ries under field conditions in 1984. Shoot growth of plants flooded in spring was variable, but decreased greatly after 35 days of flooding. In contrast, shoot growth of summer flooded plants decreased with flooding of 25 days or greater. Flooding durations greater than 25 days decreased percent fruit set and yields. Flower bud development was very sensitive to summer flooding, declining significantly with as little as 5 days of flooding.

Rabbiteye blueberries grown on Florida's flatwoods soils may become flooded if proper site selection and land preparation procedures (e.g. raised beds, tile drains) are not followed. Bushes growing on poorly drained sites have reduced vigor, growth and yields, and may die, particularly when soil and air temperatures are very high during flooding.

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Proc. Fla. State Hort. Soc. 98: 155-158. 1985.

EFFECTS OF HIGH TEMPERATURE, FERTILIZATION, AND IRRIGATION ON GROWTH AND LEAF ELEMENTAL CONTENTS OF NEWLY ESTABLISHED RABBITEYE BLUEBERRIES

FOUAD M. BASIOUNY[1]
Plant and Soil Sciences
Tuskegee University
Tuskegee, Alabama 36088
AND
ARLIE A. POWELL[2]
Alabama Cooperative Extension
Auburn University
Auburn, Alabama 36848

Additional index words. Vaccinium ashei, stomatal diffusive resistance, transpiration, Fe, Mn, Zn.

Abstract. **Subjecting 'Tifblue' rabbiteye blueberry (*Vaccinium ashei* Reade) bushes to high temperature; N, P, and K fertilization; and irrigation did not increase the leaf elemental contents. Roots retained significant levels of N, P, K, Fe, Mn, and Zn, most likely by a passive mechanism. However, translocation of these elements was impaired due to damage to the root systems from the high temperature.**

Interest in growing rabbiteye blueberries as a commercial crop has increased during the past 20 years. As fruit crops, rabbiteye blueberries are highly organized and dynamic systems with many physiological and biochemical processes which are completely dependent upon nutrients as well as moisture availability. Blueberry yield is greatly affected by nutrient and moisture levels in the soil (7, 16). Absorption and utilization of nutrients and moisture by plants are closely related to soil temperature. Cooling roots reduced the efficiency of the mechanisms which involve uptake and translocation in plants (3,11,12). Due to the fact that the native habitat of the blueberry ranges northward from Central Florida to Eastern North Carolina and westward to Eastern Texas and Southern Arkansas, the chilling requirements of rabbiteye blueberries differ significantly among different cultivars. Lowbush blueberry produced more flower buds, primordial meristems and anthacyanins in leaves at warmer than at cooler temperatures (14). Data relative to the influence of warmer temperature upon the growth and development of highbush blueberries are limited. This study was undertaken to evaluate the influence of high temperature on growth and leaf elemental contents of newly established rabbiteye blueberries.

[1]Professor of Plant and Soil Sciences.
[2]Horticultural Specialist.

Materials and Methods

Thirty-six 2-year-old, uniform 'Tifblue' blueberry plants were grown under greenhouse conditions in a 1:1:1 (v:v) mixture of sandy loam soil, sphagnum peatmoss, and vermiculite, amended with agricultural sulfur to produce soil pH 4.8. The plants were randomly divided into 2 comparable groups. Soil temperature of the first group (high level) was maintained at 50 ± 2° C by means of propagation mats and heating coils attached to a electrical thermostat. Soil temperature in the second group (normal levels as control) was between 20 ± 2° C throughout the study. A drip irrigation system was installed and monitored to deliver 7.0 and 2.5 liter/day/bush for high and normal level plants, respectively. Throughout the experiment each bush of the high level group was fertilized biweekly with 7.0 liters of of nutrient solution containing 150 ppm N as $(NH)_2SO_4$, 50 ppm P as $NaHPO_4$, and 100 ppm K as KSO_4. On the other hand, each bush of the normal group received 2.5 liters biweekly of similar nutrient solution containing 50, 17, and 33 ppm of N, P, and K, respectively. Relative humidity in the greenhouse was between 60 to 70% and no supplemental light was used. The experiment was complete randomized design with 3 replications per treatment.

At commercial ripening, stomatal diffusive resistance, transpiration rate, and leaf temperature, of uniform fully expanded leaves were determined using a Steady State Porometer (LI1600) (LICOR, Inc. Lincoln, NE). Composite samples of 30 leaves were collected from the midportion of the shoots and comparable root samples were collected at the termination of the experiment. The samples were thoroughly washed with distilled water, plotted, dried in a forced-draft oven at 75° C for 48 hr and then ground in a Wiley mill to pass a 20 mesh stainless steel sieve. Total nitrogen was determined by a modified Kjeldahl method. Levels of P, K, Cu, Fe, and Zn were determined by atomic absorption spectrophotometer.

Results and Discussion

Plant Morphology. Increasing soil temperature, N, P, K, and irrigation water enhanced the growth of young blueberry (Table 1). A few weeks after establishment, plants from the high level group initiated additional vegetative and flower shoots, and increased in height more than plants from the normal group. This observed change in growth agreed with several reports (8,9,15,17,19). These plants had a deep green foliage and developed no visual evidence of mineral element deficiencies. Flowering of these bushes continued 5 days longer and resulted in more fruit set than bushes grown with normal levels of temperature, fertilization, and irrigation water. The relative increase in plant height, number of branches, and change in color, however, continued for 7 weeks before it leveled off, after which, a gradual increase in growth was noticed in plants grown under normal soil temperature, fertilizer application and irrigation. This increase continued until the termination of the experiment. Plants from the high level groups did not show any appreciable changes in their growth characteristics, however, some of their leaves tended to be light green or developed red coloration which reflected accumulation of anthocyanin which was interpreted as being due to high temperature stress.

Leaf Water Relations. The increase in irrigation levels resulted in a significant increase in stomal diffusive resistance of blueberry leaves (Table 1). Blueberry bushes which received irrigation water at a rate of 8.0 liters/day gave higher stomatal diffusive resistance readings (approximately 10%), than bushes which received 2.5 liters/day. A direct relation between transpiration rates and leaf stomatal diffusive resistance was noticed. Higher transpiration (approximately 26%) was recorded from leaves selected on plants that received 7.0 liters/day and showed lower stomatal diffusive resistance. Meanwhile, leaves from plants received lower water regime (2.5 liters/bush/day) showed lower transpiration and higher stomatal diffusive resistance. This indicated that application of less water promoted partial closure of leaf stomata. The escape of water vapor from leaf surfaces as transpiration was restricted by the stomatal closure under low rather than high water application. This agreed with previous reports by Davies and Johnson (7) and Hussan and Basiouny (16). Data on leaf temperature were parallel to those on stomatal diffusive resistance (Table 1). Normal, levels of irrigation water (2.5 liters/day/bush) resulted in higher leaf temperature. This was due to the partial closure of stomata and restricted transpiration, which consequently led to the increase in

Table 1. Effects of high temperature, fertilization, and irrigation on plant morphology and leaf water relations of 'Tifblue' blueberry.

Treatment	Plant height[z] (cm)	Branches (no.)	Diffusive Resistance ($s\ cm^{-1}$)	Transpiration ($\mu g\ cm^{-2}s^{-1}$)	Leaf temp (°C)
Normal level[x]	103.8	5.3	2.03	10.3	38.6
High level[y]	79.6	5.1	1.84	13.8	35.9
	*[w]	*	*	*	*

[z]Average of 3 replications.
[y]Bushes received a combination of 150, 50, and 100 ppm N, P, and K, respectively, 7.0 liters/day/bush, and soil temperature maintained at 50 ± 2°C.
[x]Bushes received a combination of 50, 17, and 33 ppm N, P, and K, respectively, 2.5 liters/day/bush, and soil temperature maintained at 20 ± 2°C.
[w]*, means significantly different at 5% level.

Table 2. Effects of high temperature, fertilization, irrigation on leaf elemental contents of 'Tifblue' blueberry.

Treatment	N[z]		P (%)		K		Fe		Mn (ppm)		Zn	
	Leaves	Roots	Leaves	Roots	Leaves	Roots	Leaves	Roots	Leaves	Roots	Leaves	Roots
Normal level[x]	1.10	0.41	0.069	0.02	0.43	0.16	74.5	26.2	199.3	75.3	28.3	8.4
High level[y]	1.09	0.36	0.067	0.34	0.30	66.5	37.1	143.8	94.2	17.0	11.4	
	NS[w]	*	*	*	*	*	*	*	*	NS	*	*

[z]Average of 3 replication.s
[y]Bushes received a combination of 150, 50, and 100 ppm N, P, and K, respectively, 7.0 liters/day/bush, and soil temperature maintained at 50 ± 2 °C.
[x]Bushes received a combination of 50, 17, and 33 ppm N, P, and K, respectively, 2.5 liters/day/bush, and soil temperature maintained at 20 ± 2 °C.
[w]*, NS, NS nonsignificant, * significant at 5% level.

leaf temperature. On the other hand, the lower leaf temperature readings obtained from bushes which received irrigation water at a rate of 7.0 liters/day was attributed to the high transpiration in the leaves (16). High soil temperature which prevailed under these conditions also might have contributed to that increase in transpiration.

Leaf Elemental Contents. Samples collected from the high level group at the end of the growing season contained lower levels of N, P, K, Fe, Mn, and Zn than samples from normal level group (Table 2). Leaves from bushes treated with approximately one third the amounts of N, P, and K received by bushes from high level group showed approximately 1, 3, and 12% increases in N, P, and K, respectively, than leaves from bushes treated with high levels of these elements. In contrast, several reports (5,6,23,24) indicated a positive relationship existed between N, P, and K application amounts and the concentration of the elements in the foliage. The data obtained from these studies did not corroborate these reports. Levels of Fe, Mn, and Zn in leaves collected from bushes treated with lower levels of N, P, and K were significantly higher than in leaves sampled from plants grown with higher levels of N, P, and K. In other words, plants treated with lower level of N, P, and K induced approximately 11, 28, and 40% increases in Fe, Mn, and Zn, respectively. This also means that high applications of N, P, and K did not induce similar increase in Fe, Mn, and Zn as reported by others (1,5,23,24). In fact, under these conditions, the increase in N, P, and K contents induced significant reduction in Fe, Mn, and Zn in blueberry leaves (11, 28, and 40%, respectively).

Data on root analysis of bushes from both high and normal levels groups illustrate interesting results (Table 2). Blueberry roots from bushes which received high levels of N, P, and K were significantly higher in elemental contents than roots from bushes which received lower levels of these elements. The increases in root elemental contents was approximately 35, 50, and 47% in N, P, and K and 30, 21, and 27% in Fe, Mn, and M, respectively. There was an obvious relation between the accumulation of some elements, i.e., Fe in the leaves and their accumulation in the roots. Among the different elements tested, P accumulation in the roots was the highest, followed by K, N, Fe, Zn, and Mn.

Temperature has a significant influence on many of the plant physiological and biochemical systems. Many investigators have found various responses of different species to root and air temperature treatments (10,13,21,22). Increase in soil temperature promoted vegetative growth and increased yield (4,22), and enhanced absorption of water and nutrients (2,20). Consequently, an increase in soil temperature can provide better conditions for many of the plant processes which lead to increase growth and development. It is generally accepted that absorption and translocation are generally impeded at low root temperature but rise to a maximum between 25 to 30° C, only to decrease again at still higher temperatures (2,4). This study demonstrated that 'Tifblue' plants benefited significantly from high root-zone temperature at the early stage of plant growth and development. Beginning of about the third week after establishment and up to the 7th week, this favorable effects of high temperature was evident in terms of increased plant height, number of branches, dark green leaf color, more flowering, and fruit set. However, the observation made in subsequent weeks that blueberry growth either leveled-off or ceased, regardless of higher levels of applied N, P, and K, suggested possible problems in the absorption and translocation mechanisms. There has been several earlier reports (18,25) in which temperature of 45 to 55° C caused temporary callosing of sieve plates, blockage of translocation, and instantaneous coagulation of the phloem sap of plants.

It is apparent from the data on root analysis that blueberry roots retained significant levels of N, P, K, Fe, Mn, and Zn. Whether the retention process of these elements was an active or passive one was not fully understood. However, it is conceivable that, although the absorption process might have taken place, translocation mechanisms of the absorbed nutrients and assimilates were impaired due to blockage or damage of translocation resulted from the high temperature.

High soil temperature conditions always lead to high rate of respiration and the loss of a very considerable portion of the day's photosynthate. This, aggravated by significant reduction in the translocation process, was probably the reason for the change to a light green color of the leaves at the later stage of this studies. Despite an earlier report by Hall et al. (14) in which they indicated that the anthocyanin contents of lowbush blueberry leaves was markedly enhanced by cold temperature, the red color noticed on the leaves at later stages was attributed to leaf senescence.

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Proc. Fla. State Hort. Soc. 98: 158-162. 1985.

BREEDING BLUEBERRY CULTIVARS FOR THE CENTRAL FLORIDA PENINSULA

P. M. LYRENE AND W. B. SHERMAN
University of Florida, IFAS
Fruit Crops Department
Gainesville, FL 32611

Additional index words. Vaccinium ashei, Vaccinium corymbosum, pentaploids, chilling requirement.

Abstract. **Wild highbush blueberries (*Vaccinium corymbosum* L.) occur in woodland sites in the central Florida peninsula southward to Lake Okeechobee. This suggests that commercial blueberry production should be possible in the area if suitable cultivars are developed. Two potentially profitable markets are the local U-pick market and the April fresh-fruit shipping market. Consistent production of blueberries during early to mid April will require production sites where the last killing frost is 15 Feb. or earlier. Cultivars for this purpose must flower early and have short flowering-to-ripening intervals. For the U-pick market, high yields are more important than early ripening. Possible selections for U-pick production, include rabbiteye blueberries (*V. ashei,* Reade) selected for resistance to mild-winter-induced fruit drop and fruitful pentaploid hybrids, which combine the high plant vigor of the rabbiteye with the highbush ability to set fruit well following insufficient chilling.**

Blueberry production is expanding rapidly in North America. In 1935 there were fewer than 1,000 acres of cultivated blueberries on the continent, but estimates in 1983 placed combined cultivated acres of highbush and rabbiteye blueberries at 39,050 (15). Florida's acreage of cultivated blueberries has increased from fewer than 200 to almost 1,000 acres within the past 10 years, and the rate of expansion is accelerating. Almost all of this acreage has been planted from Ocala northward, where current cultivars are best adapted and have been tested most extensively (16,17,18).

Although their fruit is too small for commercial use, at least 3 species of native wild blueberries, *V. darrowi* Camp, *V. myrsinites* Lam., and *V. corymbosum* are abundant on acid soils as far south as Lake Okeechobee (1,11,12,20). This indicates that blueberry cultivation should be possible in the central peninsula of Florida. Two factors make this prospect interesting. One is the large potential U-pick market available around population centers in the region and the second is the possibility of producing blueberries for shipment during April, when no other fresh blueberries are available.

'Sharpblue' (19) is currently believed to be the cultivar best adapted to the area south of Ocala, although grower experience with blueberries in this area is not sufficient to allow firm conclusions. For the U-pick market, where early ripening is less important, some of the currently available rabbiteye cultivars may also prove satisfactory.

The purpose of this paper is to discuss the prospects for growing blueberries in the central Florida peninsula and to describe some breeding strategies that could result in cultivars that would perform better in the area.

Blueberry Cultural Problems In The Central Florida Peninsula

Climate. The climate between 1 Nov. and 1 Mar. is the primary reason for uncertainty regarding the performance of north-Florida blueberry cultivars in the central Florida peninsula. The 2 cultivated types, highbush and rabbiteye, are deciduous in north Florida. Flower buds ordinarily become visible in the leaf axils during Sept., Nov., and Dec. The leaves begin to abscise after the first killing frost, and plants usually lose most of their leaves by 1 Jan. North-Florida blueberry cultivars have a chilling requirement of about 200 to 300 hr below 45°F for 'Sharpblue' and 200 to 500 hr for various rabbiteye cultivars. Plants that have been inadequately chilled usually show delayed bud break in the spring. Some buds may open and grow, while others on the same stem remain dormant. flowering may be delayed a month or more, and the flowering period may be prolonged. Berry ripening also will begin later than normal and extend over a longer period. Plants may lose vigor and die if underchilling is severe and occurs for several years.

Poor fruit set is another effect of insufficient chilling (10). This is very important with many rabbiteye cultivars but much less so with highbush. Following mild winters, some rabbiteye cultivars flower normally, but set few fruit, the young berries abscising shortly after petal fall. This phenomenon is poorly understood, and it it is not clear why the problem is so much more severe with rabbiteyes than with highbush. The severity of mild-winter-induced

University of Florida Journal Series Number 6841.