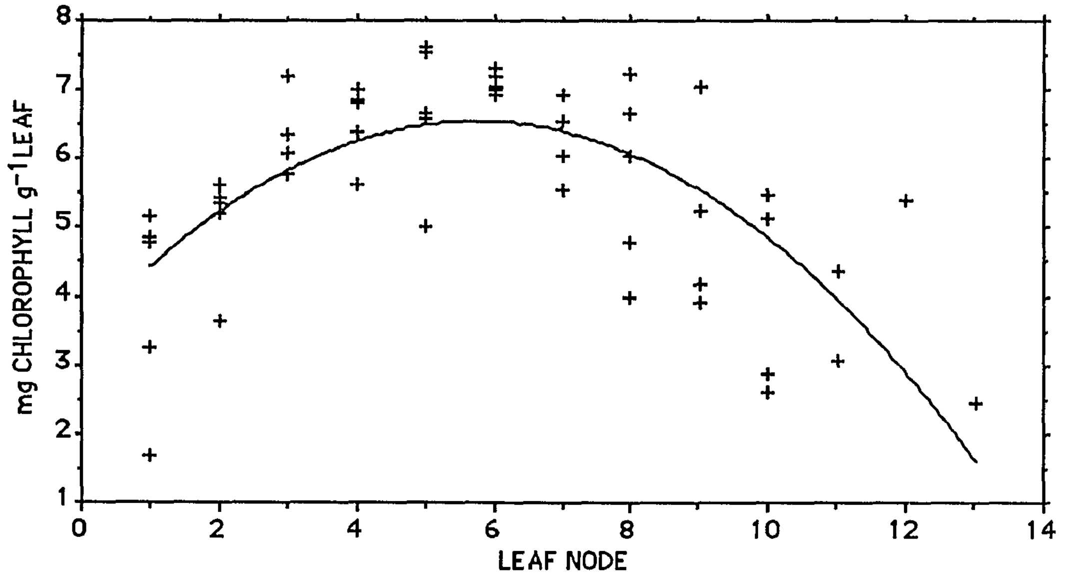

Figure 4.2. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 585, on July 3, 1986, with a second degree least squares regression (F = 23.768 (2,49 df), r^2 = 0.492, $p < .001$) superimposed.

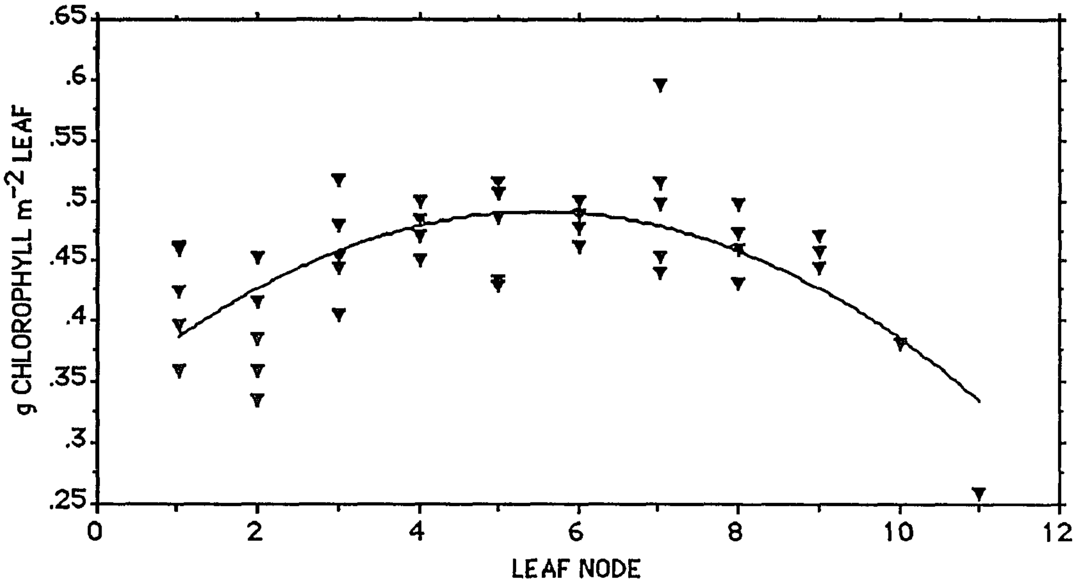

Figure 4.3. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 585, on July 3, 1986, with a second degree least squares regression (F = 17.037 (2,40 df), r^2 = 0.46, p < .001) superimposed.

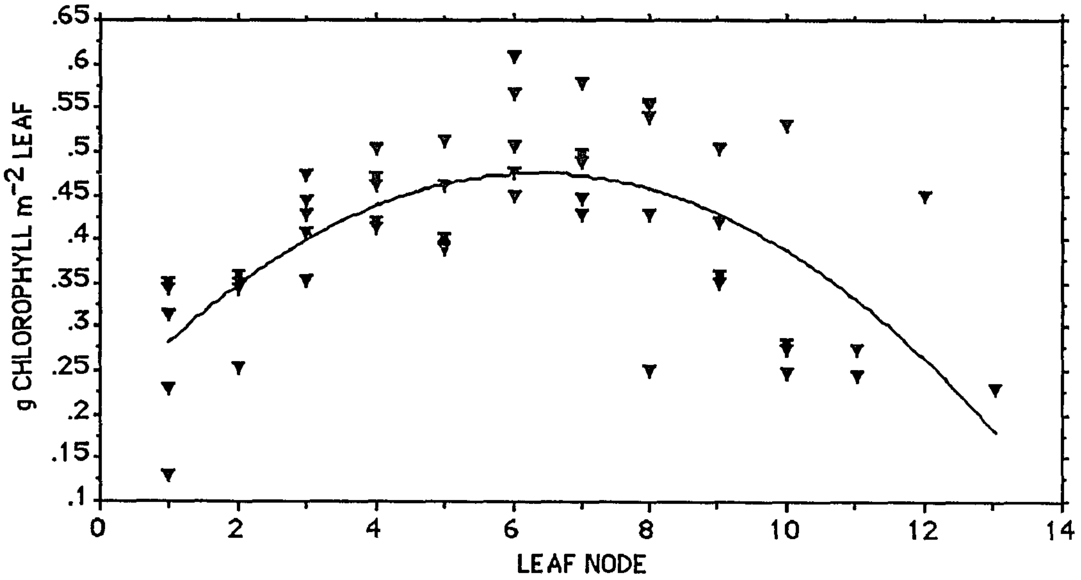

Figure 4.4. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 585, on July 3, 1986, with a second degree least squares regression (F = 20.13 (2,49 df), r^2 = 0.451, p < .001) superimposed.

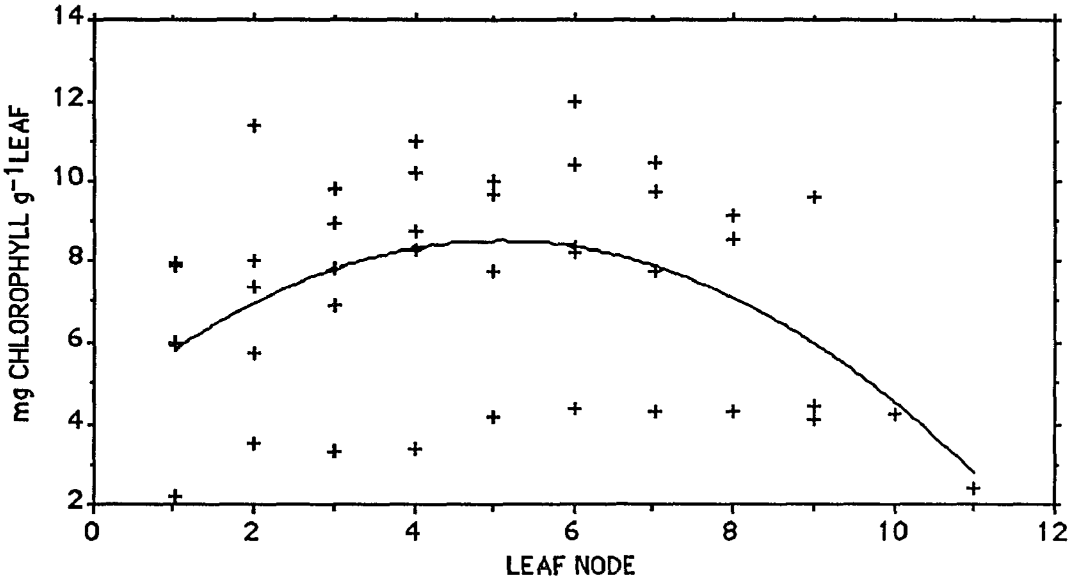

Figure 4.5. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 586, on June 20, 1986, with a second degree least squares regression (F = 5.547 (2,39 df), $r^2 = 0.221$, $p < .01$) superimposed.

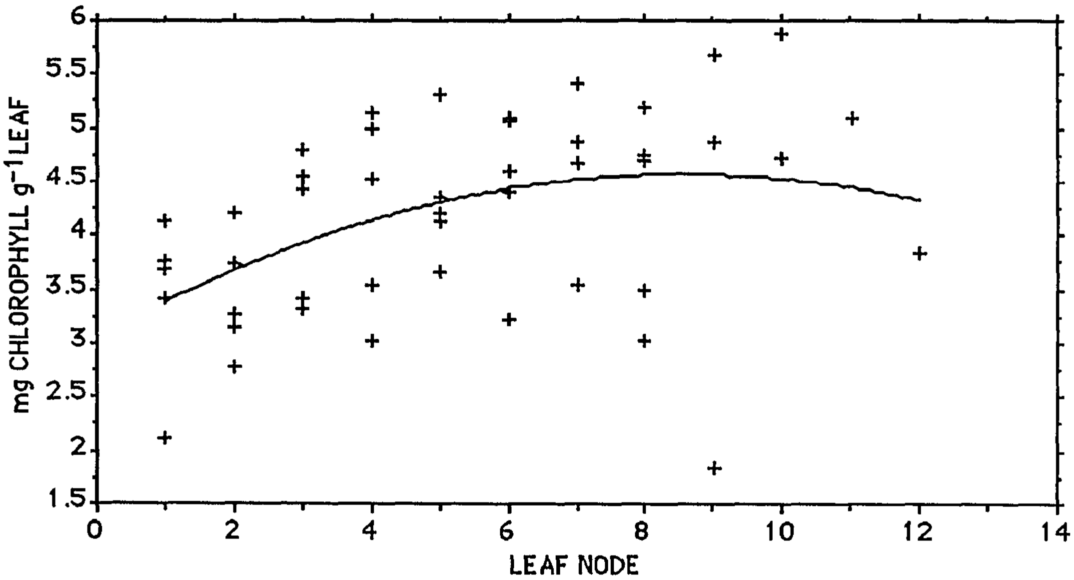

Figure 4.6. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 586, on June 20, 1986, with a second degree least squares regression (F = 5.272 (2,44 df), $r^2 = 0.193$, $p < .01$) superimposed.

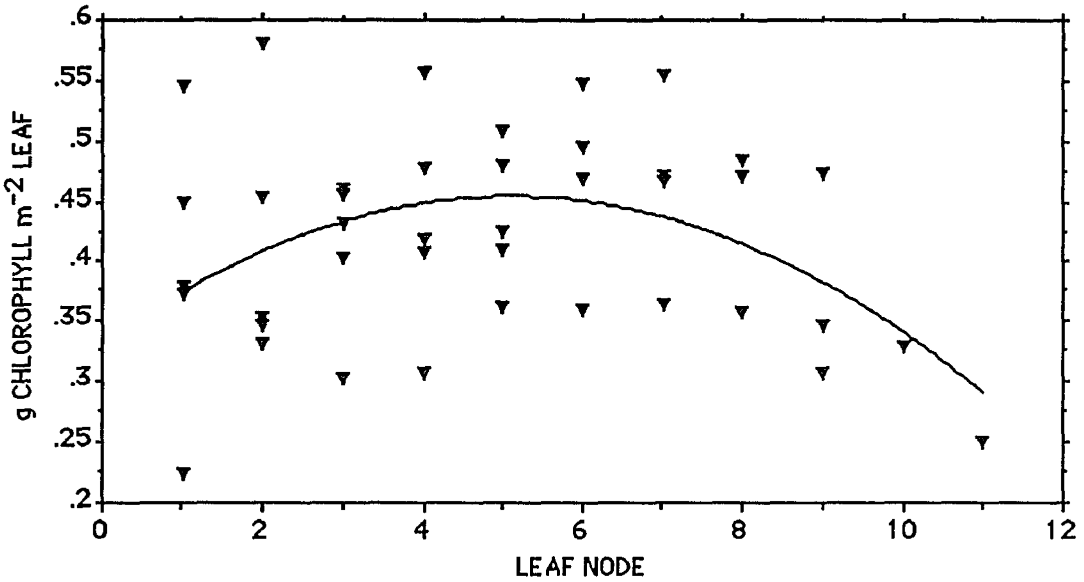

Figure 4.7. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 586, on June 20, 1986, with a second degree least squares regression (F = 4.386 (2,39 df), $r^2 = 0.184$, $p < .05$) superimposed.

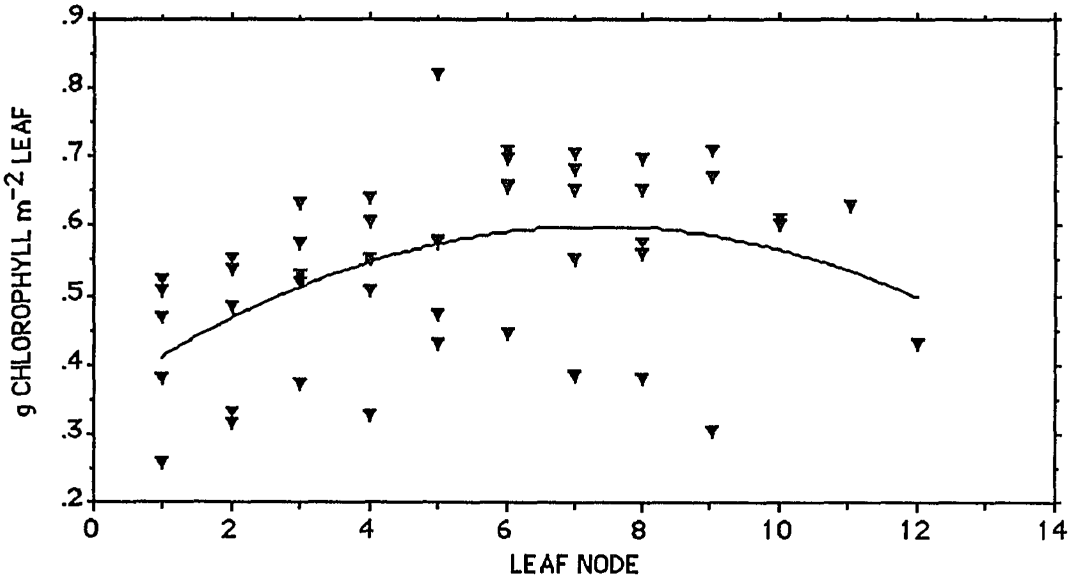

Figure 4.8. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 586, on June 20, 1986, with a second degree least squares regression (F = 6.441 (2,44 df), $r^2 = 0.226$, $p < .01$) superimposed.

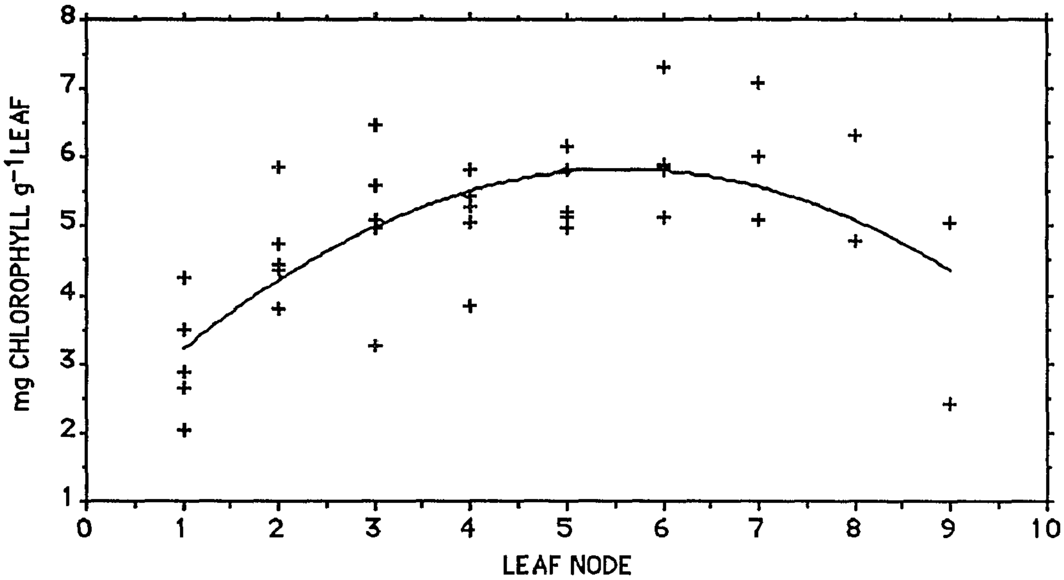

Figure 4.9. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 589, on June 30, 1986, with a second degree least squares regression (F = 17.521 (2,34 df), r^2 = 0.508, $p < .001$) superimposed.

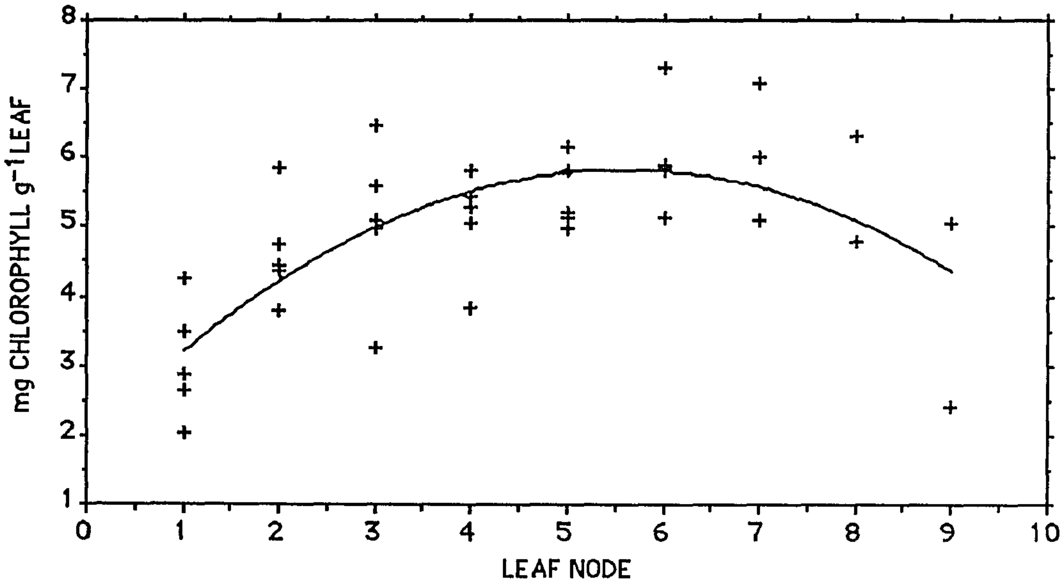

Figure 4.10. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 589, on June 30, 1986, with a second degree least squares regression (F = 29.493 (2,47 df), r^2 = 0.557, $p < .001$) superimposed.

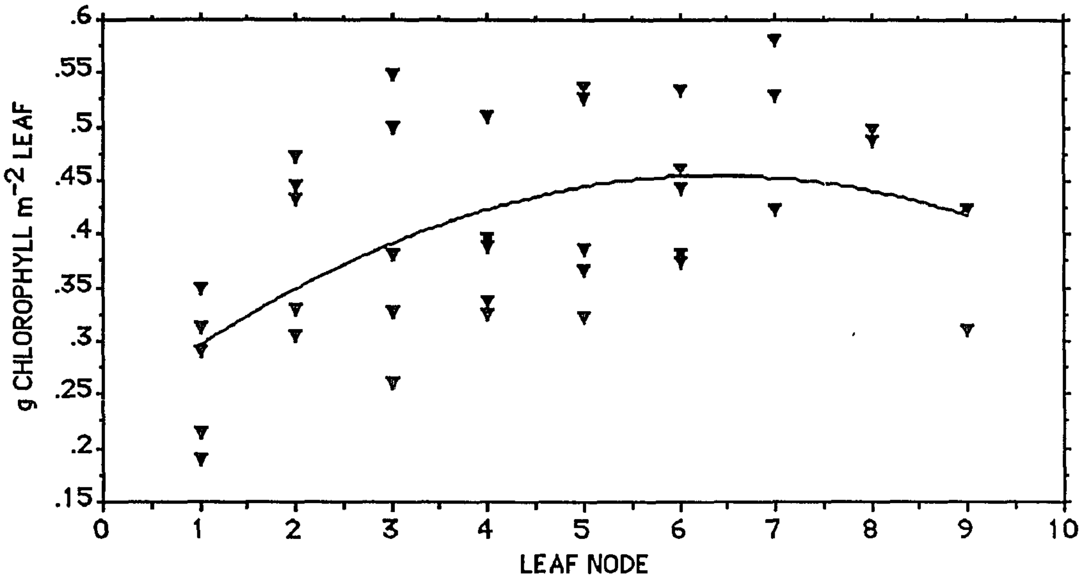

Figure 4.11. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 589, on June 30, 1986, with a second degree least squares regression (F = 7.643 (2,34 df), $r^2 = 0.31$, $p < .01$) superimposed.

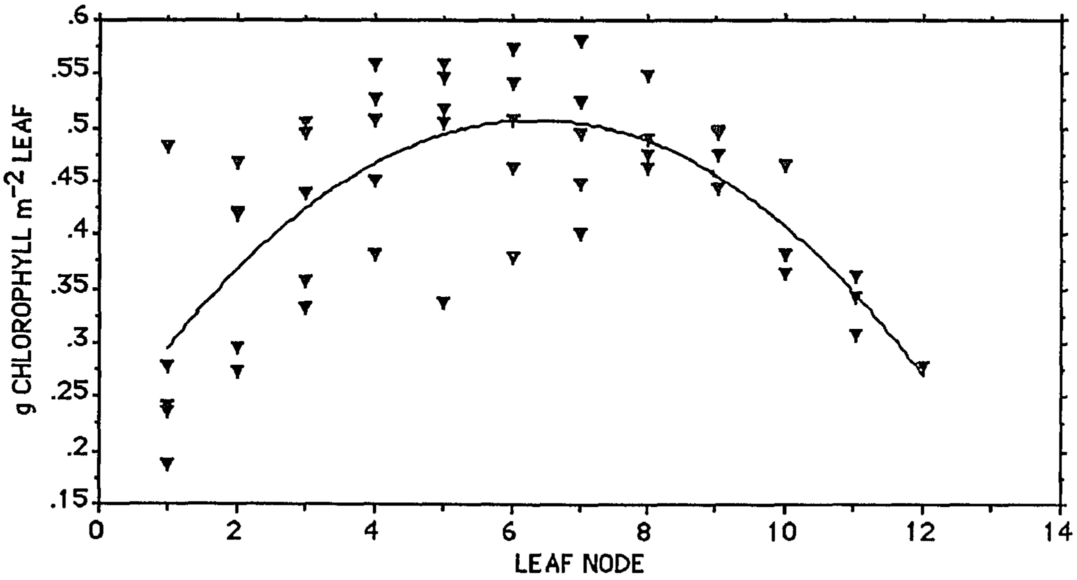

Figure 4.12. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 589, on June 30, 1986, with a second degree least squares regression (F = 27.532 (2,47 df), $r^2 = 0.54$, $p < .001$) superimposed.

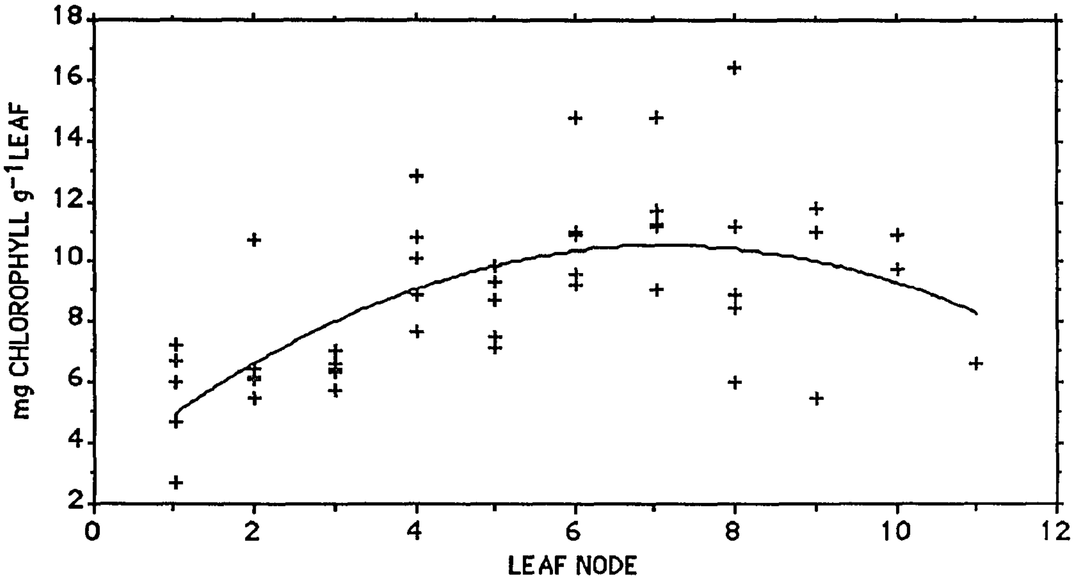

Figure 4.13. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 590, on July 8, 1986, with a second degree least squares regression (F = 14.829 (2,43 df), $r^2 = 0.408$, $p < .001$) superimposed.

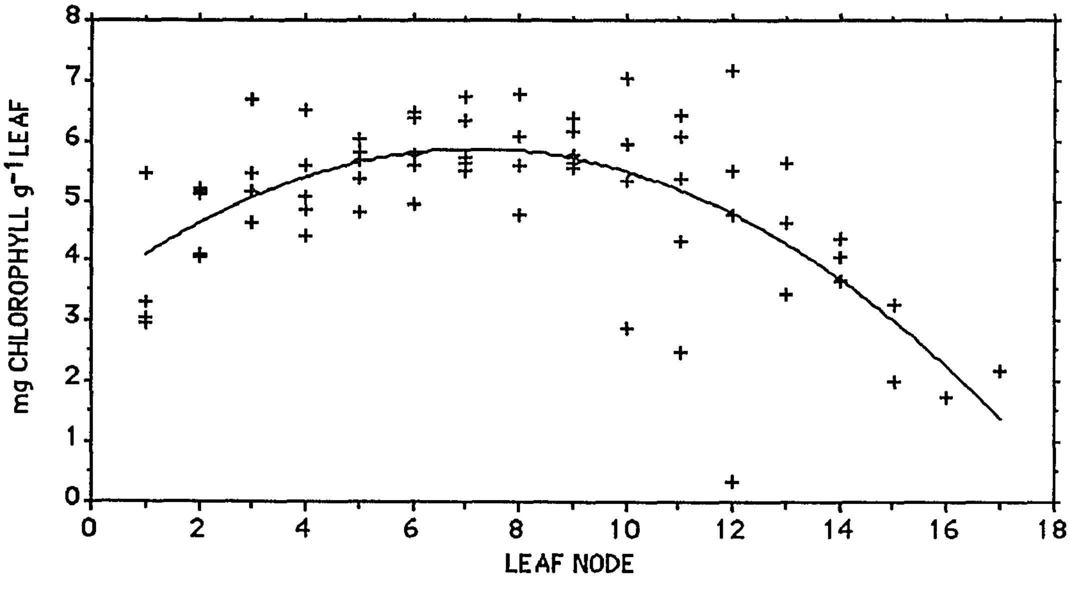

Figure 4.14. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 590, on July 8, 1986, with a second degree least squares regression (F = 26.251 (2,65 df), $r^2 = 0.447$, $p < .001$) superimposed.

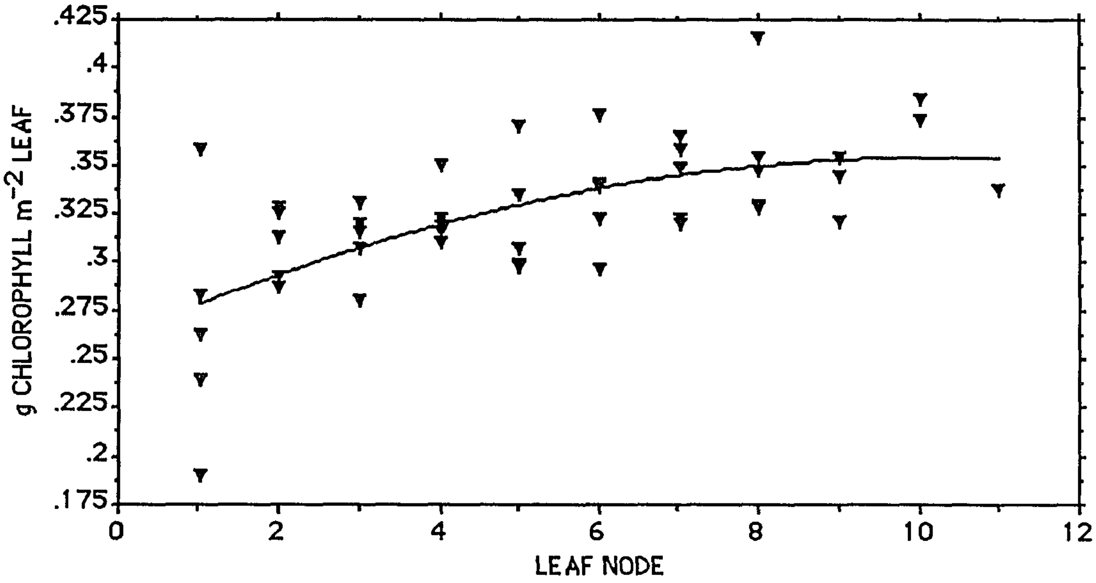

Figure 4.15. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 590, on July 8, 1986, with a second degree least squares regression (F = 15.816 (2,43 df), r^2 = 0.424, $p < .001$) superimposed.

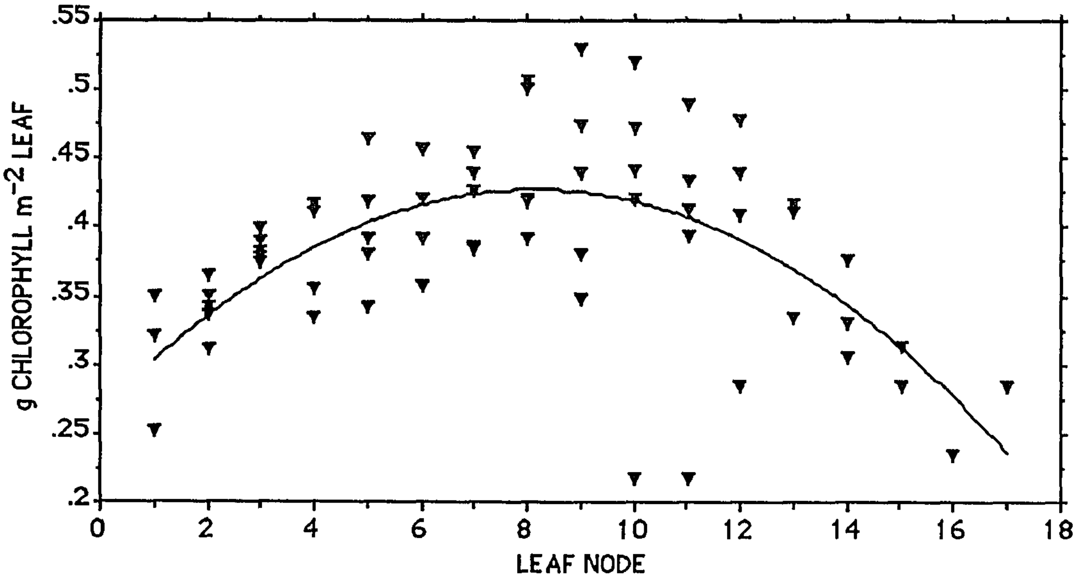

Figure 4.16. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 590, on July 8, 1986, with a second degree least squares regression (F = 20.724 (2,65 df), r^2 = 0.389, $p < .001$) superimposed.

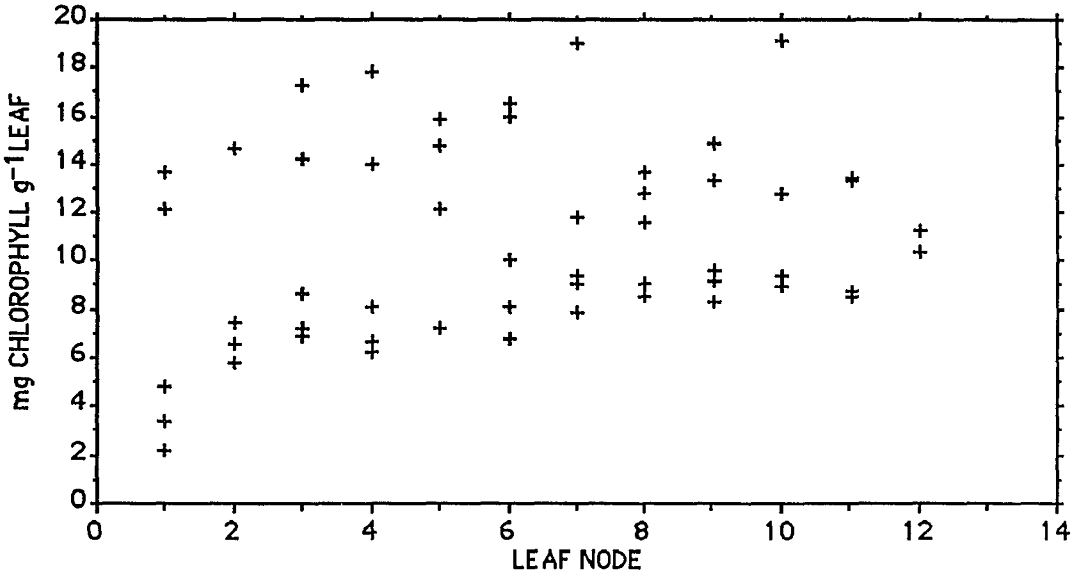

Figure 4.17. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 591, on July 17 (two shoots) and July 22 (three shoots), 1986. Linear and curvilinear regressions were not significant.

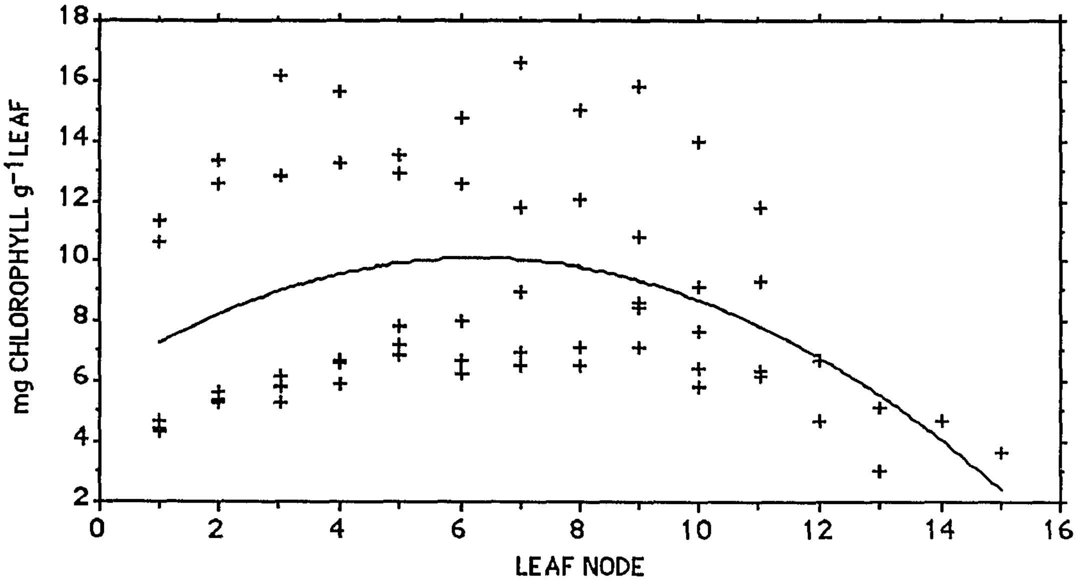

Figure 4.18. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 591, on July 17 (two shoots) and July 22 (three shoots) 1986, with a second degree least squares regression (F = 6.218 (2,57 df), $r^2 = 0.179$, $p < .01$) superimposed.

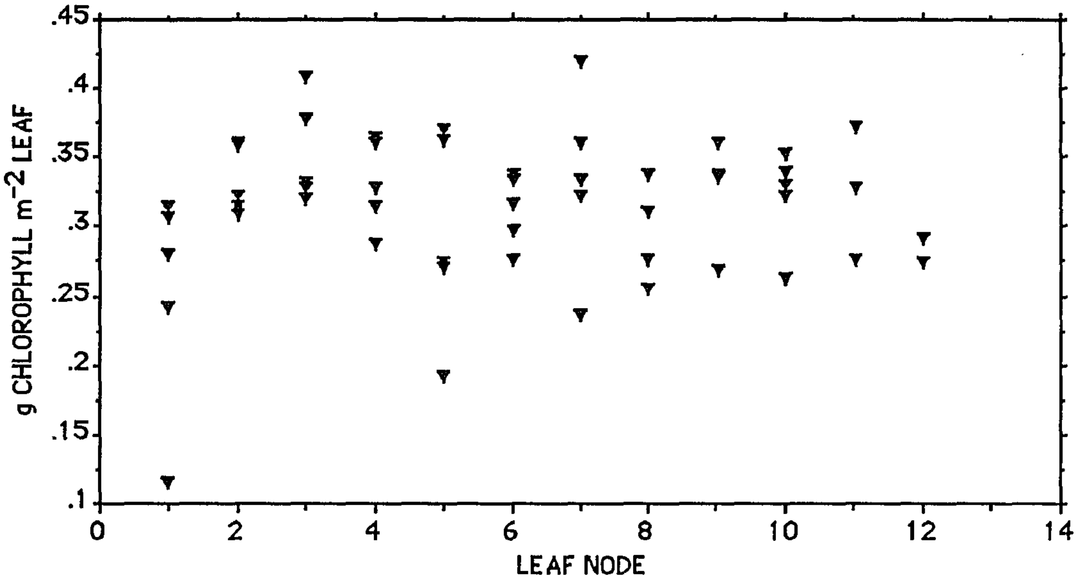

Figure 4.19. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 591, on July 17 (two shoots) and July 22 (three shoots), 1986. Linear and curvilinear regressions were not significant.

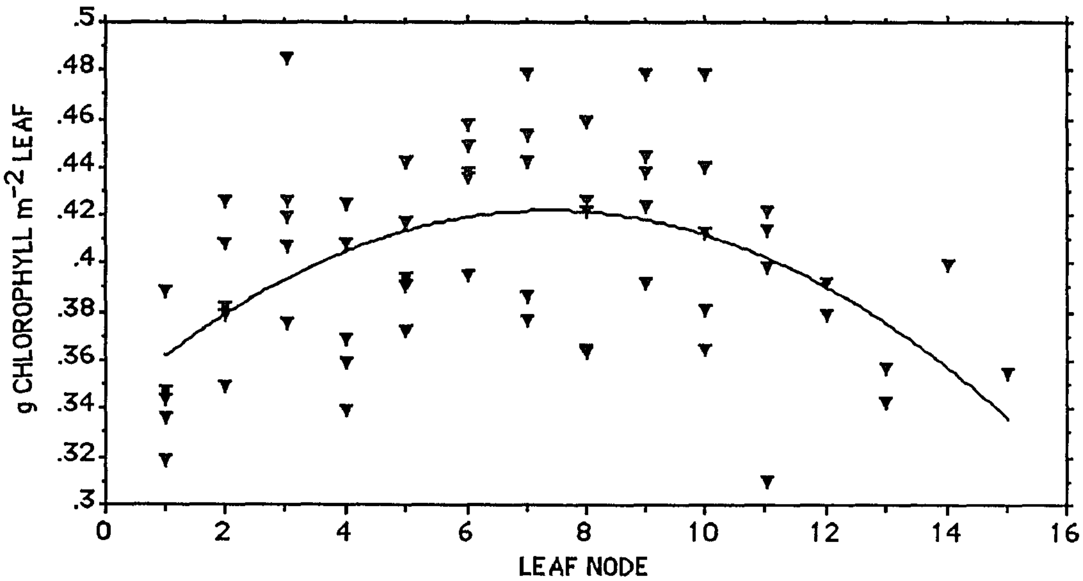

Figure 4.20. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 591, on July 17 (two shoots) and July 22 (three shoots) 1986, with a second degree least squares regression (F = 10.077 (2,57 df), r^2 = 0.261, $p < .001$) superimposed.

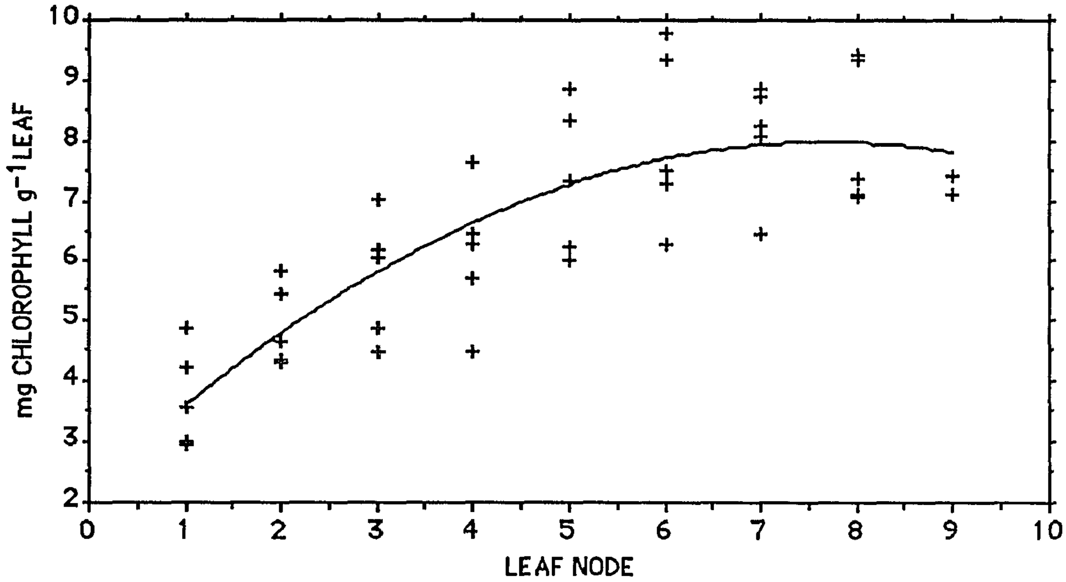

Figure 4.21. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 595, on July 25, 1986, with a second degree least squares regression (F = 43.407 (2,39 df), r^2 = 0.389, p < .001) superimposed.

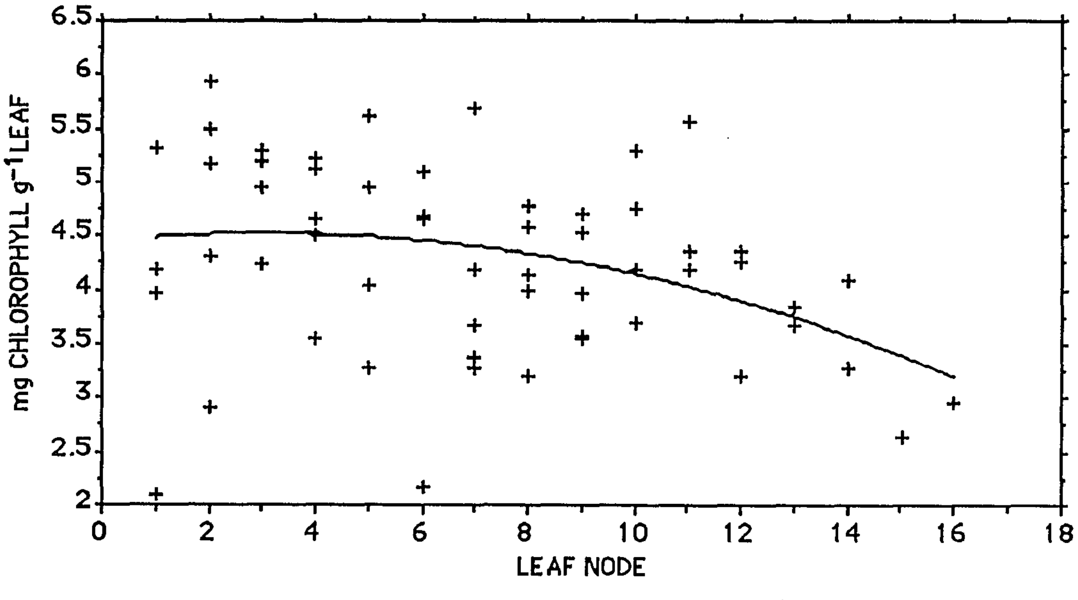

Figure 4.22. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 595, on July 25, 1986, with a second degree least squares regression (F = 4.319 (2,59 df), r^2 = 0.128, p < .05) superimposed.

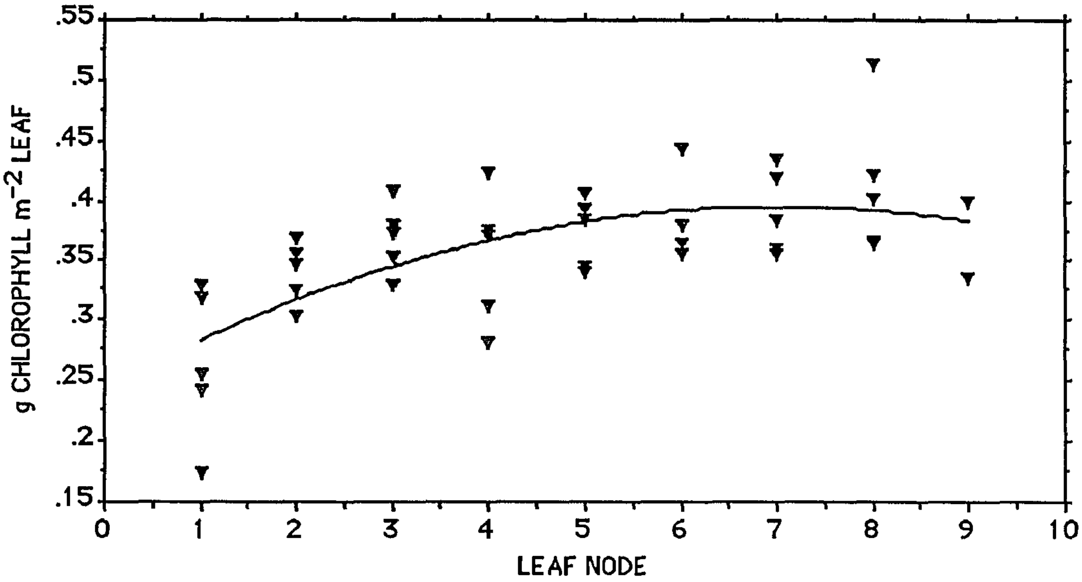

Figure 4.23. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 595, on July 25, 1986, with a second degree least squares regression (F = 15.346 (2,39 df), $r^2 = 0.44$, $p < .001$) superimposed.

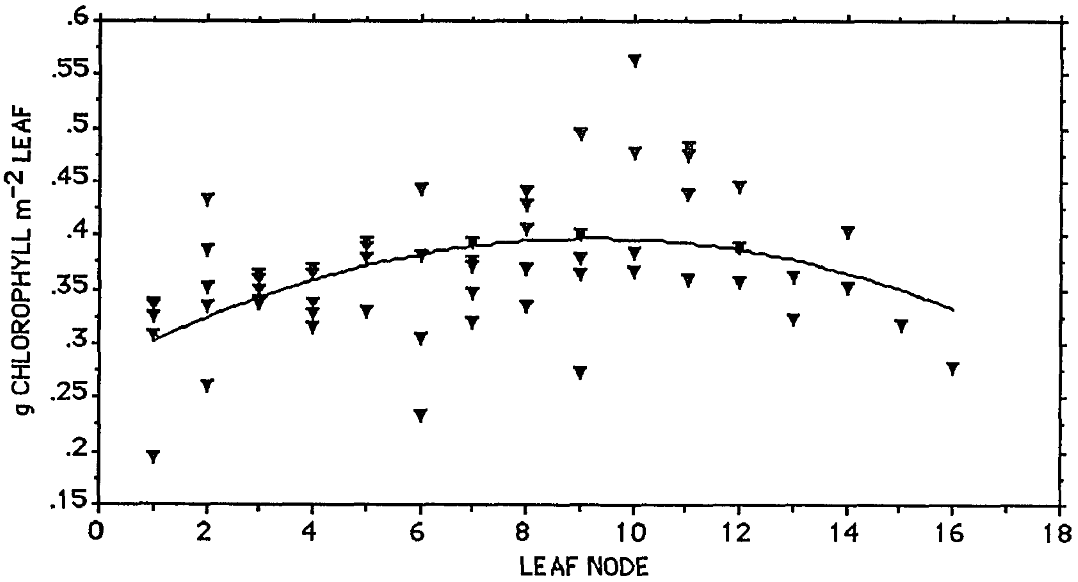

Figure 4.24. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 595, on July 25, 1986, with a second degree least squares regression (F = 8.647 (2,59 df), $r^2 = 0.227$, $p < .001$) superimposed.

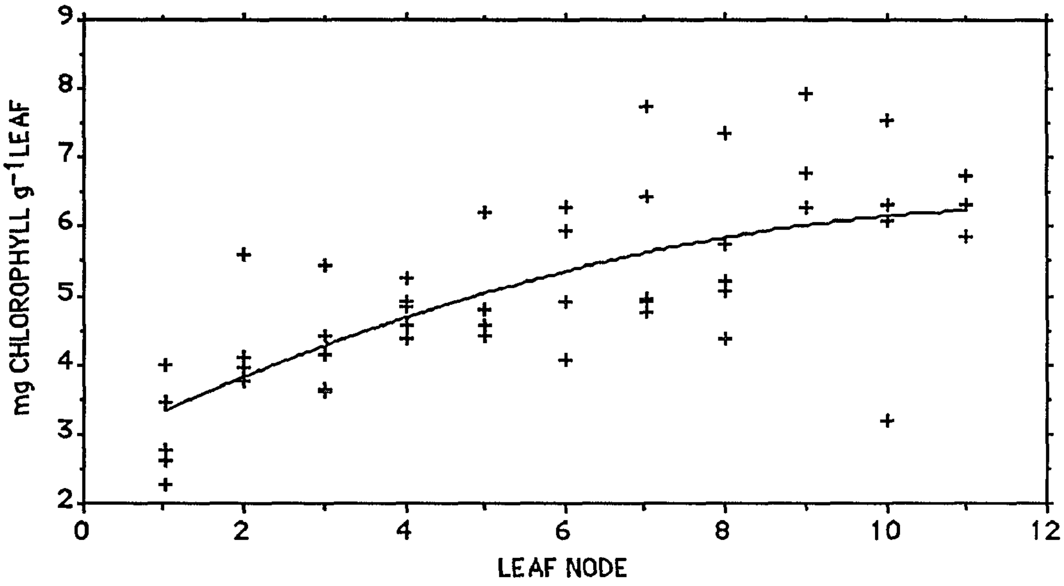

Figure 4.25. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 597, on July 15, 1986, with a second degree least squares regression (F = 23.459 (2,47 df), r^2 = 0.5, p < .001) superimposed.

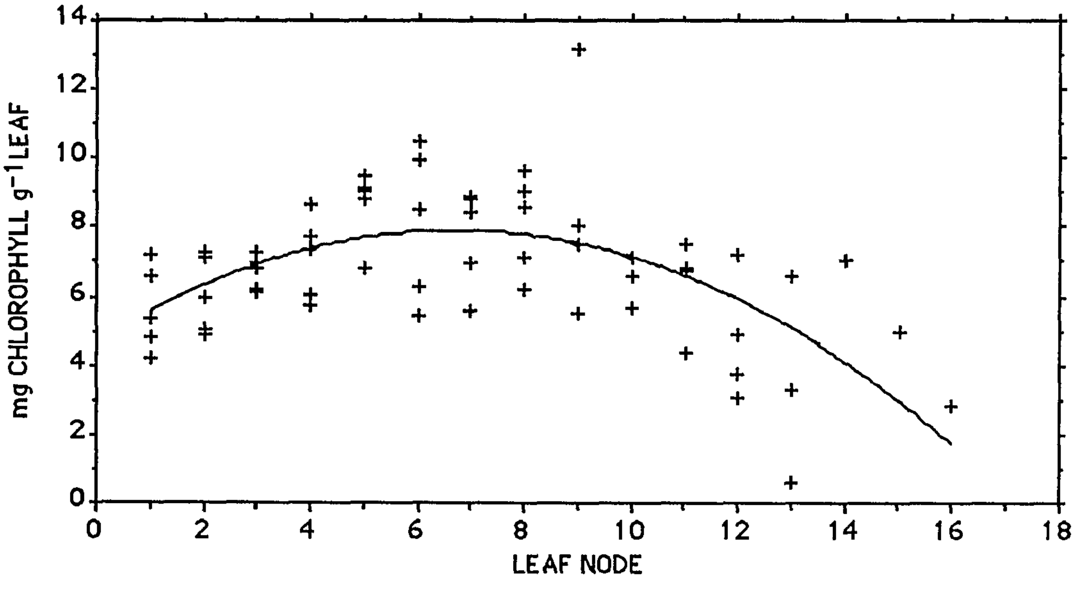

Figure 4.26. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 597, on July 15, 1986, with a second degree least squares regression (F = 17.144 (2,60 df), r^2 = 0.364, p < .001) superimposed.

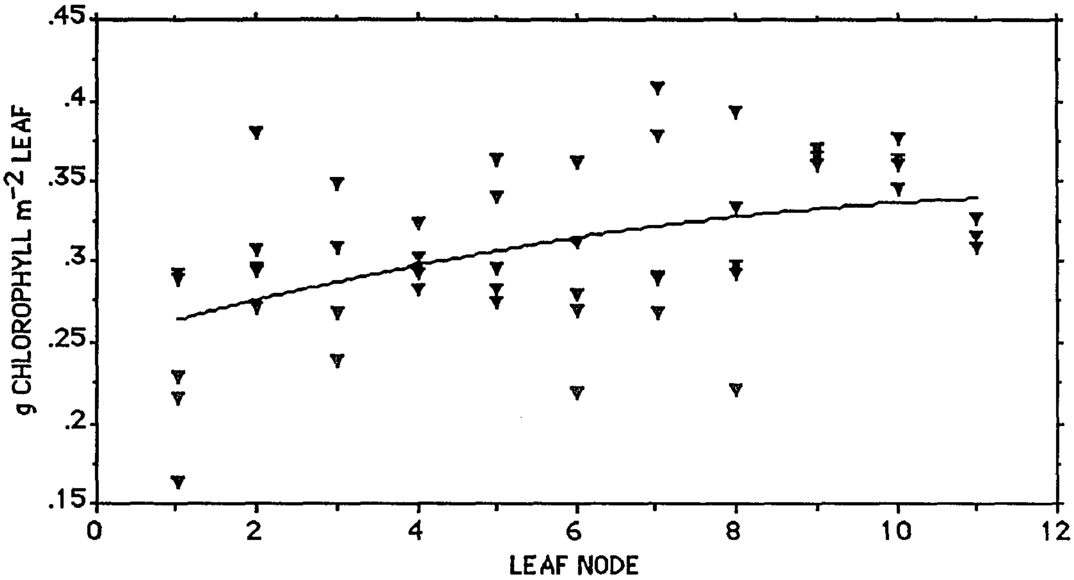

Figure 4.27. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 597, on July 15, 1986, with a second degree least squares regression (F = 6.896 (2,47 df), r^2 = 0.227, $p < .01$) superimposed.

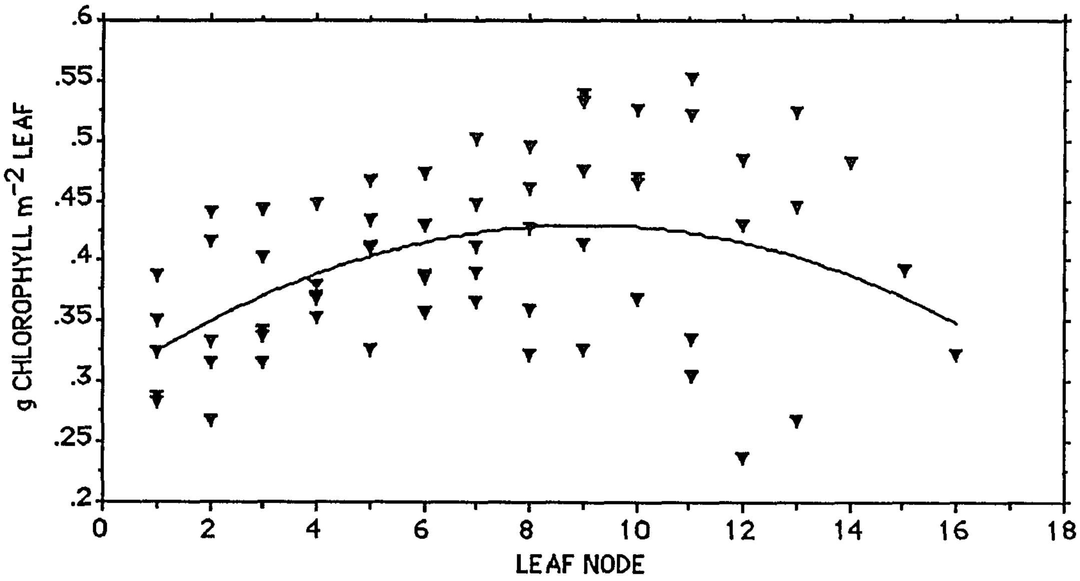

Figure 4.28. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 597, on July 15, 1986, with a second degree least squares regression (F = 6.486 (2,60 df), r^2 = 0.178, $p < .01$) superimposed.

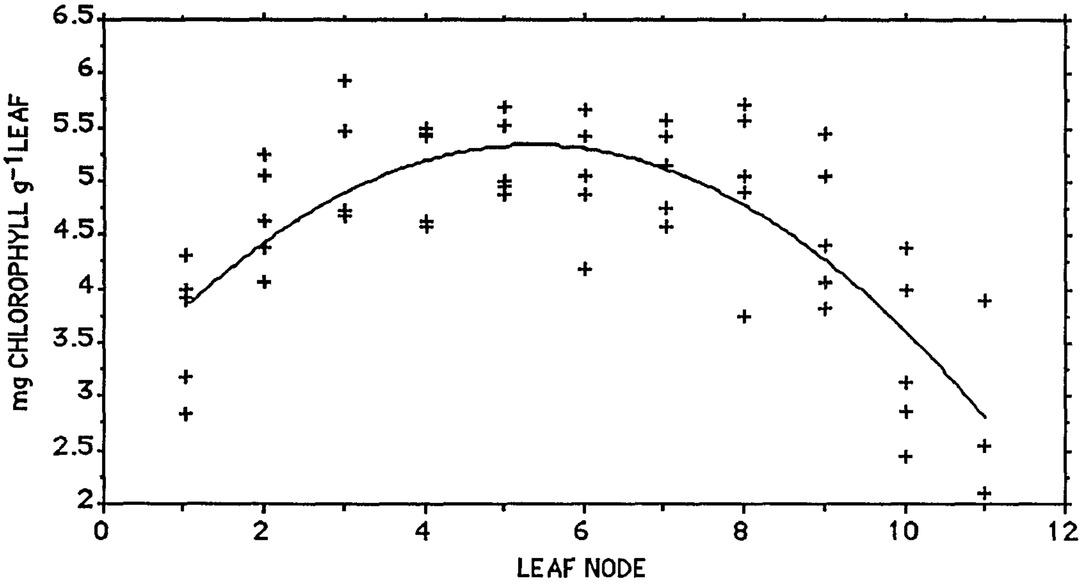

Figure 4.29. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five shade shoots of genet BR 598, on June 25, 1986, with a second degree least squares regression (F = 37.645 (2,50 df), $r^2 = 0.601$, $p < .001$) superimposed.

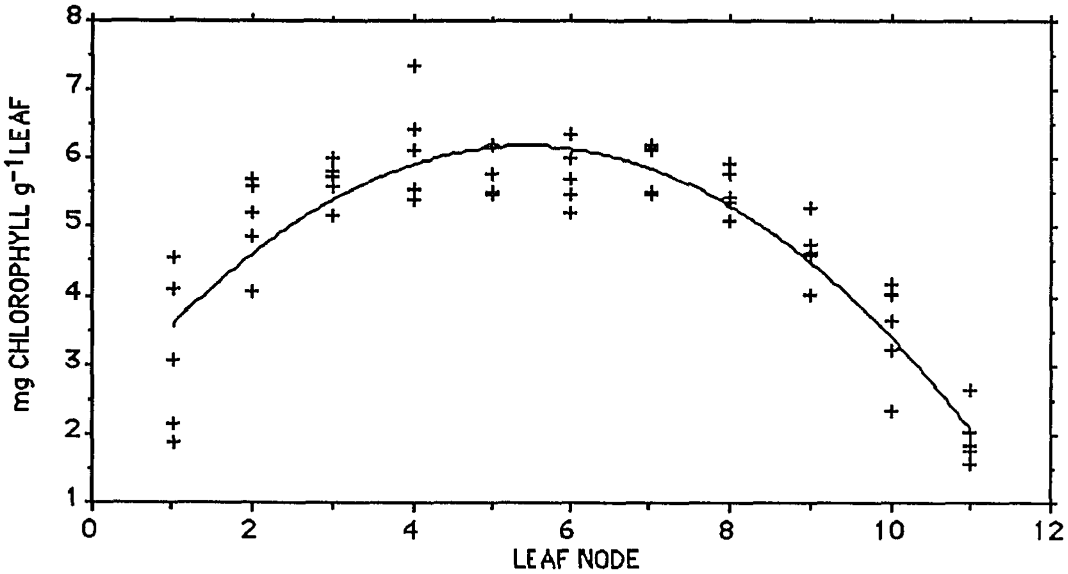

Figure 4.30. Scatterplot of chlorophyll content (mg g^{-1})for leaves at nodes along five sun shoots of genet BR 598, on June 25, 1986, with a second degree least squares regression (F = 109.573 (2,52 df), $r^2 = 0.808$, $p < .001$) superimposed.

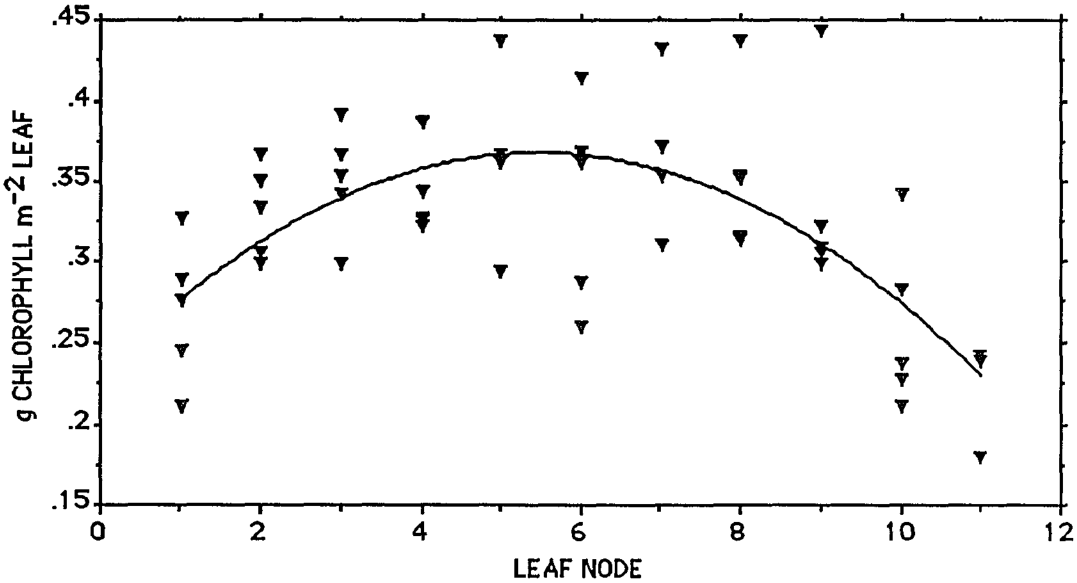

Figure 4.31. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five shade shoots of genet BR 598, on June 25, 1986, with a second degree least squares regression (F = 19.646 (2,50 df), $r^2 = 0.44$, $p < .001$) superimposed.

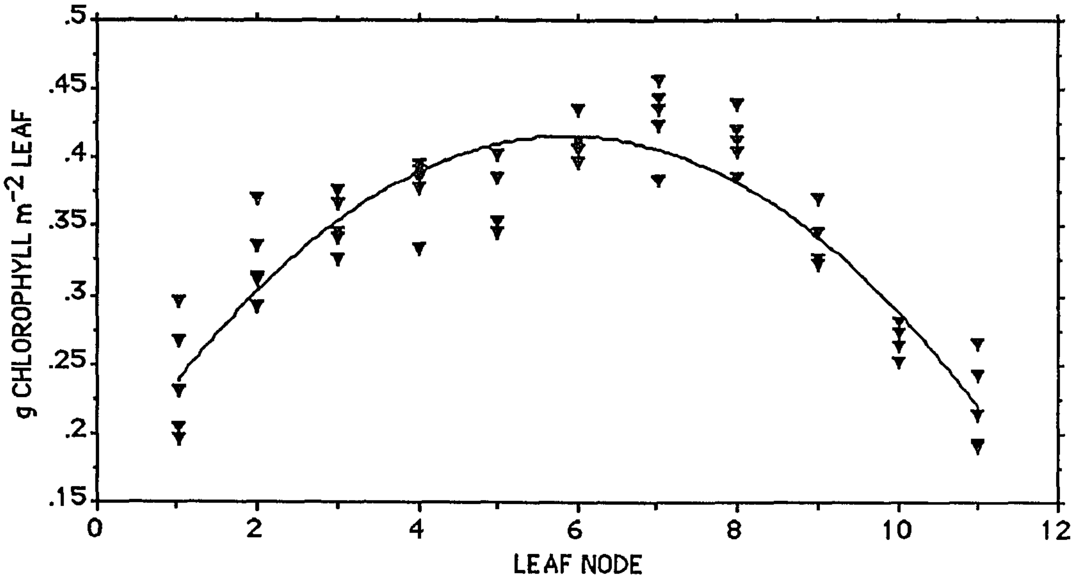

Figure 4.32. Scatterplot of chlorophyll content (g m^{-2})for leaves at nodes along five sun shoots of genet BR 598, on June 25, 1986, with a second degree least squares regression (F = 135.079 (2,52 df), $r^2 = 0.839$, $p < .001$) superimposed.

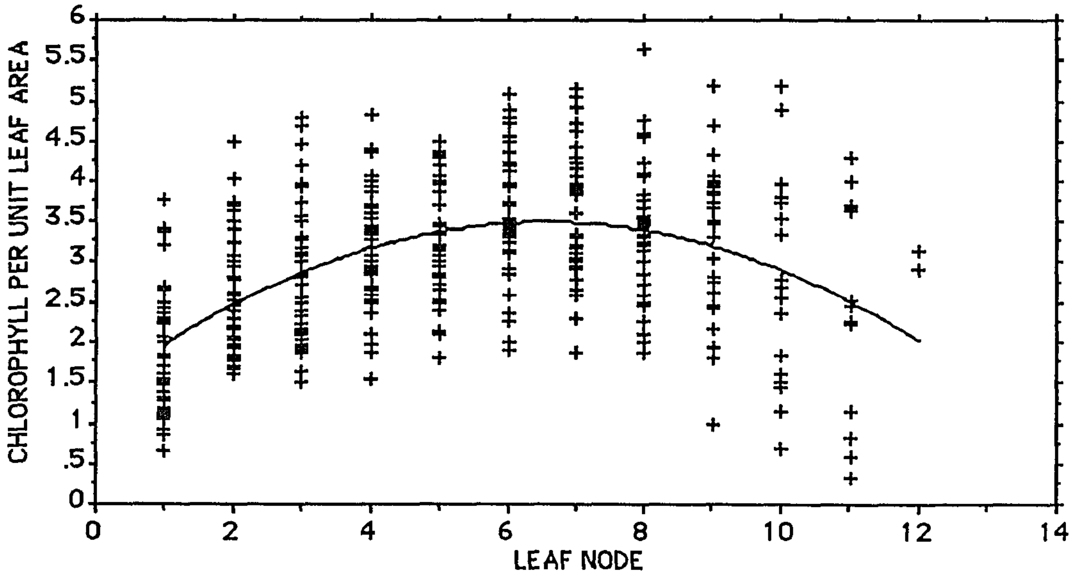

Figure 4.33. Scatterplot of chlorophyll content (mg g^{-1}) transformed into standard deviation units + 3 for shade leaves from all eight genets with a second degree least-squares regression (F = 62.155 (2,365 df), $r^2 = 0.254$, $p < .001$) superimposed.

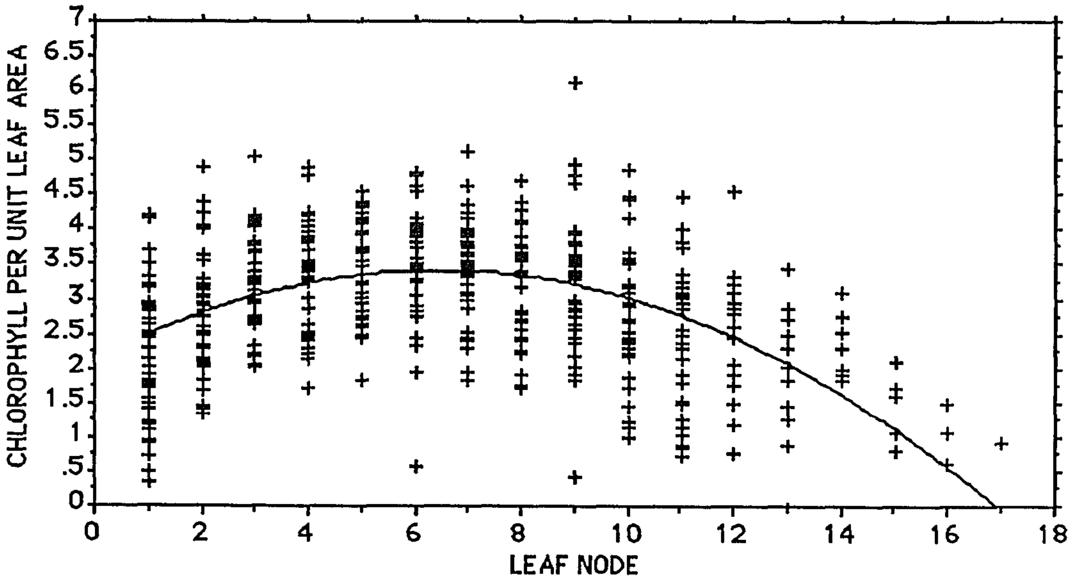

Figure 4.34. Scatterplot of chlorophyll content (mg g^{-1}) transformed into standard deviation units + 3 for sun leaves from all eight genets with a second degree least-squares regression (F = 42.731 (2,454 df), $r^2 = 0.189$, $p < .001$) superimposed.

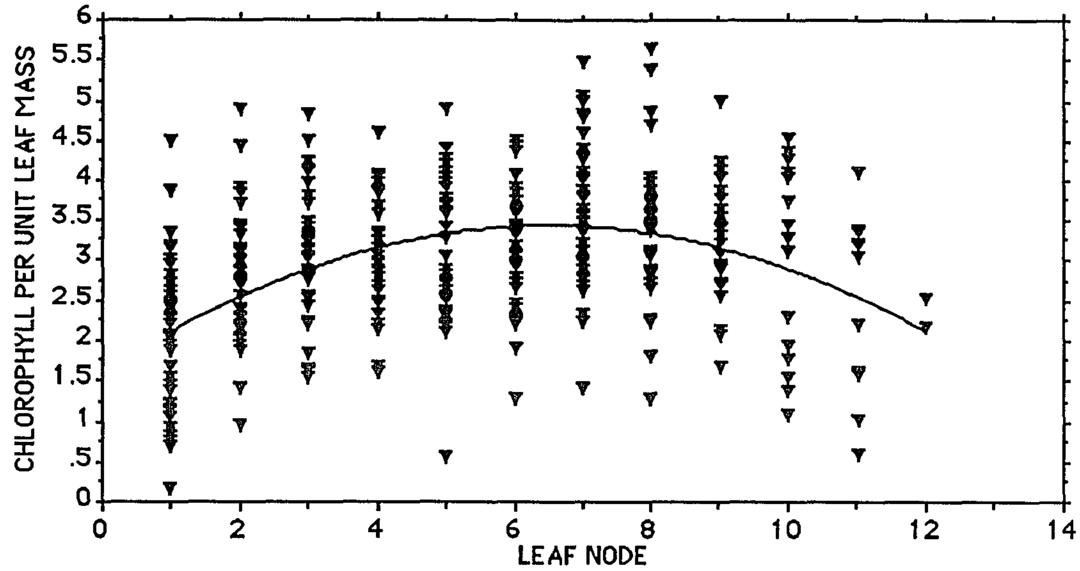

Figure 4.35. Scatterplot of chlorophyll content (g m^{-2}) transformed into standard deviation units + 3 for shade leaves from all eight genets with a second degree least-squares regression (F = 75.23 (2,365 df), r^2 = 0.249, p < .001) superimposed.

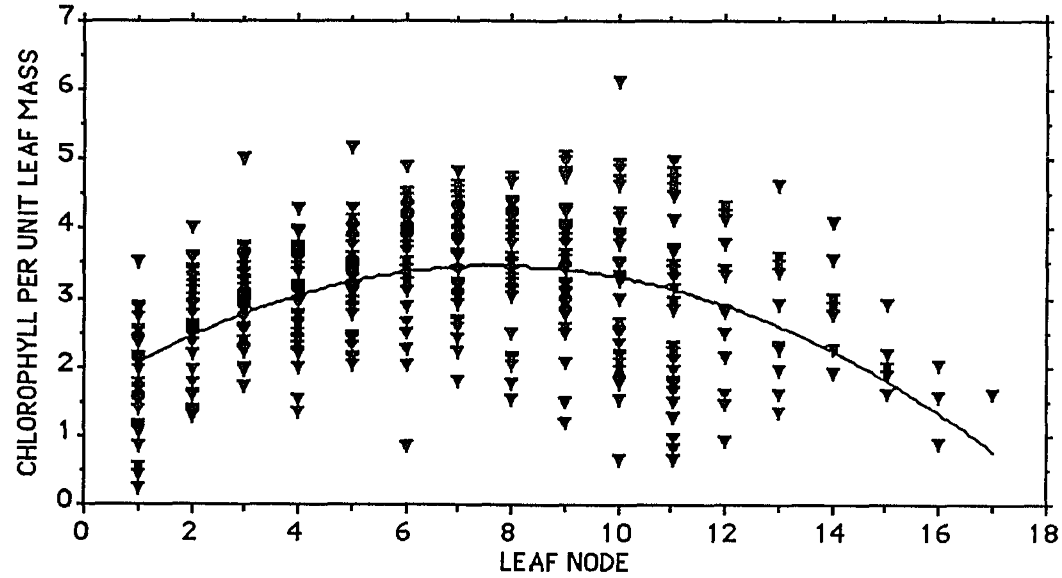

Figure 4.36. Scatterplot of chlorophyll content (g m^{-2}) transformed into standard deviation units + 3 for sun leaves from all eight genets with a second degree least-squares regression (F = 73.382 (2,454 df), r^2 = 0.244, p < .001) superimposed.

Homogeneity of Chlorophyll Content Between Leaf Shapes

In Table 4.2 the chlorophyll data were segregated on the basis of leaf form category (entire margin versus two lobed[1]). The presence of two lobed leaves along a shoot is such that the differences that might exist in chlorophyll content between leaf form categories is confounded by nodal position. Most two lobed leaves occur at the middle nodes in both sun and shade shoots, with few at the early and late nodes. Therefore, while chlorophyll content of two lobed leaves is calculated largely from leaves with peak chlorophyll content, the chlorophyll contents of entire margin leaves are estimated largely from leaves of the early or late nodal stages which have lower chlorophyll contents regardless of their leaf shape. In order to overcome this problem, I considered only leaves from nodes 6 through 11, where leaves with entire margins and two lobed leaves occurred with approximately equal frequency (see Figure 3.1) and these results are shown in Table 4.3 (mg g^{-1}) and Table 4.4 (g m^{-2}).

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[1] The percentage of single lobed leaves (right or left mitten shaped) was 9% and they were not included in the testing of this particular hypothesis.

No differences were found in chlorophyll content between entire and two lobed leaves when sun shoots and shade shoots were analyzed separately for each genet (single classification ANOVA, $p > .05$, see Table 4.3 and 4.4). Merging sun and shade shoots of each genet revealed significant differences in chlorophyll content between entire and two lobed leaves in three genets (#s 586, 585 and 590) measured as mg g^{-1} and one genet (# 598) measured as g m^{-2}. However, when the entire data set is merged for all eight genets and analyzed by single classification ANOVA, significant differences were found in chlorophyll content (mg g^{-1}) between entire and two lobed leaves of both sun (5.38 vs. 6.63 mg g^{-1}; $p < .001$) and shade (6.3 vs. 8.53 mg g^{-1}; $p < .001$) shoots and the data set at large (5.66 vs. 7.88 mg g^{-1}; $p < .001$).

Table 4.2. Mean chlorophyll content in mg g^{-1} and g m^{-2} for 516 entire and 230 two-lobed leaves from eight genets of Sassafras. Sample sizes for each ANOVA are in Table 3.1. Mean chlorophyll a/b ratios ranged from 3.02 to 3.74 and were homogeneous in all statistical comparisons.

	CHLOROPHYLL CONTENT, ALL LEAF NODES					
	mg g^{-1}			g m^{-2}		
Genet No.	Entire Margin	Two Lobed	ANOVA	Entire Margin	Two Lobed	ANOVA
585	6.43	9.00	***	.4209	.4798	ns
586	4.86	7.23	***	.4550	.5017	ns
589	4.86	5.27	ns	.4134	.4660	ns
590	5.29	7.89	***	.3399	.4798	**
591	9.1	10.51	ns	.3564	.3541	ns
595	4.58	5.29	***	.3572	.3714	ns
597	5.68	6.67	**	.3434	.3712	ns
598	4.87	3.86	ns	.3416	.2894	ns

ns = not significant; * = $0.01 < p \leq 0.05$; ** = $0.001 < p \leq 0.01$; *** = $p \leq 0.001$

Table 4.3. Mean chlorophyll content of entire and two lobed leaves from sun and shade positions at nodes 6 to 11, in mg g^{-1}. Leaf sample size is within brackets.

	CHLOROPHYLL CONTENT (mg g^{-1}) NODES 6 - 11					
	SUN			SHADE		
Genet No.	Entire Margin	Two Lobed	ANOVA	Entire Margin	Two Lobed	ANOVA
585	5.59(24)	5.48(1)	ns	7.78(7)	9.51(7)	ns
586	4.47(14)	4.10(2)	ns	5.69(7)	8.30(7)	ns
589	5.09(15)	4.32(6)	ns	5.46(10)	6.09(2)	ns
590	5.25(10)	5.94(17)	ns	-----(0)	10.63(17)	--
591	9.23(8)	10.13(12)	ns	11.35(4)	10.92(21)	ns
595	4.31(13)	4.17(13)	ns	8.44(2)	7.94(14)	ns
597	6.53(6)	7.94(21)	ns	6.85(2)	5.76(24)	ns
598	4.74(22)	3.72(2)	ns	4.80(20)	3.96(4)	ns

ns = not significant; * = $0.01 < p \leq 0.05$; ** = $0.001 < p \leq 0.01$; *** = $p \leq 0.001$

Table 4.4. Mean chlorophyll content of entire and two lobed leaves from sun and shade positions at nodes 6 to 11, in g m^{-2}. Sample sizes for each ANOVA are in Table 4.3.

	CHLOROPHYLL CONTENT (mg g^{-1}) NODES 6 - 11					
	SUN			SHADE		
Genet No.	Entire Margin	Two Lobed	ANOVA	Entire Margin	Two Lobed	ANOVA
585	.4292	.5284	ns	.4725	.4728	ns
586	.5888	.5841	ns	.3837	.4502	ns
589	.4344	.4630	ns	.4485	.4751	ns
590	.3947	.4332	ns	-----	.3499	--
591	.4156	.4194	ns	.3309	.3067	ns
595	.4164	.3784	ns	.4469	.3830	ns
597	.4706	.4298	ns	.3541	.3260	ns
598	.3596	.3141	ns	.3444	.2729	ns

ns = not significant; * = $0.01 < p \leq 0.05$; ** = $0.001 < p \leq 0.01$; *** = $p \leq 0.001$

Homogeneity of Chlorophyll Content Among Shoots

The homogeneity of chlorophyll content among shoots was tested using a two level nested ANOVA for each genet[1]. In three genets, #s 589, 590 and 598 there are no significant differences in chlorophyll content (mg g^{-1}) among shoots while in the remaining five genets, differences do exist. On the basis of leaf area, differences in chlorophyll content are present among the shoots of four genets, #s 586, 589, 595 and 597.

Homogeneity of Chlorophyll Content Among Genets

The homogeneity of chlorophyll content among genets was tested using two-way ANOVA with no replication, where rows are genets and columns are sun and shade leaves and cells are means. No significant differences were found in mean chlorophyll content among genets ($F = 2.68$ and $F = 3.31$ for mg g^{-1} and g m^{-2} respectively, when testing for genet differences; $v1, v2 = 7, 7$; $p > .05$).

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[1] Major groups are type I, sun and shade; subordinate groups are shoots; variates are leaf chlorophyll values; balanced design.

1987

Within Season Changes in the Distribution of Chlorophyll in Leaves along Shoots

GENET BR 99

The results of this analysis (mg g^{-1}) for genet 99 are shown in Figure 3.37. Greatest leaf chlorophyll content was measured in leaves of the intermediate nodes on May 26 (node 5). As leaf development continued, leaves of the distal nodes increased their chlorophyll contents relative to those of the intermediate nodes through June 30 and July 28. However, the measurement taken on September 9, late in the season, indicates that leaf senescence had begun and the leaves at all nodal positions along the shoot had lower chlorophyll contents, as expected. This trend is seen most clearly in Figure 3.39 of chlorophyll content on the basis of leaf area (g m^{-2}).

GENET BR 100

A similar pattern is seen in genet 100 where chlorophyll content on the basis of leaf weight is greatest at leaves of node four on May 26 but increases in leaves of the distal nodes through June 30 (greatest increase) and July 28 (minimal increase). However, as observed in genet 99, there is a substantial decrease in chlorophyll content in leaves at all nodes along the shoot between July 28 and September 9. This pattern is repeated when chlorophyll content is measured on the basis of leaf area (Figure 3.40), where it can be seen that the increase in chlorophyll content between June 30 and July 28 is greatest at leaves of nodes seven and eight, the youngest leaves on these shoots.

GENET BR 590

This pattern can also be seen in genet 590 (Figure 3.41). On May 26 there is a distinct curvilinear distribution of chlorophyll (mg g^{-1}) in leaves along a shoot, with greatest chlorophyll at node five. However, with relatively faster development of chlorophyll in the distal nodes, by June 30, greatest chlorophyll concentration was found in the youngest leaves (node 10). While some increase in chlorophyll content was observed between June 30 and July 28 there was little change in the pattern of distribution along the shoot until September 9, when an overall decrease in chlorophyll content was observed. When chlorophyll was measured on the basis of leaf surface area (g m^{-2}), the pattern of distribution was almost identical (Figure 3.42) to that observed for chlorophyll content on the basis of leaf fresh weight.

GENET BR 591

While overall similarities in chlorophyll content distribution continue with genet 591, there are noteworthy differences between this and the other three genets. When chlorophyll content is measured on the basis of leaf fresh weight (Figure 3.43) the familiar curvilinear pattern of May 26 (greatest chlorophyll content at node five) followed by the increase in chlorophyll content up to June 30 can be seen. However, chlorophyll content when measured on July 28 shows a decrease from June 30, while between July 28 and September 9 there is little decrease in chlorophyll content except in leaves of the proximal nodes. This pattern can be seen even more clearly when chlorophyll content is measured on the basis of leaf area (Figure 3.44). Here, chlorophyll content increases in leaves of all nodes from May 26 to June 30. However, between June 30 and July 28, increase in chlorophyll content occurs mainly in the distal nodes (8 - 11). Between July 28 and September 9 there is little change in chlorophyll content in leaves of the distal nodes, but there is a rapid decrease in leaves of the proximal nodes (1 - 7).

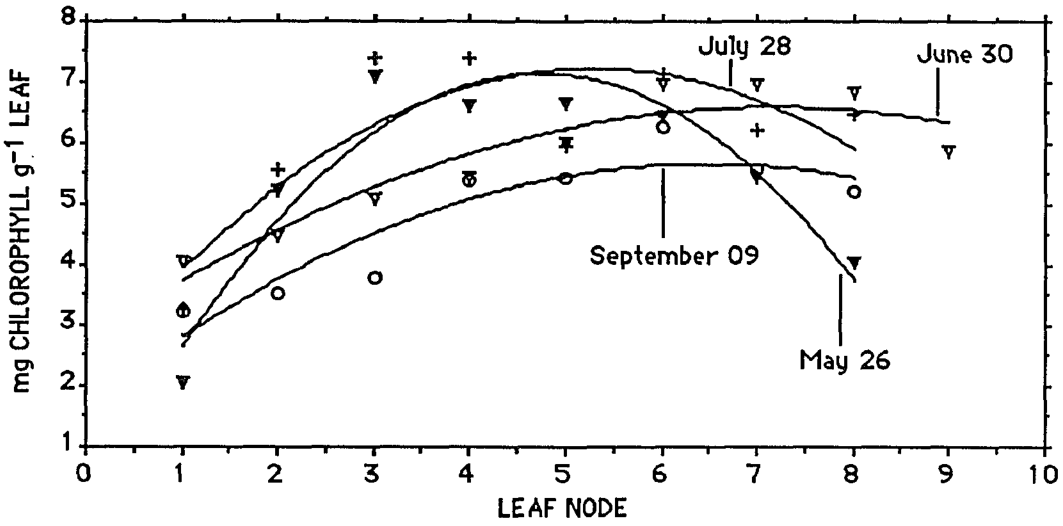

Figure 4.37. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (mg g^{-1}) in leaves of one shoot of genet BR 99 on each of four days: May 26 (r^2=0.903); June 30 (r^2=0.89); July 28 (r^2=0.681); and September 09 (r^2=0.855), 1987.

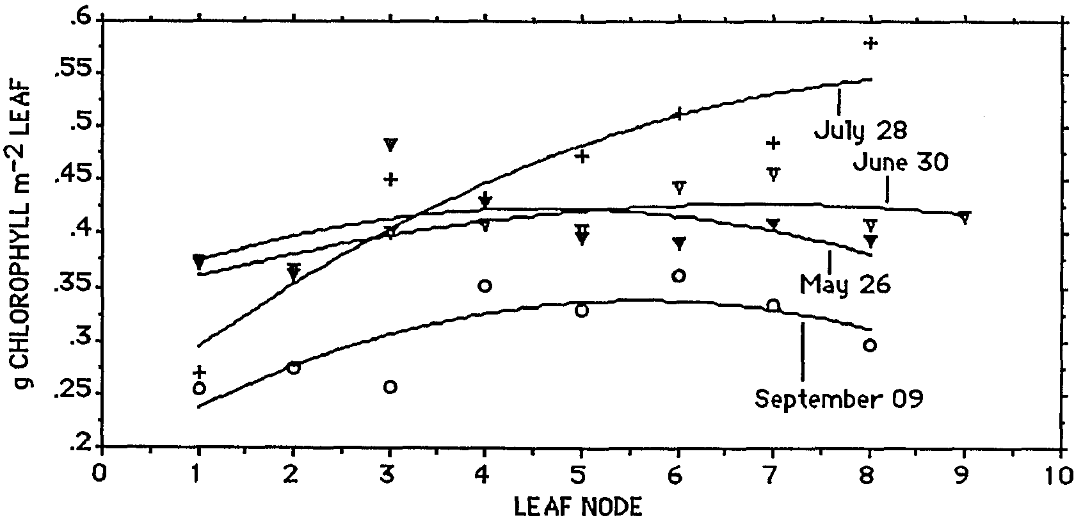

Figure 4.38. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (g m^{-2}) in leaves of one shoot of genet BR 99 on each of four days: May 26 (r^2=0.239); June 30 (r^2=0.679); July 28 (r^2=0.894); and September 09 (r^2=0.664), 1987.

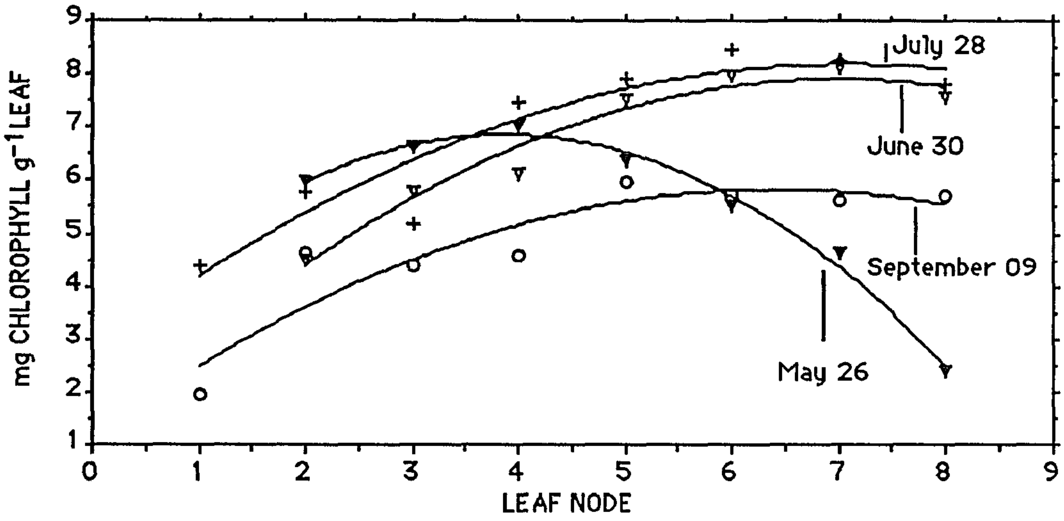

Figure 4.39. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (mg g^{-1}) in leaves of one shoot of genet BR 100 on each of four days: May 26(r^2=0.988); June 30 (r^2=0.958); July 28 (r^2=0.88); and September 09 (r^2=0.845), 1987.

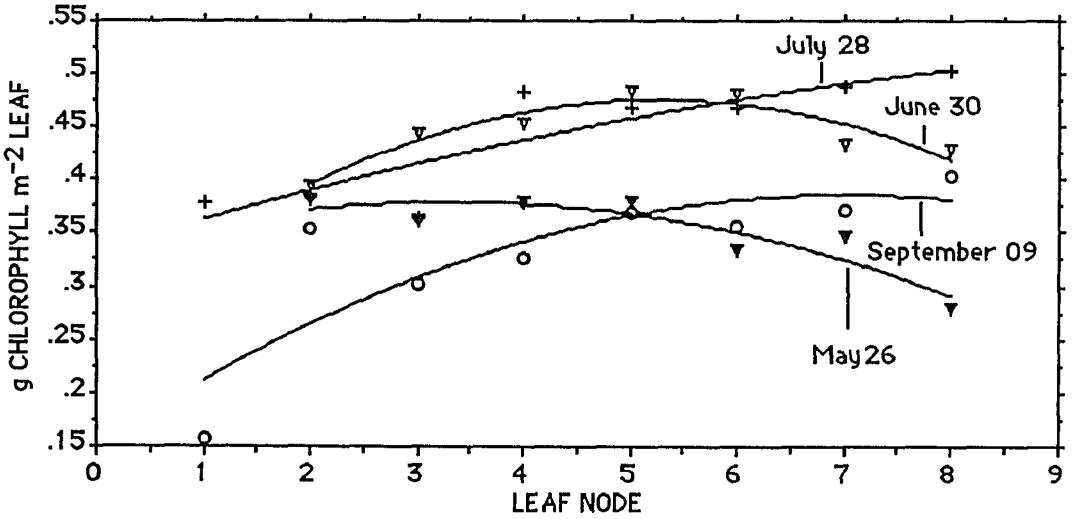

Figure 4.40. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (g m^{-2}) in leaves of one shoot of genet BR 100 on each of four days: May 26 (r^2=0.831); June 30 (r^2=0.877); July 28 (r^2=0.767); and September 09 (r^2=0.692), 1987.

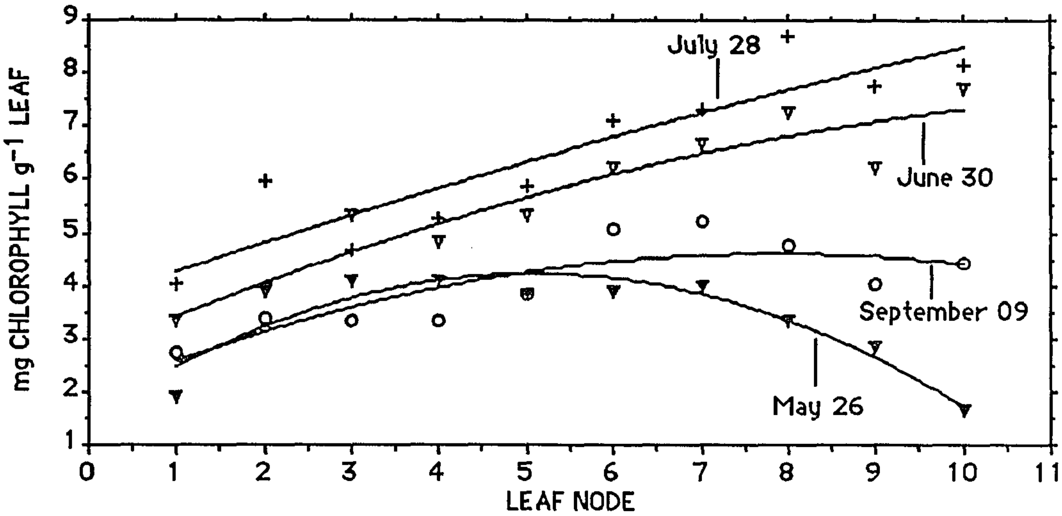

Figure 4.41. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (mg g^{-1}) in leaves of one shoot of genet BR 590 on each of four days: May 26 (r^2=0.847); June 30 (r^2=0.893); July 28 (r^2=0.828); and September 09 (r^2=0.707), 1987.

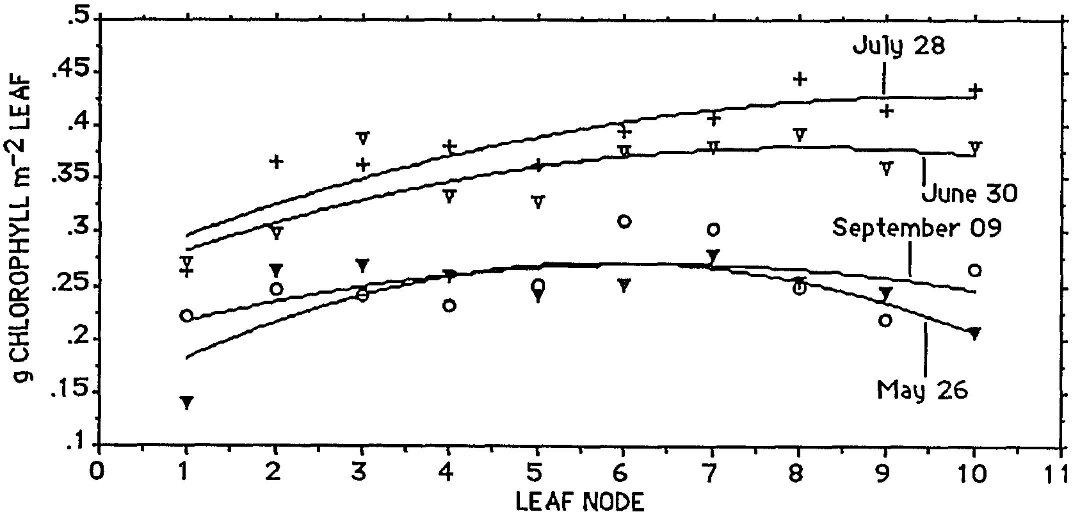

Figure 4.42. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (g m^{-2}) in leaves of one shoot of genet BR 590 on each of four days: May 26 (r^2=0.562); June 30 (r^2=0.642); July 28 (r^2=0.81); and September 09 (r^2=0.307), 1987.

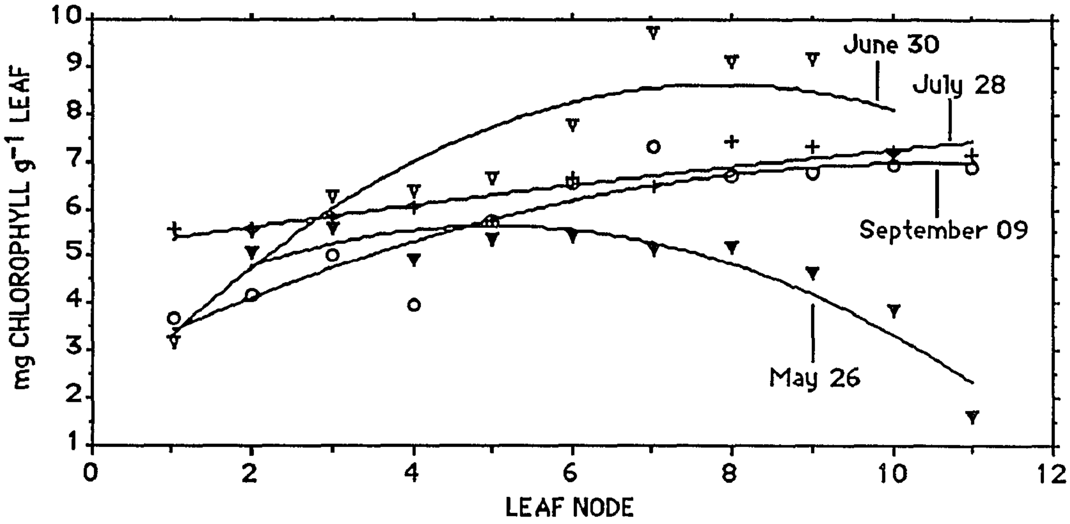

Figure 4.43. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (mg g^{-1}) in leaves of one shoot of genet BR 591 on each of four days: May 26 (r^2=0.858); June 30 (r^2=0.848); July 28 (r^2=0.846); and September 09 (r^2=0.845), 1987.

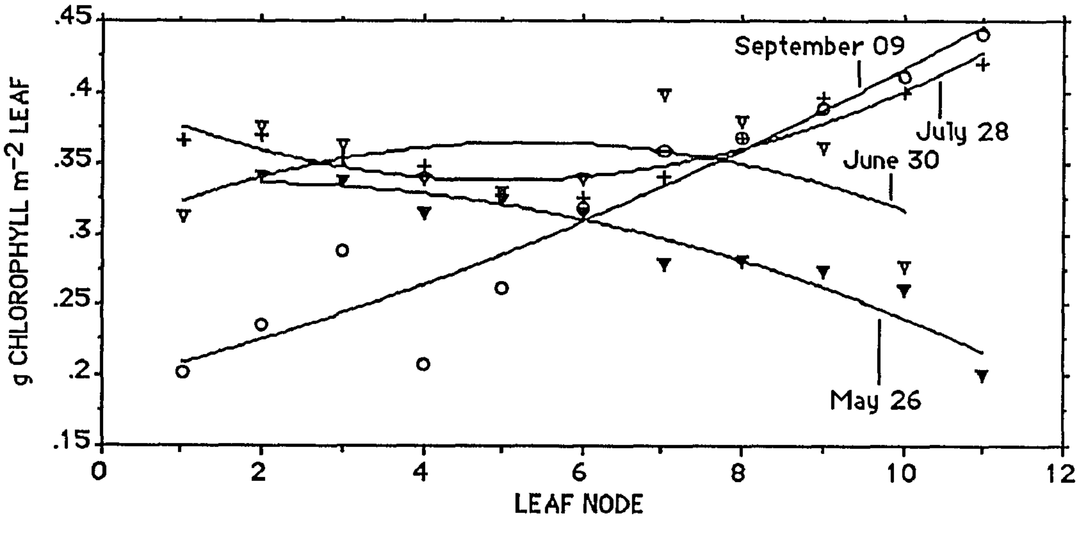

Figure 4.44. Scatterplots and least-squares regression lines (second degree polynomial) for chlorophyll concentration (g m^{-2}) in leaves of one shoot of genet BR 591 on each of four days: May 26 (r^2=0.913); June 30 (r^2=0.225); July 28 (r^2=0.878); and September 09 (r^2=0.904), 1987.

5. PHOTOSYNTHESIS

METHODS AND MATERIALS

PHOTOSYNTHESIS

The data on leaf chlorophyll contents, collected in 1986 predicted that there would be a nodal trend to the rates of photosynthesis, that this trend would be greater by considering whole leaf photosynthesis, and that there would be no significant difference in net photosynthetic rates among leaf shapes (per unit leaf surface area). While laboratory experiments could have been applied to these predictions, such experiments would not have yielded information on the actual performance of leaves under field conditions since growth environment and conditions of determination may strongly alter the values of absolute net photosynthesis (Sestak, 1985). When measuring photosynthesis in the field, high degrees of freedom are necessary to compensate for the variability in leaf microclimate. Unfortunately, large sample sizes take longer to achieve, and the results tend to be confounded with time (age) related changes in leaf function, and even larger sample sizes are needed to compensate for this. By taking repeated measurements from specific genets, and by restricting myself to a small number of tagged shoots and leaves, I was able to hold the sample size to manageable proportions and still obtain useful information on leaf photosynthesis in the field.

A Portable Photosynthesis System (LI 6200, LI-Cor Inc., Lincoln, Nebraska) was used to to measure photosynthesis in four genets of Sassafras growing along the floodplain of the Bronx River at Bronxville in Westchester County in New York. The genets used in this study were numbers 99, 100, 590 and 591, the same genets used for the demographic survey of leaf form and area. I measured gas exchange in those shoots that were tagged for the study of leaf shape and area.

The LI 6200 is a portable, microprocessor controlled, closed system Infra-Red Gas Analyzer (IRGA) for measuring gas exchange of intact leaves in the field or in the laboratory and incorporates three major components: 1. The Infra-Red Gas Analyzer (closed system); 2. The Transient Porometer; 3. The Datalogger (a computer). In addition to these, there are several sensors which yield information essential for the operation of the LI-6200, for the calculations necessary to determine certain parameters, and for the interpretation of photosynthesis data. These are a Humidity sensor (relative humidity); a Quantum Sensor (PAR 400 - 700 nm), and two K-type thermocouples (air temperature and leaf temperature).

A leaf chamber of one liter volume was used, with inserts allowing a leaf surface area from 350 mm^2 (35 mm x 10 mm) to 1400 mm^2 (35 mm x 40 mm) to be exposed to light for photosynthesis. The flow rate through the system was controlled, from 3 to 8 mm^3 sec^{-1}, depending on leaf transpiration rate, in order to best maintain relative humidity within the leaf chamber at a nearly constant level. The datalogger was set to calculate photosynthesis on the basis of a change of 2 or 5 parts per million (ppm) carbon dioxide. The change of 2 ppm was used under low light conditions when photosynthetic rate was very slow. The system was calibrated for 0 ppm CO_2 (zeroed) and for a span of 520 ppm CO_2 at the begining of each day photosynthesis was measured. A calibration gas of 520 ppm ($\pm$1%) CO_2 in Nitrogen (Union Carbide/Linde, Keasbey, N.J.) was used for the span calibration, which was always carried out at the flow rate to be used in the field that day. Once in the field, the zero CO_2 calibration was performed at hourly intervals, to compensate for changes in temperature which affect the zero point. The span calibration is sensitive to pressure, and since there is no difference in altitude between the laboratory, where the original calibration was done, and the field site in Bronxville, it was not necessary to perform the span calibration in the field.

In the field, photosynthetic rate was measured on shoots for all leaves that were large enough to to fit in the leaf chamber. This usually meant that photosynthesis in the oldest (proximal) and youngest (distal)[1] three leaves on the shoot could not be measured. When a leaf was placed within the chamber, care was taken to avoid the midrib and include only leaf lamina mostly devoid of major veins within the sampling area of the chamber, and that there should be no gaps in the sampling area. The nodal position and shape category of each leaf for which photosynthesis was measured, were recorded (manually) on the data logger. Wherever possible, the chamber with leaf was positioned so that the leaf and quantum sensor (130 mm away from the center of the cuvette) received equal amounts of light.

In order to determine if conditions within the leaf chamber were significantly different from conditions outside the chamber, relative humidity and air temperature were monitored independently of the photosynthesis system using a Solomat model 126 solid -state hygrometer (relative humidity) and a shaded K-type thermocouple (air temperature).

The datalogger is programmed[2] to use the measurements of Photosynthetically Active Radiation (PAR), leaf and air temperature, and changes in CO_2 and relative humidity to calculate photosynthesis, transpiration, vapor pressure deficit, stomatal resistance and conductance, and internal CO_2 concentration.

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[1] relative to the terminal bud scale scar

[2] LI-6200 Technical Reference Manual, LI-COE, Inc., Lincoln, Nebraska, Sept. 1987

Photosynthetic (and other) measurements were stored in the random access memory of the datalogger and a hardcopy made at the end of each day, in the laboratory. The information on the printout was then installed on a MacIntosh Plus computer as a Statview 512+ (Brainpower, Inc., Calabasas, CA) database (Appendix) for statistical and graphical analysis.

RESULTS

The results were analyzed in three ways. First, the effect of leaf shape on photosynthetic rate was considered. Since PAR was highly variable in the field, both between days and within days, the information for each day was analyzed separately. Secondly, the data were divided into several classes on the basis of PAR and analysis of variance performed. This was to ensure that confounding due to variation in PAR was kept at a minimum. Thirdly, regression analyses were used to search for nodal patterns in photosynthetic response.

Genet 99

Photosynthesis versus Leaf Shape

The overall results for this genet are shown in Table 5.1. This genet of Sassafras is small in stature (see Table 3.2) and grows under the shade of White Oak (Quercus alba). As such, it is subject to little direct sunlight, usually in the form of sun flecks that penetrate the otherwise shading canopy. While PAR, air temperature and leaf temperature were not significantly different between entire margined and two lobed leaves in the cuvette, mean PAR was higher for entire margined leaves while mean air temperature and leaf temperature were higher in two lobed leaves. Since leaf and air temperature (within the cuvette) are directly proportional to PAR, the paradox of lower PAR and higher leaf and air temperature may be a result of the merging of data from several measurements taken under different conditions. However, a more probable explanation is that the displacement between the leaf chamber and the Quantum Sensor led to innaccuracies in measuring incident PAR, especially under shade, when sun flecks are responsible for all direct sunlight incident on leaves. Sample sizes for each day were very small for this genet, largely because of the very slow rates of photosynthesis. In the absence of a sun fleck, there was usually negligible net photosynthesis. There were also no significant differences in Transpiration or vapor pressure deficit between leaves with entire margins and leaves with two lobes on this genet. Only in the case of stomatal conductance was there any statistically significant difference between leaves with different shapes, with stomatal conductance being greatest in leaves with two lobes.

Table 5.1. Mean Quantum (PAR), Air Temperature (T_{air}), Leaf Temperature (T_{leaf}), Photosynthesis (PHOTO), Stomatal Conductance (CS), Transpiration (TRNM), Vapor Pressure Deficit (VPD) and Water Use Efficiency (WUE) for entire, one lobed and two lobed leaves of genet BR 99 measured between June 10 and August 18, 1987 analyzed by single classification ANOVA. Sample size refers to the number of measurements taken (usually, No. IRGA readings/2 = No. leaves measured) .

	MEAN VALUE FOR LEAVES SHAPED			
VARIABLE	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
PAR (μ mol m^{-2} s^{-1})	47.2	---	35.6	ns
T_{air} (^oC)	27.6	---	28.3	ns
T_{leaf} (^oC)	27.6	---	28.1	ns
PHOTO (μ mol m^{-2} s^{-1})	0.974	---	0.47	ns
CS (cm s^{-1})	0.075	---	0.121	*
TRNM ($x10^{-4}$mol m^{-2} s^{-1})	10.0	---	10.0	ns
VPD (mb)	30.6	---	32.7	ns
WUE (g/kg)	3.083	---	0.849	ns
SAMPLE SIZE	61	---	2	

The information was then separated by quantum class (Table 5.2) and analyzed by single classification ANOVA (where possible). During measurement of photosynthetic rates, the light regime was usually less than 50 μ mol m^{-2} s^{-1}. Also, this genet has very few lobed leaves and therefore, except for a comparison at the 25.1 - 50.0 μ mol m^{-2} s^{-1} PAR class, no comparison was possible at higher light intensities. No significant differences were found in PAR, photosynthesis, leaf temperature, air temperature, transpiration, vapor pressure deficit or water use efficiency between entire margined and two lobed leaves of this genet. Only in the case of stomatal conductance was there any statistically significant difference between entire margined and two lobed leaves, with stomatal conductance being greatest in two lobed leaves.

Photosynthesis versus leaf age (nodal position)

Figure 5.1 is a scatterplot of net photosynthetic rates for leaves at nodal positions along shoots of this genet. Neither linear nor curvilinear regressions were significant and thus no clear pattern for net photosynthesis could be established for this genet. Both leaf age and incident PAR are confounded in this data. In an effort to overcome the effects of variation in PAR, photosynthesis measurements made under low light conditions (25.1 - 50.0 μ mol m^{-2} s^{-1}) only, were graphed (Figure 5.2). However, regressions were not significant. There were insufficient measurements at higher PAR for these to be plotted and regression analysis performed.

Table 5.2. Mean photosynthetically active radiation (PAR), air temperature, leaf temperature, photosynthesis, stomatal conductance, transpiration, vapor pressure deficit and water use efficiency for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m-2 s-1) for Entire, One Lobed and Two Lobed leaves of Sassafras genet BR 99. Sample size (number of measurements taken) is indicated within parentheses with the PAR data.

Genet BR 99

VARIABLE	PAR CLASS	MEAN VALUE ENTIRE	ONE LOBED	TWO LOBED	ANOVA
PAR (μ mol m-2 s-1)	B	37.9(56)	---	35.6(2)	ns
	C	52.3(1)	---	---	--
	E	102.7(1)	---	---	--
	F	132.4(1)	---	---	--
	G	233.2(2)	---	---	--
Air Temperature (°C)	B	27.5	---	28.3	ns
	C	28.4	---	---	--
	E	28.7	---	---	--
	F	29.3	---	---	--
	G	28.8	---	---	--
Leaf Temperature (°C)	B	27.5	---	28.1	ns
	C	28.2	---	---	--
	E	28.6	---	---	--
	F	29.1	---	---	--
	G	28.7	---	---	--
Photosynthesis (μ mol m-2 s-1)	B	0.95	---	0.47	ns
	C	1.12	---	---	--
	E	1.28	---	---	--
	F	1.16	---	---	--
	G	1.33	---	---	--
Stomatal Conductance (cm s-1)	B	0.073	---	0.121	**
	C	0.136	---	---	--
	E	0.058	---	---	--
	F	0.104	---	---	--
	G	0.078	---	---	--
Transpiration (x10-4) (mol m-2 s-1)	B	9.3	---	13.4	ns
	C	6.0	---	---	--
	E	4.0	---	---	--
	F	6.0	---	---	--
	G	5.3	---	---	--
Vapor Pressure Deficit (mb)	B	31.6	---	32.7	ns
	C	21.7	---	---	--
	E	16.0	---	---	--
	F	22.1	---	---	--
	G	18.0	---	---	--
Water Use Efficiency (g kg^{-1})	B	2.852	---	0.849	ns
	C	4.305	---	---	--
	E	7.221	---	---	--
	F	4.473	---	---	--
	G	6.167	---	---	--

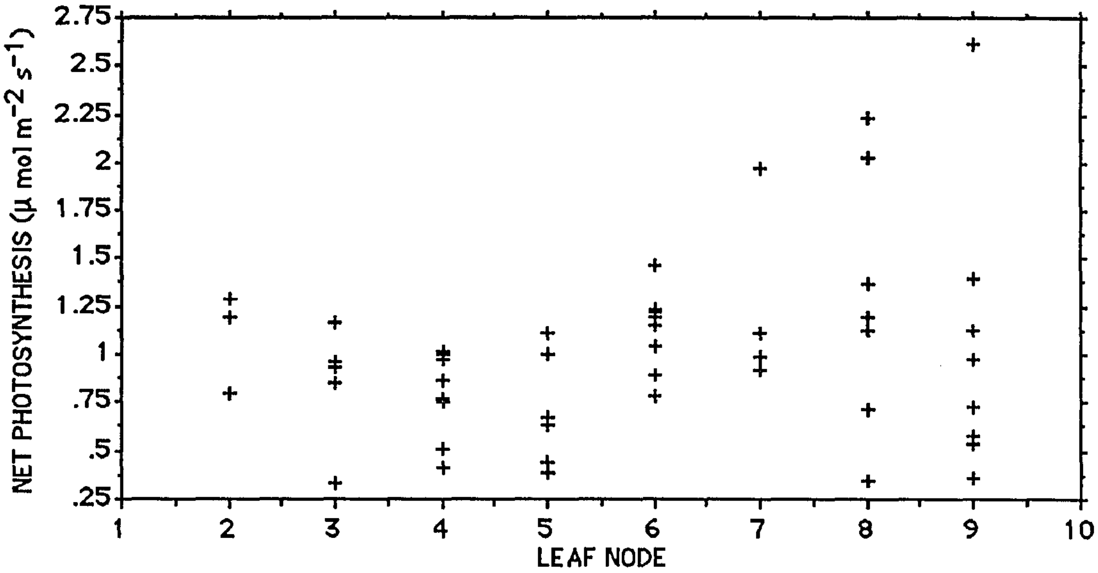

Figure 5.1. Scatterplot of photosynthetic rates for leaves at nodes along shoots of genet 99. The data shown here is for measurements taken on several days in 1987. Linear and curvilinear regressions were not significant (p > .05).

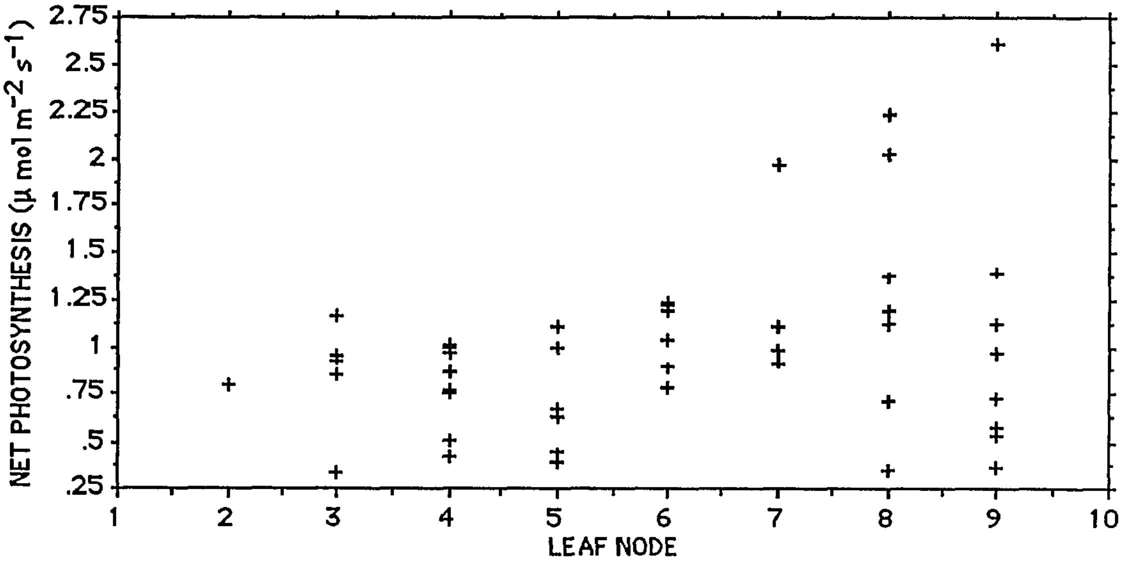

Figure 5.2. Scatterplot of photosynthetic rates at low PAR levels (25.1 - 50.0 μ mol m^{-2} s^{-1}) for leaves at nodes along shoots of genet 99. The data shown here is for measurements taken on several days in 1987. Linear and curvilinear regressions were not significant (p > .05).

Genet 100

Photosynthesis versus Leaf Shape

This genet also is small in stature (see Table 3.2) and grows adjacent to genet 99, under the shade of White Oak (Quercus alba). It also is subject to little direct sunlight, usually in the form of sun flecks. However, the light regime of this genet is more heterogeneous than that of genet BR 99 (Table 5.4). Also, leaf and air temperatures at the time of cuvette operation, are more in keeping with those one might expect on the basis of PAR (Table 5.3). Only in the case of Stomatal Conductance is there a significant difference between leaf shapes. However, it is noteworthy that the highest measured photosynthetic rates (albeit not statistically significantly so) occur in leaves with two lobes. Sample sizes for photosynthesis measurements on any one day were unavoidably small, largely because of the very slow rates of net photosynthesis occurring in the absence of sun flecks.

Breaking down this information by PAR classes (Table 5.4), the pattern I saw with genet 99, of no significant differences in PAR, air and leaf temperature, transpiration rate and vapor pressure deficit among leaf shapes is maintained. However, at PAR classes A and B, two lobed leaves have significantly greater water use efficiencies than do entire margined leaves. This is in keeping with the greater net photosynthesis rates also found in two lobed leaves at these PAR levels. The significantly lower net photosynthetic rate of two lobed leaves at PAR class D,E may be explained by the very much lower leaf temperature of these same leaves. Since leaf temperature is directly proportional to PAR incident upon the leaf, the paradox of higher PAR and lower leaf temperature may be a result of the displacement between the leaf chamber and the Quantum Sensor, in which case the lower photosynthetic rate also would be reasonable.

Photosynthesis versus leaf age (nodal position)

Figure 5.3 is a scatterplot of net photosynthetic rates for leaves at various nodal positions (ages) along shoots. Regressions were not significant and no pattern for net photosynthesis with leaf nodal position could be established. This is at least partly due to the confounding effect of merging data from several days, necessary due to the relatively small data base available for this genet. The inability to find a nodal trend for this genet may also be due to the highly variable environment (shade + sun flecks) under which net photosynthesis was measured. It was not possible to search for nodal trends in net photosynthesis by PAR class due to the small sample sizes (A = 23; B = 10; C = 4; D,E = 4; F = 3) and the incompleteness of the nodal record at each PAR class.

Table 5.3. Mean photosynthetically active radiation (PAR), air temperature (T $_{air}$), leaf temperature (T $_{leaf}$), photosynthesis (PHOTO), stomatal conductance (CS), transpiration (TRNM) vapor pressure deficit (VPD) and water use efficiency (WUE) for entire, one lobed and two lobed leaves of genet BR 100 measured between June 10 and August 18, 1987 analyzed by single classification ANOVA. Sample size is the number of measurements taken.

	MEAN VALUE FOR LEAVES SHAPED			
VARIABLE	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
PAR (μ mol m^{-2} s^{-1})	48.1	31.4	51.6	ns
T $_{air}$ (^{o}C)	28.7	27.7	28.6	ns
T $_{leaf}$ (^{o}C)	28.8	27.9	28.9	ns
PHOTO (μ mol m^{-2} s^{-1})	0.801	0.558	1.171	ns
CS (cm s^{-1})	0.075	0.056	0.055	*
TRNM (x10^{-4} mol m^{-2} s^{-1})	10.0	10.0	10.0	ns
VPD (mb)	31.0	27.7	29.8	ns
WUE (g kg^{-1})	1.908	2.493	4.961	**
SAMPLE SIZE	30	10	4	

Table 5.4. Mean photosynthetically active radiation (PAR), air temperature, leaf temperature, photosynthesis, stomatal conductance, transpiration and vapor pressure deficit for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras genet BR 100. Sample size (number of measurements taken) is indicated within parentheses with the PAR data.

Genet BR 100

VARIABLE	PAR CLASS	ENTIRE	MEAN VALUE ONE LOBED	TWO LOBED	ANOVA
PAR (μ mol m-2 s-1)	A	12.4(15)	14.5(7)	19.4(1)	ns
	B	36.7(7)	27.4(1)	36.4(2)	ns
	C	64.0(4)	---	---	--
	D,E	115.5(1)	92.5(2)	114.0(1)	ns
	G	209.4(3)	---	---	--
Air Temperature (°C)	A	26.7	27.7	31.1	ns
	B	30.8	31.2	31.1	ns
	C	30.6	---	---	--
	D,E	30.3	30.6	31.1	ns
	G	30.6	---	---	--
Leaf Temperature (°C)	A	26.7	27.7	26.4	ns
	B	30.8	31.2	31.5	ns
	C	30.8	---	---	--
	D,E	30.7	27.2	26.2	ns
	G	31.0	---	---	--
Photosynthesis (μ mol m-2 s-1)	A	0.44	0.41	0.91	ns
	B	0.67	0.97	1.43	*
	C	1.04	---	---	--
	D,E	2.39	0.88	0.92	*
	G	2.06	---	---	--
Stomatal Conductance (cm s^{-1})	A	0.064	0.060	0.034	ns
	B	0.082	0.073	0.075	ns
	C	0.075	---	---	--
	D,E	0.117	0.033	0.036	*
	G	0.097	---	---	--
Transpiration (x 10-4) (mol m^{-2} s^{-1})	A	6.7	7.6	3.2	ns
	B	12.1	11.4	11.4	ns
	C	10.9	---	---	--
	D,E	14.6	3.2	3.3	ns
	G	13.8	---	---	--
Vapor Pressure Deficit (mb)	A	25.4	27.8	22.0	ns
	B	37.8	40.0	37.7	ns
	C	36.8	---	---	--
	D,E	31.6	21.2	21.6	ns
	G	35.2	---	---	--
Water Use Efficiency (g/kg^{-1})	A	1.57	1.307	7.026	***
	B	1.367	2.082	3.04	**
	C	2.335	---	---	--
	D,E	4.018	6.851	6.739	ns
	G	3.59	---	---	--

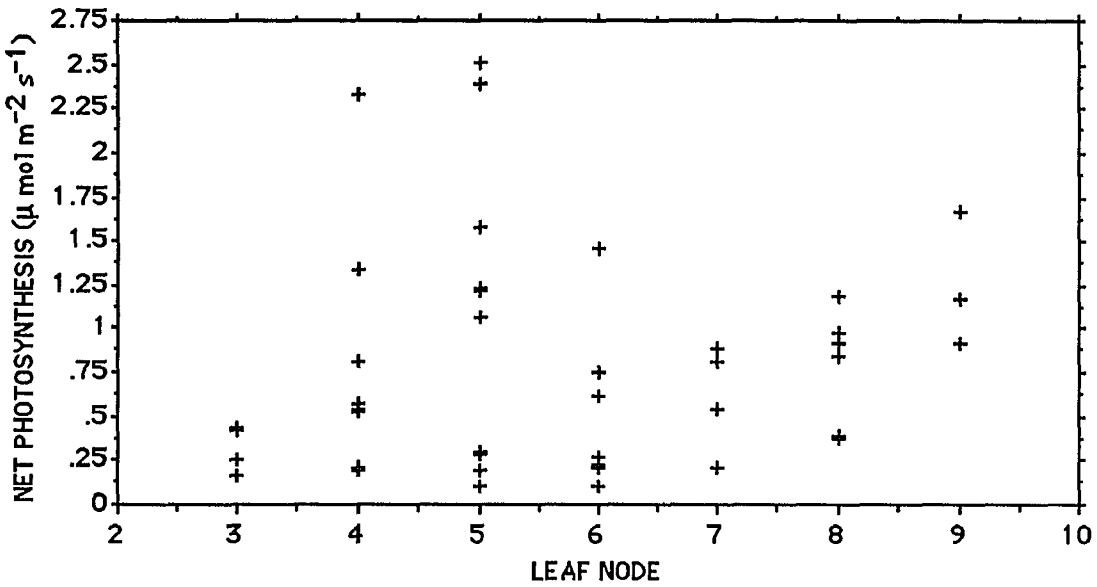

Figure 5.3. Scatterplot of photosynthetic rates for leaves at nodes along shoots of genet 100. The data shown here is for measurements taken on several days in 1987. Linear and curvilinear regressions were not significant.

Genet 590

Photosynthesis versus Leaf Shape

This genet is larger in stature than genets 99 or genet 100 (see Table 3.2) and grows on the north bank of the Bronx River, where it is a canopy dominant. The upper reaches of the canopy receive direct sunlight throughout the day, but is out of reach for photosynthesis measurement. Lower down, 2 - 3 meters above the ground, lateral branches display leaves 360° around the trunk of the tree. Photosynthesis was measured for leaves on lateral branches facing south east through north east in the eastern quadrant. Since there are few trees growing near this genet, it is virtually open grown.

Overall, the data for this genet (Table 5.5) indicate that at the time of measurement there were no significant differences in PAR, stomatal conductance, transpiration and vapor pressure deficit among leaf shapes but that differences were present in leaf and air temperature, photosynthetic rate and water use efficiency. While PAR incident upon leaves was not significantly different between leaf shapes, leaves with entire margins, when in the cuvette, may have been subject to somewhat higher PAR levels, as shown by the leaf and air temperature data, where significantly higher temperatures were recorded for leaves with entire margins. This data was then separated on the basis of Quantum classes (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} sec^{-1}) for each day measurements were taken (June 11 & 29, July 6, 21 & 29, August 18), and Analysis of Variance (ANOVA) performed. The PAR data are shown in Table 5.6 where, but for three exceptions, there are no significant differences with leaf shape. In the case of the three exceptions (June 11, class B; July 21, class A; and August 18, class E,F,G), only in the case of the July 21, class A data is there a corresponding significant difference in leaf and air temperature (Tables 5.8 and 5.7 respectively). The significantly greater net photosynthesis rates recorded for leaves with two lobes on July 21, at PAR class A may therefore be regarded as being due to a higher incident PAR. Air and leaf temperture data are presented in Table 5.7 and 5.8 respectively, and there is a high degree of congruence between leaf and air temperature in the occurence of significant differences among leaf shape. As stated before, leaf temperature is sometimes a better indicator of light incident upon a leaf than measured PAR. Neglecting data where differences in net photosynthesis (Table 5.9) have a corresponding difference in leaf temperature (Table 5.8), it can be seen that during the early part of the growing season, lobed leaves have greater net photosynthetic rates; and these differences are statistically significant on June 11, PAR class D, June 29, PAR class B, and July 6, PAR class D. By August 18, leaves with entire margins have significantly greater net photosynthesis (PAR class A). The stomatal conductance data supports the results of leaf temperature and net photosynthesis measurements, where greater leaf temperatures and/or higher rates of net photosynthesis are accompanied by higher stomatal conductances, with one exception. On August 18, PAR class B, despite leaf temperature being significantly greater for lobed leaves, net photosynthesis and stomatal conductance is significantly greater for leaves with entire margins. On this same day, at PAR class D, despite leaf temperature being greatest for entire margined leaves, stomatal conductance is greatest in lobed leaves, and this is not accompanied by a greater net photosynthetic rate. However, mean transpiration rates are significantly greater for lobed leaves at this PAR class (Table 5.11). The vapor pressure deficit data (Table 5.12) supports the findings reported above. Water use efficiency appears to be greater for leaves with entire margins on most days and under most PAR regimes.

Table 5.5. Mean photosynthetically active radiation (PAR), air temperature (T $_{air}$), leaf temperature (T $_{leaf}$), photosynthesis (PHOTO), stomatal conductance (RS), transpiration (TRNM), vapor pressure deficit (VPD) and water use efficiency (WUE) for Entire, One lobed and Two lobed leaves of genet BR590 measured between June 11 and August 18, 1987 analyzed by single classification ANOVA.

VARIABLE	MEAN VALUE FOR LEAVES SHAPED ENTIRE	ONE LOBED	TWO LOBED	ANOVA
PAR (μ mol m^{-2} s^{-1})	74.1	53.2	65.1	ns
T $_{air}$ (^{o}C)	29.0	28.4	27.7	**
T $_{leaf}$ (^{o}C)	29.0	28.4	27.6	**
PHOTO (μ mol m^{-2} s^{-1})	1.8	1.2	1.6	***
CS (cm s^{-1})	0.101	0.096	0.108	ns
TRNM (x10-^{4}mol m^{-2} s^{-1})	9.9	10.3	11.0	ns
VPD (mb)	32.4	28.7	27.5	ns
WUE (g kg^{-1})	4.892	3.8	4.156	**
SAMPLE SIZE	106	73	194	

Table 5.6. Mean photosynthetically active radiation (PAR; μ mol m^{-2} s^{-1}) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. PAR was measured on each of six days from June 11 through August 18, 1987, for genet BR 590. Sample size (number of measurements) is indicated within parentheses.

Genet BR 590

DATE	PAR	MEAN PAR VALUES FOR LEAVES SHAPED			
	CLASS	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 11	A	---	---	---	
	B	33.1(2)	45.4(1)	45.5(13)	***
	C	61.5(6)	61.4(13)	61.2(21)	ns
	D	81.4(1)	---	85.7(8)	ns
	E	114.2(13)	122.4(2)	118.4(18)	ns
JUNE 29	A	---	---	---	
	B	41.5(2)	39.0(11)	33.4(18)	ns
	C	---	61.9(1)	70.1(2)	ns
	D	---	---	94.4(2)	–
	E	---	---	---	
	F	---	---	---	
	G	278.5(2)	---	594.1(2)	ns
JULY 06	A	14.2(2)	---	14.8(15)	ns
	B	---	---	43.4(1)	–
	C	54.6(4)	61.0(3)	58.3(6)	ns
	D	88.2(11)	92.1(7)	88.7(18)	ns
	E	100.2(1)	110.0(4)	103.2(8)	ns
JULY 21	A	12.7(2)	16.2(3)	19.9(16)	***
JULY 29	A	18.6(6)	20.6(2)	15.2(5)	ns
	B	28.0(2)	33.1(3)	34.3(3)	ns
	C	---	58.5(3)	70.1(1)	ns
	D,E,F,G	---	---	162.2(5)	–
AUGUST 18	A	20.3(2)	23.4(3)	20.9(9)	ns
	B	37.0(16)	37.3(8)	37.5(16)	ns
	C	59.0(11)	---	57.1(4)	ns
	D	89.1(9)	95.4(2)	84.2(2)	ns
	E,F,G	110.6(14)	---	201.2(1)	***
ALL DAYS	A,B,C,D,E,F,G	74.1(106)	53.2(73)	65.1(194)	ns

Table 5.7. Mean air temperature (^oC) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

DATE	PAR CLASS	MEAN AIR TEMPERATURES (^oC) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 11	A	---	---	---	
	B	24.3	25.8	24.8	ns
	C	24.4	24.6	24.6	ns
	D	25.3	---	27.1	ns
	E	24.2	23.4	24.3	ns
JUNE 29	A	---	---	---	
	B	30.5	30.7	30.8	ns
	C	---	31.3	30.8	ns
	D	---	---	31.5	--
	E	---	---	---	
	F	---	---	---	
	G	31.4	---	31.2	*
JULY 06	A	24.4	---	25.1	**
	B	---	---	---	
	C	25.6	25.4	25.2	**
	D	25.5	25.4	25.8	ns
	E	26.2	26.0	25.9	ns
JULY 21	A	30.6	31.5	31.7	**
JULY 29	A	26.2	26.6	26.4	ns
	B	26.7	26.2	26.3	ns
	C	---	26.3	26.7	ns
	D, E, F, G	---	---	26.6	--
AUGUST 18	A	32.4	32.2	32.2	ns
	B	32.4	32.7	32.5	**
	C	32.5	---	32.4	ns
	D	32.4	32.2	32.3	ns
	E,F,G	32.5	---	32.5	ns
ALL DAYS	A,B,C,D,E,F,G	29.0	28.4	27.7	**

Table 5.8. Mean leaf temperature (^{o}C) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 µ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. Measurements are for each of six days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

DATE	PAR CLASS	MEAN LEAF TEMPERATURES (^{o}C)			ANOVA
		ENTIRE	ONE LOBED	TWO LOBED	
JUNE 11	A	---	---	---	
	B	24.4	25.9	24.7	ns
	C	24.4	24.6	24.6	ns
	D	24.5	---	24.8	ns
	E	24.3	23.4	24.4	ns
JUNE 29	A	---	---	---	
	B	30.7	30.7	30.7	ns
	C	---	31.3	30.8	ns
	D	---	---	31.5	--
	E	---	---	---	
	F	---	---	---	
	G	32.2	---	31.2	*
JULY 06	A	24.5	---	25.1	**
	B	---	---	---	
	C	25.6	25.4	25.2	***
	D	25.6	26.0	25.8	ns
	E	26.2	26.0	25.9	ns
JULY 21	A	30.6	31.5	31.6	**
JULY 29	A	26.3	26.8	26.8	ns
	B	26.8	26.3	27.3	ns
	C	---	26.4	27.1	ns
	D,E,F,G	---	---	26.8	--
AUGUST 18	A	32.3	32.2	32.2	ns
	B	32.3	32.7	32.5	***
	C	32.5	---	32.4	ns
	D	32.4	32.0	32.2	*
	E	32.5	---	32.4	ns
ALL DAYS	A,B,C,D,E,F,G	29.0	28.4	27.6	**

Table 5.9. Mean net photosynthesis (μ mol m^{-2} s^{-1}) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. Measurements are for each of five days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

DATE	PAR CLASS	MEAN NET PHOTOSYNTHESIS (μ mol m-2 s-1) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
	A	---	---	---	—
JUNE 11	B	1.89	0.91	1.26	ns
	C	1.89	1.35	1.90	ns
	D	0.75	---	2.77	*
	E	2.3	3.64	2.59	ns
JUNE 29	A	---	---	---	
	B	0.60	0.70	0.97	*
	C	---	0.74	0.58	ns
	D	---	---	3.70	---
	E	---	---	---	---
	F	---	---	---	---
	G	3.50	---	2.15	*
JULY 06	A	1.04	---	0.79	ns
	B	---	---	3.72	---
	C	1.81	0.71	1.29	ns
	D	2.19	1.83	3.03	***
	E	2.73	3.18	2.78	ns
JULY 21	A	0.30	0.62	0.47	*
JULY 29	A	0.49	0.45	0.46	ns
	B	1.38	1.07	0.54	ns
	C	---	0.49	0.48	ns
	D,E,F	---	---	0.49	--
AUGUST 18	A	2.02	1.42	0.98	**
	B	1.46	0.68	1.03	***
	C	1.49	---	0.80	ns
	D	1.82	3.21	2.69	ns
	E	2.62	---	1.16	ns
ALL DAYS	A,B,C,D,E,F	1.82	1.23	1.58	**

Table 5.10. Mean stomatal conductance (cm s^{-1}) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. Measurements are for each of five days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

DATE	PAR CLASS	MEAN STOMATAL CONDUCTANCE (cm s^{-1})			
		ENTIRE	ONE LOBED	TWO LOBED	ANOVA
	A	---	---	---	--
JUNE 11	B	0.066	0.046	0.062	ns
	C	0.060	0.060	0.089	**
	D	0.039	---	0.257	ns
	E	0.071	0.113	0.086	*
JUNE 29	A	---	---	---	
	B	0.044	0.054	0.079	*
	C	---	0.084	0.061	ns
	D	---	---	0.185	--
	E	---	---	---	--
	F	---	---	---	--
	G	0.106	---	0.077	ns
JULY 06	A	0.145	---	0.111	ns
	B	---	---	0.133	--
	C	0.153	0.106	0.120	*
	D	0.126	0.101	0.175	**
	E	0.114	0.141	0.147	ns
JULY 21	A	0.219	0.245	0.277	ns
JULY 29	A	0.029	0.031	0.026	ns
	B	0.036	0.037	0.029	ns
	C	---	0.029	0.027	ns
	D,E,F	---	---	0.028	--
AUGUST 18	A	0.146	0.070	0.065	ns
	B	0.110	0.045	0.062	***
	C	0.097	---	0.055	ns
	D	0.097	0.205	0.164	***
	E	0.135	---	0.065	ns
ALL DAYS	A,B,C,D,E,F	0.101	0.096	0.108	ns

Table 5.11. Mean transpiration (x1000 mol m^{-2} s^{-1}) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. Measurements are for each of five days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

DATE	PAR CLASS	MEAN TRANSPIRATION (x 10-4 mol m^{-2} s^{-1}) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
	A	---	---	---	--
JUNE 11	B	6.9	6.0	6.6	ns
	C	6.3	6.3	8.9	*
	D	4.6	---	9.7	ns
	E	7.0	10.1	8.3	ns
JUNE 29	A	---	---	---	
	B	6.7	8.3	10.8	ns
	C	---	12.7	9.1	ns
	D	---	---	23.6	--
	E	---	---	---	--
	F	---	---	---	--
	G	14.8	---	11.3	**
JULY 06	A	12.5	---	10.8	ns
	B	---	---	11.0	--
	C	12.7	10.6	11.0	ns
	D	10.9	9.7	14.1	**
	E	11.0	11.5	12.8	ns
JULY 21	A	26.0	27.1	31.1	ns
JULY 29	A	2.7	3.0	2.5	ns
	B	3.3	3.1	2.6	ns
	C	---	2.5	2.8	ns
	D,E,F	---	---	2.8	--
AUGUST 18	A	13.0	6.7	6.2	***
	B	10.9	5.0	6.4	***
	C	9.4	---	5.5	ns
	D	9.1	17.5	14.5	***
	E	12.5	---	7.0	ns
ALL DAYS	A,B,C,D,E,F	9.9	10.3	11.0	ns

Table 5.12. Mean vapor pressure deficit (VPD; mb) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 μ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. Measurements are for each of five days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

	PAR	MEAN VPD (mb)			
DATE	CLASS	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
	A	---	---	---	--
JUNE 11	B	26.2	30.8	27.3	ns
	C	26.2	26.7	25.7	ns
	D	28.7	---	32.8	ns
	E	25.2	22.7	24.9	ns
JUNE 29	A	---	---	---	
	B	38.9	39.0	36.6	*
	C	---	39.4	38.5	ns
	D	---	---	34.1	--
	E	---	---	---	--
	F	---	---	---	--
	G	34.4	---	37.8	ns
JULY 06	A	22.2	---	25.2	*
	B	---	---	22.0	--
	C	22.3	25.4	23.6	ns
	D	22.9	24.7	21.5	**
	E	24.8	21.3	23.1	ns
JULY 21	A,B,C	32.1	31.4	32.1	ns
JULY 29	A	23.0	23.5	22.3	ns
	B	22.8	21.0	21.0	ns
	C	---	21.5	24.4	ns
	D,E,F	---	---	24.0	--
AUGUST 18	A	24.7	26.1	26.8	ns
	B	27.4	32.5	29.2	***
	C	27.5	---	29.2	ns
	D	26.2	23.5	24.5	ns
	E	26.1	---	28.2	ns
ALL DAYS	A,B,C,D,E,F	32.4	28.7	27.5	ns

3

Table 5.12. Mean water use efficiency (WUE; g kg^{-1}) for each PAR Class (A = 0 - 25; B = 25.1 - 50; C = 50.1 - 75; D = 75.1 - 100; E = 100.1 - 125; F = 125.1 - 150; G = 150.1 - 700 µ mol m^{-2} s^{-1}) for Entire, One Lobed and Two Lobed leaves of Sassafras. Measurements are for each of five days from June 11 to August 18, 1987. Sample sizes (number of measurements) are in Table 5.6.

Genet BR 590

DATE	PAR CLASS	MEAN WATER USE EFFICIENCY (g kg^{-1}) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
	A	---	---	---	--
JUNE 11	B	6.785	---	4.731	*
	C	7.406	5.288	5.481	ns
	D	4.045	---	7.113	*
	E	8.17	8.848	7.457	ns
JUNE 29	A	---	---	---	
	B	2.186	2.108	2.226	ns
	C	---	1.415	1.54	ns
	D	---	---	3.9	--
	E	---	---	---	--
	F	---	---	---	--
	G	5.91	---	4.636	*
JULY 06	A	2.033	---	1.774	ns
	B	---	---	8.076	--
	C	3.614	1.562	2.803	*
	D	4.891	7.184	5.52	ns
	E	6.043	6.518	5.52	ns
JULY 21	A,B,C	0.277	0.549	0.363	*
JULY 29	A	4.396	3.743	4.82	ns
	B	10.231	8.2	4.933	ns
	C	---	4.741	4.302	ns
	D,E,F	---	---	4.245	--
AUGUST 18	A	4.033	5.101	3.841	ns
	B	3.469	3.335	4.056	ns
	C	3.832	---	3.563	ns
	D	4.759	4.482	4.514	ns
	E	5.139	---	4.051	ns
ALL DAYS	A,B,C,D,E,F	4.892	3.8	4.156	**

Photosynthesis versus nodal position

Figure 5.4 is a scatterplot of all net photosynthesis data versus leaf age (nodal position). Linear and curvilinear least squares regressions were not significant for this data. The data were then separated by date of measurement and analyzed for nodal trends by regression. Figure 5.5 represents the data for this genet collected on June 11, 1987, and a second degree polynomial regression gave a statistically significant increase in the coefficient of determination over the linear model. This was also the case for the data for June 29 (Figure 5.6), July 6 (Figure 5.7), July 21 (Figure 5.8), July 29 (Figure 5.9) and August 18 (Figure 5.10). This data bears no "correction" for variation in PAR, and the smallest leaves, usually at the proximal and distal ends of the shoot were not used for the measurement of photosynthesis as they were too small to be placed in the cuvette. Between June 11 and July 21, the shape of the regression fit suggests that leaves of the intermediate nodes have the greatest net photosynthetic rates per unit leaf area. The PAR incident on leaves near the tips of shoots tends to be more variable (less dense shade, more sunflecks) than that of leaves near the bases of shoots, and hence there is a tendency for more scatter in net photosynthesis measurements made on these leaves. The measurements of July 29 and August 18 indicate that leaves of the distal nodes have greater net photosynthetic rates than do leaves at the proximal or intermediate nodes. This suggests that as the growing season progresses, there is a gradual shift in the nodal position of greatest net photosynthetic potential from the proximal to the intermediate (where it remains for the longest time) to the distal nodes along a shoot.

However, net photosynthetic productivity, on the basis of nodal position, is also dependent upon the surface area of a leaf at a particular nodal position. Figure 5.11 displays trajectories for net photosynthesis of leaves at nodal positions versus leaf area. The product of mean net photosynthetic rate and leaf area (see Chapter 3), for leaves at each nodal position, was used to generate the y-coordinate values used in this graph. Nodal positions are indicated at intervals on the individual trajectories, for ease of identification. This information suggests that the photosynthetic performance of leaves is relatively symmetrical on either side of the most productive leaves, and that these most productive leaves are usually to be found in the region of nodes six through ten (between June 11 and August 18). It is interesting to note that for the data of August 18, despite the decline in relative net photosynthesis at the intermediate nodes (Figure 5.10), the increase in leaf area observed for these same nodes (Figure 3.16) results in leaves at these nodes maintaining their position as the most productive. The data from net photosynthesis measurements made on July 21 and July 29, 1987 were not used here due to their small sample size.

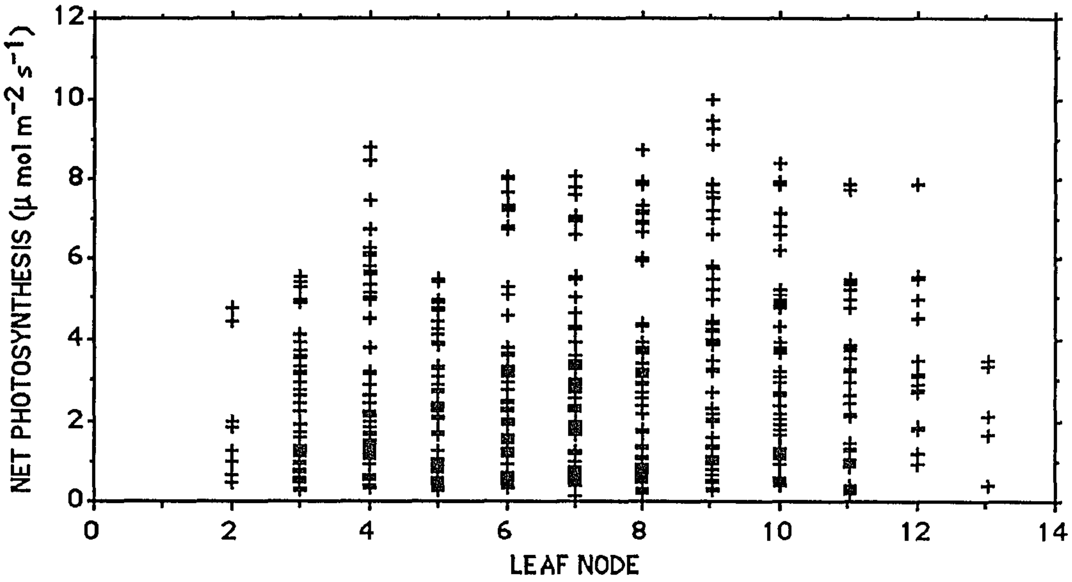

Figure 5.4. Scatterplot of photosynthetic rates for leaves at nodes along shoots of genet BR 590. The data shown here is for measurements taken on six days in 1987. Linear and curvilinear regressions were not significant.

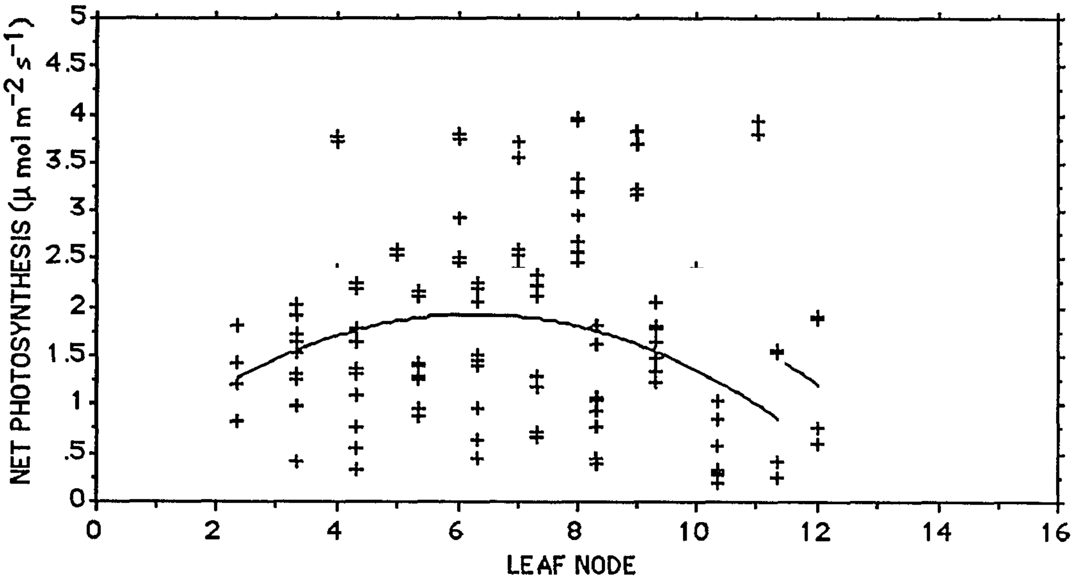

Figure 5.5. Scatterplot of net photosynthetic rates on June 11, 1987 for leaves at nodes along shoots of genet BR 590 with a second degree least squares regression (F=4.528 (2,95 df),r^2 = 0.087, p <0.05) superimposed.

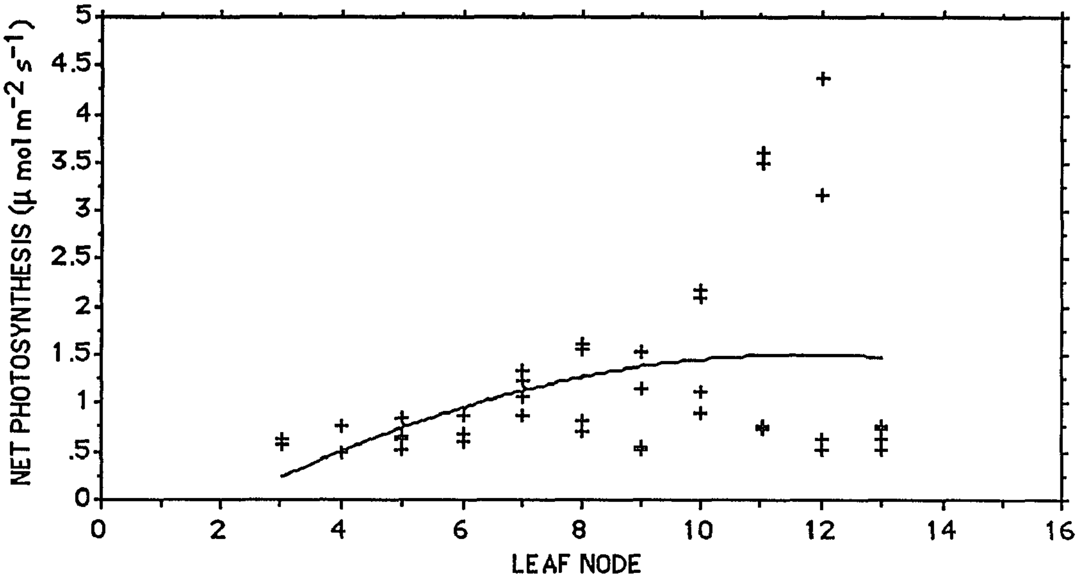

Figure 5.6. Scatterplot of net photosynthetic rates on June 29, 1987 for leaves at nodes along shoots of genet BR 590 with a second degree least squares regression (F=3.337 (2,37 df),r^2 = 0.153, p<0.05) superimposed.

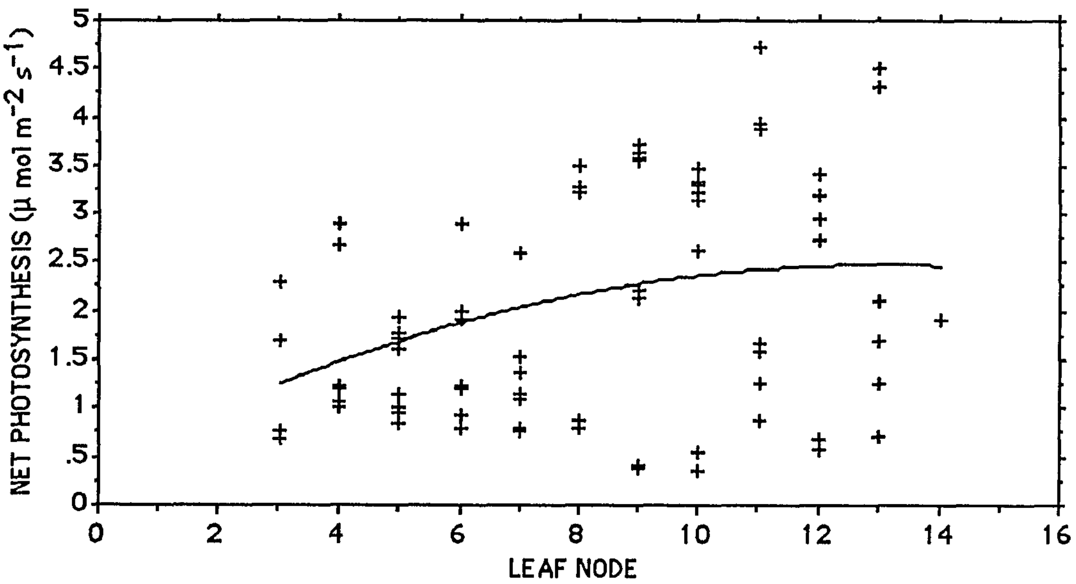

Figure 5.7. Scatterplot of net photosynthetic rates on July 6, 1987 for leaves at nodes along shoots of genet BR 590 with a second degree least squares regression (F=4.681 (2,77 df),r^2 = 0.108, p<0.05) superimposed.

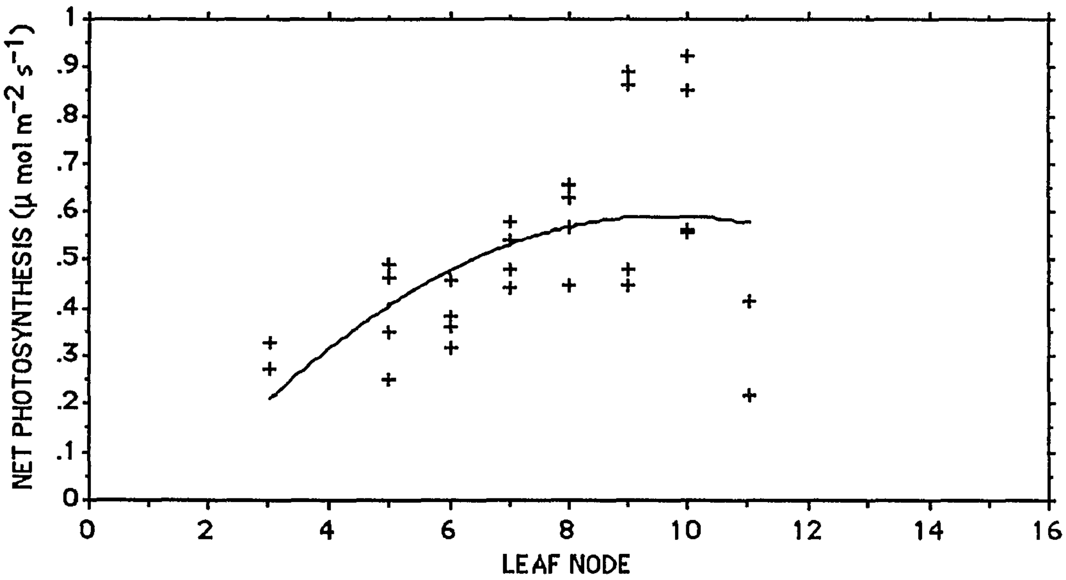

Figure 5.8. Scatterplot of net photosynthetic rates on July 21, 1987 for leaves at nodes along shoots of genet BR 590 with a second degree least squares regression (f=5.587 (2,25 df), $r^2 = 0.309$, $p<0.01$) superimposed.

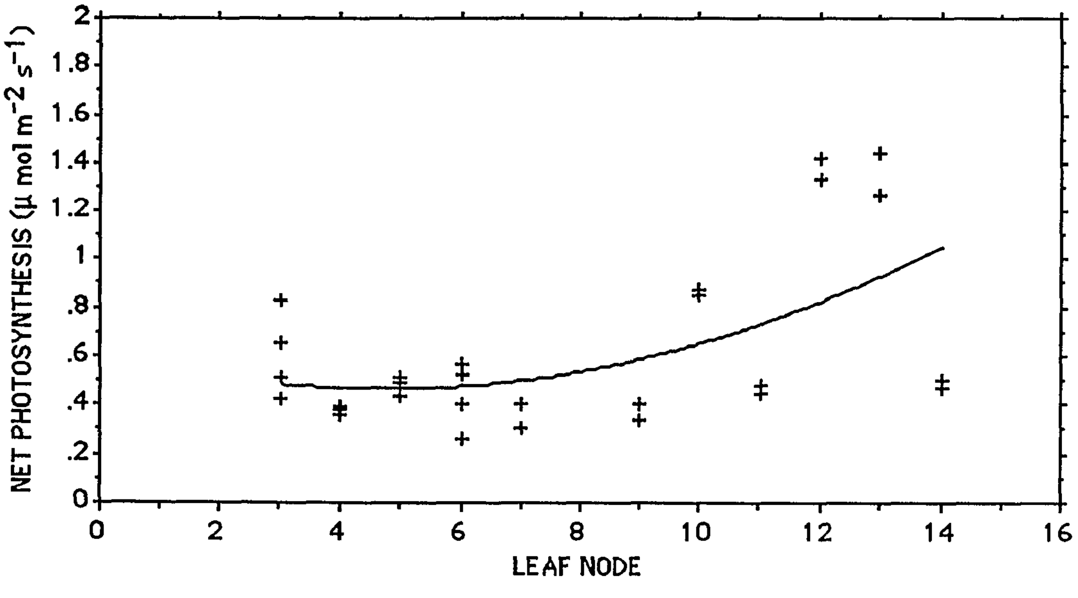

Figure 5.9. Scatterplot of net photosynthetic rates on July 29, 1987 for leaves at nodes along shoots of genet BR 590 with a second degree least squares regression (F=6.276 (2,27 df), $r^2 = 0.317$, $p<0.01$) superimposed.

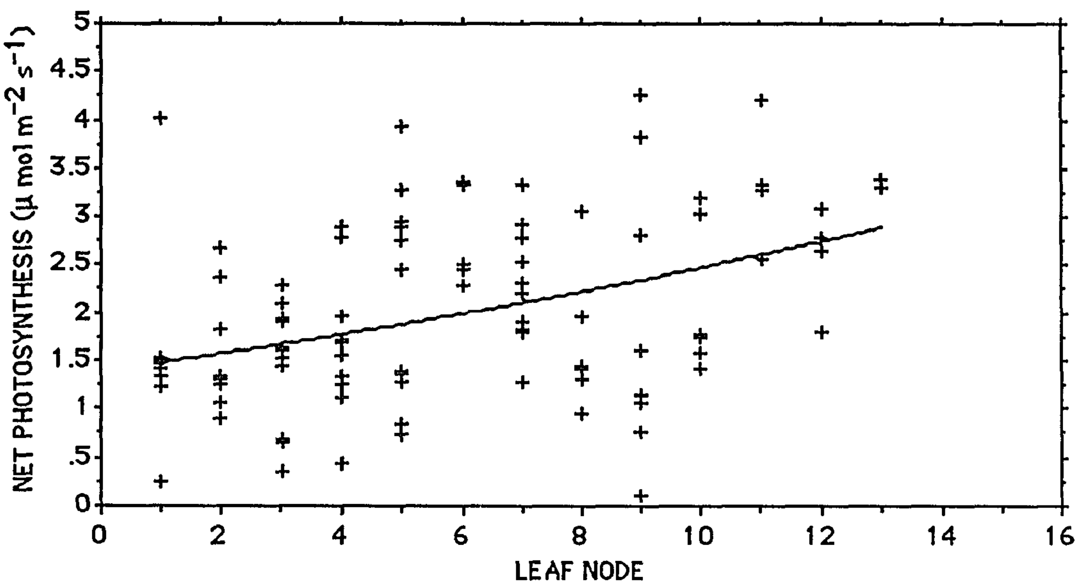

Figure 5.10. Scatterplot of net photosynthetic rates on August 18, 1987 for leaves at nodes along shoots of genet BR 590 with a second degree least squares regression (F=8.466 (2,94 df), r^2 = 0.153, p<0.001) superimposed.

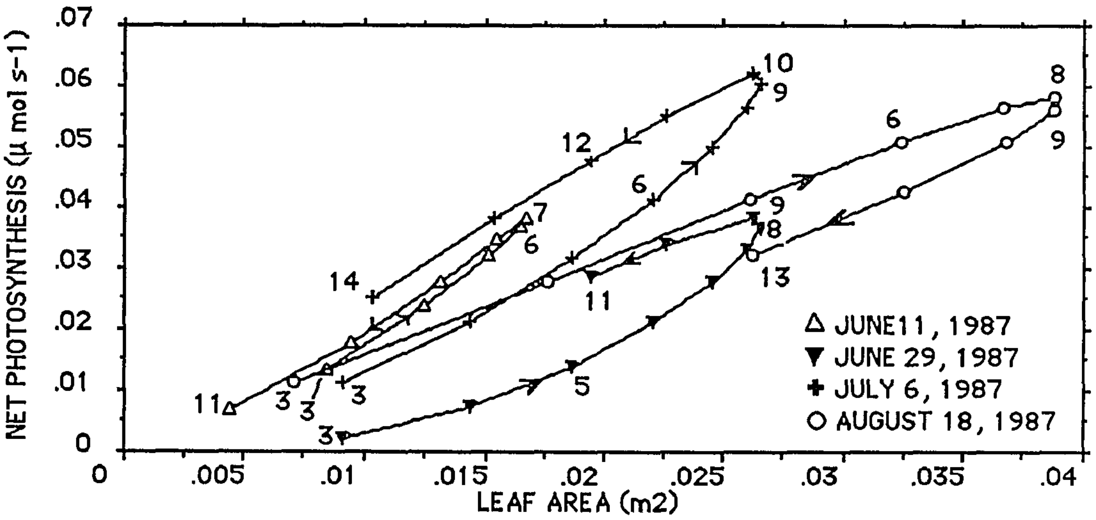

Figure 5.11. Trajectories for genet BR 590 of mean net whole leaf photosynthesis (μ mol s-1) of at nodal positions along shoots versus mean leaf area (m2) on four days. Nodal positions are indicated at intervals along each trajectory, as is the direction, from proximal to distal nodes, by arrows on each trajectory.

Genet 591

Photosynthesis versus Leaf Shape

This genet is larger in stature than genets 99 and 100 (see Table 3.2) and grows on the North Bank of the Bronx River, where it is a canopy dominant. The upper reaches of the canopy receives direct sunlight throughout the day, but is out of reach for photosynthesis measurement. Lower down, 2 - 3 meters above the ground, lateral branches display leaves with a North-Westerly aspect which receive full sunlight from midday onwards (approximately). Photosynthesis was measured for these leaves. During sampling of photosynthetic rates, the incident photosynthetically active radiation (PAR) ranged from 12.7 to 1700.0 μ mol m^{-2} s^{-1}.

The overall data for this genet (Table 5.14) indicate that there were no significant differences with leaf shapes in PAR, air and leaf temperature, vapor pressure deficit and water use efficiency, but that significant differences did exist among leaf shapes in stomatal conductance and transpiration rates. Leaves with two lobes had the highest rates for all three of these factors. The data were then separated on the basis of PAR classes (A = 0-50; B = 50.1-100; C = 100.1-200; D = 200.1-500; E = 500.1-1000; F = 1000.1-2000 μ mol m-2 sec-1) for each day measurements were taken (June10 , 17 & 24, July 21 & 29, August 12), and Analysis of Variance (ANOVA) performed. The PAR data are shown in Table 5.15 where significant differences are found on July 21, PAR class A, July 29, PAR class [A,B,C,D] and PAR class F, and August 12, PAR class F. While these differences are also seen in the air and leaf temperature data (Tables 5.16 and 5.17), leaves with two lobes have significantly greater temperatures on June 11, PAR class A, June 17, PAR class D, and August 12, PAR classes

A and E. On June 24, at PAR classes B and D, leaves with entire margins have significantly greater temperatures. However, net photosynthesis is significantly different among leaf shapes in only one instance (Table 5.18), June 24 at PAR class F, when leaves with two lobes have a net photosynthetic rate greater than leaves with one lobe. Overall, leaves with two lobes appear to have the greatest net photosynthetic rates, albeit not statistically significantly so, given my sample sizes. Stomatal conductance (Table 5.19) also is greatest in two lobed leaves on June 24, at PAR class F, as it is on June 10, class A; June 17, class A; and June 24, classes C and D, but on these occasions with no corresponding enhancement of net photosynthesis. During the early to mid growing season, leaves with two lobes have greater stomatal conductances, although not always significantly so (Table 5.19), even when leaf temperatures, and thus PAR incident upon the leaf, is greater for leaves with entire margins. However, by August 12, at high incident PAR (classes E and F), leaves with two lobes have significantly higher leaf temperature (Table 5.17) but lower stomatal conductances (Table 5.19). Although stomatal conductances are high, mean transpiration is low for entire margin leaves on August 12 (Table 5.20) and this leads to the very high values for water use efficiency on this day (Table 5.22).

Table 5.14. Mean photosynthetically active radiation (PAR), air temperature (T_{air}), leaf temperature (T_{leaf}), photosynthesis (PHOTO), stomatal conductance (RS), transpiration (TRNM) vapor pressure deficit (VPD) and water use efficiency (WUE) for Entire, One lobed and Two lobed leaves of genet BR591 measured between June 10 and August 12, 1987. Sample size indicates the total number of measurements taken.

	MEAN VALUE FOR LEAVES SHAPED			
VARIABLE	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
PAR (μ mol m^{-2} s^{-1})	316.3	405.3	377.9	ns
T_{air} (^{o}C)	26.6	26.9	27.2	ns
T_{leaf} (^{o}C)	27.1	27.4	27.8	ns
PHOTO (μ mol m^{-2} s^{-1})	2.4	2.7	3.0	ns
CS (cm s^{-1})	0.103	0.105	0.134	***
TRNM ($x10^{-4}$ mol m^{-2} s^{-1})	11.4	11.4	14.4	***
VPD (mb)	26.1	26.3	25.9	ns
WUE (g kg^{-1})	5.561	5.537	5.173	ns
SAMPLE SIZE	121	52	346	

Table 5.15. Mean photosynthetically active radiation(PAR; μ mol m^{-2} s^{-1}) for each PAR Class (A = 0-50; B = 50.1-100; C = 100.1-200; D = 200.1-500; E = 500.1-1000; F = 1000.1-2000 μ mol m^{-2} sec^{-1}) for Entire, One and Two Lobed leaves of Sassafras. PAR was measured on each of 6 days from June 10, 1987 through August 12, 1987, for genet BR 591. Sample size is indicated within parentheses.

BR 591

DATE	PAR CLASS	MEAN PAR (μ mol m^{-2} s^{-1}) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	28.1(13)	31.3(5)	31.3(26)	ns
	B	65.3(2)	81.9(1)	63.8(6)	ns
	C	125.0(1)	---	157.6(5)	ns
	D	395.8(2)	---	336.9(9)	ns
	E	729.6(6)	765.8(2)	877.5(12)	ns
	F	1124.0(2)	---	1134.4(10)	ns
JUNE 17	A	25.5(9)	28.7(8)	29.0(17)	ns
	B	74.0(6)	---	68.6(13)	ns
	C	147.3(2)	---	145.0(10)	ns
	D	320.9(4)	323.4(2)	282.2(11)	ns
	E	691.6(4)	709.2(6)	690.8(30)	ns
	F	1225.0(2)	---	1157.0(3)	ns
JUNE 24	A	33.7(12)	30.7(3)	32.8(19)	ns
	B	80.5(2)	71.6(1)	74.7(9)	ns
	C	181.5(3)	---	147.9(9)	ns
	D	302.7(7)	300.8(2)	282.8(6)	ns
	E	657.4(4)	945.9(1)	739.8(13)	ns
	F	---	1007.0(1)	1098(2)	ns
JULY 21	A	12.7(2)	17.1(2)	20.0(12)	***
JULY 29	A,B,C,D	199.3(2)	---	405.2(4)	**
	E	---	776.0(2)	741.9(6)	ns
	F	1367.0(2)	1176.3(4)	1407.4(12)	***
AUGUST 12	A	22.3(20)	14.0(6)	19.7(61)	ns
	B	93.8(1)	---	65.9(5)	ns
	C	175.1(1)	125.9(1)	152.2(7)	ns
	D	279.7(2)	336.2(1)	329.6(6)	ns
	E	821.4(2)	608.9(2)	756.4(5)	ns
	F	1354.5(8)	1700.0(2)	1447.3(18)	**
ALL DAYS	A,B,C,D,E,F	316.3(121)	405.3(52)	377.9(346)	ns

Table 5.16. Mean air temperature (^{o}C) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 u mol m^{-2} sec^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR591

DATE	PAR CLASS	MEAN AIR TEMPERATURE (^{o}C) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	22.9	22.1	23.4	*
	B	24.6	21.8	23.5	ns
	C	25.9	---	23.8	ns
	D	24.8	---	24.1	ns
	E	28.0	27.7	28.2	ns
	F	28.1	---	28.5	ns
JUNE 17	A	24.8	26.1	25.1	ns
	B	27.1	---	26.3	ns
	C	26.5	---	26.2	ns
	D	27.1	23.8	27.3	*
	E	30.2	30.1	30.5	ns
	F	32.7	---	29.8	ns
JUNE 24	A	26.9	25.2	26.4	ns
	B	28.7	25.3	27.4	ns
	C	28.4	---	27.4	ns
	D	29.8	28.5	28.3	**
	E	29.7	31.6	31.4	ns
	F	---	32.0	32.6	ns
JULY 21	A	30.6	31.0	31.5	***
JULY 29	A,B,C.D	27.9	---	28.5	*
	E	---	29.5	29.3	ns
	F	29.6	30.3	31.5	***
AUGUST 12	A	24.2	24.1	24.8	*
	B	24.8	---	26.0	ns
	C	24.3	28.4	25.4	ns
	D	25.3	28.4	26.8	ns
	E	26.1	25.8	27.8	*
	F	29.1	28.2	31.0	**
ALL DAYS	A,B,C,D,E,F	26.6	29.6	27.2	ns

Table 5.17. Mean leaf temperature (°C) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 u mol m^{-2} sec^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR 591

DATE	PAR CLASS	MEAN LEAF TEMPERATURES (°C) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	22.9	22.2	23.5	*
	B	24.8	22.4	23.6	ns
	C	26.2	—	24.1	ns
	D	25.4	---	24.3	ns
	E	28.9	29.7	29.5	ns
	F	29.8	—	30.0	ns
JUNE 17	A	24.9	26.0	25.1	ns
	B	27.2	—	26.5	ns
	C	26.5	---	26.4	ns
	D	27.2	23.8	27.7	*
	E	31.2	31.0	31.4	ns
	F	34.8	—	31.1	ns
JUNE 24	A	27.3	25.2	26.3	ns
	B	28.8	25.2	27.3	*
	C	28.5	---	27.4	ns
	D	30.5	28.8	28.2	**
	E	30.3	32.9	32.7	ns
	F	---	33.5	34.2	ns
JULY 21	A	30.2	31.0	31.5	***
JULY 29	A,B,C,D	28.5	---	29.4	**
	E	---	30.0	30.0	ns
	F	31.1	31.8	33.9	***
AUGUST 12	A	24.2	24.2	24.8	*
	B	24.7	---	26.2	ns
	C	24.3	29.3	26.8	ns
	D	25.4	29.3	27.8	ns
	E	26.3	26.0	29.6	*
	F	31.9	30.8	34.0	**
ALL DAYS	A,B,C,D,E,F	27.1	27.4	27.8	ns

Table 5.18. Mean net photosynthesis (μ mol m^{-2} s^{-1}) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 μmol m^{-2} sec^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR 591

	PAR	MEAN NET PHOTOSYNTHESIS (μ mol m^{-2} s^{-1})			
DATE	CLASS	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	1.14	0.96	1.47	ns
	B	2.50	1.28	1.76	ns
	C	3.71	—	2.93	ns
	D	3.37	---	2.78	ns
	E	5.12	4.34	5.23	ns
	F	7.26	—	5.80	ns
JUNE 17	A	0.71	1.26	1.05	ns
	B	2.29	—	2.28	ns
	C	1.68	---	3.13	ns
	D	3.02	2.27	3.65	ns
	E	4.55	5.59	6.23	ns
	F	2.93	—	4.48	ns
JUNE 24	A	1.72	1.75	1.60	ns
	B	2.41	1.26	2.98	ns
	C	2.37	---	3.15	ns
	D	2.88	3.55	3.96	ns
	E	4.05	2.03	4.48	ns
	F	---	2.08	3.84	*
JULY 21	A	0.30	0.30	0.49	ns
JULY 29	A,B,C,D	2.70	---	3.36	ns
	E	---	5.78	6.50	ns
	F	1.35	4.43	5.28	ns
AUGUST 12	A	0.83	0.54	1.17	ns
	B	0.76	---	1.18	ns
	C	1.68	4.29	5.94	ns
	D	7.77	4.26	4.03	ns
	E	6.31	3.40	3.77	ns
	F	3.96	5.46	3.25	ns
ALL DAYS	A,B,C,D,E,F	2.41	2.69	3.02	ns

Table 5.19. Mean stomatal conductance (cm s^{-1}) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 u mol m-2 sec-1) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR 591

	PAR	MEAN STOMATAL CONDUCTANCES (cm s^{-1})			
DATE	CLASS	ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	0.111	0.079	0.145	***
	B	0.160	0.038	0.145	*
	C	0.197	—	0.165	ns
	D	0.146	---	0.176	ns
	E	0.190	0.177	0.199	ns
	F	0.246	—	0.210	ns
JUNE 17	A	0.041	0.065	0.065	*
	B	0.080	—	0.091	ns
	C	0.059	---	0.106	ns
	D	0.096	0.068	0.111	ns
	E	0.132	0.153	0.172	ns
	F	0.096	—	0.106	ns
JUNE 24	A	0.104	0.101	0.116	ns
	B	0.121	0.100	0.152	ns
	C	0.091	---	0.167	**
	D	0.104	0.109	0.198	**
	E	0.132	0.065	0.146	ns
	F	---	0.063	0.110	*
JULY 21	A	0.219	0.252	0.317	ns
JULY 29	A,B,C,D	0.097	---	0.088	ns
	E	---	0.110	0.186	ns
	F	0.049	0.122	0.153	ns
AUGUST 12	A	0.063	0.500	0.078	ns
	B	0.075	---	0.063	ns
	C	0.075	0.129	0.118	ns
	D	0.054	0.132	0.155	ns
	E	0.155	0.141	0.110	ns
	F	0.134	0.146	0.105	ns
ALL DAYS	A,B,C,D,E,F	0.103	0.105	0.134	ns

Table 5.20. Mean transpiration (x 10^{-4} mol m^{-2} s^{-1}) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 u mol m^{-2} sec^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR 591

DATE	PAR CLASS	MEAN TRANSPIRATION (x 10^{-4} mol m^{-2} s^{-1}) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	10.2	7.2	12.8	**
	B	15.2	0.4	12.9	ns
	C	19.0	---	14.5	ns
	D	14.7	---	15.5	ns
	E	22.8	22.2	24.8	ns
	F	30.2	---	26.5	ns
JUNE 17	A	4.7	7.7	6.7	ns
	B	9.4	---	10.1	ns
	C	6.7	---	11.3	ns
	D	10.9	6.1	12.7	ns
	E	18.2	19.8	23.1	ns
	F	17.6	---	15.3	ns
JUNE 24	A	11.9	9.2	11.9	ns
	B	12.9	10.1	15..0	ns
	C	11..5	---	162	*
	D	136	11.6	18.9	*
	E	15.7	10.0	19.6	ns
	F	---	10.0	17.3	ns
JULY 21	A	26.0	28.4	34.0	*
JULY 29	A,B,C,D	8.9	---	8.5	ns
	E	---	11.4	17.5	ns
	F	5.8	13.4	20.4	*
AUGUST 12	A	3.9	3.5	5.4	*
	B	5.0	---	4.8	ns
	C	5.0	12.0	9.1	ns
	D	3.5	12.0	13.2	ns
	E	7.5	9.5	10.4	ns
	F	15.5	16.0	14.4	ns
ALL DAYS	A,B,C,D,E,F	11.4	11.4	14.4	***

Table 5.21. Mean vapor pressure deficit (mb) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 u mol m^{-2} sec^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR591

DATE	PAR CLASS	MEAN VAPOR PRESSURE DEFICIT (mb)			ANOVA
		ENTIRE	ONE LOBED	TWO LOBED	
JUNE 10	A	22.8	22.9	22.8	ns
	B	24.2	24.7	22.7	ns
	C	25.4	—	22.5	ns
	D	24.8	---	22.7	ns
	E	29.5	28.4	29.8	ns
	F	29.0	—	30.4	ns
JUNE 17	A	28.7	29.7	27.5	ns
	B	29.8	—	27.5	ns
	C	28.3	---	27.1	ns
	D	28.4	23.1	28.8	*
	E	34.0	33.0	33.7	ns
	F	41.6	—	34.3	ns
JUNE 24	A	28.7	23.3	27.4	ns
	B	28.5	25.9	25.9	ns
	C	32.6	---	25.7	***
	D	32.5	26.8	26.0	**
	E	29.5	34.6	32.9	ns
	F	---	38.9	36.5	ns
JULY 21	A	32.1	31.1	30.3	ns
JULY 29	A,B,C,D	22.1	---	22.9	ns
	E	---	25.6	23.4	**
	F	26.1	26.7	29.1	***
AUGUST 12	A	18.1	19.7	19.3	*
	B	18.6	---	20.9	ns
	C	17.1	25.4	20.6	ns
	D	19.0	25.4	22.0	ns
	E	18.8	18.2	26.0	*
	F	32.1	29.1	37.3	*
ALL DAYS	A,B,C,D,E,F	26.1	26.3	25.9	ns

Table 5.22. Mean water use efficiency (WUE; g kg^{-1}) for each PAR Class (A = 0 - 50; B = 50.1 - 100; C = 100.1 - 200; D = 200.1 - 500; E = 500.1 - 1000; F = 1000.1 - 2000 u mol m^{-2} sec^{-1}) for Entire, One Lobed and Two Lobed Leaves of Sassafras. Measurements are for each of six days from June 10 to August 12, 1987. Sample sizes (number of measurements) are in Table 5.15.

BR 591

DATE	PAR CLASS	MEAN WATER USE EFFICIENCY (g kg^{-1}) ENTIRE	ONE LOBED	TWO LOBED	ANOVA
JUNE 10	A	3.044	3.767	2.747	ns
	B	3.658	8.032	3.431	*
	C	4.695	---	4.793	ns
	D	5.613	---	4.416	ns
	E	5.495	4.779	5.018	ns
	F	5.889	---	5.287	ns
JUNE 17	A	3.609	3.379	4.24	ns
	B	5.788	---	5.738	ns
	C	5.896	---	7.264	ns
	D	6.925	9.055	7.321	ns
	E	6.11	6.866	6.544	ns
	F	4.068	---	7.252	ns
JUNE 24	A	3.336	4.76	3.217	ns
	B	4.615	3.043	4.747	ns
	C	5.986	---	4.818	ns
	D	4.89	7.524	5.093	*
	E	6.063	5.09	5.572	ns
	F	---	4.834	5.44	ns
JULY 21	A	0.286	0.257	0.353	ns
JULY 29	A,B,C,D	7.423	---	9.668	*
	E	---	12.397	9.194	*
	F	5.754	6.517	6.166	ns
AUGUST12	A	5.271	3.77	4.976	ns
	B	3.703	---	5.818	ns
	C	8.228	8.745	14.913	ns
	D	54.346	8.674	9.861	***
	E	22.619	8.854	8.748	ns
	F	5.52	8.348	5.493	ns
ALL DAYS	A,B,C,D,E,F	5.641	5.537	5.173	ns

Photosynthesis versus nodal position

Figure 5.12 is a scatterplot of all the net photosynthesis data versus nodal position. Linear and curvilinear least squares regressions were not significant for this data. The data were then separated by date of measurement and analyzed for nodal trends. Figure 5.13 represents the data for genet 591 collected on June 10, 1987, and a third degree polynomial regression gave a significant increase in the coefficient of determination over the second degree model. With the data for June 17 (Figure 5.14) and June 24 (Figure 5.15), a second degree model was most suited. With the data for July 21 (Figure 5.16) and July 29 (Figure 5.17), third degree polynomials provided a significant increase in the coefficient of determination over the second degree model while for the August 18 data (Figure 5.10), a second degree model was best suited. This data, as was the case for the data from genet BR 590, bears no "correction" for variation in PAR, and the smallest leaves, usually at the proximal and distal ends of the shoot were not used for the measurement of photosynthesis as they were too small to fit into the cuvette. Between June 10 and July 17, the shape of the regression suggests that leaves of the intermediate nodes have the greatest net photosynthetic rates per unit leaf area. The PAR environment of leaves near the tips of shoots tends to be more variable (less dense shade, more sunflecks) than that of leaves near the bases of shoots, and hence there is a tendency for more scatter in net photosynthesis measurements made on these leaves. The data for June 24 (Figure 5.15) indicate that leaves of the distal nodes have greater net photosynthetic rates than do leaves at the proximal or intermediate nodes, but this is probably due to higher PAR incident on the most distal leaves for which net photosynthesis was measured. Regressions generated for July 21 (Figure 5.16) and July 29 (Figure 5.17) are very susceptible to fluctuations in environmental factors (especially PAR) due to the small sample size, but they indicate that the nodal trend observed earlier in the growing season is maintained. This is confirmed by the data for August

12 (Figure 5.18) when a second degree polynomial regression was found to be the best model; and the pattern of greatest photosynthetic rates at leaves of the intermediate nodes is maintained.

Photosynthetic productivity is also dependent upon the area of the leaf. Figure 5.19 displays trajectories for net photosynthesis of leaves at nodal positions versus leaf area. The product of mean net photosynthetic rate and leaf area (see Chapter 3), for leaves at each nodal position, was used to generate the values used in this graph. Nodal positions are indicated at intervals on the individual trajectories, for ease of identification. This information suggests that the net photosynthetic performance of leaves is relatively symmetrical on either side of the most productive leaves, and that these most productive leaves are usually to be found in the region of nodes six through ten (between June 10 and August 12). In this genet, there is no sudden increase in leaf area in August, and yet the shapes of the trajectories are remarkably similar to those found in genet BR 590, as are the most productive nodes.

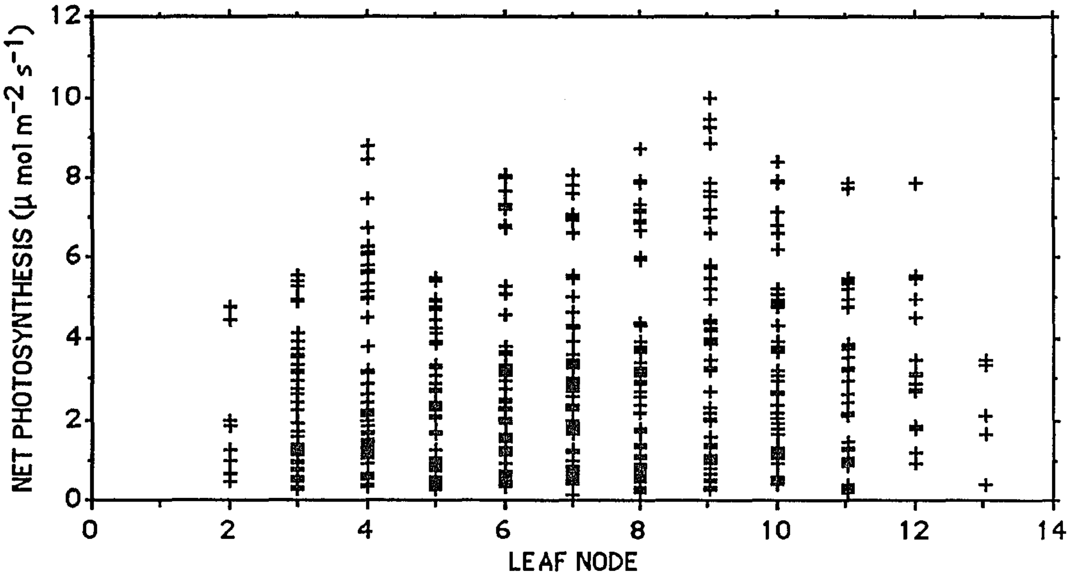

Figure 5.12. Scatterplot of photosynthetic rates for leaves at nodes along shoots of genet BR 591. The data shown here is for 519 measurements taken on six days between June 10 and August 12, 1987. Linear and curvilinear regressions were not significant.

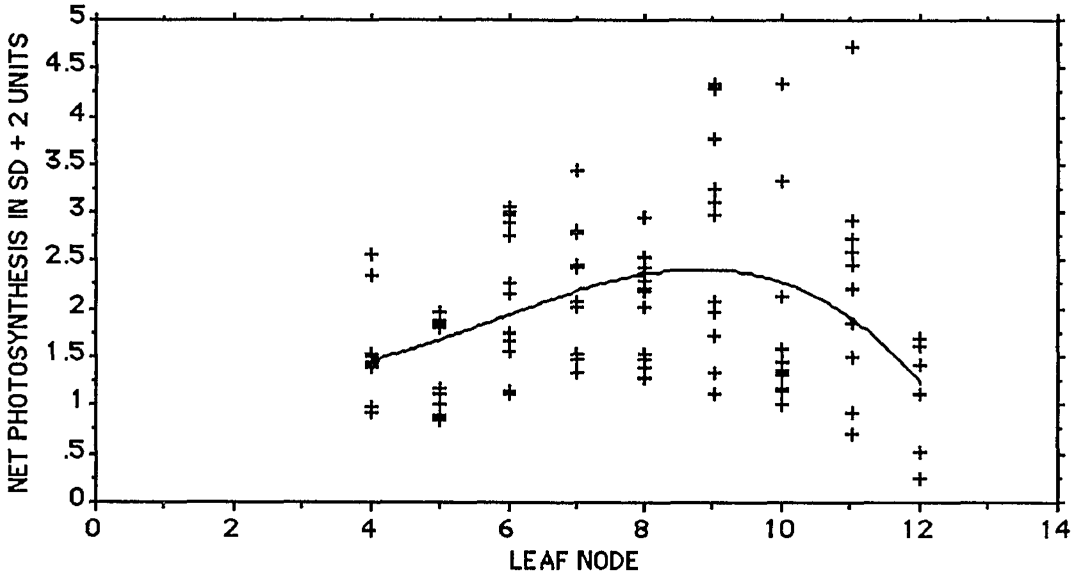

Figure 5.13. Scatterplot of net photosynthetic rates on June 10, 1987 expressed as standard deviation units + 2, for leaves at nodes along shoots of genet BR 591 with a third degree least squares regression (F=7.642 (3,88 df), r^2 = 0.141, p<0.001) superimposed.

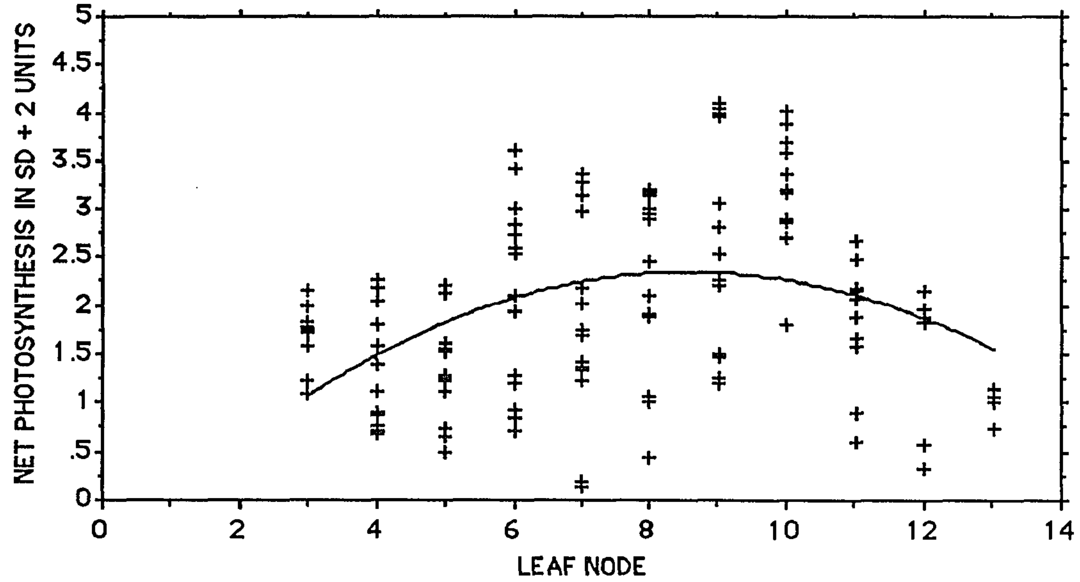

Figure 5.14. Scatterplot of net photosynthetic rates on June 17, 1987 expressed as standard deviation units + 2, for leaves at nodes along shoots of genet BR 591 with a second degree least squares regression (F=11.546(2,124 df), $r^2 = 0.157$, $p<0.001$) superimposed.

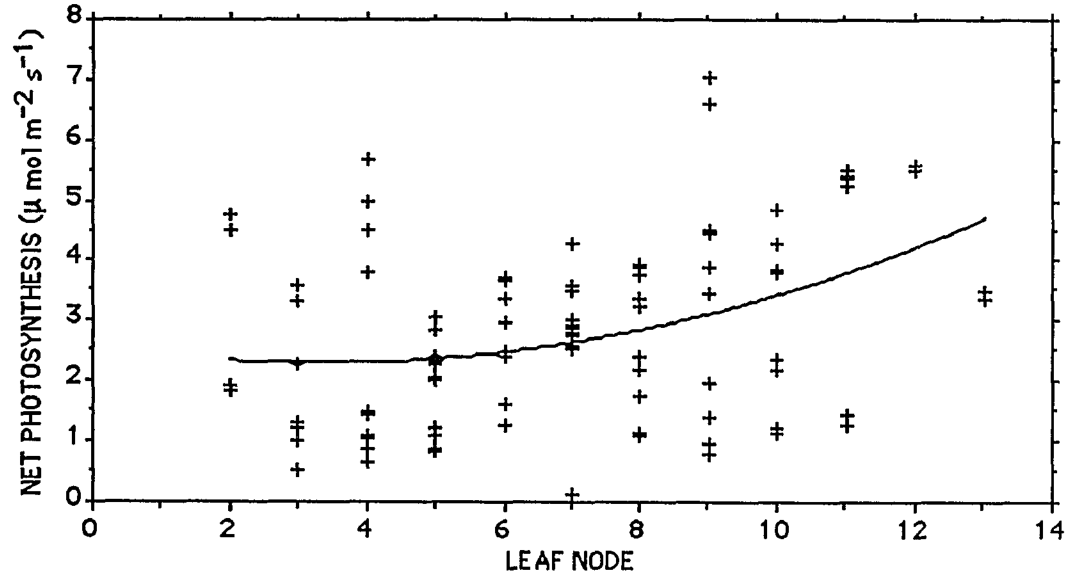

Figure 5.15. Scatterplot of net photosynthetic rates on June 24, 1987 for leaves at nodes along shoots of genet BR 591 with a second degree least squares regression (F=7.18 (2,89 df), $r^2 = 0.157$, $p<0.01$) superimposed.

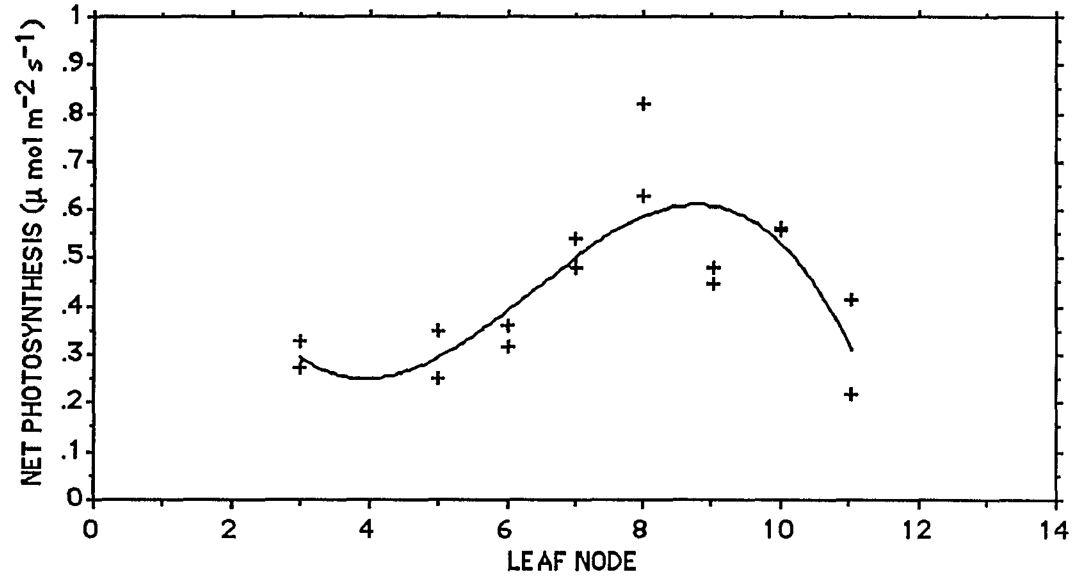

Figure 5.16. Scatterplot of net photosynthetic rates on July 21, 1987 for leaves at nodes along shoots of genet BR 591 with a third degree least squares regression (F=7.164 (3,12 df), r^2 =0.642, p<0.01) superimposed.

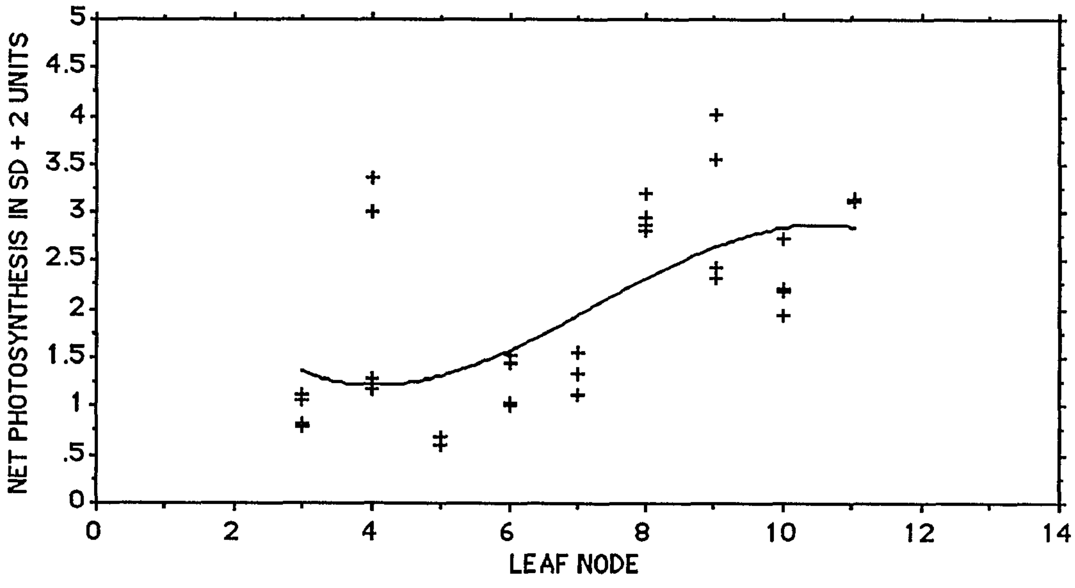

Figure 5.17. Scatterplot of net photosynthetic rates on July 29, 1987 expressed standard deviation units + 2, for leaves at nodes along shoots of genet BR 591 with a third degree least squares regression (F=6.3(3,28 df), r^2 = 0.402, p<0.01) superimposed.

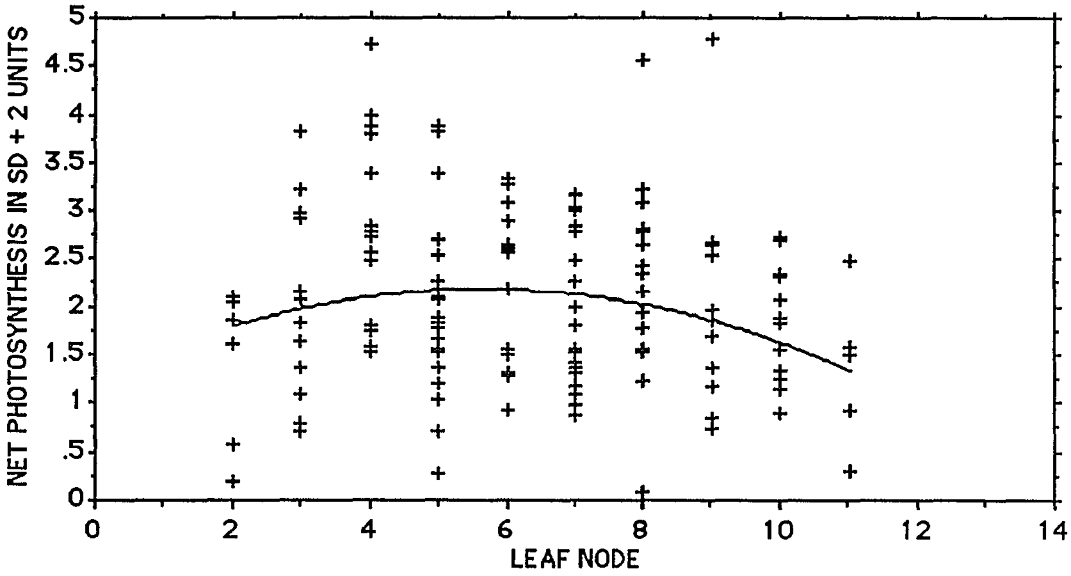

Figure 5.18. Scatterplot of net photosynthetic rates on August 12, 1987 expressed standard deviation units + 2, for leaves at nodes along shoots of genet BR 591 with a second degree least squares regression (F=3.65(2,143 df), r^2 = 0.048, p<0.05) superimposed.

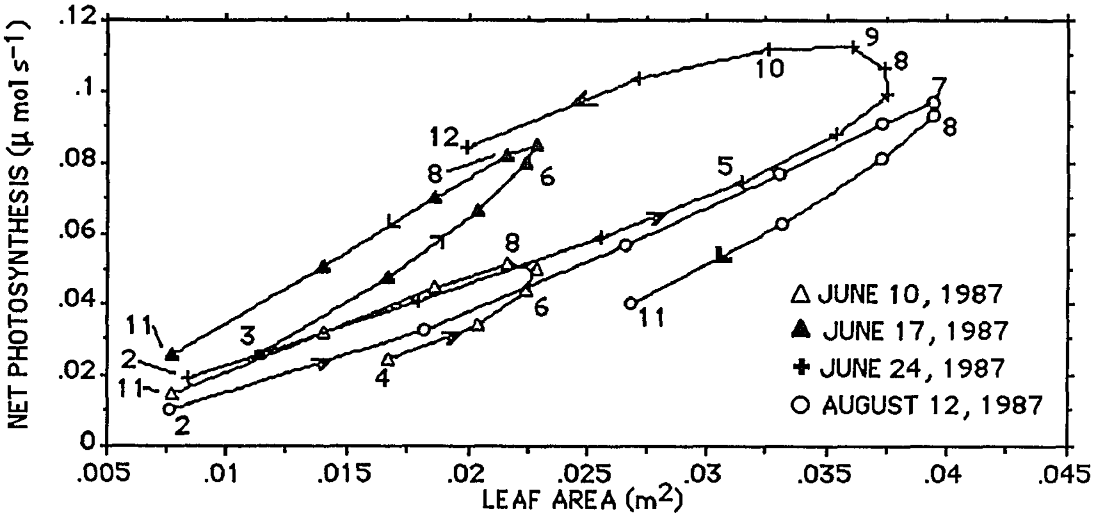

Figure 5.19. Trajectories for genet BR 591 of mean (whole leaf) net photosynthesis (μ mol s-1) of leaves at nodal positions along shoots versus mean leaf area (m2) on four days. Nodal positions are indicated at intervals along each trajectory, as is the direction, from proximal to distal nodes, by arrows on each trajectory.

6. LEAF NITROGEN CONTENT

MATERIALS AND METHODS

Leaf nitrogen content was measured for leaves collected on four days over the growing season. One shoot from genet BR 591 was harvested on each of the four sampling days, May 26, June 30, July 28 and September 09, 1987.

Leaf Nitrogen content was determined using the Kjeldahl method. Leaves were scored for form category, detached from the shoot and area determined using a digitizing pad. The leaves were then weighed, placed in vials and dried in a convection oven. Once fully dry, individual leaves were again weighed and digested in concentrated Sulphuric acid with a drop of Perchloric acid, and heated until the solution became clear. Once the solution had cooled, it was made up to a volume of 100 ml with distilled water. Sodium hydroxide (10 M) was then added to a 25 ml sample of the Sulphuric acid solution until the pH of the solution went into the alkaline range (Litmus test). This solution was steam distilled and the distilled Ammonium gas collected in Boric acid (1.0 M) containing Bromocresol green - Methyl red Mixed Indicator Solution. Once distillation was complete (tested with litmus) the Boric acid solution was titrated with 0.01 M Hydrochloric acid until the solution changed from green to a cherry red color, the endpoint of this titration.

Nitrogen content was calculated, based on the results of the titration, as m moles Nitrogen g^{-1} dry leaf and as m moles Nitrogen m^{-2} leaf area.

RESULTS

A nodal pattern very similar to that found with leaf chlorophyll content can be seen here, for leaf Nitrogen content measured per unit leaf dry weight (Figure 6.1) and for leaf Nitrogen content measured per unit leaf surface area (Figure 6.2). On May 26, leaves at the distal nodes have the lowest Nitrogen content and leaves at the proximal nodes have the greatest Nitrogen content. By June 30, the greatest Nitrogen content occurs at leaves of the intermediate, around node six. By July 28, most increase in leaf Nitrogen content has occured in leaves of the distal nodes 7 through 13, and greatest Nitrogen content occurs in leaves of nodes 9 through 11. By September 09 however, leaf nitrogen content decreased in leaves at all nodes, but most dramatically in leaves of the proximal and intermediate nodes and eaves at the distal nodes have the greatest Nitrogen content at this stage. Overall, leaves at the proximal nodes show relatively little change in Nitrogen content with time between May 26 and September 09, and while leaves at the intermediate nodes have greater Nitrogen content during the early and mid growing season, leaves of the distal nodes have the highest Nitrogen content during the late growing season.

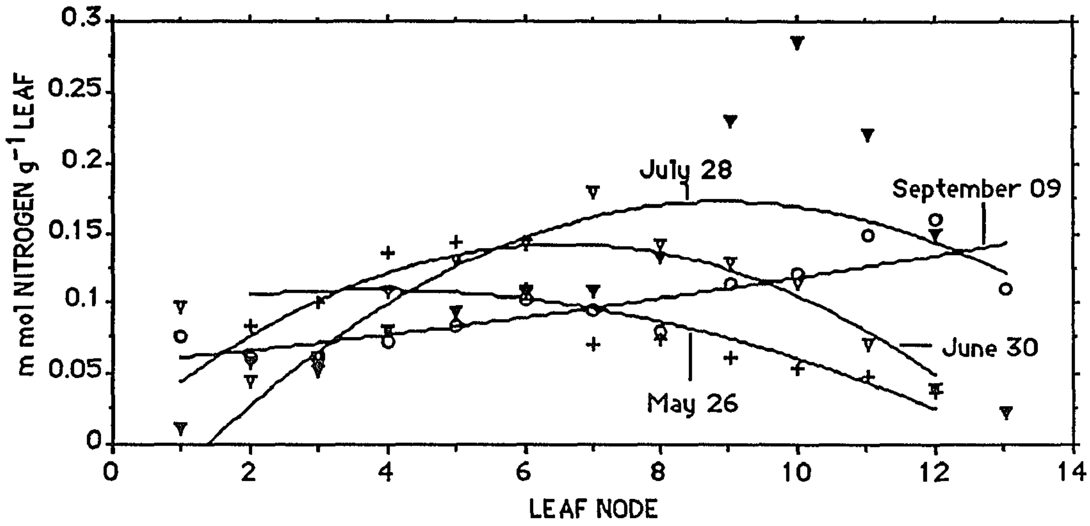

Figure 6.1. Scatterplots with second degree least squares polynomial regressions overlaid, of Nitrogen contents per gram dry weight of leaves at nodes along shoots of genet BR 591. Nitrogen content was measured on four days: May 26 ($r^2 = 0.6886$, $p<.01$); June 30 ($r^2 = 0.6419$, $p<.01$); July 28 ($r^2 = 0.5226$, $p<.05$); September 09 ($r^2 = 0.7157$, $p<.01$)

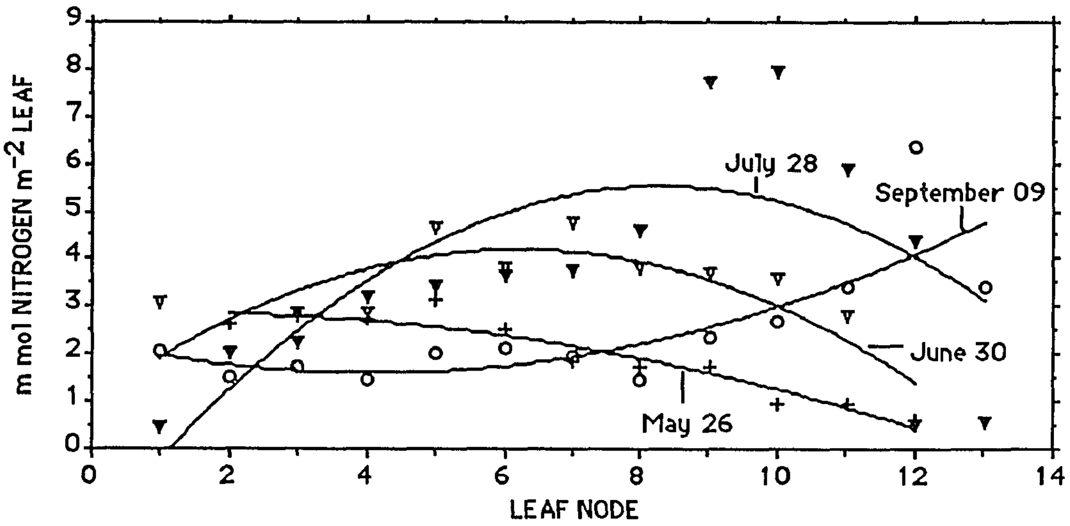

Figure 6.2. Scatterplots with second degree least squares polynomial regressions overlaid, of Nitrogen contents per square meter, of leaves at nodes along shoots of genet BR 591. Nitrogen content was measured on four days: May 26 ($r^2 = 0.9086$, $p<.001$); June 30 ($r^2 = 0.646$, $p<.01$); July 28 ($r^2 = 0.5757$, $p<.05$); September 09 ($r^2 = 0.6152$, $p<.01$).

7. LEAF XYLEM WATER POTENTIAL

MATERIALS AND METHODS

On three days, during the 1987 growing season, xylem water potential was measured for leaves with entire margins, one lobe and two lobes. These leaves were taken from shoots growing in approximately the same position as shoots used in the photosynthesis study. Xylem water potential was measured using a Scholander type pressure chamber (Model 3000, Soilmoisture Corp., Santa Barbara, California). A leaf detached from a shoot was immediately placed in the chamber with the cut end of the leaf extending out through the grommet, and pressurized until water began to be forced out of the cut end of the leaf. The pressure at which this occurs is a measure of the xylem water potential. Leaves were always removed from different shoots to ensure that the results did not become confounded with changes in xylem water potential brought about by detaching leaves.

RESULTS

The results of this study are shown in Table 7.1. I found no differences in xylem water potential among leaves with entire margins and leaves with one lobe and leaves with two lobes. While there appears to be a decrease in mean xylem water potential with time, all leaves, irrespective of shape, show a similar decrease.

Table 7.1. Mean Xylem Water Potentials of leaves of Sassafras having entire margins, one lobe and two lobes, measured on three days during the 1987 growing season. Single classification ANOVA was done for each day. Sample sizes (number of measurements) are shown within brackets.

	Mean Xylem Water Potential (mPa)			
Date	Leaf Shape Category			
Measured	Entire Margin	One Lobe	Two Lobes	ANOVA
June 10	- 1.04 ± 0.052 (n=5;-1.10 to -0.95)	-1.06 ± 0.049 (n=5;-1.12 to -0.98)	-1.04 ± 0.045 (n=5;-1.12 to -1.00)	ns
July 28	-1.11 ± 0.061 (n=5;-1.22 to -1.03)	-1.11 ± 0.051 (n=5;-1.20 to -1.04)	-1.13 ± 0.045 (n=5;-1.21 to -1.07)	ns
August 18	-1.65 ± 0.012 (n=4;-1.67 to -1.64)	-1.66 ± 0.007 (n=4;-1.67 to -1.65)	-1.67 ± 0.012 (n=4;-1.68 to -1.65)	ns

8. LEAF THERMAL CHARACTERISTICS

METHODS AND MATERIALS

In our laboratory, the images of several thousand leaves of Sassafras have been stored on computer, using the Fourier transform based Leaf Boundary Method of Kincaid and Schneider (1983). From these I chose the images of four leaves, occuring adjacent to each other along a single shoot, and having a sequence of form categories Entire, Two Lobed, Two Lobed, Entire. The leaves with two lobes had almost twice the surface area of the adjacent leaf with an entire margin (Table 8.1). The leaf images were reconstructed from their Fourier coefficients and plotted onto tracing paper using a drum plotter (Strobe model 100), and transfered onto black poster board (1.6 mm thick). The poster board was cut to the shape of the leaf image, a K-type (Chromel-Alumel) thermocouple placed in contact with the center of the abaxial side, and held in place with a cotton cloth laminate. In addition to the four leaf models produced in this manner, two additional models were constructed, where the surface area of the two entire margin leaves was made equal to that of the two lobed leaf adjacent to it (Table 8.1) using the Leaf Boundary Method software. Each leaf model was attached to a wooden holder, positioned directly under a 250 watt Quartz lamp, and the thermocouple connected to a digital readout device (Keithley). A glass diffuser was placed between the lamp and the leaf model. A free convection regime was used and two fans were also used to produce turbulent air flow: one positioned under the leaf model at a distance of one meter to produce bluff turbulence, and the other at an equal distance but horizontal to the leaf to produce side turbulence.

Before the commencement of each set of measurements, the leaf model was allowed to equilibriate to room temperature. The measurements of leaf temperature were made before the light was switched on. Once the light was switched on, leaf model temperature was measured every 15 seconds, until a quasi-steady state (Kreith, 1973) temperature was reached. Leaf model temperature was measured under four treatments: free convection; side turbulence; bluff turbulence; and side + bluff turbulent air flow. Each treatment was replicated three times per model.

RESULTS

The presence of turbulent air flow over the leaf model substantially decreased the final, steady state temperature achieved by all leaf models over the steady state temperatures achieved under free convection (Figure 8.1). However, there was little difference in final leaf temperature between between entire and two lobed leaves, even when the entire margin leaf model having a surface area equal to that of the two lobed leaf model was used (Figure 8.2).

Since response times in free convection appeared to be a different, the time constant (T_C) was calculated for each treatment, where T_C = time taken for the leaf model to reach 67% of the final temperature difference. The time constants for each treatment are shown in Table 8.1. Under conditions of free convection, leaf models with two lobes have significantly lower time constants than do leaf models having the same surface area with entire margins (Table 8.2).

Table 8.1. Comparison of Mean Time Constants (time taken for leaf model to reach 67% of final temperature) for leaf models of two leaf shape categories (Entire and Two Lobed) under four air movement treatments (Free Convection, Side Turbulence, Bluff Turbulence, and Side + Bluff Turbulence).

Leaf Node	Shape of Physical Model	Surface Area mm^2	Mean Time Constants in Seconds Free Convection	Side Turbulence	Bluff Turbulence	Side + Bluff Turbulence
4	Entire	6,510	132	49	47	39
4	Entire*	11,222	170	48	43	44
5	Two Lobes	11,222	139	49	44	42
6	Two Lobes	8,816	137	45	35	36
7	Entire*	8,816	155	56	44	43
7	Entire	4,812	127	46	44	40

* Leaf model constructed with surface area equal to adjacent two lobed leaf.

Table 8.2. Single classification ANOVA on time constants of leaf models in free convection.

Leaf Models Compared (Node, Shape, Area) vs. (Node, Shape, Area) (mm^2) (mm^2)	F	v_1	v_2	p
4, Entire, 6510 vs. 4, Entire, 11222[a]	13.3	1	4	*
4,Entire, 11222[a] vs. 5, Two Lobed, 11222	11.4	1	4	*
5,Two Lobed, 11222 vs. 6, Two Lobed, 8816	.07	1	4	ns
6, Two Lobed, 8816 vs. 7, Entire, 8816[a]	15.4	1	4	*
7, Entire, 8816[a] vs. 7, Entire, 4812	10.4	1	4	*
4, Entire, 6510 vs. 5, Two Lobed, 11222	0.7	1	4	ns
6, Two Lobed, 8816 vs. 7, Entire, 4812	1.0	1	4	ns

[a] Leaf models constructed with surface area equal to adjacent two lobed leaf.
ns = not significant; * = $0.01 < p \leq 0.05$; ** = $0.001 < p \leq 0.01$; *** = $p \leq 0.001$

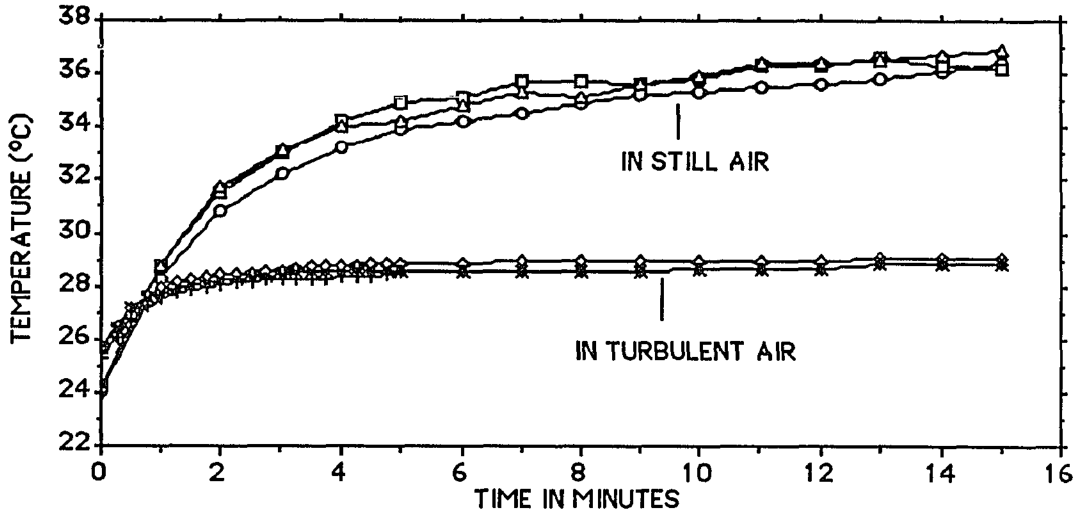

Figure 8.1. Change in leaf model (two lobed leaf, 11,222 mm^2 surface area) temperature when exposed to diffuse IR radiation in still air and in bluff + side turbulence.

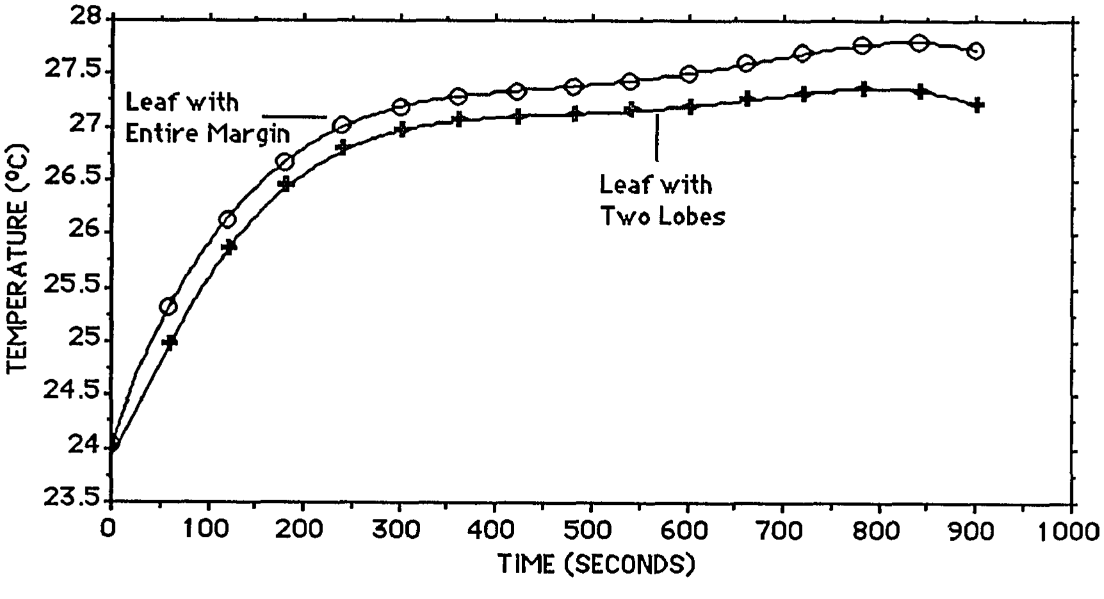

Figure 8.2. Variation in the thermal response in free convection between two leaf models with identical surface areas (11,222 mm^2), but different shapes (entire margin versus two lobes).

DISCUSSION AND CONCLUSION

In 1986 I studied the effect of shoot position ("sun" or "shade") within the canopy on leaf chlorophyll content in eight genets of Sassafras. While significant differences in leaf chlorophyll content (mg g^{-1} & g m^{-2}) were found between leaves from sun and shade positions in the canopy, it was also found that the nodal pattern of distribution for leaf chlorophyll content along shoots was similar in shoots from both sun and shade positions. Similarly, despite differences in the absolute values for leaf area, and variation in the frequency of occurence of lobed leaves, between shoots from sun and shade positions, the nodal distribution of leaf area and the nodal distribution of leaf shape is similar in shoots from both canopy positions (Kincaid, personal communication; and results from this study). Taking into consideration this similarity of nodal patterns, it appeared that a study using genets with different proportions of leaves having entire margins and leaves having lobes (sinuses) would be most useful in studying leaf form and function. Therefore, in 1987, I used two genets (BR 590 and BR 591) with a high proportion of lobed leaves and two genets (BR 99 and BR 100) with very few lobed leaves. Predicted average leaf size at the nodes (intermediate) having the greatest surface area was 39,000 and 40,000 mm2 for genets 590 and 591 respectively, and 18,000 and 25,000 mm2 for genets 99 and 100 respectively. Trees with high proportions of lobed leaves have larger leaves than trees with very few lobed leaves.

The results of the study on the nodal pattern of distribution of chlorophyll along shoots in eight genets of Sassafras during the 1986 growing season, and four genets during the 1987 growing season, indicate that leaves of the intermediate nodes have greatest chlorophyll content during much of the growing season. If leaf chlorophyll content is a good estimator of the photosynthetic capacity of a leaf, leaves of the intermediate nodes must then, in terms of photosynthesis, have the capacity to be the most productive of leaves along a shoot. In the 1986 study on eight genets, I found that at any node of these intermediate positions along a shoot, there is no statistically significant difference in total chlorophyll content between leaves with entire margins and leaves with two lobes. From this I conclude that the nodal position of a leaf is more important in determining the photosynthetic capacity of that leaf than is the shape of that leaf. The nodal position of leaves having the greatest chlorophyll content (mg g^{-1} and g m^{-2}) changed during the growing season of 1987; during the early and middle part of the growing season, greatest chlorophyll contents occured in leaves of the intermediate nodes, and migrated into leaves of the distal nodes toward the end of the season. This pattern is also seen with leaf nitrogen content.

These nodal trends are seen most clearly in shoots of Sassafras genets BR 590 and BR 591. In genets BR 99 and BR 100, shoots tended to have fewer leaves, largely due to the apparent discontinuation of leaf initiation soon after budbreak. Therefore, in these genets, leaves at the most distal nodes are equivalent (in age) to leaves of the intermediate nodes of genets BR 590 and BR 591. Genets BR 99 and BR 100 also have relatively few leaves with lobes, and lobed leaves that do occur on these genets, are positioned distal to the intermediate nodes. Since these genets also have fewer leaf nodes, it is likely that the early termination of leaf initiation is correlated with the low frequency of lobed leaves.

It has been shown that leaves reach their greatest chlorophyll and nitrogen contents at about the time they reach full expansion (e.g. Wallihan et al., 1976, Lin and Ehleringer, 1982); and I have shown that this is the case for Sassafras also. After leaves reach full expansion, chlorophyll contents decrease, but in leaves of the intermediate nodes this decrease is slow and there appears to be a substantial lag period between reaching maximum chlorophyll and nitrogen contents and subsequent decrease in chlorophyll and nitrogen content. The data suggests that instead of occuring soon after leaves reach full expansion, most decrease in chlorophyll content of leaves at the intermediate nodes occurs at a time when chlorophyll content decreases in all leaves on a shoot, with the onset of shoot senescence. Thus it appears that Sassafras invests heavily in the photosynthetic machinery of leaves at the intermediate nodes, and that this investment is maintained for a longer period of time than is the investment in the photosynthetic machinery of leaves at the proximal and distal nodes.

Leaves at the distal (and proximal) nodes are substantially smaller than leaves at the intermediate nodes. The importance to photosynthesis of leaves at the intermediate nodes is thus compounded by this pattern of leaf area distribution along shoots, since the total chlorophyll (and hence ability to harvest light energy) is greatest at these nodal positions. In genets BR 590 and BR 591, this means that leaves with two lobes, which occur with high frequency at the intermediate nodes, have greater photosynthetic capacity than most leaves with entire margins, which occur with greatest frequency at the proximal and distal nodes. However, in genets BR 99 and BR 100, the nodal positions of leaves with lobes do not coincide with the nodes subtending leaves with the largest area, or leaves with the greatest chlorophyll contents. Thus the relationship between leaf shape and photosynthetic capacity is weak for these two genets.

The difference in leaf surface area between leaves of the intermediate nodes and leaves of the proximal and distal nodes also suggests that there is a greater investment in permanent, structural components of photosynthesis in leaves at the intermediate nodes (together with an equivalent investment in the less permanent components such as chlorophyll and RUBISCO), while in the distal nodes, there is an emphasis on the less permanent components of photosynthesis. Leaf expansion growth had virtually ceased by mid June, but leaves at the most distal nodes reached greatest chlorophyll and nitrogen contents later in the season, after leaves at these nodal positions had reached full expansion. Thus, it appears that while during the major part of the growing season, leaf chlorophyll content per unit area and per unit fresh weight of leaf is closely related to the developmental stage of the leaf, toward the latter stage of the growing season this relationship breaks down and these genets, and some components of the photosynthetic machinery are translocated into leaves of the distal nodes. Since leaves at the distal nodes are less likely to be shaded, this relocation probably represents an effort by the plant to maximize returns on its investment prior to senescence and winter dormancy. This supports the view that senescence represents a controlled reallocation of resources rather than uncontrolled degeneration (Field, 1983; Field & Mooney, 1986).

When net photosynthetic rates were measured for genets BR 99, BR 100, BR 590 and BR 591, the most striking difference among genets was that, despite spending approximately equal lengths of time with each genet, genets BR 99 and BR 100 yielded only about 1/10 th the number of measurements obtained with genets BR 590 and BR 591. Leaves of genets BR 99 and BR 100 existed in light conditions at, or close to, compensation point and appeared to rely almost entirely on sun flecks for net photosynthetic carbon gain. Shoot elongation and/or the initiation of new leaves would probably not result in increased photosynthetic carbon gain for these two genets and, presumably, these plants can not afford any additional investment in leaves.

Variation in light (PAR) incident on the leaves was a major confounding influence when photosynthesis was measured. By dividing the data using PAR classes I was able to overcome this to some extent. Another problem was variation in leaf age, which was overcome by considering the measurements made on each day, separately. However, this was possible for genets BR 590 and BR 591 only; there were too few measurements on any one day for the other two genets. Finally, it was often the case that about three leaves at the distal and proximal ends of each shoot were not used in the measurement net photosynthetic rate; they were too small and/or too fragile to be placed in the gas exchange chamber. The analysis of chlorophyll contents indicated that leaves at the most distal and proximal nodes would have the lowest photosynthetic capacity for much of the growing season. As a result of being unable to measure net photosynthetic rates in these leaves, an effect similar to considering only leaves from intermediate positions, as done with the 1986 leaf chlorophyll data, was achieved. This negates, to some extent, differences in net photosynthetic rates which are due to the differences in nodal frequencies of leaves with entire margins and leaves with lobes. A comparison of net photosynthesis rates between leaf shapes was possible only with genets BR 590 and BR 591; the number of lobed leaves was too small in genets BR 99 and BR 100. Overall, when net photosynthesis data from all days and all PAR classes were merged, greatest net photosynthetic rates were seen in leaves with entire margins in genet BR 590 and in leaves with two lobes in genet BR 591. However, when this photosynthesis data is separated on the basis of day of measurement and PAR classes, significant differences in net photosynthetic rates among leaf shapes are seen only in isolated instances.

In the cuvette system used for this study, PAR does not always represent light incident on the leaf, especially under shaded conditions when sun flecks may be an important source of light for photosynthesis. Since light incident upon the leaf will raise leaf temperature, leaf temperature was used to identify instances of inaccurate PAR measurement due to the distance between the Quantum Sensor and the active region of the cuvette. If this also is taken into account in looking for differences in net photosynthetic rates among leaf shapes, there are very few instances when one leaf form category outperforms another leaf form category in net photosynthetic rate.

The pattern of distribution of net photosynthetic rates along shoots is similar to the patterns found for leaf chlorophyll content, nitrogen content, area and the frequency of leaves with two lobes. The absence of data for the most proximal and most distal leaves along a shoot is probably responsible for a less peaked appearance to the regression lines generated with this data. Nonetheless, especially during the early and middle part of the growing season, leaves at the intermediate nodes do appear to have the greatest net photosynthetic rates. Toward the latter part of the growing season, there is a tendency for leaves at the distal nodes to have high net photosynthetic rates when compared to the same distal leaves earlier in the growing season, and higher than intermediate leaves at the end of the growing season (Figures 5.5 and 5.8). While this may be explained to some extent by relatively higher light intensities at the fringe of the canopy, the chlorophyll and nitrogen content data support the idea that leaves of the distal nodes do develop a greater photosynthetic capacity (per unit area) at this stage in the growing season compared to leaves of the intermediate nodes.

When a leaf is placed in the LI - 6200 Portable Photosynthesis Systems one liter gas exchange chamber to measure net photosynthesis, certain changes are forced upon the leaf. Most importantly, the boundary layer, which would otherwise depend on the shape and surface area of the leaf and on the surrounding air, is made equal for all leaves (by using a fixed leaf area exposed for gas exchange) and then broken down by the two fans within the leaf chamber. Thus, any effect of leaf shape on net photosynthesis which is due to the actual shape of the leaf, rather than some physiological characteristic associated with leaf shape, could not be measured.

As with photosynthesis, most of the few instances of significant differences in water use efficiency among leaf shapes can be explained in terms of variation in PAR incident upon the leaf (as indicated by differences in leaf temperature). There are also no significant nodal patterns for water use efficiency, indicating that the nodal patterns for photosynthesis are not correlated the efficiency with which gas exchange occurs in leaves of the intermediate nodes.

It has been established that leaf dissection increases convective heat loss by reducing the thickness of the boundary layer (Vogel, 1968, 1970). It is therefore interesting that, in Sassafras, leaves with the greatest surface area and leaves with two lobes occur at the intermediate nodes of shoots. When the thermal characteristics of leaves with entire margins were compared with the thermal characteristics of leaves with two lobes, using leaf models, it was found that under conditions of free convection, leaf models with two lobes have significantly lower time constants (time taken to reach 67% of final temperature) than leaves of the same surface area having entire margins. Under free convection, the boundary layer is undisturbed by bulk flow, and thus differences in time constants between leaf models of equal area may be attributed to differences in boundary layer thickness caused by differences in leaf shape. When time constants were measured under conditions of turbulent air flow over the leaf models, no significant differences were found between leaf shapes, probably due to the breakdown of the boundary layer which occurs under these conditions.

Thus, it appears, under field conditions, the presence of lobing on leaves serves to enhance the convective cooling ability of these large leaves in the absence of rapid air movement. This enhancement of convective heat loss may be most important in the leaves of the intermediate nodes since much of the photosynthetic machinery is concentrated in leaves at these nodes. Leaves, by the very nature of the function they perform, namely the harvest of light energy, must tread a fine line between maximizing the collection of light energy and maintaining temperatures conducive to the optimal functioning of the photosynthetic machinery. It would appear that by forming leaves with lobes, Sassafras maximizes leaf area at those nodal positions where the photosynthetic machinery is concentrated for much of the growing season, and at the same time reduces the likelihood of thermal injury to, or the inefficient operation of the photosynthetic machinery.

There is a definite and repeating nodal pattern to certain leaf characteristics of Sassafras albidum. Leaf area, chlorophyll content, and nitrogen content, and net photosynthetic capacity change with the nodal position of a leaf such that leaves at the proximal and distal nodes are the smallest, contain the least chlorophyll and nitrogen, and have the smallest photosynthetic capacity, while leaves of the intermediate nodes are the largest, have the greatest chlorophyll and nitrogen contents (expressed as mg g^{-1} and as g m^{-2}), and the greatest photosynthetic capacity(μ mol m^{-2} s^{-1}). Due to the correlation between leaf area, and chlorophyll and nitrogen contents, the total chlorophyll and nitrogen invested in leaves of the intermediate nodes is further enhanced. Although leaf shapes are distributed in a similar nodal pattern, with lobed leaves being most frequently at the intermediate nodes and leaves with entire margins most frequently at the proximal and distal nodes, there is no evidence to suggest that there is a difference in the photosynthetic capacity of leaves with different shapes at equivalent nodal positions. As a result of the nodal patterns for leaf area, chlorophyll content, nitrogen content, and photosynthesis, leaves at the intermediate nodes which tend to have the greatest net photosynthetic capacity also tend to have the greatest proportion of lobed leaves. Lobes on leaves may enable these leaves, with the greatest investment in the photosynthetic machinery, to avoid thermal injury in a worst case, and to avoid inefficient operation in other cases, under conditions of low air movement and high irradiance by decreasing the boundary layer and increasing convectional heat loss by the leaf.

10. APPENDIX

Statview 512+ database for photosynthesis and related measurements taken in 1987.

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
1	99	11	2	O	35.08	22.71	22.72	342.80	.8004	.0366	207.8	11.23	.0800	.0007	18.4977	4.1788
2	99	11	2	O	35.11	22.88	22.80	341.70	.7020	.0301	288.1	13.65	.0732	.0006	21.7325	4.3053
3	99	11	3	O	35.02	23.13	23.14	341.60	.0552	.0316	281.0	13.02	.0707	.0006	21.1160	3.6073
4	99	11	3	O	40.00	23.21	23.24	340.60	1.1620	.0201	261.8	14.10	.0700	.0006	22.6800	5.3467
5	99	11	4	O	40.20	23.27	23.33	341.00	1.0000	.0306	278.7	13.40	.0742	.0006	19.8482	[illegible]
6	99	11	4	O	35.54	23.34	23.39	340.80	.9765	.0295	276.1	13.92	.0718	.0006	22.0961	4.4729
7	99	11	5	O	31.34	23.62	23.64	342.10	1.1100	.0219	252.6	18.69	.0534	.0003	16.0353	4.5033
8	99	11	5	O	31.66	23.67	23.68	341.00	.9995	.0219	259.5	18.69	.0535	.0004	16.4532	4.6655
9	99	11	6	O	29.32	23.54	23.55	339.40	1.2140	.0278	260.9	14.74	.0678	.0004	16.0051	7.2213
10	99	11	6	O	29.68	23.54	23.55	338.30	1.1910	.0296	265.1	13.84	.0722	.0005	16.1851	6.2693
11	99	11	5	O	32.27	23.41	23.48	340.30	.4398	.0109	267.4	37.60	.0265	.0002	16.8485	11.2908
12	99	11	5	O	39.65	23.49	23.57	339.40	.3934	.0121	278.3	33.79	.0295	.0002	18.2077	3.6660
13	99	11	8	O	30.07	23.31	23.28	340.80	1.3660	.0338	267.7	12.13	.0824	.0005	15.2252	4.2660
14	99	11	8	O	28.79	23.38	23.35	339.80	1.1900	.0362	278.6	11.33	.0882	.0005	15.4564	4.6210
15	99	55	4	O	41.42	28.51	28.53	351.90	.5094	.0208	294.0	19.38	.0515	.0007	35.8948	6.5884
16	99	55	4	O	41.01	28.53	28.54	348.60	.4093	.0196	296.5	20.52	.0487	.0007	36.0720	3.9004
17	99	55	6	O	39.36	28.71	28.65	350.70	.8874	.0310	287.2	13.00	.0769	.0010	33.7340	2.2199
18	99	55	6	O	40.49	28.75	28.71	347.70	.7878	.0316	289.6	12.75	.0784	.0011	34.7824	5.1391
19	99	55	7	O	40.13	28.64	28.78	352.50	1.1040	.0346	284.7	11.65	.0858	.0010	31.0525	4.7463
20	99	55	7	O	39.47	28.77	28.84	349.10	.9892	.0326	282.7	12.36	.0808	.0011	33.7572	5.9818
21	99	55	8	O	39.89	28.88	28.91	355.70	.3501	.0225	311.9	17.86	.0559	.0008	35.1528	3.5704
22	99	55	8	O	41.53	28.89	28.91	351.80	.7136	.0246	286.4	16.35	.0611	.0009	36.4118	2.6900
23	99	55	9	O	39.31	28.83	28.87	356.20	.7336	.0252	291.9	16.00	.0625	.0008	33.2018	2.8006
24	99	55	9	O	38.92	28.92	28.93	352.60	.5381	.0248	299.0	16.24	.0615	.0009	35.7459	2.1487
25	99	37	8	O	48.73	28.33	28.12	357.60	1.1210	.0564	307.9	7.17	.1395	.0017	32.4258	1.1092
26	99	37	8	O	62.28	28.41	28.18	352.30	1.1220	.0551	302.0	7.33	.1364	.0017	32.8423	1.7778
27	99	37	9	O	42.03	28.42	28.14	443.20	.9740	.0527	392.8	7.67	.1304	.0015	30.8468	1.6777
28	99	37	9	O	49.43	28.52	28.24	437.70	1.4030	.0443	364.8	8.10	.1098	.0014	33.6054	1.0197
29	99	37	6	O	256.20	28.96	28.89	380.90	1.4650	.0423	306.9	9.53	.1048	.0013	31.8003	.6791
30	99	37	6	O	132.40	29.25	29.06	376.00	1.1560	.0419	312.1	9.61	.1040	.0014	34.8916	.8902
31	99	37	5	O	42.94	29.33	29.27	395.70	.6368	.0208	[illegible]	19.28	.0518	.0008	37.6056	1.3111
32	99	37	5	O	38.33	29.57	29.46	389.90	.6769	.0218	318.2	18.47	.0541	.0008	38.5533	2.6795
33	99	11	2	O	102.70	28.67	28.63	391.40	1.2850	.0235	284.3	17.11	.0584	.0008	34.9278	2.4093
34	99	11	2	O	210.20	28.55	28.57	394.70	1.1950	.0209	284.7	19.25	.0519	.0007	33.0122	3.9911
35	99	11	3	O	33.73	29.24	29.20	368.20	.8459	.0243	292.4	16.58	.0603	.0009	36.9742	2.7774
36	99	11	3	O	35.13	29.11	29.11	371.90	.3289	.0235	329.6	17.15	.0582	.0008	35.3504	1.0608
37	99	11	4	O	33.70	29.39	29.39	383.70	.8685	.0331	321.5	12.14	.0823	.0011	35.0092	1.5574
38	99	11	4	O	33.14	29.48	29.48	380.30	1.0180	.0324	309.5	12.39	.0806	.0011	36.0692	1.5834
39	99	11	7	O	35.04	29.33	29.24	391.40	1.9650	.0289	264.4	13.91	.0718	.0009	31.8316	1.4829
40	99	11	7	O	35.80	29.84	29.84	362.60	1.1050	.0342	292.1	11.76	.0850	.0011	34.1762	1.7356
41	99	11	7	O	35.59	29.36	29.29	388.50	.9150	.0291	318.1	13.82	.0723	.0010	34.6114	1.9881
42	99	11	8	O	34.70	29.61	29.64	359.40	2.2300	.0518	272.8	7.77	.1287	.0015	31.0477	1.5205
43	99	11	8	O	36.04	29.66	29.40	356.80	2.0280	.0528	277.5	7.61	.1313	.0016	32.5153	1.7715
44	99	11	9	O	32.98	29.33	29.44	355.10	2.6150	.0405	233.2	8.94	.1006	.0013	34.3406	1.8135
45	99	11	9	O	31.81	29.19	29.27	358.20	1.1300	.0397	294.5	10.13	.0986	.0013	33.0351	1.8784
46	99	43	3	O	44.66	28.75	28.69	351.30	.9583	.0286	280.3	14.09	.0709	.0009	33.3284	2.9493
47	99	43	3	O	44.72	28.81	28.78	346.10	.9335	.0250	268.6	16.08	.0621	.0009	35.3519	2.8442
48	99	43	4	O	39.20	28.55	28.55	371.70	.7580	.0233	301.1	17.30	.0577	.0008	33.7522	3.8723
49	99	43	4	O	39.61	28.51	28.49	368.60	.7752	.0228	295.3	17.65	.0566	.0008	35.0348	3.7400
50	99	43	6	O	40.31	28.54	28.87	352.70	1.2320	.0279	265.1	14.43	.0692	.0009	31.9016	1.2156
51	99	43	6	O	38.70	28.59	28.83	349.50	1.0380	.0316	279.1	12.75	.0784	.0010	33.6019	.9213
52	99	43	9	T	37.19	28.08	27.86	352.00	.5831	.0565	319.3	7.15	.1397	.0016	30.1435	2.0991
53	99	43	9	T	33.95	28.45	28.33	349.00	.3567	.0413	317.7	9.78	.1022	.0013	32.9264	2.2447
54	99	55	4	O	41.42	28.51	28.53	351.90	.5094	.0208	294.0	19.38	.0515	.0007	35.8948	1.7080
55	99	55	4	O	41.01	28.53	28.54	348.60	.4093	.0196	296.5	20.52	.0487	.0007	36.0720	1.4447
56	99	55	6	O	39.36	28.71	28.65	350.70	.8874	.0310	287.2	13.00	.0769	.0010	33.7340	2.1529
57	99	55	6	O	40.49	28.75	28.71	347.70	.7878	.0316	289.6	12.75	.0784	.0011	34.7824	1.8155
58	99	55	7	O	40.13	28.64	28.78	352.50	1.1040	.0346	284.7	11.65	.0858	.0010	31.0525	2.5838
59	99	55	7	O	39.47	28.77	28.84	349.10	.9892	.0326	282.7	12.36	.0808	.0011	33.7572	2.2628
60	99	55	8	O	39.89	28.88	28.91	355.70	.3501	.0225	311.9	17.86	.0559	.0008	35.1528	1.1062
61	99	55	8	O	41.53	28.89	28.91	351.80	.7136	.0246	286.4	16.35	.0611	.0009	36.4118	2.0031
62	99	55	9	O	39.31	28.83	28.87	356.20	.7336	.0252	291.9	16.00	.0625	.0008	33.2018	2.2009
63	99	55	9	O	38.92	28.92	28.93	352.60	.5381	.0248	299.0	16.24	.0615	.0009	35.7459	1.5253
64	590	5	4	O	114.70	24.55	24.65	331.30	3.7120	.0456	187.4	8.98	.1113	.0011	24.2093	8.5316
65	590	5	4	O	111.80	24.65	24.74	325.80	3.7750	.0471	183.8	8.69	.1151	.0011	24.9702	8.1515
66	590	5	5	O	126.50	23.71	23.76	346.30	2.5380	.0261	178.9	15.70	.0636	.0006	22.8467	10.6372
67	590	5	5	O	126.80	23.96	24.02	341.10	2.6050	.0270	174.0	15.17	.0658	.0007	24.8248	9.7586
68	590	5	6	T	124.40	23.79	23.89	353.70	2.9100	.0305	188.1	13.45	.0743	.0007	23.4542	10.1920
69	590	5	6	T	126.30	23.77	23.87	348.10	2.9360	.0318	187.2	12.89	.0775	.0008	24.4938	9.4459
70	590	5	7	L	121.30	23.34	23.32	346.00	3.5500	.0458	208.9	8.96	.1116	.0010	22.2071	8.9249
71	590	5	7	L	123.40	23.51	23.51	340.50	3.7240	.0468	199.7	8.77	.1140	.0010	23.1816	8.7718
72	590	5	8	T	117.30	23.60	23.64	362.20	3.2080	.0366	209.0	11.20	.0892	.0008	22.0002	10.0858
73	590	5	8	T	115.70	23.66	23.69	356.80	3.3370	.0365	197.1	11.23	.0889	.0008	23.3806	9.8913
74	590	5	9	T	114.30	23.56	23.51	344.70	3.2160	.0430	212.4	9.54	.1048	.0009	22.0381	8.6557
75	590	5	9	T	113.10	23.61	23.54	339.10	3.1650	.0437	210.2	9.39	.1064	.0010	23.1847	7.0869
76	590	5	10	O	112.00	23.42	23.47	347.40	2.4180	.0283	198.8	14.48	.0690	.0006	22.7338	9.4189
77	590	5	10	O	116.50	23.48	23.53	342.00	2.4000	.0281	193.0	14.59	.0685	.0007	24.2893	8.8219
78	590	5	11	T	118.90	23.09	23.04	348.20	3.7850	.0503	214.5	8.17	.1223	.0010	21.5892	8.9449

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
79	590	5	11	T	120.60	23.13	24.00	342.60	3.0390	.0633	210.9	7.71	.1297	.0011	22.2578	8.6480
80	590	5	12	O	114.50	23.23	23.23	352.40	1.9200	.0378	258.5	10.87	.0019	.0008	22.2962	6.7865
81	590	5	12	O	117.90	23.41	23.42	347.10	1.8840	.0379	254.5	10.82	.0023	.0009	23.9145	5.2710
82	590	70	4	O	62.77	23.15	23.21	353.40	1.6200	.0236	231.8	17.37	.0575	.0005	22.6229	7.5350
83	590	70	4	O	57.48	23.37	23.40	347.80	1.6650	.0289	242.6	14.19	.0704	.0007	24.7790	5.8325
84	590	70	5	L	61.98	23.45	23.41	350.00	1.7290	.0287	241.3	14.30	.0699	.0006	22.9100	6.6276
85	590	70	5	L	53.45	23.42	23.40	344.60	1.1170	.0242	258.0	16.94	.0590	.0006	25.0118	4.6389
86	590	70	6	T	54.68	23.23	23.21	349.80	1.6420	.0224	220.7	18.29	.0546	.0005	23.3692	7.8346
87	590	70	6	T	53.90	23.43	23.44	344.50	1.7810	.0232	209.1	17.67	.0565	.0006	25.2552	7.6226
88	590	70	7	L	54.88	23.75	23.78	384.50	1.8610	.0229	241.0	17.90	.0558	.0005	23.7904	8.5547
89	590	70	7	L	50.19	23.88	23.90	379.20	1.7420	.0244	250.8	16.76	.0596	.0006	25.7191	6.9584
90	590	70	8	T	42.89	23.53	23.48	350.90	1.5200	.0252	242.0	16.24	.0615	.0006	23.9596	6.3446
91	590	70	8	T	47.72	23.60	23.59	345.60	1.6290	.0257	231.0	15.95	.0626	.0006	25.4832	6.2528
92	590	70	9	T	50.67	23.64	23.66	356.40	1.4220	.0210	235.5	19.53	.0512	.0005	24.0374	7.0428
93	590	70	9	T	48.31	23.76	23.77	351.00	1.2890	.0238	250.7	17.24	.0579	.0006	26.0461	5.2166
94	590	70	10	T	46.48	23.70	23.62	348.50	1.5960	.0390	269.9	10.52	.0949	.0009	23.8151	4.3945
95	590	70	10	T	47.05	23.80	23.73	343.40	1.5760	.0393	266.0	10.42	.0959	.0009	24.8609	4.1171
96	590	70	11	T	56.13	24.26	24.27	348.60	.6222	.0325	304.2	12.60	.0793	.0008	25.5625	1.8899
97	590	70	11	T	56.12	24.36	24.37	342.90	.6185	.0271	292.2	15.10	.0661	.0007	27.1556	2.1110
98	590	39	3	O	34.13	23.80	23.98	343.40	1.7770	.0236	210.2	17.35	.0576	.0006	25.3789	7.3329
99	590	39	3	O	107.80	24.19	24.35	338.00	2.1630	.0256	189.6	15.98	.0625	.0007	26.7776	7.8463
100	590	39	4	O	103.10	24.56	24.76	358.40	1.8900	.0166	236.1	24.66	.0405	.0004	26.1547	10.7526
101	590	39	4	O	113.30	25.04	25.21	353.00	1.8900	.0219	200.6	18.63	.0536	.0006	28.6915	7.4338
102	590	39	6	T	96.79	24.99	24.88	347.10	3.7890	.0538	220.1	7.59	.1316	.0012	23.9541	7.6100
103	590	39	6	T	86.95	25.16	25.02	341.40	3.7360	.0574	222.7	7.11	1.4060	.0013	24.9602	6.7775
104	590	39	7	T	88.04	25.16	25.15	353.30	2.3990	.0389	234.8	10.47	.0954	•	31.9878	•
105	590	39	7	T	89.39	25.33	25.33	348.10	2.3990	.0389	234.8	10.47	.0954	.0010	27.0393	5.7918
106	590	39	8	T	75.72	24.85	24.82	345.30	2.9430	.0429	221.9	9.52	.1050	.0010	24.3948	7.1646
107	590	39	8	T	74.27	25.04	25.00	339.90	2.6900	.0452	230.6	9.03	.1107	.0011	25.6825	5.9234
108	590	39	9	T	71.06	25.22	25.16	358.20	3.8300	.0638	246.6	6.40	.1562	.0015	24.9756	6.2447
109	590	39	9	T	73.84	25.32	25.26	352.70	3.6860	.0647	246.0	6.31	.1584	.0015	25.3581	5.8430
110	590	39	10	T	42.95	24.52	24.33	346.20	2.1620	.0439	253.8	9.32	.1072	.0010	24.6490	5.1598
111	590	39	10	T	61.26	24.78	24.60	340.80	2.1350	.0453	251.4	9.02	.1108	.0011	25.8760	4.6998
112	590	39	11	T	60.92	25.01	24.82	345.70	1.3970	.0574	293.0	7.12	.1405	.0013	24.9608	2.5496
113	590	39	11	T	53.71	25.24	25.07	340.80	.6890	.0574	307.8	7.11	.1406	.0014	26.0458	1.2015
114	590	68	4	O	60.09	24.78	24.72	369.50	2.3710	.0318	236.0	12.83	.0779	.0008	25.6150	7.3680
115	590	68	4	O	32.03	24.92	24.90	364.10	2.0020	.0301	242.8	13.58	.0736	.0008	26.9702	6.2366
116	590	68	5	L	50.43	24.31	24.30	352.90	1.4580	.0227	237.1	18.00	.0555	.0006	25.4584	6.3374
117	590	68	5	L	71.35	24.43	24.47	347.60	1.6640	.0243	224.5	16.79	.0595	.0006	27.0757	6.3320
118	590	68	6	T	59.42	24.17	24.20	367.30	1.6120	.0225	239.3	18.15	.0550	.0006	25.3394	7.0638
119	590	68	6	T	91.32	24.34	24.38	361.90	1.7430	.0252	236.9	16.23	.0615	.0007	26.9001	6.4594
120	590	68	7	T	107.40	24.33	24.48	349.80	1.3030	.0205	235.0	19.92	.0501	.0005	25.9449	6.0341
121	590	68	7	T	113.40	24.64	24.79	344.40	1.8070	.0245	212.6	16.66	.0600	.0007	27.7236	6.6106
122	590	68	8	T	119.10	25.09	25.07	365.10	3.9520	.0473	235.6	8.63	.1158	.0011	24.7452	8.6270
123	590	68	8	T	122.90	25.12	25.11	379.70	3.9340	.0462	227.4	8.83	.1131	.0011	25.4962	8.5434
124	590	68	9	T	114.90	24.93	25.05	342.90	2.1460	.0271	202.8	15.07	.0663	.0007	25.9480	7.6020
125	590	68	9	T	116.40	24.97	25.10	337.50	1.9700	.0285	213.3	14.30	.0698	.0008	27.2463	6.3286
126	590	68	10	T	118.60	24.95	25.05	361.60	1.8310	.0262	236.2	15.57	.0641	.0006	25.0947	6.9592
127	590	68	10	T	122.80	25.13	25.22	356.40	1.6870	.0279	244.9	14.63	.0683	.0007	27.4132	5.5301
128	590	68	11	T	124.40	24.97	25.08	346.60	.5394	.0283	301.4	14.42	.0693	.0008	27.5243	1.7339
129	590	68	11	T	120.70	25.31	25.42	340.90	.9271	.0299	276.3	13.65	.0732	.0008	28.8479	2.7070
130	590	71	3	O	117.60	25.08	25.30	369.40	1.1830	.0162	238.2	25.18	.0397	.0004	27.4903	6.4991
131	590	71	3	O	101.50	24.97	25.18	364.10	1.5580	.0182	212.6	22.41	.0446	.0005	28.8153	7.2971
132	590	71	4	O	81.36	25.32	25.47	368.50	.7539	.0160	277.7	25.48	.0392	.0005	28.6751	4.0454
133	590	71	4	O	74.43	25.69	25.81	363.00	1.3490	.0195	236.5	20.89	.0478	.0006	30.5631	5.6605
134	590	71	5	L	57.22	25.98	26.10	370.60	.6800	.0166	288.9	24.49	.0408	.0005	29.9358	3.3929
135	590	71	5	L	45.41	25.80	25.89	365.40	.9132	.0186	270.6	21.87	.0457	•	30.8410	•
136	590	71	6	T	50.10	26.14	26.18	373.90	1.3200	.0201	253.5	20.19	.0495	.0006	28.7529	5.6985
137	590	71	6	T	49.96	26.11	26.18	368.90	1.2290	.0172	238.6	23.68	.0422	.0005	30.5969	5.8138
138	590	71	7	T	45.56	25.66	25.70	351.10	.7831	.0191	270.8	21.25	.0470	.0005	28.8915	3.5208
139	590	71	7	T	43.95	25.79	25.83	345.90	.9761	.0207	255.0	19.69	.0507	.0006	30.4643	3.8739
140	590	71	8	T	43.72	25.40	24.41	369.90	1.0670	.0175	257.4	23.29	.0429	.0005	28.0800	5.4111
141	590	71	8	T	43.29	25.34	25.34	364.60	1.0060	.0161	249.6	25.24	.0396	.0005	29.7435	5.2253
142	590	71	9	T	45.12	25.46	25.50	382.60	.7398	.0211	310.6	19.27	.0518	.0006	28.0518	3.1160
143	590	71	9	T	44.05	25.92	25.96	377.70	.7995	.0213	300.6	19.08	.0523	.0006	30.6309	3.0538
144	590	81	4	O	55.65	24.60	24.61	407.50	2.0770	.0223	243.3	18.31	.0546	.0006	26.1436	8.8922
145	590	81	4	O	58.41	24.86	24.89	402.20	2.2610	.0223	224.6	18.27	.0547	.0006	27.6996	9.1490
146	590	81	5	L	58.47	24.81	24.80	362.20	1.9890	.0252	222.1	16.23	.0616	.0006	25.7740	7.7073
147	590	81	5	L	59.15	24.83	24.84	356.80	2.1300	.0281	221.0	14.55	.0687	.0007	27.1224	7.0573
148	590	81	6	T	55.35	24.35	24.47	379.00	2.4480	.0310	238.5	13.17	.0759	.0007	24.5374	8.0307
149	590	81	6	T	56.56	24.75	24.67	373.50	2.5190	.0372	249.8	10.99	.0909	.0009	26.2970	6.5798
150	590	81	7	T	79.76	24.26	24.26	351.00	2.5960	.0346	217.4	11.83	.0844	.0008	77.4942	8.1722
151	590	81	7	T	78.01	24.44	24.47	345.60	2.5530	.0318	203.6	12.86	.0777	.0008	25.9200	7.8169
152	590	81	8	T	73.18	24.39	24.30	345.70	2.5560	.0424	235.6	9.66	.1035	.0010	24.4194	6.3245
153	590	81	8	T	72.05	24.55	24.46	340.30	2.4660	.0415	231.4	9.85	.1014	.0010	25.5133	5.9607
154	590	81	9	T	69.51	24.58	24.66	345.50	1.1310	.0200	241.9	20.38	.0490	.0005	26.4606	5.2888
155	590	81	9	T	69.83	24.75	24.83	340.20	1.3870	.0226	228.3	18.03	.0554	.0006	28.1550	5.4149
156	590	81	10	T	65.99	24.92	24.93	350.30	1.9970	.0319	236.4	12.80	.0781	.0008	25.4682	6.1992

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
157	590	81	10	T	66.69	25.04	25.05	344.70	1.0040	.0334	235.1	12.21	.0818	.0000	20.0775	6.5773
158	590	81	11	L	66.40	24.00	25.01	347.10	.6108	.0218	284.8	18.73	.0533	.0006	27.9861	2.0558
159	590	81	11	L	70.82	25.33	25.36	341.80	1.2010	.0267	254.9	15.26	.0655	.0008	29.3343	3.8609
160	590	81	12	L	70.84	25.20	25.17	379.60	.6010	.0259	326.5	15.71	.0636	.0007	27.9785	2.0808
161	590	81	12	L	74.94	25.26	25.19	373.80	.7541	.0260	311.1	15.60	.0637	.0007	29.0191	2.6293
162	590	70	3	O	42.10	30.48	30.48	339.70	.5686	.0179	270.3	22.39	.0446	.0007	37.6844	2.1099
163	590	70	3	O	40.98	30.61	30.61	337.40	.6344	.0174	259.3	22.94	.0435	.0007	40.1227	2.2614
164	590	70	4	L	48.97	30.30	30.31	342.50	.4912	.0184	281.1	21.79	.0458	.0007	37.1054	1.8011
165	590	70	4	L	45.33	30.42	30.43	340.20	.7534	.0213	264.1	18.82	.0531	.0008	39.5339	2.2455
166	590	70	5	T	66.68	30.76	30.71	339.80	.6468	.0260	281.2	15.40	.0649	.0009	37.3716	1.6798
167	590	70	5	T	73.44	30.82	30.83	337.70	.5069	.0229	282.5	17.45	.0573	.0009	39.6516	1.3003
168	590	70	6	L	40.67	30.90	30.98	347.70	.6933	.0210	275.2	19.04	.0525	.0008	38.6640	2.1300
169	590	70	6	L	42.91	30.88	30.95	345.70	.8643	.0206	258.5	19.43	.0514	.0008	40.1840	2.6026
170	590	70	7	T	48.38	30.85	30.70	350.10	1.0690	.0481	206.0	8.33	.1200	.0016	34.7658	1.6533
171	590	70	7	T	43.10	30.90	30.81	348.00	.8809	.0326	285.6	12.28	.0813	.0012	36.9380	1.8600
172	590	70	8	L	40.80	30.90	30.80	353.00	.8100	.0236	278.9	17.02	.0587	.0008	38.9140	2.3461
173	590	70	8	L	42.73	30.89	30.86	350.90	.7234	.0223	278.9	17.90	.0558	.0009	39.3715	2.0693
174	590	70	9	T	45.47	31.00	30.66	362.20	1.5200	.0700	309.1	5.72	.1748	.0021	32.7953	1.7695
175	590	70	9	T	44.28	31.07	30.76	360.00	1.1370	.0585	310.0	6.84	.1462	.0019	34.5447	1.4859
176	590	70	10	T	505.30	31.15	31.09	361.60	2.1140	.0316	235.0	12.66	.0789	.0011	37.2296	4.5691
177	590	70	10	T	682.90	31.23	31.38	359.40	2.1830	.0303	224.2	13.20	.0757	.0011	38.3103	4.7033
178	590	70	11	O	327.70	31.41	32.21	354.40	3.4840	.0422	202.9	9.47	.1056	.0015	34.3953	5.7667
179	590	70	11	O	229.30	31.47	32.17	352.00	3.6080	.0406	190.4	9.84	.1016	.0015	35.5023	6.0524
180	590	70	12	T	97.08	31.53	31.56	368.30	4.3700	.0757	254.9	5.28	.1893	.0024	33.8397	4.4464
181	590	70	12	T	91.71	31.53	31.45	365.80	3.1820	.0726	275.3	5.50	.1816	.0023	34.2897	3.3530
182	590	70	13	L	61.94	31.31	31.25	339.20	.7361	.0336	284.1	11.91	.0840	.0013	39.4088	1.4145
183	590	70	13	L	48.08	31.25	31.18	336.20	.5271	.0311	289.6	12.83	.0778	.0012	40.0071	1.0743
184	590	90	5	L	27.66	30.36	30.40	345.20	.6297	.0180	269.8	22.23	.0449	.0007	38.9700	2.2303
185	590	90	5	L	25.40	30.49	30.54	343.00	.8585	.0210	258.1	19.02	.0525	.0008	39.9593	2.5469
186	590	90	6	T	31.74	30.54	30.53	345.00	.6757	.0214	276.4	18.69	.0534	.0007	35.8183	2.2108
187	590	90	6	T	29.73	30.70	30.71	342.80	.6092	.0211	276.9	18.95	.0527	.0008	39.3631	1.8360
188	590	90	7	T	31.77	30.49	30.43	342.10	1.3460	.0349	263.2	11.49	.0869	.0011	33.4663	2.9365
189	590	90	7	T	28.91	30.51	30.47	339.90	1.2410	.0293	254.4	13.66	.0731	.0010	35.7413	2.9941
190	590	90	8	T	28.49	30.54	30.55	364.40	1.6250	.0359	273.8	11.16	.0895	.0011	33.0313	3.4714
191	590	90	8	T	27.44	30.63	30.67	362.00	1.5710	.0339	268.8	11.81	.0846	.0012	35.2519	3.3212
192	590	90	9	T	29.73	30.68	30.67	359.50	.5276	.0215	299.6	18.61	.0537	.0008	38.9527	1.5799
193	590	90	9	T	29.42	30.80	30.79	357.50	.5461	.0206	293.9	19.38	.0515	.0008	40.4369	1.6398
194	590	90	10	T	30.20	30.81	30.75	358.20	1.1100	.0273	247.7	14.63	.0683	.0009	35.3483	2.9080
195	590	90	10	T	31.62	30.85	30.87	356.10	.9021	.0218	270.3	18.34	.0545	.0008	38.1448	2.7150
196	590	90	11	T	33.85	30.87	30.90	342.00	.7306	.0207	266.9	19.31	.0517	.0008	37.6986	2.3354
197	590	90	11	T	28.28	30.85	30.87	339.80	.7770	.0225	264.9	17.81	.0561	.0009	39.6128	2.1888
198	590	90	12	T	29.01	30.78	30.73	342.50	.6382	.0244	281.5	16.41	.0609	.0009	37.8636	1.7411
199	590	90	12	T	28.91	30.85	30.79	340.50	.5181	.0231	284.7	17.29	.0578	.0009	39.8268	1.4139
200	590	90	13	L	29.88	30.72	30.74	341.80	.6278	.0193	270.6	20.70	.0482	.0007	38.4596	2.1116
201	590	90	13	L	30.75	30.79	30.80	339.50	.7707	.0213	261.8	18.82	.0531	.0009	39.7196	2.0308
202	590	60	4	O	13.23	24.37	24.42	356.10	1.0190	.0629	318.9	6.50	.1537	.0013	20.9699	1.9846
203	590	60	4	O	15.22	24.52	24.58	354.30	1.0640	.0557	310.3	7.34	.1361	.0012	23.4650	2.0819
204	590	60	5	T	12.72	24.99	25.05	356.70	.8583	.0534	317.6	7.65	.1306	.0012	23.3611	1.7578
205	590	60	5	T	15.51	25.15	25.21	354.50	.9439	.0433	305.4	9.42	.1061	.0011	25.7162	2.1493
206	590	60	6	T	18.24	25.23	25.29	357.80	.9161	.0540	317.4	7.56	.1323	.0012	23.1577	1.8694
207	590	60	6	T	16.72	25.30	25.37	355.80	.7943	.0415	310.8	9.82	.1018	.0010	25.9247	1.8687
208	590	60	7	T	15.93	25.27	25.32	373.40	1.1490	.0500	322.5	8.15	.1226	.0011	23.5742	2.4845
209	590	60	7	T	16.05	25.41	25.45	371.30	1.0860	.0434	316.2	9.40	.1063	.0011	25.7872	2.4684
210	590	60	8	T	14.40	25.48	25.50	360.10	.8624	.0663	325.5	6.15	.1626	.0015	24.0205	1.4006
211	590	60	8	T	14.08	25.44	25.47	358.00	.7925	.0525	319.3	7.77	.1286	.0013	25.6611	1.5058
212	590	60	9	T	12.66	24.94	24.93	362.70	.4056	.0387	331.3	10.54	.0948	.0010	25.9818	1.0262
213	590	60	9	T	12.12	24.83	24.84	360.50	.3710	.0294	325.0	13.89	.0719	.0008	27.6474	1.1513
214	590	60	10	T	12.76	24.78	24.80	357.30	.3506	.0305	324.3	13.38	.0748	.0008	26.7180	1.0844
215	590	60	10	T	16.07	24.77	24.79	355.10	.5339	.0270	308.3	15.11	.0661	.0007	28.0223	1.7698
216	590	60	11	T	19.52	24.78	24.80	357.10	.8710	.0468	314.1	8.73	.1144	.0010	23.3090	2.0374
217	590	60	11	T	11.83	24.82	24.86	354.70	1.2480	.0455	296.6	6.99	.1112	.0011	25.2617	2.7663
218	590	60	12	T	12.73	25.00	25.01	363.40	.6904	.0585	330.8	6.98	.1432	.0013	23.7899	1.2773
219	590	60	12	T	103.70	25.03	25.04	361.20	.5691	.0464	326.9	8.81	.1135	.0012	25.9266	1.2088
220	590	60	13	L	57.99	25.21	25.28	366.30	.7036	.0450	326.8	9.07	.1102	.0011	25.2135	1.5719
221	590	60	13	L	89.65	25.31	25.55	364.00	1.2500	.0372	294.8	10.97	.0911	.0010	27.0069	3.1016
222	590	70	3	O	96.99	25.59	25.68	357.50	2.2980	.0570	280.0	7.15	.1398	.0012	21.3100	4.8376
223	590	70	3	O	89.82	25.65	25.70	355.20	2.3000	.0562	275.9	7.26	.1378	.0010	•	5.5136
224	590	70	4	L	89.36	25.98	26.06	369.60	2.6780	.0542	276.1	7.51	.1331	.0012	23.1868	5.4401
225	590	70	4	L	87.76	26.06	26.14	367.40	2.8890	.0532	265.4	7.64	.1308	.0012	24.4811	5.6569
226	590	70	5	T	104.00	26.10	26.24	362.40	1.6120	.0420	286.9	9.69	.1031	.0010	24.0749	4.0119
227	590	70	5	T	104.20	26.09	26.23	360.20	1.7180	.0401	276.8	10.14	.0985	.0010	25.9809	4.1441
228	590	70	6	L	98.46	26.04	26.19	359.40	1.9050	.0477	282.6	8.53	.1172	.0010	21.4962	4.6891
229	590	70	6	L	127.90	26.15	26.34	357.20	1.9980	.0460	273.6	8.84	.1131	.0011	24.1420	4.5200
230	590	70	7	T	96.69	25.99	26.16	357.80	2.5870	.0517	264.1	7.87	.1271	.0011	22.5067	5.6144
231	590	70	7	T	93.36	26.08	26.20	355.60	2.6070	.0521	261.2	7.81	.1280	.0013	23.7771	4.9638
232	590	70	8	T	83.60	26.15	26.29	360.70	3.2870	.0751	277.4	5.42	.1844	.0014	19.5960	5.7502
233	590	70	8	T	86.04	26.11	26.27	358.40	3.2230	.0758	276.5	5.37	.1862	.0015	21.1559	5.1702
234	590	70	9	T	83.77	25.92	25.83	359.40	3.5540	.0898	262.8	4.54	.2204	.0016	19.4679	5.4129

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
235	590	70	9	T	81.28	25.91	25.83	357.00	3.5750	.0927	281.5	4.39	.2276	.0018	20.6881	4.9682
236	590	70	10	O	86.57	25.99	25.99	355.00	3.4780	.0830	274.3	4.91	.2038	.0016	20.6367	5.3326
237	590	70	10	O	85.01	26.02	26.00	352.60	3.1350	.0842	279.3	4.84	.2066	.0017	21.8464	4.4915
238	590	70	11	T	89.38	25.88	25.79	364.90	3.9340	.1115	294.6	3.65	.2736	.0020	19.3487	4.9265
239	590	70	11	T	84.90	25.88	25.79	362.50	3.8880	.1106	292.0	3.69	.2713	.0020	20.2987	4.6783
240	590	70	12	T	86.09	25.52	25.46	354.20	3.4270	.0977	284.7	4.17	.2395	.0018	20.1440	4.6454
241	590	70	12	T	83.29	25.55	25.48	351.90	3.1900	.0950	284.6	4.29	.2329	.0018	21.1122	4.2355
242	590	77	3	L	60.67	25.43	25.56	374.60	.6751	.0463	337.0	8.30	.1135	.0011	24.1288	1.5277
243	590	77	3	L	64.45	25.45	25.48	372.40	.7542	.0380	325.1	10.71	.0933	.0010	26.8385	1.8576
244	590	77	5	T	67.22	25.25	25.25	359.10	1.7830	.0603	298.8	6.76	.1478	.0012	21.8140	3.4931
245	590	77	5	T	65.88	25.29	25.31	356.90	1.9360	.0564	288.2	7.23	.1382	.0013	23.4925	3.7484
246	590	77	6	T	55.54	24.98	25.05	362.10	1.2080	.0530	312.9	7.70	.1296	.0011	21.5712	2.6960
247	590	77	6	T	51.93	25.05	25.14	359.90	1.2410	.0464	303.2	8.79	.1137	.0011	24.2664	2.7943
248	590	77	7	T	58.15	25.11	25.10	364.10	.7671	.0446	322.9	9.16	.1092	.0010	23.8692	1.8410
249	590	77	7	T	61.12	25.26	25.30	361.90	.7963	.0335	309.1	12.19	.0820	.0009	26.7381	2.2424
250	590	77	9	O	79.53	25.51	25.63	472.40	2.2090	.0482	382.1	8.46	.1181	.0010	21.7846	5.3396
251	590	77	9	O	79.13	25.57	25.69	470.10	2.1430	.0474	379.6	8.60	.1162	.0011	23.8081	4.8092
252	590	77	10	T	87.27	25.37	25.45	354.70	3.2370	.0694	266.3	5.88	.1700	.0014	21.6042	5.5790
253	590	77	10	T	78.31	25.36	25.39	352.60	2.6350	.0706	279.1	5.78	.1730	.0015	22.5819	4.2815
254	590	77	11	O	62.04	25.66	25.60	362.10	1.5880	.0682	312.4	5.97	.1674	.0013	20.6765	2.9380
255	590	77	11	O	67.32	25.72	25.65	359.90	1.6600	.0627	303.8	6.50	.1537	.0014	23.2999	2.9596
256	590	77	13	O	91.53	25.58	25.71	357.00	2.1010	.0667	293.5	6.11	.1636	.0013	21.2305	3.8076
257	590	77	13	O	70.28	25.51	25.62	354.50	1.6960	.0622	297.4	6.55	.1525	.0014	22.9236	3.0453
258	590	81	3	O	76.85	24.72	24.76	363.80	1.6940	.0387	260.6	10.55	.0947	.0008	22.7142	4.8770
259	590	81	3	O	81.27	24.81	24.82	361.60	1.6950	.0359	272.1	11.39	.0877	.0008	24.4740	4.8891
260	590	81	4	O	98.77	25.33	25.50	368.50	1.1950	.0299	291.0	13.64	.0732	.0007	23.3803	4.2596
261	590	81	4	O	96.98	25.59	25.75	366.30	1.2170	.0261	277.0	15.57	.0641	.0007	26.6130	4.3534
262	590	81	5	L	94.58	25.82	25.99	363.40	1.0070	.0278	291.5	14.61	.0684	.0007	24.8744	3.6121
263	590	81	5	L	89.19	25.95	26.10	361.10	1.1540	.0262	275.4	15.51	.0644	.0007	27.9403	3.9122
264	590	81	6	T	89.19	25.70	25.74	368.00	2.8830	.0606	278.6	6.72	.1486	.0012	20.4247	6.0018
265	590	81	6	T	94.74	25.76	25.80	365.70	2.9070	.0575	270.8	7.08	.1411	.0012	22.1524	5.8662
266	590	81	7	T	89.38	25.61	25.77	372.00	1.5170	.0336	286.5	12.13	.0823	.0007	22.3489	5.0376
267	590	81	7	T	98.92	25.77	25.93	369.80	1.3720	.0300	282.2	13.55	.0737	.0008	25.5930	4.4526
268	590	81	8	T	100.20	26.00	26.02	357.50	3.4950	.0578	247.3	7.04	.1420	.0012	21.2066	7.3302
269	590	81	8	T	98.56	26.10	26.11	355.00	3.4930	.0577	244.1	7.05	.1418	.0012	22.6959	6.8716
270	590	81	9	T	43.44	26.08	26.08	389.50	3.7180	.0540	264.4	7.54	.1325	.0011	21.9460	8.0759
271	590	81	9	T	102.00	26.08	26.07	387.20	3.6360	.0537	263.5	7.58	.1320	.0012	23.1360	7.5365
272	590	81	10	T	92.43	25.95	26.00	355.30	3.3020	.0547	245.4	7.45	.1342	.0011	20.9073	7.4094
273	590	81	10	T	108.90	25.92	25.96	352.80	3.3400	.0559	243.4	7.29	.1371	.0012	22.3379	6.8668
274	590	81	11	T	101.40	25.90	25.79	377.90	4.7360	.0896	278.1	4.54	.2199	.0017	20.7183	6.8003
275	590	81	11	T	101.20	25.94	25.81	375.40	4.7260	.0940	279.4	4.33	.2307	.0018	21.4875	6.2642
276	590	81	12	O	97.91	26.18	26.27	362.20	2.9440	.0465	246.6	8.76	.1142	.0011	23.6061	6.8001
277	590	81	12	O	100.20	26.15	26.22	360.00	2.7290	.0463	251.1	8.78	.1138	.0011	24.7630	6.0429
278	590	81	13	L	106.60	25.92	25.89	381.50	4.3100	.0695	268.1	5.86	.1706	.0013	19.3779	8.3406
279	590	81	13	L	104.80	25.99	25.95	379.00	4.5050	.0693	260.2	5.87	.1702	.0013	20.7867	8.1579
280	590	81	14	L	100.80	25.84	25.98	356.60	1.9050	.0451	276.5	9.02	.1108	.0009	21.0798	6.0539
281	590	81	14	L	96.01	25.98	26.13	354.30	1.9100	.0420	267.7	9.70	.1030	.0010	23.9568	4.7723
282	590	31	3	O	12.37	30.55	30.56	376.20	.2748	.0981	353.7	4.09	.2444	.0028	30.9563	.2404
283	590	31	3	O	13.07	30.65	30.66	375.20	.3265	.0779	349.3	5.15	.1941	.0024	33.1972	.3307
284	590	31	5	L	16.74	30.83	30.84	365.60	.3511	.1185	344.6	3.38	.2956	.0031	28.5820	.2791
285	590	31	5	L	17.40	31.14	31.15	364.50	.2504	.0833	340.8	4.80	.2081	.0026	33.6348	.2345
286	590	31	6	T	18.21	31.32	31.24	369.90	.3147	.1151	347.9	3.48	.2876	.0032	30.9708	.2389
287	590	31	6	T	20.71	31.36	31.28	368.60	.3595	.0924	343.5	4.33	.2310	.0029	33.5949	.3082
288	590	31	7	T	17.99	31.37	31.40	389.10	.5429	.0180	362.2	3.71	.2609	.0031	31.1210	.4312
289	590	31	7	T	17.74	31.41	31.43	388.20	.4833	.0967	360.5	4.14	.2416	.0029	32.7853	.4038
290	590	31	8	T	25.19	31.25	31.20	356.30	.5694	.1478	335.2	2.71	.3691	.0035	26.7591	.3976
291	590	31	8	T	21.69	31.40	31.34	355.20	.6281	.1338	331.1	2.99	.3343	.0036	29.9492	.4290
292	590	31	9	T	20.43	31.54	31.49	368.00	.4802	.1359	346.0	2.94	.3398	.0035	28.6460	.3379
293	590	31	9	T	20.43	31.63	31.58	366.70	.4485	.1197	342.7	3.34	.2994	.0034	31.8031	.3187
294	590	31	10	T	20.54	31.62	31.51	357.70	.5565	.1622	337.2	2.46	.4055	.0038	26.9767	.3567
295	590	31	10	T	20.41	31.76	31.63	356.70	.5638	.1499	334.3	2.67	.3751	.0039	29.8174	.3514
296	590	31	11	T	20.59	31.82	31.70	356.00	.4171	.1386	334.8	2.88	.3467	.0037	29.9271	.2777
297	590	31	11	T	20.86	31.92	31.85	355.00	.2162	.1250	334.7	3.20	.3128	.0036	32.3742	.1456
298	590	81	5	L	14.80	30.97	30.99	362.00	.4916	.0945	336.6	4.27	.2359	.0018	30.3385	.6557
299	590	81	5	L	14.74	31.46	31.48	359.80	.4651	.0713	329.8	5.61	.1784	.0024	35.3561	.4798
300	590	81	6	T	17.30	31.82	31.87	365.70	.3841	.0727	337.3	5.49	.1819	.0024	35.2371	.3809
301	590	81	6	T	18.50	32.13	32.19	363.70	.4603	.0496	327.1	8.03	.1244	.0019	39.2255	.6030
302	590	81	7	T	17.09	32.05	32.07	366.80	.4432	.0741	337.3	5.39	.1856	.0024	35.2435	.4428
303	590	81	7	T	18.20	32.17	32.20	364.90	.5770	.0534	325.9	7.47	.1339	.0020	38.7109	.7122
304	590	81	8	L	13.10	32.29	32.30	366.70	.6538	.0893	335.7	4.47	.2238	.0028	33.9042	.5696
305	590	81	8	L	16.69	32.25	32.29	365.50	.4505	.0746	335.7	5.34	.1871	.0025	35.6952	.4400
306	590	81	9	L	13.65	31.29	31.25	361.40	.8925	.1162	332.8	3.44	.2902	.0030	28.4628	.7290
307	590	81	9	L	13.77	31.46	31.44	360.30	.8635	.1087	330.2	3.68	.2718	.0031	30.7461	.6919
308	590	81	10	L	20.83	31.57	31.68	361.00	.9229	.1167	332.6	3.43	.2918	.0029	27.0549	.7779
309	600	81	10	L	20.35	31.70	31.82	360.00	.8535	.1063	329.6	3.76	.2658	.0030	30.5982	.6934
310	600	34	3	T	41.40	26.00	27.85	368.10	.4257	.0113	264.5	38.08	.0277	.0003	20.4983	3.7930
311	600	34	3	T	13.67	26.43	27.09	367.00	.5169	.0117	282.5	34.74	.0287	.0003	22.7210	4.2007
312	600	34	4	T	31.18	26.62	27.64	355.10	.3631	.0098	284.3	41.13	.0243	.0002	21.0091	3.9400

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
313	590	34	4	T	118.90	26.75	27.23	354.20	.3955	.0115	287.0	35.04	.0285	.0003	23.0780	3.5127
314	590	34	5	L	53.28	26.78	27.03	345.90	.5086	.0109	260.2	37.19	.0268	.0002	21.9789	5.1107
315	590	34	5	L	18.34	26.77	27.12	344.90	.4665	.0121	271.3	33.47	.0298	.0003	23.1482	3.9991
316	590	34	6	T	9.90	26.31	26.45	338.00	.5629	.0118	250.5	34.41	.0290	.0002	20.9679	5.5602
317	590	34	6	T	9.80	26.34	26.45	337.00	.4061	.0138	278.9	29.29	.0341	.0003	22.1285	3.2549
318	590	34	7	O	14.32	25.94	26.00	345.40	.4053	.0128	284.0	31.76	.0314	.0003	21.0275	3.7006
319	590	34	7	O	8.97	26.16	26.20	344.30	.3076	.0134	295.7	30.35	.0329	.0003	22.8760	2.4764
320	590	81	3	O	22.60	26.02	26.07	341.80	.6557	.0131	250.9	30.94	.0323	.0003	22.4364	5.4778
321	590	81	3	O	22.81	26.21	26.26	340.70	.8290	.0139	234.0	29.26	.0341	.0003	23.1564	6.3672
322	590	81	4	O	20.15	26.39	26.45	345.70	.3792	.0090	266.5	45.19	.0221	.0002	23.6698	4.3538
323	590	81	4	O	22.46	26.57	26.63	344.70	.3894	.0097	268.3	41.76	.0239	.0002	24.8206	3.9992
324	590	81	5	L	28.48	26.40	26.44	340.20	.4917	.0123	264.8	32.97	.0303	.0003	23.2301	4.2467
325	590	81	5	L	22.76	26.43	26.47	339.10	.4383	.0130	273.5	31.12	.0321	.0003	23.8110	3.4861
326	590	81	6	T	21.32	26.33	26.39	356.00	.5282	.0073	231.1	55.38	.0180	.0002	22.0283	8.1001
327	590	81	6	T	21.29	26.55	26.61	356.00	.2606	.0092	297.1	44.06	.0226	.0002	23.8157	2.9865
328	590	81	9	T	205.20	26.57	26.81	340.90	.3348	.0099	274.5	40.68	.0245	.0003	25.3196	3.2382
329	590	81	9	T	99.53	26.61	26.79	339.90	.4039	.0106	266.0	38.24	.0261	.0003	26.2066	3.5411
330	590	81	10	T	30.43	26.37	26.50	342.10	.8476	.0136	232.1	29.77	.0335	.0003	21.5293	7.0578
331	590	81	10	T	75.68	26.50	26.64	341.00	.8769	.0158	241.2	25.61	.0390	.0004	22.3436	6.0903
332	590	81	11	T	311.90	26.47	26.58	351.50	.4487	.0098	267.0	41.24	.0242	.0002	22.9524	4.8407
333	590	81	11	T	70.12	26.66	27.12	350.40	.4845	.0110	267.6	36.70	.0272	.0003	24.3813	4.3024
334	590	81	12	O	28.03	26.63	26.75	459.90	1.3280	.0138	291.7	29.31	.0341	.0003	22.5397	10.4820
335	590	81	12	O	27.96	26.71	26.82	458.80	1.4250	.0152	294.1	26.62	.0375	.0003	23.0243	9.9804
336	590	81	13	L	28.41	26.14	26.21	341.20	1.2720	.0153	198.9	26.52	.0377	.0003	19.6159	10.4704
337	590	81	13	L	42.33	26.18	26.27	340.10	1.4380	.0179	202.0	22.64	.0441	.0004	20.0861	9.8839
338	590	81	14	L	61.82	26.02	26.12	341.80	.4647	.0120	296.3	33.91	.0294	.0002	20.6864	4.6019
339	590	81	14	L	70.19	26.03	26.17	340.60	.4978	.0124	265.3	32.84	.0304	.0003	21.9563	4.5106
340	590	5	1	O	67.45	32.08	32.18	346.90	1.2760	.0323	270.1	12.33	.0810	.0008	25.2644	3.9123
341	590	5	1	O	75.28	32.22	32.31	345.70	1.4310	.0320	260.0	12.45	.0803	.0008	26.4936	4.2211
342	590	5	2	T	60.00	31.93	32.03	347.50	1.0160	.0266	273.0	15.01	.0666	.0007	24.9810	3.8162
343	590	5	2	T	67.63	32.13	32.26	346.40	.8563	.0250	275.4	15.94	.0627	.0007	27.0795	3.2547
344	590	5	3	L	24.07	32.02	32.04	347.20	1.5530	.0299	250.5	13.36	.0748	.0007	25.2127	5.2039
345	590	5	3	L	21.76	32.10	32.12	346.00	1.8070	.0328	244.1	12.14	.0823	.0008	26.0984	5.3179
346	590	5	4	T	45.39	32.20	32.22	347.00	1.2760	.0277	259.6	14.36	.0696	.0007	26.2893	4.3893
347	590	5	4	T	20.10	32.32	32.35	345.80	1.0830	.0283	270.2	14.06	.0710	.0007	28.2261	3.7528
348	590	5	5	O	60.97	32.35	32.30	347.70	1.3180	.0366	276.0	10.87	.0919	.0009	26.3881	3.4778
349	590	5	5	O	40.12	32.45	32.40	348.60	1.2330	.0373	279.1	10.67	.0936	.0010	27.3023	3.0871
350	590	5	6	T	82.84	32.23	32.13	352.40	3.0880	.0663	263.0	6.01	.1663	.0015	24.6808	4.9538
351	590	5	6	T	85.57	32.29	32.19	351.10	2.2880	.0642	279.6	6.21	.1610	.0015	24.9142	3.7465
352	590	5	7	O	17.57	32.25	32.21	356.50	2.0700	.0434	265.9	9.18	.1089	.0011	25.3652	4.8033
353	590	5	7	O	69.33	32.37	32.32	355.50	1.2330	.0429	295.0	9.28	.1077	.0011	26.1328	2.8167
354	590	5	8	O	121.70	32.51	32.63	344.40	2.8290	.0460	231.5	8.65	.1155	.0011	25.5574	6.0816
355	590	5	8	O	86.49	32.53	32.59	343.00	1.8490	.0464	264.9	8.59	.1164	.0012	25.8926	3.9158
356	590	5	9	O	118.30	32.46	32.39	343.40	3.9240	.0710	239.5	5.62	.1780	•	25.1698	•
357	590	5	9	O	101.60	32.50	32.43	341.90	3.5260	.0749	251.4	5.32	.1879	.0018	25.2599	4.9126
358	590	70	2	O	51.97	32.52	32.62	346.00	.5296	.0152	274.4	26.13	.0382	.0005	31.4250	2.7365
359	590	70	2	O	50.40	32.62	32.72	344.80	.5138	.0161	276.6	24.73	.0404	.0005	33.7815	2.3411
360	590	70	3	L	42.21	32.70	32.79	350.40	.0967	.0118	319.3	33.71	.0296	.0004	33.5636	.6019
361	590	70	4	L	38.02	32.76	32.82	357.80	.4924	.0123	277.0	32.34	.0309	.0004	32.5308	3.0340
362	590	70	4	L	43.58	.32.78	32.84	356.30	.6934	.0143	261.1	27.76	.0360	.0005	35.1167	3.4256
363	590	70	5	T	35.13	32.23	32.25	352.80	.3141	.0169	306.6	23.61	.0423	.0005	31.0008	1.5010
364	590	70	5	T	38.83	32.29	32.44	351.50	.5548	.0178	284.3	22.31	.0448	.0006	33.3842	2.3030
365	590	70	7	T	32.84	.32.32	32.36	348.00	.7293	.0133	246.7	29.81	.0335	.0004	28.2861	4.7730
366	590	70	7	T	31.88	.32.43	32.47	347.00	.7412	.0156	255.8	25.53	.0391	.0005	30.4673	3.8879
367	590	70	8	L	34.85	32.58	32.65	352.10	.5227	.0123	268.0	32.32	.0309	.0004	32.0507	3.2680
368	590	70	8	L	32.96	32.73	32.79	351.10	.5654	.0138	268.4	28.72	.0348	.0005	34.3672	2.9458
369	590	70	9	T	47.94	32.72	32.70	348.10	1.1720	.0200	239.9	19.91	.0502	.0006	28.4693	5.1681
370	590	70	9	T	50.44	32.75	32.72	347.00	.6477	.0226	285.7	17.58	.0568	.0007	29.8729	2.4139
371	590	70	10	T	34.09	32.67	32.72	346.80	.5617	.0127	260.0	31.30	.0319	.0004	32.4402	3.3796
372	590	70	10	T	50.17	.32.72	32.78	345.80	.6321	.0140	256.9	28.32	.0353	.0005	34.2693	3.2626
373	590	70	11	O	67.34	.32.60	32.56	346.30	1.3740	.0233	237.2	17.09	.0584	.0007	29.0161	5.1234
374	590	70	11	O	79.08	.32.60	32.58	345.00	1.7830	.0263	221.9	15.11	.0661	.0008	29.5461	5.7701
375	590	70	12	T	201.20	32.50	32.42	345.30	1.1600	.0259	259.1	15.38	.0650	.0007	28.4399	4.0041
376	590	70	12	T	36.10	.32.54	32.47	344.20	1.2950	.0274	253.6	14.52	.0688	.0008	29.2502	4.0951
377	590	70	13	T	34.33	.32.20	32.18	345.60	1.4270	.0395	271.8	10.10	.0989	.0008	29.7893	4.1250
378	590	70	13	T	35.24	32.25	32.23	344.50	1.3890	.0409	274.1	9.74	.1027	.0009	30.2952	3.8117
379	590	90	3	L	24.23	.32.37	32.44	351.90	.8913	.0209	269.9	19.00	.0526	.0005	26.6328	3.9696
380	590	90	3	L	30.40	.32.48	32.57	350.80	.8701	.0216	271.5	18.39	.0543	.0006	28.6148	3.4915
381	590	90	5	T	18.22	.32.22	32.21	346.00	.6436	.0261	281.0	15.26	.0655	.0006	25.2536	3.2236
382	590	90	5	T	21.30	.32.11	32.04	344.90	.6382	.0264	292.2	15.09	.0662	.0007	26.9454	2.2786
383	590	90	6	T	19.53	.32.00	31.99	351.90	1.2070	.0275	268.2	14.52	.0688	.0007	25.0389	4.4318
384	590	90	6	T	20.02	32.14	32.12	350.80	1.1430	.0280	271.3	14.26	.0701	.0007	28.4860	3.8064
385	590	90	7	T	24.67	32.27	32.31	355.80	1.4730	.0259	251.7	15.36	.0650	.0006	24.6997	5.7654
386	590	90	7	T	22.25	32.40	32.45	354.70	1.3380	.0274	262.7	14.52	.0688	.0007	26.0350	4.6899
387	590	90	8	T	26.39	32.60	32.60	358.40	.7121	.0205	287.8	19.42	.0514	.0006	28.0761	3.0716
388	590	90	8	T	30.88	32.68	32.70	367.40	.8072	.0208	274.2	19.20	.0518	.0006	29.9980	3.4750
389	590	90	9	T	10.46	31.87	31.91	348.30	.4366	.0223	302.5	17.80	.0558	.0008	27.3305	1.7850
390	590	90	9	T	22.94	32.32	32.41	347.10	.6452	.0231	285.9	17.24	.0579	.0007	31.7461	2.1900

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
391	590	90	10	T	47.53	32.51	32.65	350.20	1.4260	.0255	258.3	15.68	.0641	.0008	24.9874	6.5020
392	590	90	10	T	30.33	32.52	32.66	358.00	1.3780	.0270	262.2	14.71	.0679	.0007	26.1850	4.8214
393	590	90	11	T	37.91	32.53	32.58	349.80	1.2290	.0335	276.1	11.87	.0841	.0009	27.8326	3.3234
394	590	90	11	T	39.65	32.61	32.67	348.60	1.4750	.0338	263.4	11.78	.0848	.0009	28.7238	3.8275
395	590	90	12	L	38.07	32.53	32.64	348.20	.0779	.0277	275.9	14.37	.0695	.0008	29.8120	3.0488
396	590	90	12	L	38.35	32.71	32.82	347.00	1.2500	.0292	262.0	13.61	.0734	.0007	31.7115	4.4876
397	590	5	1	O	98.69	32.12	32.15	352.60	4.1750	.0576	221.3	6.92	.1444	.0014	24.7225	7.5326
398	590	5	1	O	53.49	32.21	32.26	351.20	1.4650	.0472	267.2	8.45	.1183	.0011	25.2364	3.1352
399	590	5	2	O	32.28	32.36	32.30	343.40	2.8710	.0565	247.6	7.06	.1416	.0013	25.0454	5.2638
400	590	5	2	O	59.32	32.40	32.31	342.00	2.5810	.0563	254.3	7.08	.1413	.0013	25.3150	4.7114
401	590	5	3	O	91.82	32.45	32.40	350.00	.9335	.0388	297.5	10.26	.0974	.0010	25.7823	2.3867
402	590	5	3	O	78.45	32.57	32.53	348.70	.9003	.0370	295.2	10.75	.0929	.0010	27.0631	2.2035
403	590	5	4	O	46.54	32.65	32.60	341.50	1.9120	.0519	267.9	7.68	.1302	.0013	26.6647	3.5719
404	590	5	4	O	62.59	32.72	32.68	340.10	2.1720	.0511	257.3	7.79	.1283	.0013	26.9993	4.0592
405	590	5	5	O	101.90	32.67	32.43	343.80	2.9420	.0840	273.1	4.74	.2109	.0019	24.7802	3.8257
406	590	5	5	O	107.20	32.70	32.52	342.40	4.0930	.0860	250.7	4.63	.2158	.0019	24.7936	5.1626
407	590	5	7	O	48.08	32.68	32.61	347.30	2.1270	.0679	282.6	5.86	.1705	.0016	25.2680	3.2451
408	590	5	7	O	52.33	32.72	32.67	345.90	2.5150	.0677	271.7	5.88	.1700	.0016	25.4193	3.8201
409	590	5	9	O	98.28	32.29	32.25	363.40	1.3060	.0364	291.5	10.94	.0913	.0009	25.7242	3.5481
410	590	5	9	O	64.10	32.43	32.47	362.30	1.3690	.0366	287.4	10.87	.0919	.0009	26.7473	3.5364
411	590	5	10	O	23.12	32.48	32.33	355.70	1.9680	.0728	298.1	5.47	.1827	.0016	24.4848	2.9272
412	590	5	10	O	25.79	32.52	32.38	354.50	1.9850	.0692	294.2	5.76	.1735	.0016	24.6550	3.0796
413	590	6	1	O	97.44	32.41	32.36	348.80	1.2830	.0343	274.6	11.62	.0860	.0009	26.6024	3.5777
414	590	6	1	O	109.00	32.46	32.48	347.60	2.0650	.0385	246.9	10.35	.0965	.0010	27.2198	4.9956
415	590	6	2	O	96.24	32.53	32.56	347.10	2.7170	.0405	226.0	9.84	.1015	.0009	24.2126	7.0505
416	590	6	2	O	110.40	32.59	32.65	346.00	2.3450	.0366	229.9	10.87	.0919	.0009	24.7884	6.5169
417	590	6	3	O	108.90	32.62	32.65	348.80	2.3960	.0510	258.8	7.81	.1280	.0013	25.9115	4.6374
418	590	6	3	O	102.90	32.59	32.59	347.60	2.5190	.0509	253.6	7.82	.1278	.0013	26.0284	4.8742
419	590	6	4	O	44.72	32.18	32.07	346.20	1.4060	.0332	265.2	11.99	.0833	.0008	25.1650	4.3022
420	590	6	4	O	103.80	32.30	32.33	344.90	2.1690	.0380	239.4	10.49	.0953	.0010	26.0615	5.5474
421	590	6	5	L	95.70	32.19	32.02	342.80	3.1010	.0812	267.3	4.91	.2036	.0018	23.9721	4.2652
422	590	6	5	L	95.10	32.20	32.03	341.40	3.3180	.0826	262.6	4.83	.2070	.0018	24.0193	4.4897
423	590	6	6	O	109.60	32.27	32.13	350.16	2.8040	.0653	267.1	6.11	.1637	.0015	25.0797	4.5104
424	590	6	6	O	109.40	32.34	32.23	349.10	3.3660	.0705	257.4	5.66	.1767	.0017	25.2807	4.9837
425	590	71	1	O	35.77	32.34	32.20	346.00	1.0430	.0339	281.9	11.75	.0851	.0009	28.5407	2.7657
426	590	71	1	O	36.72	32.40	32.26	345.00	1.0310	.0341	281.5	11.68	.0855	.0009	29.1150	2.6625
427	590	71	2	O	110.20	32.48	32.52	346.40	.9939	.0192	248.4	20.77	.0481	.0006	30.0448	4.3190
428	590	71	2	O	132.80	32.51	32.55	345.40	.6776	.0192	273.0	20.75	.0481	.0006	31.1774	2.8293
429	590	71	3	O	41.29	32.51	32.52	355.20	1.1740	.0175	232.7	22.78	.0438	.0005	29.8674	5.2615
430	590	71	3	O	37.70	32.51	32.53	354.10	1.0550	.0189	249.1	21.07	.0474	.0006	30.6774	4.5395
431	590	71	4	O	33.16	32.38	32.30	352.00	1.2630	.0386	284.1	10.32	.0968	.0011	28.8002	2.9141
432	590	71	4	O	37.38	32.40	32.33	350.90	1.2810	.0378	281.1	10.52	.0949	.0011	29.1150	2.9747
433	590	71	5	O	33.02	32.24	32.00	345.10	1.2040	.0509	292.5	7.84	.1275	.0013	27.5980	2.2528
434	590	71	5	O	32.32	32.27	32.03	343.90	1.2840	.0518	289.4	7.70	.1299	.0013	27.7397	2.3502
435	590	71	7	O	32.75	32.22	32.07	348.80	1.2650	.0525	294.7	7.59	.1316	.0014	28.5836	2.2006
436	590	71	7	O	34.80	32.24	32.08	347.70	1.2160	.0524	295.0	7.61	.1314	.0014	28.5580	2.1269
437	591	100	3	O	1323.00	26.43	29.05	350.20	1.1010	.0287	274.8	14.14	.0707	.0007	20.6410	3.6694
438	591	100	3	O	1529.00	26.84	29.48	349.10	1.9120	.0302	233.2	13.45	.0743	.0008	21.7733	5.7907
439	591	100	4	T	1731.00	27.75	30.35	359.70	2.2340	.0310	229.6	13.05	.0766	.0008	21.1969	6.6779
440	591	100	4	T	1729.00	27.99	30.52	358.50	2.1500	.0318	235.2	12.71	.0786	.0009	22.0120	6.1107
441	591	100	5	L	1714.00	28.10	30.68	350.40	5.4140	.0586	185.0	6.90	.1448	.0016	22.8648	8.2524
442	591	100	5	L	1686.00	28.20	30.87	348.80	5.5140	.0594	182.5	6.81	.1469	.0016	22.9567	8.1811
443	591	100	6	T	765.80	28.38	31.17	362.20	3.0860	.0369	210.9	11.00	.0908	.0011	23.3989	7.0801
444	591	100	6	T	604.90	28.54	31.25	361.00	3.0670	.0362	208.8	11.15	.0896	.0011	23.8496	7.0742
445	591	100	7	L	125.90	28.37	29.33	339.90	4.2930	.0522	193.4	7.74	.1291	.0013	23.1765	8.3350
446	591	100	7	L	336.20	28.42	29.32	338.40	4.2580	.0534	196.0	7.56	.1322	.0013	23.2988	8.1074
447	591	100	8	T	68.77	27.88	28.02	340.70	2.7160	.0473	235.9	8.55	.1169	.0010	22.4705	6.4360
448	591	100	8	T	48.59	27.83	27.91	339.60	1.7290	.0490	270.5	8.26	.1210	.0011	22.4512	3.9929
449	591	100	9	T	105.80	27.25	27.37	347.30	1.0150	.0215	260.0	18.84	.0530	.0005	22.4033	5.2020
450	591	100	9	T	83.13	27.15	27.28	346.10	1.0180	.0222	260.6	18.27	.0547	.0005	23.0119	4.9345
451	591	100	10	T	45.40	26.58	26.49	342.70	2.6700	.0791	276.5	5.14	.1949	.0014	19.7971	4.5334
452	591	100	10	T	37.98	26.57	26.48	341.40	2.9370	.0819	271.8	4.96	.2015	.0015	19.6466	4.8367
453	591	18	3	O	49.96	24.69	24.61	340.70	•	.0293	435.7	13.94	.0717	.0005	17.8884	•
454	591	18	3	O	93.83	24.80	24.74	341.20	.7574	.0305	291.5	13.37	.0747	.0005	18.7133	3.3676
455	591	18	4	O	256.50	25.33	25.43	361.30	6.7470	.0206	•	19.76	.0505	.0003	18.6573	54.4020
456	591	18	4	O	302.80	25.36	25.45	359.50	8.7900	.0231	•	17.63	.0567	.0004	18.8849	49.7912
457	591	18	5	T	13.05	25.46	25.53	339.80	3.3320	.0481	217.4	8.47	.1179	.0009	18.9878	9.2571
458	591	18	5	T	13.20	25.50	25.60	338.50	2.9020	.0453	224.5	8.99	.1112	.0008	19.1752	8.4632
459	591	18	6	T	36.10	25.62	25.68	349.00	1.1900	.0268	267.7	15.18	.0658	.0005	18.9584	5.8599
460	591	18	6	T	27.35	25.66	25.71	348.00	1.1280	.0290	274.9	14.05	.0711	.0006	19.7065	4.9452
461	591	18	7	T	29.26	25.66	25.67	345.80	2.2820	.0465	256.3	8.76	.1141	.0008	18.6465	6.7134
462	591	18	7	T	24.12	25.67	25.68	344.40	2.3360	.0468	253.5	8.70	.1149	.0008	18.8560	6.7432
463	591	18	8	T	21.83	25.58	25.60	353.20	3.1270	.0499	241.1	8.17	.1224	.0009	18.8405	8.5176
464	591	18	8	T	21.47	25.60	25.63	352.10	3.1000	.0532	246.7	7.67	.1303	.0010	18.9495	7.8891
465	591	18	9	T	21.47	25.89	25.66	345.30	2.6970	.0530	252.4	7.70	.1299	.0009	19.1485	6.9888
466	591	18	9	T	20.79	25.71	25.65	244.30	1.3180	.0513	292.5	7.95	.1257	.0009	18.9643	3.4907
467	591	18	10	T	21.45	25.67	25.73	343.00	1.2950	.0624	299.2	6.53	.1531	.0011	18.4560	2.8868
468	591	18	10	T	20.93	25.69	25.76	341.60	4.3090	.0632	220.0	6.45	.1549	.0011	18.5551	9.4478

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
469	591	18	11	T	34.55	25.61	25.60	346.80	3.8420	.0384	174.3	10.61	.0941	.0007	18.8989	13.6119
470	591	18	11	T	30.58	25.69	25.56	344.60	.3587	.0372	318.8	10.94	.0914	.0007	19.8061	1.2416
471	591	31	5	L	11.45	23.31	23.34	364.00	.4221	.0184	317.4	22.30	.0448	.0003	17.7852	3.2100
472	591	31	5	L	11.72	23.42	23.46	362.90	.4632	.0180	311.0	22.80	.0438	.0003	19.3798	3.3136
473	591	31	6	O	11.62	23.04	23.02	301.80	.4008	.0208	320.1	13.77	.0725	.0004	15.6419	2.7164
474	591	31	6	O	11.46	23.13	23.11	360.70	.4990	.0300	324.5	13.67	.0731	.0005	16.9456	2.4835
475	591	31	7	T	12.78	23.38	23.42	354.80	.4559	.0176	303.8	23.28	.0429	•	17.6364	•
476	591	31	7	T	12.28	23.31	23.34	353.70	.4076	.0177	306.6	23.23	.0430	.0003	18.9892	3.0145
477	591	31	8	T	12.20	23.32	23.35	364.90	.5485	.0283	324.2	14.50	.0669	.0005	16.8525	2.8865
478	591	31	8	T	12.31	23.29	23.31	363.80	.5369	.0295	324.6	13.93	.0717	.0005	17.6807	2.5924
479	591	31	9	T	16.77	23.77	23.35	354.90	.5054	.0172	298.6	23.88	.0418	.0003	17.9798	4.2680
480	591	31	9	T	17.65	23.32	23.40	354.00	.5064	.0173	297.0	23.73	.0421	.0003	18.6945	3.8368
481	591	31	10	T	12.47	23.08	23.14	360.20	.4802	.0196	311.5	20.92	.0477	.0003	17.0602	3.5772
482	591	31	10	T	12.40	23.13	23.21	359.20	.4441	.0187	311.0	21.93	.0455	.0003	18.4968	3.1773
483	591	31	11	T	13.44	23.20	23.34	361.00	.2863	.0169	323.1	24.32	.0411	.0003	19.1347	2.1791
484	591	31	11	T	16.98	23.39	23.43	359.80	.3279	.0160	315.6	25.57	.0391	.0003	21.0507	2.4179
485	591	31	5	L	661.40	25.77	25.95	340.20	3.9260	.0564	217.0	7.23	.1383	.0010	17.6720	9.9438
486	591	31	5	L	656.30	25.88	26.09	339.00	2.8820	.0586	248.9	6.95	.1438	.0010	18.0187	6.8811
487	591	31	6	O	851.70	26.05	26.27	339.20	4.5660	.0552	194.5	7.38	.1355	.0010	18.2261	11.4068
488	591	31	6	O	791.10	26.14	26.37	337.60	8.0600	.0384	-10.8	10.59	.0944	.0007	18.4459	28.1401
489	591	31	7	T	376.50	26.53	26.70	339.90	3.2770	.0464	215.1	8.76	.1142	.0009	19.4948	9.1037
490	591	31	7	T	530.80	26.62	26.83	338.60	3.0290	.0468	223.1	8.68	.1152	.0009	19.8391	8.1647
491	591	31	8	T	105.60	26.74	27.17	348.00	14.5300	.0436	-201.8	9.31	.1073	.0008	7.8239	42.9844
492	591	31	8	T	118.80	26.83	27.36	345.90	8.7510	.0731	138.0	5.56	.1799	.0014	18.6125	15.8365
493	591	31	9	T	328.60	27.03	27.63	359.60	3.3110	.0707	270.8	5.74	.1743	.0014	20.2996	5.6581
494	591	31	9	T	326.80	27.15	27.83	358.30	4.9770	.0693	228.4	5.85	.1709	.0014	20.5019	8.5114
495	591	31	10	T	186.10	27.28	28.53	346.10	8.4090	.0748	149.1	5.42	.1845	.0016	19.9970	12.9293
496	591	31	10	T	177.00	27.35	28.58	344.50	7.1500	.0864	195.2	4.69	.2130	.0018	20.0559	9.5862
497	591	31	12	T	333.10	27.89	30.03	348.10	3.5060	.0899	269.7	4.50	.2221	.0021	20.7424	4.0130
498	591	31	12	T	286.50	27.97	30.23	346.10	7.8800	.0837	176.9	4.83	.2068	.0020	20.7079	9.5318
499	591	45	3	O	28.56	24.45	24.46	345.40	1.5570	.0350	264.9	11.67	.0856	.0006	16.5553	6.7746
500	591	45	3	O	38.12	24.54	24.57	344.20	1.8760	.0349	248.4	11.71	.0853	.0006	17.1508	7.8877
501	591	45	4	O	25.49	24.82	24.89	392.20	1.7180	.0280	283.5	14.59	.0684	.0005	16.5707	9.2623
502	591	45	4	O	23.79	24.88	24.95	391.10	1.4900	.0282	295.7	14.50	.0689	.0005	17.3031	7.6529
503	591	45	5	T	57.35	25.19	25.35	354.60	.5318	.0193	300.2	21.11	.0473	.0004	18.7094	3.6271
504	591	45	5	T	50.12	25.34	25.48	353.40	.7014	.0189	283.0	21.55	.0463	.0015	20.7365	1.1282
505	591	45	6	T	22.78	25.32	25.33	350.20	1.4380	.0344	272.9	11.87	.0842	.0006	18.3181	5.7759
506	591	45	6	T	8.97	25.37	25.38	349.00	1.5970	.0369	269.1	11.03	.0905	.0007	18.8342	5.8120
507	591	45	7	T	22.07	25.35	25.43	343.50	.8068	.0205	270.6	19.85	.0503	.0004	19.0857	5.1167
508	591	45	7	T	21.71	25.43	25.51	342.40	.7683	.0209	273.1	19.45	.0513	.0004	20.4298	4.4734
509	591	45	8	T	22.59	25.44	25.44	341.00	1.1070	.0450	291.4	9.06	.1103	.0008	18.4491	3.4077
510	591	45	8	T	22.82	25.48	25.47	339.90	1.3210	.0479	285.3	8.51	.1175	.0009	18.8465	3.7396
511	591	45	9	T	21.05	25.44	25.46	340.50	1.1380	.0473	291.5	8.62	.1160	.0009	18.9091	3.2447
512	591	45	9	T	21.53	25.48	25.50	339.40	1.3900	.0487	282.9	8.38	.1193	.0009	19.2165	3.7904
513	591	45	10	T	21.02	25.30	25.31	343.40	1.0190	.0278	275.1	14.67	.0681	.0005	17.8197	5.1651
514	591	45	10	T	20.93	25.40	25.40	342.30	.9107	.0300	283.6	13.58	.0736	.0006	18.8820	4.0375
515	591	45	11	O	22.23	25.50	25.55	340.80	1.0010	.0314	279.7	12.98	.0770	.0006	18.6452	4.3018
516	591	45	11	O	21.49	25.61	25.66	339.60	1.0310	.0331	279.2	12.30	.0812	.0006	19.5689	4.0086
517	591	59	2	O	25.71	23.42	23.49	350.20	.4335	.0164	297.3	25.05	.0399	.0003	19.7738	3.3140
518	591	59	2	O	21.46	23.54	23.60	349.10	.4618	.0167	293.8	24.55	.0407	.0003	20.9151	3.2629
519	591	59	3	O	13.47	23.68	23.75	350.50	.4830	.0148	288.3	27.65	.0361	.0003	18.9608	4.2661
520	591	59	3	O	13.62	23.67	23.75	349.50	.4911	.0150	286.5	27.33	.0365	.0003	20.2152	3.9889
521	591	59	4	O	14.17	23.78	23.85	351.50	.5534	.0163	287.7	25.09	.0398	.0003	17.8975	4.7080
522	591	59	4	O	13.81	23.76	23.82	350.40	.5636	.0172	287.7	23.85	.0419	.0003	19.2021	4.2425
523	591	59	5	T	13.77	23.70	23.75	347.60	.4589	.0195	300.5	21.04	.0475	.0003	17.6361	3.3154
524	591	59	5	T	14.06	23.76	23.81	346.30	.5338	.0195	292.4	20.96	.0476	.0004	19.2221	3.5178
525	591	59	6	T	14.33	23.82	23.87	353.40	.4220	.0193	308.6	21.18	.0471	.0003	18.3084	2.9640
526	591	59	6	T	14.58	23.93	23.98	352.40	.6168	.0198	292.0	20.69	.0483	.0004	19.5442	3.9708
527	591	59	7	T	13.97	23.76	23.77	346.30	.5039	.0302	310.6	13.55	.0737	.0005	16.6021	2.5270
528	591	59	7	T	13.97	23.63	23.83	345.20	.5988	.0313	304.9	13.10	.0762	.0005	17.3628	2.7283
529	591	59	8	T	13.40	23.86	24.01	344.80	.5581	.0175	282.4	23.33	.0428	.0004	22.1345	3.5298
530	591	59	8	T	13.48	23.88	24.03	343.60	.4271	.0170	291.6	24.11	.0414	.0004	22.5701	2.7534
531	591	59	9	T	15.06	24.11	24.24	344.00	.2296	.0141	305.7	29.02	.0344	.0003	23.3391	1.7136
532	591	59	8	T	18.43	24.18	24.33	343.00	.2721	.0135	298.2	30.25	.0330	.0003	24.2085	2.0495
533	591	59	2	O	1427.00	31.15	34.21	361.00	.9637	.0245	277.5	16.33	.0612	.0009	30.5306	2.5323
534	591	59	2	O	1425.00	31.66	34.77	359.60	1.2410	.0245	257.5	16.28	.0614	.0010	32.1823	3.0962
535	591	59	3	T	1414.00	31.98	34.16	359.00	3.1670	.0365	200.4	10.93	.0914	.0013	31.5151	5.8403
536	591	59	3	T	1412.00	32.11	34.30	357.70	2.9400	.0370	210.5	10.79	.0926	.0014	31.8554	5.3083
537	591	59	4	T	1406.00	31.94	35.25	341.60	2.0870	.0288	205.9	13.86	.0721	.0011	31.3778	4.4587
538	591	59	4	T	1405.00	32.19	35.51	340.30	2.1260	.0260	199.1	14.22	.0703	.0011	32.1821	4.5572
539	591	59	5	T	1399.00	32.02	35.53	358.60	2.1110	.0350	240.3	11.39	.0877	.0014	31.7527	3.6431
540	591	59	5	T	1398.00	32.23	35.76	357.20	3.2680	.0336	180.2	11.87	.0842	.0014	32.2808	5.7775
541	591	59	6	T	1389.00	32.16	35.11	339.70	2.7420	.0364	199.3	10.96	.0911	.0014	31.5108	4.7809
542	591	59	6	T	1270.00	32.37	35.49	338.30	2.7460	.0356	194.8	11.19	.0892	.0014	32.0628	4.7545
543	591	59	7	T	1377.00	32.05	35.10	339.70	1.9480	.0306	218.0	13.03	.0767	.0012	31.8835	3.9433
544	591	59	7	T	1375.00	32.25	35.55	338.50	1.9340	.0305	216.7	13.06	.0765	.0012	32.4752	3.7987
545	591	76	2	L	14.95	24.05	24.09	344.20	.6749	.0270	294.4	15.13	.0660	.0003	18.2391	5.2666
546	591	76	2	L	14.00	24.21	24.26	343.20	.6601	.0266	293.1	15.40	.0649	.0005	19.3378	3.2197

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
547	591	76	4	O	14.31	24.38	24.47	350.20	.5289	.0247	305.9	16.52	.0605	.0005	18.5171	2.8687
548	591	76	4	O	13.80	24.51	24.60	340.30	.5440	.0249	303.5	16.43	.0608	.0004	19.8258	3.0788
549	591	76	5	T	15.17	24.75	24.82	349.40	.5618	.0189	291.8	21.55	.0464	.0004	19.3700	3.7806
550	591	76	5	T	16.22	24.75	24.83	348.20	.5251	.0188	292.6	21.66	.0461	.0004	20.9100	3.2943
551	591	76	6	L	16.38	24.87	24.94	356.80	.5242	.0164	294.4	24.93	.0400	.0004	20.7743	3.5007
552	591	76	6	L	15.76	24.90	24.97	355.90	.4643	.0159	297.4	25.60	.0390	.0003	22.1246	3.2634
553	591	76	7	T	14.88	24.87	24.93	357.30	.7681	.0214	289.2	19.10	.0523	.0004	19.5243	4.5853
554	591	76	7	T	16.53	24.84	24.89	356.30	.8634	.0221	282.8	18.47	.0541	.0004	20.2881	4.8006
555	591	76	8	T	16.44	24.71	24.73	350.80	.8109	.0307	298.9	13.29	.0752	.0005	17.5156	3.8013
556	591	76	8	T	16.26	24.72	24.73	349.70	.9267	.0335	295.2	12.21	.0818	.0006	18.3142	3.8173
557	591	76	9	T	16.44	25.23	25.34	354.80	1.3520	.0169	217.0	24.13	.0414	.0003	18.9857	10.3699
558	591	76	9	T	18.70	25.23	25.33	353.60	.3575	.0172	309.2	23.62	.0423	.0004	20.8057	2.4681
559	591	76	10	T	16.88	25.11	25.20	344.60	.3697	.0151	294.7	26.93	.0371	.0003	20.6872	2.9080
560	591	76	10	T	17.43	25.27	25.36	343.50	.4276	.0150	285.1	27.10	.0369	.0003	23.1492	3.0233
561	591	80	3	T	188.70	24.10	24.22	358.90	.8158	.0178	275.9	22.97	.0435	.0003	17.8591	6.3413
562	591	80	3	T	183.20	24.19	24.29	357.80	.8925	.0182	269.1	22.49	.0444	.0003	18.9216	6.4083
563	591	80	4	O	48.29	24.25	24.31	355.60	1.7230	.0280	247.6	14.62	.0683	.0005	16.5203	9.3259
564	591	80	4	O	175.10	24.30	24.34	354.40	1.6830	.0307	256.8	13.34	.0749	.0005	17.0612	8.0794
565	591	80	5	T	325.90	24.50	24.61	353.80	1.2240	.0176	233.5	23.23	.0430	.0003	16.9072	10.1352
566	591	80	5	T	70.09	24.57	24.66	352.70	.9111	.0194	267.8	21.07	.0474	.0003	18.0862	6.4453
567	591	80	6	O	16.91	23.57	23.53	346.30	.5441	.0318	310.3	12.89	.0775	.0005	15.7876	2.7489
568	591	80	6	O	16.99	23.77	23.73	345.30	.6848	.0313	300.3	13.09	.0763	.0014	17.3498	1.1611
569	591	80	7	T	19.99	24.10	24.12	343.30	.6873	.0344	301.4	11.90	.0840	.0006	18.2691	2.7555
570	591	80	7	T	20.59	24.18	24.19	342.30	.7332	.0343	297.8	11.93	.0837	.0006	18.9535	2.8452
571	591	80	8	T	17.82	24.46	24.52	355.10	.7680	.0226	291.1	18.11	.0552	.0004	17.2437	4.9216
572	591	80	8	T	17.61	24.52	24.57	354.00	.7788	.0237	291.3	17.22	.0580	.0004	18.5840	4.3999
573	591	80	3	T	912.10	27.64	29.20	349.50	5.5610	.0532	166.9	7.61	.1314	.0012	20.8484	11.0199
574	591	80	3	T	968.20	27.83	29.44	348.00	4.1120	.0491	199.1	8.25	.1212	.0012	21.2812	8.6000
575	591	80	4	O	1085.00	28.94	31.23	350.10	6.2720	.0772	201.3	5.22	.1914	.0021	23.1341	7.4001
576	591	80	4	O	1129.00	29.08	31.43	348.50	6.1350	.0821	209.9	4.91	.2035	.0022	23.2286	6.7672
577	591	80	5	T	1467.00	29.61	32.88	355.20	2.2860	.0498	263.3	8.08	.1237	.0016	24.7877	3.5445
578	591	80	5	T	1466.00	29.83	33.13	353.70	4.2760	.0495	196.5	8.12	.1231	.0016	25.2061	6.5568
579	591	80	6	O	1460.00	29.41	32.34	340.30	7.3050	.0842	180.9	4.78	.2090	.0025	24.6824	7.1078
580	591	80	6	O	1458.00	29.63	32.71	338.50	6.7350	.0812	185.6	4.95	.2019	.0025	24.9155	6.6264
581	591	80	7	T	1451.00	30.06	33.17	352.60	3.9520	.0779	251.1	5.15	.1940	.0025	26.3647	3.8419
582	591	80	7	T	1451.00	30.22	33.34	351.00	6.6020	.0804	198.0	5.00	.2001	.0026	26.3870	6.2121
583	591	80	8	T	1459.00	30.61	33.75	337.90	5.9490	.0533	139.6	7.53	.1328	.0018	27.7267	7.9294
584	591	80	8	T	1453.00	30.73	33.79	336.20	6.0510	.0545	139.1	7.35	.1360	.0019	27.8588	7.8994
585	591	31	3	O	12.37	30.55	30.56	376.20	.2748	.0981	353.7	4.09	.2444	.0028	30.9563	.2404
586	591	31	3	O	13.07	30.65	30.66	375.20	.3265	.0779	349.3	5.15	.1941	.0024	33.1972	.3307
587	591	31	5	L	16.74	30.83	30.84	365.60	.3511	.1185	344.6	3.38	.2956	.0031	28.5820	.2791
588	591	31	5	L	17.40	31.14	31.15	364.50	.2504	.0833	430.8	4.80	.2081	.0026	33.6348	.2345
589	591	31	6	T	18.21	31.32	31.24	369.90	.3147	.1151	347.9	3.48	.2876	.0032	30.9708	.2389
590	591	31	6	T	20.71	31.36	31.28	368.60	.3595	.0924	343.5	4.33	.2310	.0029	33.5949	.3082
591	591	31	7	T	17.99	31.37	31.40	389.10	.5429	.1080	362.2	3.71	.2699	.0031	31.1210	.4312
592	591	31	7	T	17.74	31.41	31.43	388.20	.4833	.0967	360.5	4.14	.2416	.0029	32.7853	.4038
593	591	31	8	T	20.18	31.15	31.07	365.80	11.8200	.1422	209.6	2.81	.3551	.0032	25.1406	.6360
594	591	31	8	T	21.69	31.40	31.34	355.20	.6281	.1338	331.1	2.99	.3343	.0036	29.9492	.4290
595	591	31	9	T	20.43	31.54	31.49	368.00	.4802	.1359	346.0	2.94	.3398	.0035	28.6460	.3379
596	591	31	9	T	20.43	31.63	31.58	366.70	.4485	.1197	342.7	3.34	.2994	.0034	31.8031	.3187
597	591	31	10	T	20.54	31.62	31.51	357.70	.5565	.1622	337.2	2.46	.4055	.0038	26.9767	.3567
598	591	31	10	T	20.41	31.76	31.63	356.70	.5638	.1499	334.3	2.67	.3751	.0039	29.8174	.3514
599	591	31	11	T	20.59	31.82	31.70	356.00	.4171	.1386	334.8	2.88	.3467	.0037	29.9271	.2777
600	591	31	11	T	20.86	31.92	31.85	355.00	.2162	.1250	334.7	3.20	.3128	.0036	32.3742	.1456
601	591	21	3	O	175.60	27.81	28.50	341.90	2.7740	.0382	212.7	10.59	.0944	.0009	22.0775	7.8477
602	591	21	3	O	223.00	27.93	28.56	340.40	2.6360	.0399	221.6	10.13	.0986	.0009	22.3401	6.9975
603	591	21	4	T	427.40	28.30	29.20	332.20	2.9100	.0328	177.6	12.32	.0811	.0008	22.2397	9.2188
604	591	21	4	T	351.30	28.39	29.33	330.90	3.1560	.0300	150.4	13.44	.0743	.0007	22.4514	10.7460
605	591	21	6	T	400.00	28.68	29.55	338.40	3.7880	.0415	178.5	9.71	.1030	.0010	23.3376	9.1820
606	591	21	6	T	442.20	28.76	29.61	337.10	3.5920	.0377	170.9	10.70	.0934	.0009	23.4803	9.5265
607	591	21	7	T	629.00	28.95	29.65	338.00	3.3290	.0310	153.2	13.00	.0769	.0008	23.5072	10.7658
608	591	21	7	T	663.90	29.06	29.82	336.60	2.7670	.0323	186.2	12.47	.0801	.0008	23.7821	8.4599
609	591	21	8	T	705.70	29.25	30.09	341.00	6.9780	.0835	190.0	4.82	.2073	.0019	22.5756	8.9383
610	591	21	8	T	717.70	29.31	30.17	339.20	7.1180	.0885	193.2	4.55	.2197	.0020	22.4666	8.6454
611	591	21	9	T	878.10	29.58	30.23	338.30	9.9840	.1130	176.4	3.56	.2807	.0026	24.0461	9.2504
612	591	21	9	T	856.90	29.64	30.23	336.40	8.8320	.1021	178.8	3.94	.2537	.0024	23.8894	9.1057
613	591	21	10	L	786.50	29.49	29.98	339.60	6.8050	.0472	93.3	8.52	.1174	.0012	25.5320	13.8223
614	591	21	10	L	765.60	29.56	30.10	338.20	4.7880	.0413	138.1	9.73	.1027	.0011	25.6085	10.9712
615	591	69	3	O	1330.00	29.47	31.09	357.70	1.3710	.0193	229.1	20.81	.0480	.0006	25.7345	5.9669
616	591	69	3	O	1404.00	29.70	31.16	356.50	1.3370	.0201	234.7	20.00	.0499	.0006	26.5032	5.5418
617	591	69	4	L	1109.00	30.03	31.19	349.40	8.4650	.0763	152.2	5.27	.1898	.0020	25.1214	10.3573
618	591	69	4	L	1098.00	30.11	31.32	347.80	7.4800	.0828	184.0	4.85	.2061	.0022	25.0469	8.4562
619	591	69	5	L	1239.00	30.34	32.07	341.50	.9895	.0182	239.1	21.99	.0454	.0006	27.6234	4.2318
620	591	69	5	L	1259.00	30.77	32.74	340.40	.7771	.0188	257.4	21.31	.0469	.0006	28.9799	3.0227
621	591	69	6	T	1250.00	31.01	33.39	335.80	1.9130	.0275	207.6	14.53	.0687	.0009	29.0109	4.9540
622	591	69	6	T	1262.00	31.29	33.81	334.60	1.9540	.0285	207.6	14.01	.0713	.0010	29.6528	4.7304
623	591	69	7	T	1463.00	31.23	33.69	335.60	3.4520	.0438	191.5	9.13	.1095	.0015	28.4773	5.7131
624	591	69	7	T	1440.00	31.44	33.96	334.20	3.4060	.0390	176.5	10.26	.0974	.0013	28.8437	6.2170

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
625	591	69	8	T	1454.00	31.28	33.50	332.20	7.3160	.0880	170.4	4.50	.2222	.0028	28.0369	6.3108
626	591	69	8	T	1439.00	31.44	33.76	330.20	7.9580	.0840	157.4	4.70	.2099	.0027	27.9937	7.2420
627	591	69	9	T	1433.00	31.73	33.95	333.10	6.5330	.0645	175.7	6.20	.1613	.0022	30.0677	6.1389
628	591	69	9	T	1431.00	31.85	34.10	331.60	5.8630	.0678	172.9	5.89	.1698	.0023	30.0771	6.1784
629	591	69	10	T	1420.00	31.01	34.11	332.80	6.2500	.0625	153.5	7.01	.1314	.0018	29.5503	7.0424
630	591	69	10	T	1426.00	31.75	34.33	331.30	5.1410	.0517	153.0	7.73	.1294	.0018	29.6708	6.9189
631	591	69	11	T	1432.00	31.77	34.10	330.10	7.7120	.0921	174.2	4.34	.2304	.0030	29.0940	6.2182
632	591	69	11	T	1433.00	31.87	34.32	328.30	7.8470	.0916	169.2	4.35	.2292	.0030	28.0305	6.3212
633	591	18	4	O	35.01	23.62	23.69	345.40	1.0950	.0472	295.3	8.69	.1150	.0011	23.4603	2.5089
634	591	18	4	O	28.08	23.72	23.77	342.20	1.1490	.0432	286.3	9.50	.1052	.0010	24.5694	2.7484
635	591	18	5	O	56.44	23.59	23.62	345.50	1.0520	.0490	298.2	8.37	.1195	.0011	23.6396	2.3153
636	591	18	5	O	29.18	23.75	23.79	342.20	1.0760	.0429	288.8	9.56	.1045	.0014	24.6154	1.9087
637	591	18	6	T	25.05	23.54	23.63	347.10	3.1870	.0845	273.3	4.85	.2058	.0017	21.0151	4.6699
638	591	18	6	T	27.91	23.65	23.78	343.60	3.2570	.0845	268.3	4.85	.2059	.0017	21.5000	4.6506
639	591	18	7	T	33.61	23.43	23.39	345.00	1.6990	.0589	285.1	6.97	.1434	.0013	22.4752	3.3151
640	591	18	7	T	40.68	23.61	23.62	341.80	1.6620	.0563	281.5	7.29	.1372	.0012	23.3227	3.2523
641	591	18	8	T	29.19	23.16	23.31	344.70	2.3820	.0649	273.3	6.33	.1579	.0013	21.0900	4.4505
642	591	18	8	T	132.10	23.34	23.66	341.30	2.5630	.0614	261.3	6.69	.1495	.0013	22.0091	4.7767
643	591	18	9	T	200.60	23.25	23.21	344.80	2.1560	.0763	286.8	5.39	.1856	.0015	21.5767	3.4269
644	591	18	9	T	150.10	23.43	23.45	341.10	3.1920	.0757	260.1	5.43	.1842	.0016	22.1052	4.9670
645	591	18	10	T	68.15	23.64	23.66	364.60	1.7630	.0660	308.0	6.22	.1607	.0014	22.8114	3.0286
646	591	18	10	T	36.62	23.85	23.85	361.40	1.6320	.0664	308.2	6.18	.1618	.0015	23.4197	2.7232
647	591	18	11	T	136.80	24.16	24.37	349.70	4.9570	.0906	247.0	4.52	.2211	.0019	21.6673	6.5419
648	591	18	11	T	291.50	24.26	24.39	345.80	2.9230	.0926	281.4	4.42	.2261	.0019	22.0305	3.7399
649	591	18	12	T	385.60	24.19	24.35	347.00	1.8000	.0586	284.5	6.99	.1430	.0013	23.0416	3.3924
650	591	18	12	T	522.40	24.41	24.71	343.70	1.8670	.0550	275.5	7.44	.1343	.0013	24.1870	3.5230
651	591	18	4	O	562.00	28.84	30.01	350.90	5.3880	.0740	213.8	5.45	.1834	.0024	31.4957	5.5499
652	591	18	4	O	774.30	28.90	29.64	347.60	5.6580	.0767	209.3	5.26	.1901	.0024	31.4298	5.8273
653	591	18	5	O	600.10	27.82	28.47	345.00	4.6960	.0753	226.8	5.37	.1861	.0022	29.4704	5.2700
654	591	18	5	O	635.10	28.08	28.84	341.60	4.7770	.0722	217.1	5.60	.1784	.0021	29.9275	5.4597
655	591	18	6	T	818.80	27.82	29.36	342.30	5.1430	.0709	206.8	5.71	.1752	.0022	29.7704	5.6789
656	591	18	6	T	838.90	28.11	29.72	338.80	5.3130	.0731	202.8	5.53	.1808	.0023	30.1549	5.6027
657	591	18	7	T	910.00	28.32	30.00	345.80	5.5490	.0791	213.0	5.11	.1957	.0025	30.3894	5.3593
658	591	18	7	T	1028.00	28.67	30.39	342.30	5.5070	.0777	208.3	5.19	.1925	.0025	30.8708	5.3042
659	591	18	8	T	998.20	28.23	30.25	344.60	4.3080	.0640	217.2	6.31	.1584	.0021	30.2705	4.9878
660	591	18	8	T	1087.00	28.69	30.90	341.00	4.3770	.0643	211.8	6.28	.1592	.0022	31.1714	4.8447
661	591	18	9	T	1057.00	28.78	30.47	342.90	7.1960	.0984	203.8	4.10	.2439	.0031	30.6941	5.5894
662	591	18	9	T	991.30	29.04	30.73	339.00	7.8680	.1004	191.2	4.02	.2489	.0032	30.8276	5.9720
663	591	18	10	T	1068.00	28.61	20.71	346.20	3.9090	.0636	228.4	6.35	.1575	.0021	31.9323	4.6177
664	591	18	10	T	1074.00	28.91	29.95	342.70	3.7300	.0625	227.8	6.45	.1549	.0021	32.4019	4.4341
665	591	18	11	T	987.70	28.70	29.37	344.60	4.7820	.0796	229.1	5.07	.1971	.0024	30.8162	4.8678
666	591	18	11	T	1046.00	28.86	29.98	341.10	5.2400	.0807	217.3	5.00	.2000	.0025	30.9507	5.0694
667	591	18	12	T	993.30	28.69	30.08	348.30	2.7380	.0602	256.4	6.71	.1491	.0020	31.1634	3.4143
668	591	18	12	T	474.30	29.01	30.32	344.80	3.0960	.0640	248.0	6.30	.1587	.0021	31.8790	3.5821
669	591	27	3	O	20.93	22.22	22.22	411.90	1.2310	.0498	358.0	8.27	.1209	.0010	21.8859	2.8837
670	591	27	3	O	21.12	22.40	22.42	408.90	1.2300	.0465	351.9	8.85	.1129	.0010	22.5859	2.9842
671	591	27	4	O	22.98	22.48	22.60	371.00	1.3060	.0435	310.3	9.47	.1055	.0009	20.9710	3.6191
672	591	27	4	O	42.36	22.64	22.72	367.80	1.2320	.0377	302.3	10.91	.0915	.0008	22.7327	3.6248
673	591	27	5	O	35.44	22.57	22.62	348.40	.9646	.0417	299.3	9.88	.1011	.0009	21.7962	2.6952
674	591	27	5	O	28.24	22.74	22.78	345.30	.9348	.0360	291.0	11.43	.0874	.0008	23.4519	2.7973
675	591	27	6	L	45.50	22.81	22.82	348.10	.9485	.0509	306.1	8.09	.1236	.0011	21.7355	2.1977
676	591	27	6	L	24.68	23.00	23.00	344.90	.9327	.0451	299.1	9.12	.1096	.0010	23.2389	2.2680
677	591	27	7	T	32.72	22.91	22.96	459.80	1.8330	.0510	386.3	8.06	.1240	.0010	21.3202	4.2952
678	591	27	7	T	50.56	23.01	23.06	456.50	1.7880	.0472	379.3	8.71	.1148	.0010	22.4929	4.2891
679	591	27	8	T	195.80	23.10	23.21	345.20	1.7840	.0587	284.2	7.00	.1427	.0012	21.1883	3.6591
680	591	27	8	T	238.60	23.23	23.32	341.90	2.1710	.0581	269.2	7.08	.1412	.0012	22.2592	4.3011
681	591	27	9	T	468.50	23.03	23.12	342.80	4.0140	.0775	246.4	5.31	.1883	.0015	20.4559	6.5579
682	591	27	9	T	457.80	23.16	23.23	339.30	3.9490	.0806	247.3	5.10	.1960	.0016	20.9870	6.0783
683	591	27	10	T	235.10	23.25	23.44	390.50	3.0520	.0709	307.2	5.80	.1724	.0014	20.4057	5.4036
684	591	27	10	T	280.30	23.38	23.36	387.50	1.8960	.0706	330.6	5.82	.1719	.0014	21.4054	3.2627
685	591	27	11	T	65.49	23.15	23.22	349.10	1.2790	.0627	303.9	6.55	.1526	.0013	21.9649	2.3859
686	591	27	11	T	35.60	23.23	23.39	346.30	2.6430	.0556	256.8	7.39	.1353	.0012	22.6562	5.3210
687	591	27	12	T	28.25	23.09	23.42	345.00	.9300	.0470	300.6	8.75	.1143	.0010	22.7542	2.1688
688	591	27	12	T	39.54	23.50	23.93	341.70	1.2070	.0421	282.3	9.76	.1024	.0010	24.2772	2.9143
689	591	31	5	O	13.37	21.38	21.44	453.30	.9023	.0226	374.9	18.25	.0547	.0005	21.0711	4.7018
690	591	31	5	O	12.81	21.46	21.49	448.10	.8643	.0177	354.5	23.32	.0428	.0004	23.3321	5.1914
691	591	31	6	L	20.38	21.59	21.71	339.70	.7085	.0142	248.0	29.06	.0344	.0003	24.3344	5.0423
692	591	31	6	L	81.87	21.82	22.37	334.30	1.2800	.0156	191.7	26.36	.0379	.0004	24.6594	8.0321
693	591	31	7	L	29.52	21.35	21.33	345.00	.5980	.0287	299.8	14.41	.0693	.0006	22.2383	2.3658
694	591	31	7	L	36.50	21.52	21.92	341.80	1.6120	.0245	224.6	16.83	.0593	.0006	23.0572	6.9615
695	591	31	8	T	14.99	21.56	21.50	343.20	1.0530	.0582	303.6	7.10	.1408	.0011	19.0922	2.4486
696	591	31	8	T	6.81	21.73	21.65	339.90	1.0220	.0536	298.1	7.70	.1298	.0011	20.7421	2.3742
697	591	31	9	T	18.17	21.86	21.73	353.50	.5026	.0720	331.2	5.74	.1742	.0013	19.9914	.9172
698	591	31	9	T	20.20	22.00	21.92	350.40	.9521	.0609	313.5	6.78	.1475	.0012	21.0312	1.9301
699	591	31	10	T	92.08	21.84	21.83	341.20	2.0420	.0585	273.6	7.06	.1415	.0011	20.2334	4.4556
700	591	31	10	T	21.36	21.95	21.88	337.90	.6053	.0566	309.5	7.29	.1370	.0011	21.1947	1.3042
701	591	31	11	T	23.14	21.78	21.79	418.60	.4142	.0454	390.2	9.08	.1100	.0009	21.1866	1.0954
702	591	31	11	T	24.00	22.15	22.22	415.60	.3038	.0303	384.4	13.62	.0734	.0007	23.5400	1.0707

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
703	591	31	3	O	70.47	25.67	25.88	347.60	3.9370	.0818	254.7	4.98	.2006	.0019	24.8240	5.0011
704	591	31	3	O	125.00	25.94	28.16	343.80	3.7140	.0801	253.7	5.09	.1965	.0019	25.4346	4.0053
705	591	31	4	O	961.10	26.92	28.34	351.40	5.0270	.0800	232.1	5.08	.1969	.0022	26.9917	5.4831
706	591	31	4	O	944.80	27.18	28.60	348.00	5.1760	.0827	228.8	4.91	.2038	.0024	27.4562	5.3796
707	591	31	5	L	988.10	27.49	29.45	347.40	4.4540	.0720	220.3	5.63	.1770	.0022	28.0582	4.0601
708	591	31	5	L	845.50	27.87	29.97	343.80	4.2330	.0714	229.6	5.67	.1765	.0023	28.8126	4.5926
709	591	31	6	O	1100.00	27.91	29.65	345.70	7.1860	.0987	207.8	4.10	.2439	.0030	28.8192	5.8983
710	591	31	6	O	1148.00	28.24	30.00	341.90	7.3410	.1000	202.8	4.04	.2472	.0031	29.1227	5.8789
711	591	31	7	T	1314.00	27.96	29.50	346.40	7.0100	.0996	212.5	4.06	.2460	.0030	29.0520	5.7483
712	591	31	7	T	1293.00	28.22	29.77	342.70	7.0810	.1004	208.6	4.03	.2483	.0030	29.2202	5.7170
713	591	31	8	T	1299.00	28.08	29.35	347.70	7.2420	.1012	211.9	4.00	.2501	.0030	29.0235	5.9647
714	591	31	8	T	1078.00	28.30	29.48	344.10	6.6860	.1001	216.5	4.04	.2476	.0029	29.1537	5.5777
715	591	31	9	T	858.30	28.33	29.55	350.10	7.5120	.1086	217.6	3.72	.2686	.0032	29.3228	5.7565
716	591	31	9	T	778.10	28.58	29.75	346.50	7.6800	.1078	210.8	3.75	.2666	.0032	29.4682	5.9131
717	591	31	10	T	833.00	28.73	30.08	345.70	5.1030	.0851	229.3	4.74	.2107	.0027	30.8067	4.6479
718	591	31	10	T	999.80	29.04	30.50	342.30	4.8910	.0825	227.0	4.89	.2046	.0027	31.1816	4.4906
719	591	44	3	O	404.00	24.75	25.36	345.80	3.2010	.0585	243.2	6.99	.1431	.0014	24.6700	5.4617
720	591	44	3	O	387.60	24.86	25.41	342.50	3.5400	.0608	234.0	6.72	.1486	.0015	25.0256	5.7644
721	591	44	4	O	38.44	24.34	24.21	348.20	1.4400	.0849	308.0	4.82	.2072	.0018	22.8631	1.9703
722	591	44	4	O	36.74	24.51	24.39	344.90	1.3810	.0803	304.2	5.10	.1961	.0017	23.3996	1.9420
723	591	44	5	T	35.83	24.53	24.52	393.70	1.6900	.0626	335.2	6.54	.1528	.0014	23.8004	2.9377
724	591	44	5	T	38.13	24.66	24.65	390.50	1.6600	.0583	329.4	7.01	.1426	.0014	24.6167	2.9767
725	591	44	6	T	39.48	24.45	24.32	346.80	1.6150	.0745	298.7	5.50	.1819	.0016	23.6303	2.4133
726	591	44	6	T	39.84	24.55	24.44	343.60	1.5450	.0709	295.3	5.77	.1731	.0016	24.0483	2.3778
727	591	44	8	T	39.67	24.37	24.31	348.00	1.2980	.0637	302.0	6.42	.1557	.0014	23.7939	2.2243
728	591	44	8	T	39.89	24.51	24.44	344.60	1.3560	.0606	295.3	6.75	.1482	.0014	24.5666	2.3591
729	591	44	9	T	52.65	24.65	24.57	347.70	1.5810	.0702	298.1	5.83	.1716	.0016	23.9342	2.4622
730	591	44	9	T	42.46	24.73	24.65	344.60	1.3340	.0701	300.6	5.83	.1715	.0016	24.3988	2.0396
731	591	44	10	T	39.41	25.12	25.15	350.50	1.1000	.0495	297.6	8.25	.1211	.0012	25.9132	2.3740
732	591	44	10	T	40.02	25.20	25.27	347.20	1.3420	.0450	284.8	9.06	.1103	.0012	26.6915	2.8292
733	591	44	11	T	73.79	24.80	25.00	349.10	2.0820	.0536	272.6	7.63	.1310	.0013	24.7843	3.9618
734	591	44	11	T	173.20	25.04	25.63	345.70	2.1760	.0518	263.5	7.89	.1267	.0013	25.6685	4.0223
735	591	100	3	O	37.18	23.16	23.28	350.50	1.3320	.0198	230.8	20.70	.0506	.0005	23.9700	6.9303
736	591	100	3	O	39.89	23.50	24.38	347.20	1.7260	.0208	201.1	19.72	.0506	.0006	25.6242	7.6129
737	591	100	4	T	72.59	23.98	25.10	350.90	1.4240	.0191	219.4	21.39	.0467	.0005	22.8766	7.4508
738	591	100	4	T	23.19	24.05	24.42	347.10	1.8220	.0231	208.0	17.70	.0564	.0006	25.4231	7.5877
739	591	100	5	L	17.30	23.69	23.68	385.00	.3959	.0228	342.3	17.93	.0557	.0006	25.4535	1.7071
740	591	100	5	L	17.18	23.71	23.71	382.30	.2539	.0180	343.9	22.74	.0439	.0005	27.2177	1.2913
741	591	100	6	L	306.20	23.68	23.74	362.00	2.2260	.0268	216.9	15.30	.0683	.0006	22.0338	9.4549
742	591	100	6	L	340.60	23.94	23.91	358.70	2.3150	.0280	213.4	14.63	.0683	.0007	24.0971	8.6545
743	591	100	7	T	59.27	24.37	24.50	363.10	1.0010	.0201	269.9	20.36	.0491	.0005	24.9559	4.9433
744	591	100	7	T	24.36	24.45	24.48	359.50	1.0160	.0223	272.1	18.35	.0544	.0006	27.0963	4.1983
745	591	100	8	O	11.14	24.25	24.28	354.90	.2209	.0151	316.3	27.04	.0369	.0004	28.2743	1.2840
746	591	100	9	T	49.41	24.40	24.50	353.10	2.0560	.0277	220.3	14.78	.0676	.0007	26.4047	7.0474
747	591	100	9	T	139.40	24.49	24.88	349.80	2.3020	.0261	194.9	15.64	.0639	.0007	27.0178	7.9689
748	591	100	10	T	44.33	24.55	24.59	432.00	2.6210	.0263	257.3	15.51	.0644	.0006	24.0203	10.3785
749	591	100	10	T	154.70	24.66	24.77	428.80	3.0730	.0275	233.6	14.87	.0672	.0007	25.4207	10.9857
750	591	100	3	O	92.92	29.37	29.51	358.00	4.9570	.0616	210.5	6.54	.1529	.0018	30.4579	6.7661
751	591	100	3	O	206.40	29.63	29.69	352.30	4.9150	.0624	207.2	6.45	.1550	.0019	31.9805	6.3519
752	591	100	4	T	705.80	29.27	29.36	367.00	3.1290	.0358	209.5	11.24	.0889	.0011	32.1256	6.8498
753	591	100	4	T	943.00	29.38	29.60	361.80	3.1910	.0351	197.9	11.46	.0872	.0012	34.0666	6.6524
754	591	100	5	L	859.60	29.61	30.61	354.10	3.8630	.0391	177.9	10.27	.0973	.0013	32.1017	7.2650
755	591	100	5	L	913.00	29.85	31.02	348.50	4.1000	.0411	170.0	9.77	.1203	.0015	34.0044	6.8777
756	591	100	6	L	598.80	29.91	30.52	382.60	7.7020	.0815	208.5	4.93	.2028	.0025	31.3196	7.5585
757	591	100	6	L	604.90	29.93	30.55	376.90	8.0030	.0824	198.5	4.88	.2049	.0025	31.6081	7.6956
758	591	100	7	T	858.40	29.89	30.46	352.40	7.6210	.0813	180.9	4.95	.2021	.0025	31.6212	7.4489
759	591	100	7	T	751.70	30.10	30.73	346.60	6.9490	.0805	187.2	4.99	.2003	.0025	32.2825	6.6846
760	591	100	8	O	793.90	30.35	31.72	345.70	3.6810	.0394	176.9	9.77	.0982	.0014	34.5162	6.2531
761	591	100	8	O	731.60	30.68	32.42	340.10	3.7710	.0410	172.8	9.77	.1023	.0016	36.3147	5.7289
762	591	100	9	T	520.60	30.73	30.90	347.40	5.7600	.0647	185.0	6.20	.1614	.0021	33.3588	6.8226
763	591	100	9	T	600.60	30.94	31.10	341.70	5.7600	.0649	179.6	6.17	.1620	.0021	34.5619	6.5765
764	591	100	10	T	585.40	30.55	31.08	346.90	6.8430	.0764	182.1	5.25	.1903	.0025	33.5863	6.7041
765	591	100	10	T	624.00	30.77	30.94	341.50	4.9900	.0750	214.9	5.34	.1871	.0024	34.3299	5.0064
766	591	27	6	T	16.42	24.36	24.33	349.80	.3316	.0249	314.3	16.42	.0608	.0006	26.7096	1.2561
767	591	27	8	T	17.65	24.67	24.67	363.30	.3073	.0198	323.0	20.62	.0484	.0005	28.1562	1.3786
768	591	27	8	T	16.12	24.61	24.68	359.70	.6742	.0139	267.3	29.30	.0341	.0004	29.1651	4.0964
769	591	27	9	T	19.02	24.45	24.49	365.70	.6585	.0177	288.1	23.00	.0434	.0005	27.8063	3.2377
770	591	31	3	O	17.27	24.97	25.16	360.40	.5657	.0140	280.7	29.05	.0344	.0004	29.0603	3.4190
771	591	31	3	O	17.58	25.20	25.27	357.20	.6927	.0151	268.5	26.91	.0371	.0005	30.2395	3.7460
772	591	31	4	O	15.70	25.42	25.49	353.60	.4137	.0158	296.1	25.75	.0388	.0005	29.6205	2.1849
773	591	31	4	O	17.90	25.43	25.43	350.70	.3318	.0131	294.5	30.95	.0323	.0004	30.8168	2.0276
774	591	31	6	L	19.38	25.52	25.57	351.00	.3182	.0134	297.2	30.25	.0330	.0004	30.6600	1.9037
775	591	31	6	L	24.12	25.60	25.65	347.70	.3464	.0113	282.9	35.90	.0278	.0004	31.4125	2.4154
776	591	31	7	O	27.60	25.72	25.78	351.30	.5076	.0164	286.4	24.72	.0404	.0005	30.0109	2.5483
777	591	31	7	O	44.83	25.83	25.87	348.10	.6164	.0181	277.8	22.45	.0445	.0006	31.1251	2.7271
778	591	31	8	T	41.35	25.74	25.83	353.50	.7293	.0127	246.3	32.05	.0311	.0004	30.9201	4.5999
779	591	31	8	T	24.86	25.80	25.90	350.20	1.0640	.0145	217.8	28.07	.0356	.0004	31.4370	5.7862
780	591	31	9	T	24.60	25.75	25.77	351.70	1.3750	.0219	238.0	18.56	.0538	.0006	26.0657	6.0033

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
781	591	31	9	T	25.10	25.72	25.68	348.70	.7657	.0270	260.7	14.57	.0685	.0008	28.8049	2.4030
782	591	31	10	T	28.03	25.60	25.62	340.20	1.1300	.0321	278.5	12.60	.0787	•	26.2635	•
783	591	31	10	T	28.14	25.57	25.58	346.20	1.1380	.0337	277.4	12.07	.0827	.0005	•	6.0971
784	591	31	11	T	37.46	25.47	25.37	347.90	.9182	.0419	298.6	9.73	.1028	.0011	26.4981	2.1209
785	591	31	11	T	31.78	25.52	25.46	344.00	.8621	.0403	200.3	10.10	.0980	.0011	27.8780	1.9327
786	591	31	13	T	41.21	25.63	25.58	350.10	.3788	.0515	323.9	7.82	.1262	.0013	26.6539	.7100
787	591	31	13	T	70.18	25.66	25.62	346.70	.3949	.0415	316.4	9.81	.1018	.0011	28.2695	.8574
788	591	45	3	O	627.10	29.74	30.35	347.20	5.3180	.0655	197.5	6.14	.1627	.0021	31.9892	6.2900
789	591	45	3	O	613.60	30.06	30.68	341.50	5.4210	.0656	189.3	6.12	.1632	.0021	33.1967	6.1697
790	591	45	4	T	599.90	30.51	31.74	350.30	5.8230	.0654	185.3	6.14	.1629	.0023	33.7013	6.2581
791	591	45	4	T	529.90	30.69	31.91	344.60	6.1050	.0660	175.1	6.08	.1645	.0023	34.3989	6.3809
792	591	45	5	L	648.00	30.50	31.47	351.00	4.9140	.0596	198.6	6.73	.1486	.0020	33.5613	5.9059
793	591	45	5	L	630.70	30.88	31.83	345.30	4.9520	.0577	187.2	6.95	.1439	.0021	35.1130	5.8900
794	591	45	6	T	673.50	30.89	31.60	390.40	6.8300	.0735	217.3	5.45	.1834	.0025	34.9005	6.5989
795	591	45	6	T	728.70	31.05	31.84	384.40	6.7230	.0727	212.3	5.50	.1816	.0025	35.3134	6.4537
796	591	45	7	T	675.80	30.84	31.78	347.90	8.0770	.0905	181.8	4.43	.2259	.0031	34.2574	6.4277
797	591	45	7	T	635.70	31.03	32.01	341.90	7.8030	.0890	178.7	4.50	.2223	.0031	34.4621	6.2514
798	591	45	8	T	704.70	31.21	32.03	356.60	7.9230	.0808	176.3	4.95	.2018	.0028	34.5355	7.0071
799	591	45	8	T	652.00	31.30	32.11	350.50	7.8870	.0817	172.9	4.90	.2042	.0028	34.8088	6.8574
800	591	45	9	T	440.90	30.89	31.93	347.90	4.2870	.0450	175.5	8.89	.1124	.0017	35.7805	6.3113
801	591	45	9	T	509.10	31.05	32.17	342.30	4.3780	.0477	174.8	8.40	.1190	.0018	36.8414	5.9010
802	591	45	10	T	510.30	30.97	32.19	341.20	7.8570	.0910	179.7	4.40	.2271	.0032	34.3485	6.0841
803	591	45	10	T	672.10	31.14	32.41	335.50	7.9440	.0923	174.7	4.34	.2306	.0032	34.4848	6.0152
804	591	45	11	T	973.80	31.54	33.47	386.60	3.1940	.0346	215.7	11.54	.0866	.0014	37.2360	5.4877
805	591	45	11	T	1217.00	32.08	34.12	381.00	3.7340	.0377	198.2	10.56	.0946	.0017	39.8174	5.5091
806	591	45	12	O	1288.00	32.46	34.39	346.80	2.6900	.0355	202.7	11.23	.0890	.0016	40.7708	4.1540
807	591	45	12	O	1162.00	32.86	35.15	341.40	3.1600	.0411	194.6	9.68	.1033	.0019	42.3656	3.9826
808	591	76	3	L	43.25	27.32	27.41	347.90	2.4470	.0381	229.3	10.62	.0940	.0011	29.5980	5.4703
809	591	76	3	L	43.21	27.37	27.48	342.40	2.7310	.0371	208.6	10.91	.0915	.0011	30.8275	6.0101
810	591	76	4	O	82.77	27.08	27.27	357.30	1.6400	.0223	224.4	18.15	.0550	.0007	29.8725	6.0837
811	591	76	4	O	73.05	27.39	27.56	352.00	1.9590	.0244	207.3	16.59	.0602	.0008	32.3912	6.1421
812	591	76	5	T	402.10	27.07	27.14	350.10	4.8970	.0414	145.5	9.79	.1021	.0011	27.4365	10.9130
813	591	76	5	T	254.90	27.23	27.49	344.20	2.7830	.0428	224.1	9.47	.1055	.0012	29.0730	5.5954
814	591	76	6	L	32.86	27.54	27.63	347.10	1.5240	.0314	253.6	12.87	.0776	.0009	30.5997	3.9724
815	591	76	6	L	32.00	27.65	26.69	341.60	2.0480	.0379	238.4	10.67	.0936	.0012	32.1270	4.2630
816	591	76	7	T	1092.00	28.53	29.40	384.70	4.6460	.0444	197.5	9.09	.1099	.0014	30.8880	8.1259
817	591	76	7	T	1162.00	28.86	29.82	379.00	5.0550	.0460	182.8	8.77	.1140	.0015	32.3417	8.1218
818	591	76	8	T	754.70	29.45	30.84	358.90	6.8590	.0674	175.0	5.97	.1674	.0022	30.7271	7.7429
819	591	76	8	T	836.80	29.72	30.98	353.30	6.6860	.0688	176.6	5.84	.1710	.0023	31.7512	7.2444
820	591	76	9	T	674.10	29.59	30.86	348.10	9.4170	.0982	171.2	4.10	.2439	.0031	30.7200	7.5252
821	591	76	9	T	730.00	29.76	31.11	342.00	9.2620	.0982	168.0	4.10	.2441	.0031	30.9673	7.3045
822	591	76	10	T	673.40	29.51	30.21	361.70	6.6280	.0674	183.7	5.97	.1673	.0021	30.9595	7.8253
823	591	76	10	T	912.40	29.77	30.61	356.00	6.2560	.0627	175.9	6.41	.1560	.0020	32.0984	7.5506
824	591	76	11	T	814.80	30.14	31.60	347.20	3.8250	.0443	190.0	9.05	.1104	.0016	32.8555	6.0281
825	591	76	11	T	721.70	30.48	31.77	341.60	3.5730	.0457	196.8	8.78	.1139	.0017	34.9514	5.2159
826	591	76	12	T	568.10	30.60	31.92	346.20	4.5200	.0556	195.4	7.21	.1386	.0020	34.5026	5.5237
827	591	76	12	T	576.00	30.70	31.73	340.50	4.9670	.0575	181.7	6.98	.1433	.0021	35.1871	5.8901
828	591	80	5	T	139.70	25.77	25.93	347.60	2.6850	.0300	190.5	13.59	.0735	.0008	26.1050	8.5616
829	591	80	5	T	100.30	25.82	25.90	344.20	2.2620	.0304	210.9	13.40	.0746	.0008	27.5014	6.7876
830	591	80	6	T	67.96	25.93	26.12	354.00	3.2740	.0375	199.8	10.86	.0920	.0009	25.2657	8.6431
831	591	80	6	T	133.50	25.98	26.02	350.80	2.4980	.0390	233.6	10.43	.0958	.0010	26.6338	6.0636
832	591	80	7	O	134.80	26.11	26.27	351.50	1.1900	.0202	243.1	20.11	.0497	.0006	27.5929	5.2779
833	591	80	7	O	93.45	26.20	26.36	348.00	1.2250	.0210	239.5	19.35	.0516	.0006	30.0393	4.8147
834	591	80	8	T	202.20	26.16	26.86	350.20	3.2610	.0357	189.4	11.39	.0877	.0009	25.7690	8.5200
835	591	80	8	T	170.70	26.27	26.86	346.90	2.8770	.0369	207.1	11.01	.0907	.0010	27.1471	6.9764
836	591	80	9	O	240.70	26.39	26.72	365.70	2.1500	.0244	210.0	16.66	.0599	.0007	27.2298	7.9410
837	591	80	9	O	159.70	26.52	26.63	362.30	2.1790	.0280	222.3	14.50	.0689	.0008	29.0794	6.6945
838	591	80	10	T	62.47	26.44	25.75	352.80	3.1870	.0389	206.8	10.44	.0957	.0010	26.0274	7.7974
839	591	80	10	T	99.21	26.52	26.87	349.40	3.6770	.0413	191.5	9.83	.1017	.0011	27.2794	8.0798
840	591	80	11	T	244.90	25.60	25.86	374.60	2.4530	.0270	214.1	15.02	.0665	.0007	27.4421	8.1537
841	591	80	11	T	277.20	26.73	26.92	371.30	2.5930	.0277	205.7	14.64	.0682	.0008	29.1636	7.9564
842	591	81	4	O	491.80	26.06	26.08	379.60	2.6020	.0349	244.7	11.66	.0857	.0009	25.5151	7.1024
843	591	81	4	O	344.80	26.15	26.21	376.10	2.3950	.0343	248.5	11.84	.0844	.0009	27.8370	6.3057
844	591	81	5	O	50.54	26.07	26.21	349.40	2.2540	.0330	225.7	12.33	.0810	.0009	26.8320	6.3640
845	591	81	5	O	51.51	26.25	26.34	343.70	1.6770	.0318	244.2	12.79	.0781	.0009	29.0078	4.5592
846	591	81	6	T	67.26	26.50	27.28	347.20	2.2590	.0367	233.5	11.07	.0903	.0010	27.0486	5.4489
847	591	81	6	T	222.10	26.87	28.41	341.90	3.1780	.0375	189.7	10.81	.0924	.0012	29.2816	6.5813
848	591	81	7	T	51.34	26.96	27.15	364.50	2.2070	.0287	225.4	14.14	.0707	.0008	29.4491	6.4940
849	591	81	7	T	80.01	27.18	27.57	359.10	2.7090	.0302	199.1	13.40	.0746	.0009	31.2082	7.0452
850	591	81	8	T	160.90	27.20	27.50	381.20	2.9610	.0297	204.9	13.65	.0732	.0009	29.2245	8.4232
851	591	81	8	T	394.10	27.32	27.54	376.00	2.9310	.0317	210.6	12.79	.0781	.0010	30.8540	7.4582
852	591	81	9	T	230.80	27.14	27.62	349.70	5.2570	.0587	189.4	6.91	.1447	.0015	26.6408	8.3390
853	591	81	9	T	144.70	27.52	27.72	344.30	4.2090	.0627	220.0	6.46	.1548	.0017	28.2727	6.0409
854	591	81	10	T	190.20	27.08	27.37	346.30	5.1410	.0895	236.9	4.54	.2204	.0022	26.2855	5.6304
855	591	81	10	T	205.20	27.13	27.36	340.30	5.2680	.0889	228.1	4.57	.2190	.0022	26.6517	5.7539
856	591	81	11	T	115.50	27.06	27.02	348.90	3.2540	.0600	246.3	6.76	.1478	.0015	27.0165	5.2001
857	591	81	11	T	229.40	27.22	27.16	343.00	3.2220	.0594	240.0	6.83	.1464	.0016	28.3968	4.9452
858	591	81	12	T	92.94	26.63	26.50	385.70	2.9140	.0552	284.5	7.36	.1359	.0014	26.6157	5.1514

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
859	591	81	12	T	60.59	26.87	26.77	380.50	2.8680	.0547	279.3	7.42	.1347	.0015	28.2748	4.8013
860	591	81	13	T	60.60	27.17	27.30	347.50	1.6510	.0369	260.0	10.98	.0910	.0011	29.6601	3.7925
861	591	81	13	T	57.45	27.34	27.51	342.10	2.1180	.0410	244.0	9.08	.1033	.0013	31.0030	4.0001
862	591	100	3	O	19.22	24.65	24.46	355.80	.5424	.0512	325.1	7.98	.1252	.0012	25.0582	1.0998
863	591	100	3	O	22.51	24.71	24.62	362.00	2.2570	.0460	268.9	8.88	.1128	.0011	28.1346	4.8238
864	591	100	4	T	24.89	24.80	24.85	354.10	.8956	.0255	283.9	16.01	.0624	.0006	26.0093	3.3737
865	591	100	4	T	23.03	24.97	24.99	350.70	.6545	.0248	293.5	16.47	.0607	.0007	28.2143	2.3429
866	591	100	5	L	22.95	25.14	25.19	361.20	2.4090	.0406	253.4	10.04	.0995	.0009	21.7442	6.8916
867	591	100	5	L	19.93	25.21	25.16	357.60	1.2160	.0443	299.7	9.22	.1084	.0010	24.7545	2.8418
868	591	100	6	L	49.22	25.21	25.22	351.20	1.6190	.0388	271.5	10.61	.0950	.0009	23.2705	4.5462
869	591	100	6	L	71.56	25.27	25.22	347.60	1.2580	.0408	284.2	10.00	.0999	.0010	25.9042	3.0434
870	591	100	7	T	121.00	25.28	25.11	365.50	2.5890	.0517	271.5	7.89	.1267	.0011	22.9724	5.6647
871	591	100	7	T	41.01	25.28	25.12	362.10	.1321	.0487	343.3	8.38	.1193	.0012	26.1894	.2682
872	591	100	9	T	26.39	25.36	25.33	360.30	.9455	.0334	300.6	12.21	.0918	.0005	•	4.8677
873	591	100	9	T	26.77	25.54	25.53	356.70	.8083	.0307	299.1	13.26	.0753	.0010	28.5258	1.9294
874	591	100	10	T	27.63	25.79	25.67	365.50	1.2350	.0583	317.2	6.99	.1431	.0014	24.9103	2.2110
875	591	100	10	T	28.81	25.77	25.65	362.30	1.1230	.0575	316.0	7.08	.1412	.0014	26.4440	1.9175
876	591	45	3	O	36.71	28.90	30.75	351.80	3.3210	.0578	241.5	6.97	.1434	.0018	27.9718	4.5648
877	591	45	3	O	36.99	29.17	31.11	348.50	3.6050	.0574	228.9	7.01	.1425	.0019	29.7583	4.6943
878	591	45	4	O	275.70	29.29	30.30	351.60	4.5020	.0572	207.3	7.04	.1419	.0017	29.1695	6.4179
879	591	45	4	O	233.10	29.40	30.25	348.40	3.8200	.0608	229.4	6.62	.1511	.0019	30.3888	5.0049
880	591	45	5	T	162.40	27.49	27.52	346.30	2.8550	.0724	268.8	5.60	.1786	.0016	23.8852	4.2891
881	591	45	5	T	79.65	27.68	27.54	343.10	3.0690	.0798	266.3	5.07	.1971	.0019	25.9949	3.9196
882	591	45	6	T	85.70	27.79	27.25	369.90	3.3570	.0512	249.3	7.90	.1265	.0012	25.5339	6.6219
883	591	45	6	T	69.13	27.87	27.80	366.10	2.4200	.0558	249.3	7.90	.1265	.0015	27.6796	4.0665
884	591	45	7	T	206.70	27.71	27.42	354.70	3.4840	.1013	284.8	4.00	.2502	.0021	23.3800	4.0182
885	591	45	7	T	198.40	27.78	27.47	351.20	4.3000	.1039	269.0	3.90	.2566	.0023	24.6922	4.5882
886	591	45	8	T	59.09	27.96	27.82	363.30	3.3830	.0620	260.0	6.53	.1531	.0015	26.0060	5.4979
887	591	45	8	T	74.76	28.06	27.90	359.90	3.2290	.0640	262.6	6.32	.1583	.0017	27.6563	4.7781
888	591	45	9	T	120.00	27.91	27.71	349.00	3.4430	.0666	250.7	6.08	.1645	.0016	26.1562	5.2178
889	591	45	9	T	146.70	28.06	27.89	345.60	3.8990	.0662	235.0	6.11	.1637	.0017	27.6463	5.6055
890	591	45	10	T	480.00	28.33	28.11	349.30	2.1850	.0579	273.3	6.97	.1434	.0015	28.2368	3.5067
891	591	45	10	T	975.30	28.51	28.28	346.10	2.3750	.0565	262.5	7.14	.1399	.0016	30.0788	3.6638
892	591	45	11	O	983.40	28.91	29.46	374.30	1.2750	.0229	268.0	17.58	.0568	.0007	30.3359	4.4078
893	591	45	11	O	407.10	29.14	29.36	370.90	1.4390	.0229	268.0	17.58	.0568	.0008	34.5413	4.2036
894	591	59	2	T	35.43	26.60	26.73	370.90	1.9380	.0359	268.7	11.31	.0884	.0010	27.6441	4.9007
895	591	59	2	T	34.91	26.64	26.74	367.90	1.8190	.0349	268.2	11.62	.0860	.0010	29.0622	4.5068
896	591	59	3	O	28.84	26.90	27.55	350.70	.9853	.0281	278.5	14.43	.0692	.0008	29.2590	2.8892
897	591	59	3	O	32.58	27.00	27.45	347.80	1.0120	.0328	281.6	12.36	.0808	.0010	31.0758	2.4359
898	591	59	4	T	29.82	27.25	27.40	355.10	•	.0332	355.4	12.21	.0818	.0010	31.4723	•
899	591	59	4	T	28.41	27.34	27.68	366.10	•	.0383	1066.0	10.57	.0945	.0012	31.9856	•
900	591	59	5	T	29.72	27.16	27.14	368.60	1.2160	.0380	301.4	10.67	.0936	.0010	28.1230	2.8931
901	591	59	5	T	29.83	27.24	27.22	365.50	1.0720	.0378	303.1	10.71	.0933	.0011	30.4582	2.3649
902	591	59	7	T	39.65	26.71	26.62	354.60	2.8600	.0613	265.7	6.63	.1508	.0013	23.2243	5.2401
903	591	59	7	T	39.81	26.84	26.71	351.40	2.5370	.0632	272.4	6.42	.1557	.0015	25.3363	4.1402
904	591	59	8	T	82.59	27.06	27.26	346.90	1.7390	.0490	275.8	8.29	.1207	.0012	25.3525	3.5301
905	591	59	8	T	134.70	27.23	27.46	343.80	2.3910	.0538	257.0	7.53	.1327	.0014	27.7730	4.0359
906	591	60	4	O	88.77	28.32	28.66	377.20	1.4600	.0255	268.9	15.82	.0631	.0008	29.5234	4.7479
907	591	60	4	O	38.09	28.46	28.66	374.00	1.4700	.0232	254.8	17.37	.0575	.0008	32.9599	4.7585
908	591	60	6	O	193.00	28.42	28.60	348.70	2.5080	.0417	236.1	9.68	.1033	.0012	30.0418	5.0260
909	591	60	6	O	282.60	28.48	28.64	345.10	2.9540	.0417	214.8	9.69	.1032	.0013	31.3460	5.6951
910	591	60	5	O	194.40	28.45	28.47	362.40	2.2810	.0341	237.2	11.84	.0844	.0011	33.7494	5.0145
911	591	60	5	O	157.10	28.44	28.43	359.10	2.3300	.0344	232.6	11.74	.0851	.0011	33.9468	5.0548
912	591	60	7	L	292.40	28.46	28.93	356.20	3.6030	.0417	202.5	9.69	.1032	.0011	25.6589	8.2284
913	591	60	7	L	309.20	28.53	28.75	352.70	3.5010	.0461	215.0	8.76	.1141	.0013	28.0070	6.8203
914	591	60	8	T	162.00	28.52	28.77	347.60	2.1960	.0653	278.7	6.18	.1617	.0016	25.8244	3.3070
915	591	60	8	T	167.70	28.59	28.82	343.80	3.9030	.0534	210.4	7.56	.1322	.0015	28.2129	6.5428
916	591	60	9	T	233.20	28.33	28.35	346.90	4.4890	.0747	234.7	5.41	.1848	.0018	25.1668	6.2200
917	591	60	9	T	262.10	28.45	28.40	343.40	4.4530	.0778	235.1	5.21	.1921	.0019	26.6464	5.6586
918	591	60	10	T	269.00	28.51	28.27	348.80	4.2970	.0840	250.9	4.81	.2080	.0020	25.5218	5.3853
919	591	60	10	T	245.90	28.62	28.40	345.30	4.8610	.0481	235.9	4.80	.2083	.0021	26.8510	5.7655
920	591	60	11	T	517.70	28.69	28.85	343.60	5.4130	.0775	215.4	5.21	.1919	.0018	24.6804	7.3051
921	591	60	11	T	527.80	28.77	28.95	340.10	5.3940	.0762	210.0	5.29	.1889	.0019	26.1032	6.9838
922	591	60	12	T	63.96	28.86	28.77	351.10	5.5280	.0877	232.7	4.60	.2173	.0021	26.3197	6.3677
923	591	60	12	T	45.21	28.92	28.86	347.50	5.5970	.0867	226.5	4.65	.2150	.0022	27.2579	6.2671
924	591	60	13	O	72.27	29.03	28.93	348.80	3.3670	.0722	251.8	5.58	.1790	.0018	27.3924	4.4815
925	591	60	13	O	42.94	29.08	28.98	345.30	3.4770	.0698	248.7	5.78	.1730	.0019	28.8486	4.5345
926	591	67	2	O	550.70	29.08	29.41	348.00	4.7630	.0616	207.7	6.54	.1529	.0016	26.3586	7.3703
927	591	67	2	O	[illegible]	29.38	30.11	344.40	4.4840	.0600	207.2	6.71	.1490	.0017	28.5316	6.3695
928	591	67	3	O	[illegible]	30.14	31.33	346.90	1.2080	.0240	248.4	16.71	.0598	.0008	32.7945	3.5335
929	591	67	3	O	[illegible]	30.75	31.66	343.50	1.2990	.0236	235.9	16.92	.0590	.0009	38.1874	3.4039
930	591	67	4	O	390.20	31.09	32.18	347.10	4.9630	.0632	201.7	6.33	.1578	.0020	31.1861	5.9686
931	591	67	4	O	505.90	31.27	32.35	343.40	5.6990	.0684	189.5	5.85	.1708	.0023	32.5909	6.1064
932	591	67	5	L	945.90	31.59	32.93	388.80	2.0230	.0261	244.0	15.27	.0654	.0010	34.6375	5.0902
933	591	67	5	L	1007.00	32.00	33.53	385.50	2.0750	.0250	229.9	15.94	.0627	.0010	38.8799	4.8341
934	591	67	6	T	882.10	31.56	32.92	353.50	3.7010	.0448	202.1	8.91	.1122	.0015	32.1286	5.8931
935	591	67	6	T	807.10	31.91	33.40	350.00	3.6910	.0468	203.3	8.52	.1173	.0017	34.8574	5.1731
936	591	67	7	T	782.80	32.08	33.71	373.60	2.9260	.0350	218.9	11.39	.0877	.0013	34.2644	5.4601

	GENET	SHOOT	NODE	SHAPE	QNTM	T AIR	T LEAF	CO2	PHOTO	C MOL	C INT	RS	CS	TRNM	VPD	WUE
937	691	67	7	T	873.30	32.38	34.11	370.20	2.7610	.0344	219.4	11.58	.0863	.0014	37.4902	4.7979
938	691	67	8	T	1149.00	32.51	34.19	364.80	3.7680	.0431	203.2	9.24	.1081	.0017	35.3874	5.5510
939	691	67	8	T	1048.00	32.78	34.29	361.30	3.9140	.0447	198.9	8.90	.1123	.0018	37.8467	5.3284
940	691	67	9	T	686.80	32.67	33.79	344.30	7.0230	.0864	191.3	4.61	.2167	.0030	34.2102	5.7302
941	691	67	9	T	628.60	32.81	33.98	340.60	6.6020	.0868	195.7	4.60	.2175	.0031	35.0305	5.2300
942	691	67	10	T	638.10	32.57	34.78	377.50	3.8280	.0410	205.1	9.70	.1030	.0017	35.7431	5.6312
943	691	67	10	T	679.20	32.81	35.04	374.10	3.8000	.0409	201.5	9.73	.1027	.0017	37.8605	5.3297
944	691	67	11	T	918.60	31.51	33.33	348.70	6.2500	.0667	201.8	5.99	.1669	.0023	31.3672	5.6156
945	691	67	11	T	999.80	31.89	33.73	345.10	5.5180	.0662	189.9	6.04	.1656	.0024	33.3139	5.6271
946	691	80	4	T	62.33	25.80	25.83	353.50	1.0880	.0319	284.8	12.76	.0783	.0008	25.9620	3.3069
947	691	80	4	T	30.21	25.85	25.86	350.30	1.0400	.0323	283.6	12.59	.0793	.0009	28.4765	2.8549
948	691	80	5	O	28.95	25.87	25.94	360.50	.8317	.0261	293.8	15.60	.0640	.0007	28.7483	2.7842
949	691	80	5	O	40.68	25.95	25.99	357.10	.8863	.0288	291.7	14.12	.0707	.0008	29.9063	2.5627
950	691	80	7	T	95.08	25.66	25.54	430.20	3.0170	.0759	349.9	5.37	.1861	.0018	22.6365	4.6373
951	691	80	7	T	118.60	25.74	25.58	426.80	2.8010	.0752	350.1	5.42	.1845	.0017	23.9291	4.1139
952	691	80	8	O	41.20	26.03	26.03	359.10	1.0790	.0393	300.3	10.34	.0966	.0010	26.6483	2.6146
953	691	80	8	O	35.30	26.23	26.11	356.10	1.1260	.0445	299.8	9.14	.1093	.0012	28.6195	2.2724
954	691	80	9	T	37.88	26.27	26.05	377.30	1.4030	.0798	334.4	5.10	.1961	.0018	24.4071	1.9189
955	691	80	9	T	43.26	26.32	26.14	373.80	1.9480	.0741	316.0	5.49	.1821	.0018	25.7021	2.6959
956	100	26	3	O	10.05	23.82	23.83	338.00	.2540	.0357	317.9	11.46	.0871	.0006	16.2424	1.1016
957	100	26	3	O	10.80	24.15	24.19	336.90	.1618	.0242	316.6	16.93	.0590	.0004	18.2421	.9049
958	100	26	4	O	9.23	24.32	24.31	365.30	.5719	.0253	319.3	16.18	.0617	.0004	16.9946	3.2988
959	100	26	4	O	12.67	24.34	24.34	364.40	.5216	.0264	322.6	15.51	.0644	.0005	17.6003	2.8061
960	100	26	5	O	10.17	24.44	24.41	338.10	.2883	.0304	313.7	13.47	.0742	.0005	17.3096	1.3699
961	100	26	5	O	11.28	24.51	24.51	337.10	.2962	.0260	309.3	15.69	.0636	.0005	18.2756	1.5456
962	100	26	6	L	7.54	24.72	24.74	341.00	.2192	.0182	311.9	22.44	.0445	.0003	18.3764	1.6138
963	100	26	6	L	8.58	24.68	24.74	340.10	.2058	.0154	308.0	26.45	.0378	.0004	18.3036	1.1738
964	100	29	4	O	4.10	24.93	24.93	338.80	.2032	.0224	314.1	18.22	.0548	.0004	19.2111	1.1736
965	100	29	4	O	3.50	25.05	25.09	337.50	.1887	.0172	308.9	23.76	.0420	.0004	21.0028	1.2878
966	100	29	5	O	6.83	25.25	25.28	350.60	.1926	.0169	321.1	24.12	.0414	.0003	20.7652	1.3494
967	100	29	5	O	7.61	25.18	25.22	349.70	.1074	.0139	324.8	29.39	.0340	.0003	22.8864	.8316
968	100	29	6	L	6.63	25.53	25.62	337.40	.2095	.0147	303.7	27.61	.0362	.0003	21.1328	1.6454
969	100	29	6	L	18.76	25.64	25.73	336.70	.1035	.0147	313.3	27.60	.0362	.0003	23.1380	.7444
970	100	29	8	L	107.10	25.83	26.44	337.40	.8416	.0124	218.7	32.71	.0305	.0003	20.7562	7.5960
971	100	29	8	L	77.79	26.06	27.93	336.30	.9144	.0144	222.9	28.14	.0355	.0004	21.6616	6.1059
972	100	29	9	T	114.00	25.97	26.24	344.50	.9212	.0147	233.3	27.64	.0361	.0003	21.6267	6.7388
973	100	29	9	T	19.43	25.98	26.40	343.40	.9128	.0140	228.0	29.03	.0344	.0003	22.0161	7.0260
974	100	51	5	O	115.50	30.61	30.71	363.10	2.3940	.0470	263.3	8.52	.1173	.0015	31.6001	4.0176
975	100	51	5	O	160.20	30.82	30.89	357.60	2.5050	.0451	249.1	8.88	.1126	.0016	35.3540	3.9230
976	100	51	6	O	47.96	30.46	30.41	367.50	.6114	.0368	320.5	10.88	.0919	.0013	36.1422	1.1519
977	100	51	6	O	37.48	30.73	30.62	361.40	.7454	.0346	305.7	11.58	.0863	.0013	38.7864	1.3967
978	100	51	7	O	45.09	31.15	31.12	410.90	.5484	.0296	357.0	13.53	.0738	.0011	38.6180	1.1975
979	100	51	7	O	32.57	31.33	31.30	408.30	.8048	.0274	336.4	14.58	.0685	.0011	40.5328	1.8022
980	100	51	8	O	28.46	31.38	31.32	362.60	.3808	.0360	324.3	11.09	.0901	.0014	38.4181	.6889
981	100	51	8	O	21.78	31.45	31.82	359.80	1.1930	.0325	278.9	12.27	.0814	.0013	40.2401	2.2147
982	100	29	4	O	232.20	30.31	30.95	360.70	1.3440	.0317	273.5	12.65	.0790	.0011	34.1598	2.9548
983	100	29	4	O	235.90	30.53	31.14	357.40	2.3260	.0397	243.4	10.08	.0991	.0015	36.1567	3.8916
984	100	29	5	O	67.69	30.73	30.92	375.50	1.2250	.0317	293.5	12.63	.0791	.0011	34.9704	2.7152
985	100	29	5	O	22.94	30.86	31.05	372.10	1.5740	.0336	275.9	11.93	.0838	.0012	37.4309	3.0804
986	100	29	6	L	13.59	30.90	30.82	394.60	.2688	.0398	361.6	10.04	.0995	.0014	35.5529	.4647
987	100	29	6	L	22.98	31.01	31.05	391.30	1.4590	.0349	301.5	11.46	.0872	.0013	38.6966	2.6893
988	100	29	7	O	23.14	30.89	30.82	366.40	.2123	.0338	335.1	11.83	.0845	.0012	37.8014	.4163
989	100	29	7	O	72.17	31.07	31.04	363.30	.8871	.0311	296.0	12.85	.0777	.0012	39.4668	1.8000
990	100	29	8	L	23.34	31.14	31.14	378.60	.3853	.0306	336.1	13.09	.0763	.0012	38.4132	.8167
991	100	29	8	L	27.38	31.16	31.15	374.50	.9722	.0291	298.6	13.76	.0726	.0011	39.9609	2.0816
992	100	29	9	T	33.50	31.12	31.51	388.60	1.1770	.0264	295.6	15.12	.0661	.0010	36.8286	2.9127
993	100	29	9	T	39.27	31.17	31.41	385.20	1.6730	.0336	282.9	11.92	.0838	.0013	38.5547	3.1672
994	100	86	3	O	17.16	30.76	30.73	364.60	.4386	.0285	319.2	14.03	.0712	.0010	37.3205	1.0236
995	100	86	3	O	15.44	30.68	30.63	361.60	.4178	.0229	310.9	17.45	.0572	.0009	39.5758	1.1429
996	100	86	4	O	36.55	30.16	30.16	390.70	.5391	.0300	341.1	13.35	.0748	.0010	35.0089	1.2741
997	100	86	4	O	57.82	30.29	30.40	387.80	.8187	.0258	314.9	15.54	.0643	.0010	37.8731	2.0668
998	100	86	5	O	58.19	30.43	30.63	360.40	1.2190	.0309	278.1	12.95	.0771	.0011	35.0261	2.7590
999	100	86	5	O	28.66	30.50	30.54	357.30	1.0600	.0347	288.2	11.56	.0864	.0013	36.9734	2.0577

QNTM = PAR, µ mol m^{-2} s^{-1}; Tair= ^{o}C; Tleaf= ^{o}C; CO2= ppm; PHOTO= µ mol m^{-2} s^{-1}; C MOL= µ mol m^{-2} s^{-1}; C INT= ppm; RS= s cm^{-1}; CS= cm s^{-1}; TRNM= mol m^{-2} s^{-1}; VPD= mb; WUE= g kg^{-1}

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