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To the Graduate Council:

I am submitting herewith a thesis written by Charles W. Johnson entitled "Response of Three Species of Woody Ornamental Plants Under Various Ecological Regimes in Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Horticulture.

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RESPONSE OF THREE SPECIES OF WOODY ORNAMENTAL PLANTS UNDER VARIOUS ECOLOGICAL REGIMES IN TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Charles W. Johnson

June 1968

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ABSTRACT

A study of the response of three species of woody ornamental plants, Mahonia pinnata, Buxus sempervirens, and Taxus media browni, was initiated in 1967 to determine how these plants would respond to (1) directional exposure; (2) background color; and (3) different climatic regimes of Tennessee.

Mahonia pinnata plants placed at the north exposure had longer leaves than those at the south and west exposure and were taller and had less winter burn than those at the west exposure. Leaves were longer at Crossville than at Jackson, Knoxville, and Spring Hill. Mahonia pinnata plants at Knoxville had a greater increase in height and a greater maximum width than did those at any of the other locations.

Taxus media browni plants at the north exposure had (1) a greater increase in height than those at the east exposure; (2) longer shoots and a greater increase in width than those at the south exposure; (3) a darker green color than those at the east, south, and west exposures.

Buxus sempervirens plants were darker green at the north exposure than at the west and south exposures and had a greater increase in height and had longer shoots at Knoxville than at any of the other locations.

The south and west exposures had a greater yearly mean of the weekly maximum temperatures than did the east and north exposures. The

south, west, and east exposures had a greater summer mean of the weekly maximum temperatures than did the north exposure. Spring Hill had the highest yearly and summer mean of the weekly maximum temperatures.

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CHAPTER I

INTRODUCTION

Plant growth is dependent upon all the factors that make up the environment. The main climatic elements in agriculture are temperature, moisture, sunlight, and wind. The plant that is being grown must find suitable patterns of these within its microclimate, or fail as an economic asset. Temperature influences the rate of each physiological process occurring in plants including growth. Therefore, the structural development and physiological reactions of a plant may vary greatly, depending upon the temperature pattern of that plant's environment.

All crops have three "cardinal" temperatures for growth, a minimum, an optimum, and a maximum. These so-called cardinal points on the temperature scale may vary greatly with different species. The micro temperature and light intensity around the plant is also influenced by macro climatic factors of the surroundings.

The objectives of this investigation were fourfold. The first was to determine how the color of a structure, used as a background, would effect the temperature of the plant's microclimate. The second was to determine if directional exposure had any effect upon temperature and plant growth. The third was to determine how three species of woody ornamental plants would respond to combinations of different

directional exposure and background color. The last was to determine if the plants would respond differently to background color and directional exposure if they were grown in different regions of Tennessee.

CHAPTER II

REVIEW OF LITERATURE

I. ENVIRONMENTAL FACTORS INFLUENCING PLANT GROWTH

The main climatic elements in agriculture are temperature, moisture, sunlight and wind with their affect upon evaporation. The plant that is being grown must find suitable patterns of these within its microclimate, or fail as an economic asset (5). Griffiths (5) reports that plant growth is dependent upon all the factors that make up the environment. No particular level of one factor should be referred to as the optimum for growth of a species without specifying at least the approximate levels or conditions of the other important components of the environment. No single optimum for any factor exists that will hold without regard to the status of the other factor.

Many of the environmental conditions to which plants are subjected are in turn influenced by more remote factors. Meyers et al. (9) reports that the intensity and quality of impinging sunlight, for example, are functions of the angle of the earth's inclination to the sun, the pitch of the slope upon which the light falls, and the direction toward which the slope faces. The soil-water content is controlled not only by the precipitation but by the surface runoff and by factors which influence the rate of evaporation such as air temperature, humidity, wind, and insolation.

Temperature influences the rate of each physiological process occurring in plants including growth (9). Meyers et al. (9) reports that temperature exerts qualitative as well as quantitative effects upon the development of plants. Therefore, the structural development and physiological reactions of a plant may vary greatly, depending upon the temperature pattern of that plant's environment. Whether a plant can survive or not in a given habitat often depends upon the temperature extremes which occur in that habitat.

All crops have three "cardinal" temperatures for growth, a minimum, an optimum, and a maximum. These so-called cardinal points on the temperature scale may vary greatly with different species. A distinction should be drawn between the extremes of temperature at which the growth of a plant ceases, and the extremes of temperature which a plant can tolerate without death resulting. Meyers et al. (9) reports that the minimum temperature which a plant can tolerate without injury is almost invariably below that at which growth ceases; likewise plants can usually endure without lethal effects, at least temporarily, temperatures considerably in excess of the maximum at which growth occurs.

Meyers et al. (9) found that a given plant may cease to grow when the temperatures to which it is exposed rises to 104°F. Death, however, occurs only if the temperature of the plant is raised to 131° or 141°F. Within this intervening range of temperatures the plant passes into a state of heat rigor in which it neither grows nor exhibits

growth movements. There is a corresponding range of temperatures between the lowest temperature at which a plant will grow and its death point as a result of cold. Within this zone of temperatures the plant passes into a corresponding condition of cold rigor.

Injury to Plants at Relatively High Temperatures

Wheaton (19) found that leaves exposed to bright sunlight may show a temperature as much as 25°F. higher than that of the surrounding air. Most plants cannot withstand air temperatures above 125°F. no matter what their degree of maturity. Kramer (7) reported that exposure to relatively high temperatures often causes reduced growth and injury in trees. These effects may be the result of direct heat injury or of metabolic disturbances associated with very high respiration rates or even with desiccation of tops. Meyers et al. (9) reported that high leaf temperatures resulting either from intense insolation or high air temperatures or both may result in excessive rates of transpiration. A relatively high rate of water loss, particularly at times when the rate of absorption of water is slow, often leads to death of some or all of the leaves or branches on a plant as a result of desiccation. In extreme cases entire plants are killed in this way. Relatively high temperatures often induce metabolic disturbances which are detrimental or even fatal to plants. High temperatures frequently cause a stunting of plants because a disproportionate amount of the foods manufactured is consumed in respiration (9).

Meyers et al. (9) reports that air temperatures in temperate regions seldom exceed 104°F., and although the temperature of an isolated plant organ often exceeds that of the atmosphere, lethal temperatures are seldom attained. The surface temperatures of some soils, however, may attain values of 158°F. or even higher when exposed to intense insolation. Attempts to reforest bare areas have sometimes failed because of such high soil-surface temperatures. The living cells of the stems of the young trees which had been set out were killed at the soil line by contact with soil at a temperature above their thermal death point, thus causing death of the entire transplant.

Injury to Plants at Relatively Low Temperatures

Kramer (7) reported that decreases in temperature slow down physiological activity, and a sudden drop in temperature or very low temperatures often cause serious injuries. Pickett (11) reports that the extent of damage depends on the intensity of the freeze, the length of time the temperature remains below the critical level, and the developmental stage of the plant. Winter injury commonly is caused by actual freezing, but sometimes is caused by desiccation of tissues. Much winter and early spring injury in evergreens occurs as a result of an excess of transpiration over absorption. It is not uncommon for the air to warm up sufficiently for a short time during sunny days of winter or spring to bring about a high rate of transpiration. Since the soil is cold or frozen, water is not absorbed through the roots rapidly enough to replace the transpirational loss. Munger (10)

described this type of injury on Douglas-fir and called it "parch blight." Voigt (17) found desiccation injury in several conifers in Wisconsin and referred to it as "winter-drought injury." The injury was confined to parts of trees which were most exposed to warm southerly winds and subject to high transpiration.

Meyers et al. (9) reports that a similar type of injury may result to some plants as a result of frost heaving of the soil. Such heaving often tears the roots loose from the soil or in extreme cases may even break them. When environmental conditions favor high transpiration rates the root system may not have time to securely re-establish itself in the soil, and the plant may be so severely desiccated that death or marked injury results.

Many plant tissues are killed or injured when exposed to temperatures low enough to cause ice formation within them. This is the most frequent and fundamental type of low-temperature injury in temperate climates (9). Meyers et al. (9) reports that when tissues of higher plants freeze, crystallization of water most commonly takes place in the intercellular spaces. The ice crystals enlarge at the expense of water which not only comes from the cells immediately bordering the intercellular spaces but also from cells farther away by passage through intervening cells. The more the temperature drops the greater the proportion of the water which freezes in the tissues.

When freezing occurs very rapidly, crystallization of water takes place within the cells instead of in the intercellular spaces (9).

Siminovitch and Scarth (13) reported that formation of ice crystals within cells probably occurs only rarely, but has been achieved in laboratory experiments under conditions of very rapid freezing. According to Pfeiffer (12), rapid freezing usually is more harmful than slow freezing.

Meyers et al. (9) found that intracellular crystallization of water causes ice to form in the cytoplasm or in the vacuole, or both, or it may form between the cell wall and the protoplasm. Ice formation within cells is often accompanied by ice formation in the intercellular spaces. Kramer and Kozlowski (7) reported that formation of ice crystals within cells invariably kills them, but ice crystals in intercellular spaces may or may not injure cells. Meyers et al. (9) found that in intracellular freezing small crystals of ice ramify throughout the cytoplasm and their lacerating effect is apparently so effective in disorganizing the protoplasmic structure that death of the cells results.

Meyers et al. (9) reports that freezing injury under some conditions appears to result, not at the time of ice formation in the intercellular spaces, but during the subsequent thawing. This is especially prone to occur when the thawing is rapid. Death under these conditions apparently results from mechanical distortions of the protoplasm attendant upon the rapid re-entry of water into the cells from the intercellular spaces.

II. SPECIES SELECTED FOR EXPERIMENT

Mahonia pinnata

Named in honor of Bernard McMahon (1775-1816), friend of Jefferson and prominent American horticulturist, is the genus Mahonia, containing a large number of very excellent evergreen holly-like shrubs (16, 3). In the Pacific Northwest the native species are known as Oregon-grape because of their grape-like blue fruits. In the Southwest species are called agarita or algerita, which is Spanish for sour or bitter in reference to the taste of the berries (16).

There are about 50 species of Mahonia (14, 16). They are found in North and Central America and in southern and eastern Asia. The 16 species native to the United States are all found west of the Mississippi, but some of them have been grown in the eastern half of the country for over a century (16). The Lewis and Clark Expedition into the Northwest Territory is credited with bringing this splendid native plant back to the East Coast (23).

Only one of the half dozen species found commonly in cultivation in the United States is an exotic; all the rest are natives (16). The distinguishing characteristics of this genus are the unusual leaves and the yellow inner bark of the stems (16, 3). Mahonia aquifolium, the Oregon-grape, is possibly the most choice evergreen foliage plant of this group. Its compound leaves are coarse in texture, and each glossy dark green leaflet, with its spiny teeth, looks very much like a Holly leaf (21).

Tallest of all and one of the most desirable of the Mahonias is Mahonia pinnata, officially the cluster mahonia, but also called California barberry, wavyleaf hollygrape, and shinyleaf mahonia. The Mahonia pinnata is like an enlarged and improved Mahonia aquifolium, but is thought by some to be only a variety of the Oregon-grape, but consistently higher (1, 16, 14). The Mahonia pinnata reaches a height of about 12 feet in the wild but as much as 16 feet in cultivation. The foliage is grayish green in color and the leaves have 7 to 13 bristly margined leaflets, each one glossy green on top and paler but still glossy on the under side. The leaflets crowd each other and often overlap. The yellow flowers are very fragrant, and appear in clusters 3 to 4 inches long all down the stems in March and April. The berries are dark blue to purplish black, with a waxy bloom, and ripen in August or September (16, 14).

The Mahonia is native to the rainy Pacific Northwest and, although somewhat unpredictable, is successful in the Upper South and cooler parts of the Piedmont. It seems to prefer alkaline soils, and will stand full exposure to sun in the summer (20). The Mahonia pinnata is easily grown in some shade and shelter, but here it is often leggy (20, 21, 1). Although the plant is perfectly hardy, the foliage is liable to winter injury, and this damage is aggravated by over-exposure to sun and winds (1, 14, 21). The compound leaves turn a bronzy purple in the autumn and hold this rich color through the winter. Exposure to winter sunshine scorches and kills the leaves. This severe

damage will not kill the plant as it will send out new leaves in the spring, but it will reduce its vitality (3).

Buxus sempervirens

The boxwood has been in cultivation since ancient times and bears its Roman name. If injured or severely cut back it has great recuperative power, thus confirming its appropriate name, sempervirens, which means "evergreen" (3). The common boxwood has been intimately associated with gardens in North America since early colonial times when no garden in any of the Southern colonies was considered complete without it. The center of climatic adaptation for boxwoods is the Chesapeake Bay region and the foothills of the Blue Ridge in Virginia and North Carolina. Fine specimens are also found in the Piedmont of South Carolina, in Tennessee and Kentucky, in the vicinity of Delaware Bay, on Long Island, N. Y., and on the Pacific coast (15).

The area of best adaption for boxwood is approximately determined by the following climatic features: (1) normal minimum temperature in winter not lower than 0°F., (2) a definite period of winter rest with mean temperature between 30° and 40°F., (3) annual rainfall of 30 to 40 inches, about evenly divided between the summer and winter seasons. With artificial winter protection, the cultivation of the boxwood has extended into southern New England, but where the minimum temperatures reach -10°F., especially if prolonged, boxwood growing becomes highly precarious (18).

The boxwood is highly tolerant of shade and is often planted in heavy shade adjacent to walls or under tall trees. It thrives better with more light, however, and does best in full sunlight, provided the soil can furnish enough moisture especially during dry, cold periods in the winter when exposure to strong light may otherwise cause the foliage to sunburn. An ideal site in this respect is one that provides direct sunlight for part of the day and only partly shade at other times (18).

A wide range of soil types, from sandy loam to heavy clay, are suitable for boxwoods. Soil texture is important only as it influences moisture-holding capacity. Best growth is made in fairly heavy clay that is well supplied with organic matter (15). Boxwood soil must be well drained and aerated and should have a porous subsoil (13, 15). Boxwoods will not tolerate a soggy or stagnant soil (15). If the planting site has no natural drainage, boxwoods can be "planted high"; that is the hole for the root ball can be made shallower than the depth of the root ball (18). Tests show that boxwoods are relatively indifferent to soil reaction; they will grow in a peat soil as acid as that used for rhododendrons, and they thrive in a soil rich in lime. Certainly boxwoods do not need an acid soil; in fact, there is some evidence that the foliage color is a deeper green and the plants are sturdier in a neutral soil or one in which lime is abundant (18).

Boxwoods which are thoroughly watered at regular intervals make better growth and suffer less from disease, spider mites, and freezing

than those whose water supply is at times deficient and again excessive (23, 18). Frequent and light watering which wets only the surface of the soil is detrimental. The boxwood is well adapted in root and leaf structure to endure moderately dry conditions, and it is a mistake to water boxwoods so persistently through the season that the foliage is always "soft." Most of the watering should be done before mid-summer, and it is important not to permit a deficiency of rainfall to cause a growth check before this time. From mid-summer on, water can be given more sparingly, allowing shoot growth to slacken and harden before freezing weather is expected. Boxwoods that suffer a growth check before mid-summer because of deficiency of water often start into second growth with the advent of fall rains and suffer from winter injury because of their immaturity (18). A pronounced bronze leaf color during the winter is symptomatic of this type of injury, but the normal green color usually returns in the spring. Complete blanching of the foliage is indicative of death by freezing, but except in newly transplanted devitalized plants severe freezing injury is usually restricted to "second growth" (18).

Like all broad-leaved evergreens, boxwood continues to transpire moisture from its leaves during the winter. If the autumn is dry, several liberal waterings will help to supply the needed moisture during the winter. Rain, turning to ice on the leaves, is particularly disastrous to boxwood. The bright sunlight shining through the ice, which acts as a lens, causes severe burning and sometimes the complete destruction of the leaves (3).

Cold damage can also cause the bark to split. Branches will show poor color often one and two years later, and upon close examination the bark may be found to have split from the wood. Sometimes the damage can be found while the foliage is still rich green, and then it takes the leaves a year or so to die (6).

Taxus media browni

The yew with its dark green color is one of the most striking of all the evergreen shrubs and trees. Their hardiness, adaptability to sun or shade, freedom from pests, variation of growth habit and excellent foliage along with their bright red, fleshy fruits are among the reasons for their increasing popularity.

There are yews in England which must be a thousand years old, their trunk circumferences being at least 30 feet (24). These excellent evergreens are rather slow in growth, when compared with deciduous trees, with wood that is hard and close-grained. The yews resemble each other so much that a few botanists have suggested in the past that there is only one species, Taxus baccata, and that all other yews are merely geographical varieties of this (23, 24, 2).

Poisonous properties of the yews have been recorded. Caesar writes that Cativolcus, King of the Eburones, poisoned himself by drinking the juice of the yew. The toxic material is probably an alkaloid name taxine, a heart depressant, present in the leaves, and to a lesser extent in the twigs and bark (23, 24).

Many yews fail to produce fruit. The species is dioecious. Plants of both sexes are necessary to insure fruiting (20). One staminate plant is sufficient for every six or eight pistillate or fruiting plants (21, 23).

There are seven species and over 100 varieties of yews being grown in the United States, although not all are available from nurseries. Of the seven species grown, the Chinese yew, Taxus chinensis, and the Pacific yew, Taxus brevifolia, are little seen in cultivation. The English yew, Taxus baccata, is the least hardy (24). The Japanese yew, Taxus cuspidata, has proved to be the hardiest of all yews and is perfectly happy in the coldest parts of New England northward to Ottawa and also in much of the Middle West (22).

The Japanese yew was first introduced into this country in 1861 by Dr. George R. Hall. This plant has shown its good qualities time and time again and now is being grown by the majority of American nurseries. It has proved itself hardy under trying winter conditions; although not foolproof, it can be grown where many other evergreens cannot (24, 23).

About 1900, a new species of yew originated as a result of a cross between the English and Japanese yews (23, 14). Mr. T. D. Hatfield, Superintendent of the Hunnewell Estate in Wellesley, Massachusetts, had grown a number of seedlings which were given the specific name of Taxus media (22, 23). This hybrid is broadly pyramidal, frequently has a central leader and grows into tree form. The hardy

qualities of the Japanese yew and the ornamental qualities of the English yew are merged in this plant to give an excellent ornamental evergreen (23). One of the seedlings, resulting from this cross, is called Taxus media browni, the Brown yew. The Taxus media browni is a staminate plant and has a compact columnar form with short, dark green foliage (4).

The yew is tolerant of acid or alkaline soils in sun or shade, but needs good drainage. Its southern limits probably will be Washington, Atlanta, and Memphis where it can be grown only in cool, moist shade (21). Their need for coolness and moisture is far more important than the soil type in which they are growing. All of them are unsuited to the prairie states (14).

CHAPTER III

MATERIALS AND METHODS

This study was concerned with the response of woody ornamental plants to directional exposure and high and low background reflection in five distinct climatic regimes in Tennessee.

The species used were Taxus media browni, Buxus sempervirens, and Mahonia pinnata. The plants were of small landscape size approximately 15 inches wide and 18 inches tall.

Structures were constructed from 4' x 8' sheets of plywood which were crossed to form four sections. A sheet 4' x 4' was used as a roof over the structure. Directional exposure was obtained by placing the plants at the north, east, south, and west side of the plywood structures. Figure 1 shows Buxus sempervirens plants at the south and west exposures of a white structure. Figure 2 shows the arrangement of six structures at the Knoxville location.

High light reflection was obtained by painting half of the structures white. The other structures were painted dark brown for low light reflection. This was to give some comparison to a white house or one with a surface which reflects bright sunlight as to one that would tend to absorb light such as a dark wall.

As the study is concerned with how the plants would respond in different parts of the state, the experiment was set up in Crossville, Jackson, Springfield, Knoxville, and Spring Hill. Per station there

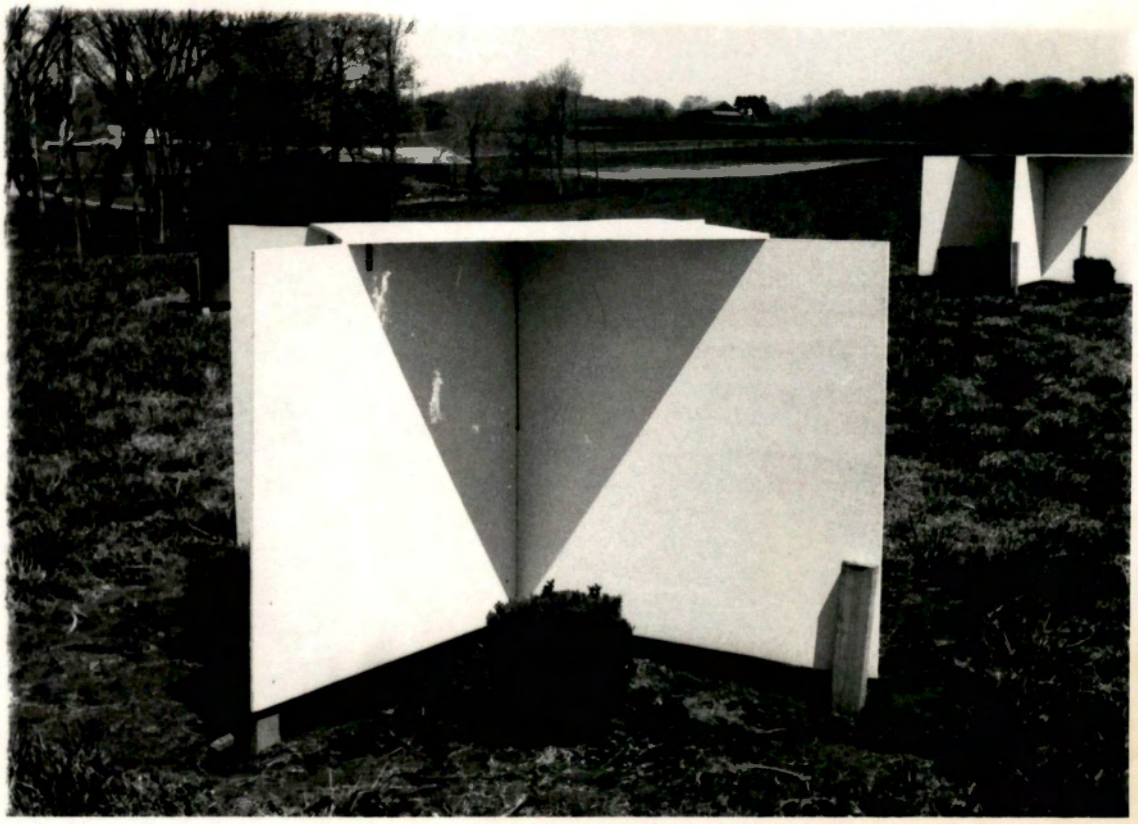


Figure 1. Buxus sempervirens plants at the south and west exposure of a white structure.



Figure 2. Arrangement of six structures at Knoxville.

are 12 structures of which six are dark brown and six white. At the five stations, each species is replicated four times for each directional exposure and twice for each color of background.

The structures were placed in an 8' x 8' clean cultivated area within a 160' x 160' or 320' x 80' plot depending on the land available at each station. At all stations one boundary line ran in an east-west direction. The land had a slope of less than 10 per cent and the soil type was representative of the region.

Weekly soil and air temperatures were taken throughout the year. The air thermometers were Taylor maximum and minimum, bimetallic, dial type thermometer with a range from -30° to ± 120°F. The air thermometers were placed with the temperature sensing element 2 inches below the top of the plant. The soil thermometers were the mercury-filled type with a range of -31° to 124°F. The soil thermometers were placed directly under the air thermometers to a depth of six inches below the soil surface.

Cultural practices consisted of keeping the cultivated areas weed free by the use of Paraquat, a contact weed killer, and annual loosening of the soil to a depth of two inches. During the summer the clean cultivated areas were utilized for exposure studies on low-growing annual flowers. Three species were used: Geranium Nittany Lion, Ageratum Blue Mist, and Petunia Linda. Four plants were set at each directional exposure.

I. LOCATION OF EXPERIMENT STATIONS

Tennessee includes great ranges in elevation, geology, topography, climate and soil; thus its agriculture has a diversity of crop and livestock production. This great diversity was taken into account in locating the 16 research units of the Agriculture Experiment Station.

Five of these stations were selected for this study because they represented five major ecological regimes of the state in regard to soils and climate.

Springfield (Highland Rim)

The Springfield station represents the counties of the Highland Rim--that part of Middle Tennessee which surrounds the Central Basin and extends from the Tennessee River to the foot of the Cumberlands.

The climate of the Highland Rim is one of mild winters, warm summers, and abundant rainfall. The mean annual temperature is 59°F., but considerable temperature changes are frequent. Average maximum daily temperatures vary from about 50°F. in January to about 90°F. in July. Average minimum daily temperatures range from about 31°F. in January to about 67°F. in July. Over a 26-year period, temperatures at Springfield ranged between 106°F. and -18°F.

The growing season at Springfield averages 206 days. The mean dates of the last spring and first fall occurrence of 32°F. are April 7 and October 30, respectively.

Average annual precipitation varies from about 48 inches in the northern Rim in Tennessee to 54 inches in the southern Rim. From

April through September rainfall averages about 21 inches in the north and 24 inches in the south.

Compared with the remainder of Tennessee, temperatures on the Highland Rim are warmer than on the Cumberland Plateau and eastern mountains, colder than in the southwest and about the same as in the valley of East Tennessee. Rainfall is about the same as in West Tennessee and the southern half of the valley of East Tennessee. It is about 8 inches annually more than in the northern half of the valley of East Tennessee, slightly more than in the Central Basin, about 8 inches less than on the Cumberland Plateau. The Highland Rim also has less snow and longer growing season than the higher elevations.

Spring Hill (Central Basin)

The Middle Tennessee Experiment Station is in Maury County, 8 miles north of Columbia, Tennessee. The station serves the "Central Basin," which includes all or part of 15 counties. The Central Basin is surrounded by the Highland Rim, which lies at a higher elevation.

The climate of the Basin is described as humid, temperate, and continental with a mean temperature of 59°F., a 48 inch average rainfall, and a 209 day frost free season. The growing season extends from the first week in April to the third week of October. Temperatures average about 40° in January and 78° in July. Over a 40-year period, maximum and minimum temperatures were 108° and 14° below zero.

Jackson (West Tennessee)

The 21 counties west of the Tennessee River are usually considered to form the region of the state known as West Tennessee.

The climate of West Tennessee is humid, temperate, and continental. Because of relatively little difference in elevation, there are only minor differences in climate across West Tennessee. Over a 39-year period at Jackson, rainfall has averaged about 49 inches and the frost-free season about 202 days. The average date for the last killing frost in the spring is April 6, and for the first killing frost in the fall October 25. Temperatures average 41°F. in January and 80° in July. Maximum and minimum temperatures recorded were 110° and -21°. Extremes in length of growing season have been 164 and 233 days. Average length of growing season across West Tennessee ranges from 200 days in the northeast part of the area to 230 days near Memphis. In spite of the relatively high total rainfall, periods of drouth are frequent because of irregular distribution of rainfall.

Crossville (Cumberland Plateau)

Climatic conditions on the Plateau vary from those of either the east or the west adjoining areas which are at elevations of 1,000 or more feet lower than the Plateau. The average growing season on the Plateau will range from about 170 to 200 days. Spring frosts generally end in late April and come again after mid October, but striking exceptions occur some years.

An average annual rainfall of 55 inches on the Plateau is five inches more than the average for the state as a whole. Over a 31-year period at Crossville, the rainfall varied from 41 to 70 inches. Perhaps more important is the summer distribution of this precipitation. It may be rated "excellent" for agriculture with an average of 4.0 to 4.6 inches per month from April through August.

Elevation contributes to favorable summer temperatures. During some summers, maximum temperatures seldom exceed the middle 90's. Temperatures are several degrees higher in nearby areas of lower elevation.

Knoxville (Valley of East Tennessee)

Knoxville, situated on the Tennessee River, has an elevation of about 1,000 feet, an average rainfall of about 46 inches and a growing season of about 200 days. Average annual temperature is 60°; average July temperature, 79°; and average January temperature, 41°. The highest and lowest temperatures recorded are 102° and -15°.

II. RECORDS TAKEN FOR EACH SPECIES

Data for the summer records were collected in October 1967 and the winter records in March 1968. Other plant performance records were taken when response was anticipated.

Taxus media browni

Data were collected on the increase in plant height, increase in width, length of the longest shoots, and winter color.

As all plants were sheared at equal height before growth started, the plant height was considered as the length of the new growth above the sheared level. Increase in width was measured as the increase in diameter. Length of the longest shoots was recorded as the average of the three longest shoots above the sheared level. Plant color was rated from zero to three with zero as dead foliage, two as dull or off color foliage, and three as a dark green plant.

Mahonia pinnata

Records taken for Mahonia pinnata were increase in height, length of terminal leaflet, plant width, leaf length, and winter burn damage.

Increase in height was measured as the average of the length of the three tallest shoots above the 12 inch sheared level. Length of the terminal leaflet was the average of four terminal leaflets. Length of the leaf was the average of four mature terminal leaves. Plant width was measured as the greatest plant diameter. Winter burn damage was recorded in percentage of leaves that had burned on the leaflets.

Buxus sempervirens

For Buxus sempervirens data were collected on the growth of side branches, increase in height, length of the longest shoots, and winter color.

Growth of side branches was the combined total of three measurements on each of the sides. Increase in height was the length of most shoots above the sheared level. Length of the longest shoots was recorded as the average length of the three tallest shoots above the sheared level. Plant color was rated from one to four with one for a plant with dull brownish leaves and four for a plant with shiny dark green leaves.

CHAPTER IV

RESULTS AND DISCUSSION

I. MAHONIA PINNATA

Leaf Length

The effect of directional exposure upon the length of the Mahonia pinnata leaf with plants at different locations in the state against white or brown backgrounds is shown in Tables I and II.

Statewide the greatest leaf length was recorded on the north side of the brown structures (Table I). These leaves were longer than those on the east, west, and south side of brown structures and south and west side of white structures. Leaves on the north side of the white structures were significantly longer than those on the west side of white and south side of brown structures.

The leaf length was, regardless of the background color, greater at the north exposure than that at the south or west exposure.

Leaf length of Mahonia pinnata with white background at Crossville was greater than that of the plants at any of the other locations except for those against brown backgrounds in Jackson and Springfield (Table II). Leaf length of the plants with brown background at Crossville and Springfield was greater than that of those with brown background at Knoxville and those with white or brown background at Spring Hill. Plants at Jackson with brown backgrounds had greater leaf length than those at Spring Hill.

TABLE I

LENGTH OF MAHONIA PINNATA LEAVES AND TERMINAL LEAFLET AS INFLUENCED BY COLOR OF STRUCTURE AND DIRECTION OF EXPOSURE

	White Structures		Brown Structures		All Structures	
Direction	Length of Leaf	Length of Terminal Leaflet	Length of Leaf	Length of Terminal Leaflet	Length of Leaf	Length of Terminal Leaflet
North	4.45	2.10	4.60	1.93	4.53	2.01
East	4.28	2.03	4.10	1.83	4.19	1.93
South	4.08	1.80	3.75	1.70	3.91	1.75
West	3.83	1.68	4.10	1.83	3.96	1.75
Duncan at .05 =	.48	.44	.48	.44	.34	.31

TABLE II

LENGTH OF *MAHONIA PINNATA* LEAVES AND TERMINAL LEAFLET AS INFLUENCED BY COLOR OF STRUCTURE AT DIFFERENT LOCATIONS

Location	White Structures		Brown Structures		All Structures	
	Length of Leaf	Length of Terminal Leaflet	Length of Leaf	Length of Terminal Leaflet	Length of Leaf	Length of Terminal Leaflet
Knoxville	4.13	2.00	3.81	1.56	3.96	1.79
Spring Hill	3.75	1.78	3.66	1.69	3.70	1.73
Jackson	4.13	1.88	4.25	1.97	4.19	1.92
Springfield	4.06	1.81	4.44	1.81	4.25	1.81
Crossville	4.72	2.03	4.53	2.06	4.63	2.05
Duncan at .05 = .55		NS	.55	NS	.38	.35

Plants at Crossville had longer leaves than those at Jackson, Knoxville, and Spring Hill. Plants at Jackson had longer leaves than those at Spring Hill.

Length of Terminal Leaflets

The effect of directional exposure upon the length of the Mahonia pinnata terminal leaflet of plants at different locations in the state against white or brown backgrounds is shown in Tables I and II.

There was no significant difference in the length of the terminal leaflet of the Mahonia pinnata plants at different directional exposures (Table I).

According to the data in Table II the terminal leaflets at Crossville had a mean average length of 2.05 inches which was significantly greater than those at Spring Hill which had a mean length of 1.73 inches.

Additional information on the length of leaves and terminal leaflets of Mahonia pinnata may be found in Tables XXIX-XXXVI in the Appendix.

Plant Width

The effect of directional exposure upon width of the Mahonia pinnata plants at different locations in the state against white or brown backgrounds is shown in Tables III, IV, V, and VI.

TABLE III

MAXIMUM WIDTH OF MAHONIA PINNATA WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	19.0	18.5
East	17.2	18.3
South	17.5	18.6
West	16.5	19.8

19.8	19.0	18.6	18.5	18.3	17.5	17.2	16.5
a	b	c	d	e	f	g	h

Duncan at .05 = 4.5.

Members of groups underlined are not significantly different.

TABLE IV

MAXIMUM WIDTH OF MAHONIA PINNATA WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	18.8
East	17.8
South	18.1
West	18.2

18.8	18.2	18.1	17.8
a	b	c	d

Duncan at .05 = 1.00.

Members of groups underlined are not significantly different.

TABLE V

MAXIMUM WIDTH OF MAHONIA PINNATA WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	20.4	24.4
Spring Hill	19.0	18.1
Jackson	18.9	18.6
Springfield	14.8	16.8
Crossville	14.8	16.1

24.4	20.4	19.0	18.9	18.6	18.1	16.8	16.1	14.8	14.8
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 5.5.

Members of groups underlined are not significantly different.

TABLE VI

MAXIMUM WIDTH OF MAHONIA PINNATA WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	22.4
Spring Hill	18.6
Jackson	18.8
Springfield	15.8
Crossville	15.4

22.4	18.8	18.6	15.8	15.4
a	b	c	d	e

Duncan at .05 = 1.11.

Members of groups underlined are not significantly different.

Plants at Knoxville which had a brown background were significantly wider than the plants at Jackson, Spring Hill, Springfield, and Crossville with brown background (Table V). Plants at Knoxville with white background were greater in width than those at Spring Hill and Crossville with white background.

According to Table VI plants with the greatest maximum width were at Knoxville and had a mean average width of 22.4 inches. Plants at Jackson with a mean width of 18.8 inches were significantly wider than those at Springfield with 15.8 inches and plants at Crossville with a width of 15.4 inches. Plants at Spring Hill with a mean width of 18.6 inches were wider than those at Springfield and Crossville.

Increase in Height

The effect of directional exposure upon the increase in height of the Mahonia pinnata plants at different locations in the state against white or brown backgrounds is shown in Tables VII, VIII, IX, and X.

Statewide, the plants at the north exposure with brown background had a greater increase in height than those at the west exposure with white background (Table VII).

According to the data in Table VIII, the plants at the north exposure increase in height by 9.4 inches while those on the west exposure increased by 6.0 inches.

Plants at Knoxville with the brown background increased in height more than those at any of the other locations with the exception of

TABLE VII

INCREASE IN HEIGHT OF MAHONIA PINNATA WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	8.4	10.3
East	8.9	8.2
South	6.9	8.2
West	5.4	6.6

10.3	8.9	8.4	8.2	8.2	6.9	6.6	5.4
a	b	c	d	e	f	g	h

Duncan at .05 = 4.2.

Members of groups underlined are not significantly different.

TABLE VIII

INCREASE IN HEIGHT OF MAHONIA PINNATA WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	9.4
East	8.6
South	7.6
West	6.0

9.4	8.6	7.6	6.0
a	b	c	d

Duncan at .05 = 2.9.

Members of groups underlined are not significantly different.

TABLE IX

INCREASE IN HEIGHT OF MAHONIA PINNATA WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	12.6	15.1
Spring Hill	5.1	6.6
Jackson	5.9	7.5
Springfield	9.3	8.4
Crossville	4.1	4.0

15.1	12.6	9.3	8.4	7.5	6.6	5.9	5.1	4.1	4.0
--a-	b	c	d	e	f	g	h	i	j

Duncan at .05 = 4.8.

Members of groups underlined are not significantly different.

TABLE X

INCREASE IN HEIGHT OF MAHONIA PINNATA WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	13.9
Spring Hill	5.9
Jackson	6.6
Springfield	8.8
Crossville	4.1

13.9	8.8	6.6	5.9	4.1
a	b	c	d	e

Duncan at .05 = 3.3.

Members of groups underlined are not significantly different.

those at Knoxville with white background (Table IX). Those at Knoxville with white background had a greater increase in height than those with brown background at Jackson, Spring Hill and Crossville and those with white background at Spring Hill, Jackson, and Crossville. Mahonia pinnata plants at Springfield with white background increased in height more than those at Crossville with white or brown backgrounds.

As shown in Table X, the plants at Knoxville increased in height by 13.9 inches and were greater than those at Springfield with 8.8 inches, Jackson with 6.7 inches, Spring Hill with 5.9 inches, and Crossville with 4.1 inches.

Winter Damage

The effect of directional exposure upon the susceptibility of the Mahonia pinnata to winter burn with plants at different locations in the state against white or brown backgrounds is shown in Tables XI and XII.

Plants at the west exposure with white background had winter burn on 50-75 percent of their leaves, while those at the south, east, and north exposures with brown background had only 25-50 percent of their leaves burned (Table XI). Winter burn was also greater at the west exposure with brown background and the east exposure with white background than the leaves of the plants at the north exposure with brown background.

TABLE XI

WINTER DAMAGE ON MAHONIA PINNATA WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	2.7	2.1
East	3.2	2.4
South	2.9	2.4
West	3.5	3.2

3.5	3.2	3.2	2.9	2.7	2.4	2.4	2.1
a	b	c	d	e	f	g	h

Rating: 1 = 0-25%, 2 = 25-50%, 3 = 50-75%, and 4 = 75-100%.

Duncan at .05 = 1.09.

Members of groups underlined are not significantly different.

TABLE XII

WINTER DAMAGE ON MAHONIA PINNATA WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	2.40
East	2.80
South	2.65
West	3.35

3.35	2.80	2.65	2.40
a	b	c	d

Rating: 1 = 0-25%, 2 = 25-50%, 3 = 50-75%, and 4 = 75-100%.

Duncan at .05 = .77.

Members of groups underlined are not significantly different.

According to Table XII, the north exposure had less winter burn than the west exposure. The plants at the north exposure had burn on 25-50 percent of the leaves while 50-75 percent of the leaves were burned at the west exposure.

II. TAXUS MEDIA BROWNI

Increase in Height

The effect of directional exposure upon the increase in height of Taxus media browni with plants at different locations in the state against white or brown backgrounds is shown in Tables XIII and XIV.

Plants at the north exposure with white background had a greater increase in height than the plants at the east exposure with white and brown backgrounds and those at the south exposure with brown background (Table XIII). Increase in height was greater at the west exposure with white background than it was at the east exposure with white background and the south exposure with brown background. Plants at the south exposure with white background also had a greater increase in height than those with the brown background.

As shown in Table XIII, the Taxus media browni plants at the north exposure had a greater increase in height than those at the east exposure.

Plants at Knoxville which had a white background had a greater increase in height than the plants at all other locations with the exception of those at Jackson with white background and those at

TABLE XIII

INCREASE IN WIDTH AND HEIGHT OF TAXUS MEDIA BROWNI AS INFLUENCED BY COLOR OF STRUCTURE AND DIRECTION OF EXPOSURE

	White Structures		Brown Structures		All Structures	
Direction	Increase in Width	Increase in Height	Increase in Width	Increase in Height	Increase in Width	Increase in Height
North	4.70	2.63	4.15	2.25	4.43	2.44
East	4.10	1.83	3.85	1.85	3.98	1.84
South	3.75	2.48	3.30	1.53	3.53	2.00
West	3.60	2.58	4.20	2.00	3.90	2.29
Duncan at .05 =	1.05	.74	1.05	.74	.73	.52

TABLE XIV

INCREASE IN WIDTH AND HEIGHT OF *TAXUS MEDIA BROWNI* AS INFLUENCED BY COLOR OF STRUCTURE AT DIFFERENT LOCATIONS

Location	White Structures		Brown Structures		All Structures	
	Increase in Width	Increase in Height	Increase in Width	Increase in Height	Increase in Width	Increase in Height
Knoxville	3.91	3.03	4.16	2.09	4.03	2.56
Spring Hill	4.13	1.84	4.00	1.69	4.06	1.77
Jackson	4.28	2.88	3.66	2.13	3.96	2.50
Springfield	3.66	2.28	4.00	2.25	3.82	2.27
Crossville	4.22	1.84	3.56	1.38	3.89	1.61
Duncan at .05 =	NS	.85	NS	.85	NS	.58

Springfield with white and brown backgrounds (Table XIV). The plants at Springfield with white background had a greater increase in height than those plants at Spring Hill and Crossville with white and brown backgrounds. Plants at Springfield with brown background increased in height more than those at Crossville with brown background.

Taxus media browni plants at Knoxville and Jackson increased more in height than the plants at Spring Hill and Crossville. Plants at Springfield increased more in height than those at Crossville.

Increase in Width

The effect of directional exposure upon the increase in width of the Taxus media browni with plants at different locations in the state against white or brown backgrounds is shown in Tables XIII and XIV.

As shown in Table XIII, the plants at the north exposure with white background had an increase in width of 4.7 inches and were greater than those at the west exposure with white background with an increase in width of 3.6 inches and those at the south exposure with brown background with an increase of 3.3 inches.

The plants at the north exposure had an increase in width of 4.4 inches and were greater than those at the south exposure which had an increase in width of 3.3 inches.

Across the state there was no significant difference between locations in regard to an increase in width of the Taxus media browni plants (Table XIV).

Additional information in the increase in width and height of Taxus media browni may be found in Tables XXXVIII-XLIII in the Appendix.

Length of the Longest Shoots

The effect of directional exposure upon the length of the longest shoots of Taxus media browni with plants at different locations in the state against white or brown backgrounds is shown in Tables XV, XVI, XVII, and XVIII.

According to Table XV, the shoot length of the Taxus media browni was longer on the east and north exposures with brown background than it was on the south exposure with brown background. With brown background the shoot length measured 4.3 inches on the east and north exposures while the south exposure measured 2.7 inches.

As shown in Table XVI, the shoot length was, regardless of background color, greater at the north exposure than it was at the south exposure.

The length of the longest shoots of the Taxus media browni plants at Jackson was 5.1 inches (Table XVII). This was greater than the plants at Spring Hill with brown background and a shoot length of 3.3 inches. It was also greater than those at Crossville with white background and a shoot length of 2.8 inches.

There was no significant difference in the length of the longest shoots of the Taxus media browni plants at different locations in the state (Table XVIII).

TABLE XV

LENGTH OF LONGEST SHOOTS OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	4.13	4.25
East	3.30	4.33
South	3.43	2.73
West	3.83	3.95

4.33	4.25	4.13	3.95	3.83	3.43	3.30	2.73
a	b	c	d	e	f	g	h

Duncan at .05 = 1.50.

Members of groups underlined are not significantly different.

TABLE XVI

LENGTH OF LONGEST SHOOTS OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	4.19
East	3.81
South	3.08
West	3.89

4.19	3.89	3.81	3.08
a	b	c	d

Duncan at .05 = 1.04.

Members of groups underlined are not significantly different.

TABLE XVII

LENGTH OF LONGEST SHOOTS OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	3.38	3.50
Spring Hill	3.41	3.25
Jackson	5.06	3.88
Springfield	3.66	3.78
Crossville	2.84	4.66

5.06	4.66	3.88	3.78	3.66	3.50	3.41	3.38	3.25	2.84
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 1.71.

Members of groups underlined are not significantly different.

TABLE XVIII

LENGTH OF LONGEST SHOOTS OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	3.44
Spring Hill	3.33
Jackson	4.47
Springfield	3.72
Crossville	3.75

4.47	3.75	3.72	3.44	3.33
a	b	c	d	e

Duncan at .05 = 1.18.

Members of groups underlined are not significantly different.

Winter Color

The effect of directional exposure upon the winter color of Taxus media browni with plants at different locations in the state against white or brown backgrounds is shown in Tables XIX and XX.

According to Table XIX, the plants at the north exposure with brown background had a darker green color than those at the east and south exposures with white and brown background and those at the west exposure with a white background. Plants at the north exposure with white background and those at the east and west exposure with brown background had a darker green color than those at the south exposure with white and brown backgrounds.

As shown in Table XX, the plant color was, regardless of background color, darker at the north exposure than it was at the east, west, or south exposure. The plants at the east and west exposure were darker green than those at the south exposure.

III. BUXUS SEMPERVIRENS

Increase in Height

The effect of directional exposure upon the increase in height of Buxus sempervirens with the plants at different locations in the state against white or brown backgrounds is shown in Tables XXI and XXII.

There was no significant difference in the increase in height of Buxus sempervirens with plants at different directional exposures (Table XXI).

TABLE XIX

WINTER COLOR OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	2.6	3.7
East	2.0	2.3
South	0.9	0.7
West	1.6	2.5

3.7	2.6	2.5	2.3	2.0	1.6	0.9	0.7
a	b	c	d	e	f	g	h

Duncan at .05 = 1.34.

Members of groups underlined are not significantly different.

TABLE XX

WINTER COLOR OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	3.2
East	2.2
South	0.8
West	2.1

3.2	2.2	2.1	0.8
a	b	c	d

Rating: 0 = Dead, 1 = Brown, 2 = Light Green, 3 = Med. Green, and 4 = Dark Green.

Duncan at .05 = .93.

Members of groups underlined are not significantly different.

TABLE XXI

INCREASE IN WIDTH AND HEIGHT OF BUXUS SEMPERVIRENS AS INFLUENCED BY COLOR OF STRUCTURE AND DIRECTION OF EXPOSURE

	White Structures		Brown Structures		All Structures	
Direction	Increase in Width	Increase in Height	Increase in Width	Increase in Height	Increase in Width	Increase in Height
North	2.73	1.73	2.60	1.50	2.67	1.61
East	2.35	2.20	2.50	1.68	2.43	1.94
South	1.98	1.70	2.08	1.40	2.03	1.55
West	2.15	1.98	2.23	1.40	2.19	1.69
Duncan at .05 =	NS	NS	NS	NS	NS	NS

TABLE XXII

INCREASE IN WIDTH AND HEIGHT OF *BUXUS SEMPERVIRENS* AS INFLUENCED BY COLOR OF STRUCTURE AT DIFFERENT LOCATIONS

Location	White Structures		Brown Structures		All Structures	
	Increase in Width	Increase in Height	Increase in Width	Increase in Height	Increase in Width	Increase in Height
Knoxville	2.22	3.56	2.13	2.13	2.18	2.84
Spring Hill	2.03	1.25	2.34	1.16	2.19	1.20
Jackson	2.38	1.78	2.31	1.44	2.35	1.61
Springfield	2.47	1.41	2.63	1.34	2.55	1.38
Crossville	2.41	1.50	2.34	1.41	2.37	1.45
Duncan at .05 =	NS	.93	NS	.93	NS	.64

Statewide, the greatest increase in height was recorded at Knoxville with white background (Table XXII). Plants at Knoxville with brown background had a greater increase in height than those at Spring Hill with brown background.

Buxus sempervirens plants at Knoxville increased in height more than did the plants at any of the other locations.

Growth of Side Branches

The effect of directional exposure upon the growth of side branches of Buxus sempervirens with the plants at different locations in the state against white or brown backgrounds is shown in Tables XXI and XXII.

There was no significant difference in the growth of the side branches of Buxus sempervirens with the plants at different directional exposures against white or brown backgrounds (Table XXI).

As shown in Table XXII, there was no significant difference in the growth of side branches of Buxus sempervirens with plants at different locations in the state with either white or brown structures.

Additional information on the increase in height and growth of side branches of Buxus sempervirens may be found in Tables XLIV-XLVIII in the Appendix.

Length of Longest Shoots

The effect of directional exposure upon the length of the longest shoots of Buxus sempervirens with plants at different locations in the

state against white or brown backgrounds is shown in Tables XXIII and XXIV.

According to Table XXIII, there was no significant difference in the length of the longest shoots of Buxus sempervirens with plants at different directional exposures.

The length of the longest shoots was greater at Knoxville with both white and brown backgrounds than it was at any of the other locations in the state (Table XXIV).

Winter Color

The effect of directional exposure upon the color of Buxus sempervirens with plants at different locations in the state against white or brown backgrounds is shown in Tables XXV and XXVI.

Plants at the north exposures with white and brown backgrounds had a darker green color than did those at the west and south exposures with white and brown backgrounds (Table XXV). Buxus sempervirens at the east exposure with white and brown backgrounds were darker green than those at the south exposure with white background.

According to Table XXVI, the plants at the north exposure were darker green than those at the west and south exposure. Plants at the east exposure were darker green than those at the south exposure.

TABLE XXIII

LENGTH OF THE LONGEST TERMINAL SHOOTS OF BUXUS SEMPERIVERNS WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	2.68	2.10
East	2.43	3.00
South	2.53	2.30
West	2.65	2.78

3.00	2.78	2.68	2.65	2.53	2.43	2.30	2.10
a	b	c	d	e	f	g	h

Duncan at .05 = 1.25.

Members of groups underlined are not significantly different.

TABLE XXIV

LENGTH OF THE LONGEST TERMINAL SHOOTS OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	4.56	3.88
Spring Hill	1.81	2.38
Jackson	1.84	2.19
Springfield	2.25	2.16
Crossville	2.38	2.13

4.56	3.88	2.38	2.38	2.25	2.19	2.16	2.13	1.84	1.81
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 1.43.

Members of groups underlined are not significantly different.

TABLE XXV

WINTER COLOR OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	4.0	3.8
East	3.2	3.3
South	1.9	2.4
West	2.7	2.8

4.0	3.8	3.3	3.2	2.8	2.7	2.4	1.9
a	b	c	d	e	f	g	h

Duncan at .05 = .99.

Members of groups underlined are not significantly different.

TABLE XXVI

WINTER COLOR OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Direction	White and Brown Structures
North	3.9
East	3.3
South	2.2
West	2.8

3.9	3.3	2.8	2.2
a	b	c	d

Duncan at .05 = .63.

Members of groups underlined are not significantly different.

IV. TEMPERATURE RECORDS

Yearly Mean of the Weekly Maximums

The effect of directional exposure upon the maximum weekly temperatures from April 1, 1967 to April 1, 1968 when thermometers were placed at different locations in the state in white or brown structures is shown in Tables XXVII and XXVIII.

For a one year period from April 1, 1967 to April 1, 1968 the yearly mean of the weekly maximum temperatures was greater at the west and south exposures with white background than at any of the other exposures with white or brown backgrounds (Table XXVII). The east exposure of the white structures had a greater yearly mean of the weekly maximum temperatures than all the other exposures with white or brown backgrounds with the exception of the south and west exposures with white backgrounds. The south exposure with brown background had a greater yearly mean of the weekly maximum temperatures than the north and east exposures with brown background and the north exposure with white background. The west and east exposure with brown background had a greater yearly mean of the weekly maximum temperatures than did the north exposure with white or brown backgrounds.

Regardless of color, the south and west exposures had a greater yearly mean of the weekly maximum temperatures than did the east and north exposures (Table XXVII). The average maximum temperature was 14.1° higher at the south exposure than at the north exposure.

TABLE XXVII

THE YEARLY, SUMMER, AND WINTER MEAN OF THE WEEKLY MAXIMUM TEMPERATURES AS INFLUENCED BY COLOR OF STRUCTURE AND DIRECTION OF EXPOSURE

	White Structure			Brown Structure			All Structure		
Direction	Yearly Mean	Summer Mean	Winter Mean	Yearly Mean	Summer Mean	Winter Mean	Yearly Mean	Summer Mean	Winter Mean
North	79.5	91.3	14.0	79.0	90.7	14.4	79.3	91.0	14.2
East	95.0	107.9	15.0	88.3	100.6	14.4	91.7	104.2	14.7
South	97.6	107.9	15.2	92.1	102.3	15.5	94.9	105.1	15.4
West	98.1	109.3	14.5	90.1	100.4	14.6	94.1	104.9	14.6
Duncan at .05 =	3.1	2.5	NS	3.1	2.5	NS	2.1	1.8	NS

TABLE XXVIII

THE YEARLY, SUMMER, AND WINTER MEAN OF THE WEEKLY MAXIMUM TEMPERATURES AS INFLUENCED BY COLOR OF STRUCTURE AT DIFFERENT LOCATIONS

Location	White Structures			Brown Structures			All Structures		
	Yearly Mean	Summer Mean	Winter Mean	Yearly Mean	Summer Mean	Winter Mean	Yearly Mean	Summer Mean	Winter Mean
Knoxville	90.6	100.1	15.7	84.5	96.6	17.0	87.5	98.3	16.3
Spring Hill	98.9	112.1	16.3	89.8	104.3	14.6	94.5	108.2	15.5
Jackson	91.0	103.8	16.9	90.3	98.6	15.8	90.7	101.2	16.4
Springfield	93.0	102.7	12.1	87.3	97.7	12.4	90.2	100.2	12.3
Crossville	89.4	101.9	12.5	84.7	95.3	13.8	87.0	98.6	13.1
Duncan at .05 =	3.2	2.8	3.1	3.2	2.8	3.1	2.3	2.0	2.2

The white structures at Spring Hill had a greater yearly mean of the weekly maximum temperatures than any of the other locations in the state (Table XXVIII). The white structures at Springfield had a greater yearly mean of the weekly maximum temperatures than the white structures at Crossville and the brown structures at Springfield, Crossville, and Knoxville. The yearly mean of the weekly maximum temperatures at the white structures at Jackson and Knoxville were greater than those at the brown structures at Knoxville, Springfield, and Crossville. The temperature was greater at Jackson and Spring Hill with the brown structures and Crossville with the white structures than it was at the brown structures at Crossville and Knoxville.

The yearly mean of the weekly maximum temperatures was greater at Spring Hill than it was at any of the other locations in the state. Jackson and Springfield had higher temperatures than did Knoxville and Crossville.

Summer Mean of the Weekly Maximums

The effect of directional exposure upon the maximum weekly temperatures from June 21, 1967 to September 22, 1967 when thermometers were placed at different locations in the state in white or brown structures is shown in Tables XXVII and XXVIII.

During the summer season from June 21, 1967 to September 22, 1967 the summer mean of the weekly maximum temperatures was greater at the west, south, and east exposures of the white structures than it was at the north exposure of the white structures and the north,

east, south, and west exposure of the brown structure (Table XXVII). The west exposure of the white structure was 18.6° higher than the north exposure of the brown structure. The south, east, and west exposures at the brown structures had a higher summer mean of the weekly maximum temperatures than did the north exposure at either the white or brown structure.

The summer mean of the weekly maximum temperatures was, regardless of color, greater at the south, west, and east exposures than it was at the north exposure.

The white structures at Spring Hill had a greater summer mean of the weekly maximum temperatures than did the white and brown structures at any of the other locations (Table XXVIII). The brown structures at Spring Hill and the white structures at Jackson had a higher summer mean of the weekly maximum temperatures than did all the other locations with the exception of the white structures at Spring Hill. The white structures at Springfield and Crossville had higher temperatures than did the white structures at Knoxville and the brown structures at Jackson, Knoxville, Springfield, and Crossville. Brown structures at Knoxville and Crossville had cooler temperatures than did the white structures at Knoxville. The brown structures at Jackson had a higher summer mean temperature than did the brown structures at Crossville.

The summer mean of the weekly maximum temperature was greatest at Spring Hill. At Spring Hill the temperature was 7.0° higher than Jackson, 8.0° higher than Springfield, 9.6° higher than Crossville,

and 10.1° higher than Knoxville. Jackson had higher temperatures than did Knoxville.

Winter Mean of the Weekly Minimums

The effect of directional exposure upon the minimum weekly temperatures from December 26, 1967 to March 25, 1968 when thermometers were placed at different locations in the state in white or brown structures is shown in Tables XXVII and XXVIII, pages 64 and 65.

During the winter season from December 26, 1967 to March 25, 1968 there was no significant difference in the winter mean of the weekly minimum temperatures at the different directional exposures (Table XXVII, page 64).

The brown structures at Knoxville had a winter mean of the weekly minimum temperatures higher than did the white and brown structures at Crossville and Springfield (Table XXVIII, page 65). The white structures at Knoxville and Spring Hill and the white and brown structures at Jackson had higher weekly minimum temperatures than did the white structures at Crossville and the white and brown structures at Springfield.

The winter mean of the weekly minimum temperatures was higher at Jackson, Knoxville, and Spring Hill than it was at Crossville and Springfield.

Additional information on the yearly, summer, and winter mean of the weekly maximum and minimum temperatures may be found in Tables XLIX-LIX in the Appendix.

CHAPTER V

SUMMARY

The response of three species of woody ornamental plants to directional exposure and high and low background reflection in five distinct climatic regimes in Tennessee was studied during 1967 and 1968 on The University of Tennessee Agricultural Experiment Stations at Knoxville, Crossville, Spring Hill, Springfield, and Jackson.

The objectives of this investigation were to determine how Mahonia pinnata, Buxus sempervirens, and Taxus media browni would respond when placed at different directional exposures against white or brown backgrounds at different locations in the state.

The study showed the Mahonia pinnata plants at the north exposure had longer leaves than those at the south and west exposure and were taller and had less winter burn than those at the west exposure. Plants at Crossville had longer leaves than did the plants at Jackson, Knoxville, and Spring Hill. Plants at Crossville also had longer terminal leaflets than did the plants at Spring Hill. The Mahonia pinnata plants at Knoxville had a greater increase in height and a greater maximum width than did the plants at any of the other locations.

Taxus media browni plants at the north exposure had a greater increase in height than those at the east exposure and had longer shoots and a greater increase in width than did the plants at the

south exposure. Plants at the north exposure also had a darker green color than did the plants at the east, south, and west exposure.

Buxus sempervirens plants at Knoxville increase in height and had longer shoots than did the plants at any of the other locations. The plants at the north exposure were darker green than those at the west and south exposure.

The south and west exposures had a greater yearly mean of the weekly maximum temperatures than did the east and north exposures. The south, west, and east exposures had a greater summer mean of the weekly maximum temperatures than did the north exposure. Spring Hill had the highest yearly and summer mean of the weekly maximum temperatures. The winter mean of the weekly minimum temperatures was higher at Jackson, Knoxville, and Spring Hill than at Crossville and Springfield.

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APPENDIX

TABLE XXIX

LENGTH OF MAHONIA PINNATA LEAF WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	4.45	4.60
East	4.28	4.10
South	4.08	3.75
West	3.83	4.10

4.60	4.45	4.28	4.10	4.10	4.08	3.83	3.75
a	b	c	d	e	f	g	h

Duncan at .05 = .48.

Members of groups underlined are not significantly different.

TABLE XXX

LENGTH OF MAHONIA PINNATA LEAF WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	4.53
East	4.19
South	3.91
West	3.96

4.53	4.19	3.96	3.91
a	b	c	d

Duncan at .05 = .34.

Members of groups underlined are not significantly different.

TABLE XXI

LENGTH OF MAHONIA PINNATA LEAF WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	4.13	3.81
Spring Hill	3.75	3.66
Jackson	4.13	4.25
Springfield	4.06	4.44
Crossville	4.72	4.53

4.72	4.53	4.44	4.25	4.13	4.13	4.06	3.81	3.75	3.66
a	b	c	d	e	f	g	h	i	j

Duncan at .50 = .55.

Members of groups underlined are not significantly different.

TABLE XXXII

LENGTH OF MAHONIA PINNATA LEAF WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	3.96
Spring Hill	3.70
Jackson	4.19
Springfield	4.25
Crossville	4.63

4.63	4225	4.19	3.96	3.70
a	b	c	d	e

Duncan at .05 = .38.

Members of groups underlined are not significantly different.

TABLE XXIII

LENGTH OF MAHONIA PINNATA TERMINAL LEAFLET WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	2.10	1.93
East	2.03	1.83
South	1.80	1.70
West	1.68	1.83

2.10	2.03	1.93	1.83	1.83	1.80	1.70	1.68
a	b	c	d	e	f	g	h

Duncan at .05 = .44.

Members of groups underlined are not significantly different.

TABLE XXXIV

LENGTH OF MAHONIA PINNATA TERMINAL LEAFLET WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	2.01
East	1.93
South	1.75
West	1.75

2.01	1.93	1.75	1.75
a	b	c	d

Duncan at .05 = .31.

Members of groups underlined are not significantly different.

TABLE XXXV

LENGTH OF MAHONIA PINNATA TERMINAL LEAFLET WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	2.00	1.56
Spring Hill	1.78	1.69
Jackson	1.88	1.97
Springfield	1.81	1.81
Crossville	2.03	2.06

2.06	2.03	2.00	1.97	1.88	1.81	1.81	1.78	1.69	1.56
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = .51.

Members of groups underlined are not significantly different.

TABLE XXXVI

LENGTH OF MAHONIA PINNATA TERMINAL LEAFLET WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	1.79
Spring Hill	1.73
Jackson	1.92
Springfield	1.84
Crossville	2.05

2.05	1.97	1.92	1.84	1.73
a	b	c	d	e

Duncan at .05 = .35.

Members of groups underlined are not significantly different.

TABLE XXXVII

INCREASE IN HEIGHT OF *TAXUS MEDIA BROWNI* WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	2.63	2.25
East	1.83	1.85
South	2.48	1.53
West	2.58	2.00

2.63	2.58	2.48	2.25	2.00	1.85	1.83	1.53
a	b	c	d	e	f	g	h

Duncan at .05 = .74.

Members of groups underlined are not significantly different.

TABLE XXXVIII

INCREASE IN HEIGHT OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	2.44
East	1.84
South	2.00
West	2.29

2.44	2.29	2.00	1.84
a	b	c	d

Duncan at .05 = .52.

Members of groups underlined are not significantly different.

TABLE XXXIX

INCREASE IN HEIGHT OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	3.03	2.09
Spring Hill	1.84	1.69
Jackson	2.88	2.13
Springfield	2.28	2.25
Crossville	1.84	1.38

3.03	2.88	2.88	2.25	2.13	2.09	1.84	1.84	1.69	1.38
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = .85.

Members of groups underlined are not significantly different.

TABLE XL

INCREASE IN HEIGHT OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	2.56
Spring Hill	1.77
Jackson	2.50
Springfield	2.27
Crossville	1.61

2.56	2.50	2.27	1177	1.61
a	b	c	d	e

Duncan at .05 = .58.

Members of groups underlined are not significantly different.

TABLE XLI

INCREASE IN WIDTH OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	4.70	4.15
East	4.10	3.85
South	3.75	3.30
West	3.60	4.20

4.70	4.20	4.15	4.10	3.85	3.75	3.60	3.30
a	b	c	d	e	f	g	h

Duncan at .05 = 1.05.

Members of groups underlined are not significantly different.

TABLE XLII

INCREASE IN WIDTH OF *TAXUS MEDIA BROWNI* WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	4.43
East	3.98
South	3.53
West	3.90

Duncan at .05 = .73.

Members of groups underlined are not significantly different.

TABLE XLIII

INCREASE IN WIDTH OF TAXUS MEDIA BROWNI WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	3.91	4.16
Spring Hill	4.13	4.00
Jackson	4.28	3.66
Springfield	3.66	4.00
Crossville	4.22	3.56

4.28	4.22	4.16	4.13	4.00	4.00	3.91	3.66	3.66	3.56
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 1.20.

Members of groups underlined are not significantly different.

TABLE XLIV

INCREASE IN HEIGHT OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES TN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	1.73	1.50
East	2.20	1.68
South	1.70	1.40
West	1.98	1.40

2.20	1.98	1.73	1.70	1.68	1.50	1.40	1.40
a	b	c	d	e	f	g	h

Duncan at .05 = .81.

Members of groups underlined are not significantly different.

TABLE XLV

INCREASE IN HEIGHT OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	3.56	2.13
Spring Hill	1.25	1.16
Jackson	1.78	1.44
Springfield	1.41	1.34
Crossville	1.50	1.41

3.56	2.13	1.78	1.50	1.44	1.41	1.41	1.34	1.25	1.16
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = .93.

Members of groups underlined are not significantly different.

TABLE XLVI

INCREASE IN HEIGHT OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	2.84
Spring Hill	1.20
Jackson	1.61
Springfield	1.38
Crossville	1.45

2.84	1.61	1.45	1.38	1.20
a	b	c	d	e

Duncan at .05 = .64.

Members of groups underlined are not significantly different.

TABLE XLVII

INCREASE IN WIDTH OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	2.73	2.60
East	2.35	2.50
South	1.98	2.08
West	2.15	2.23

2.73	2.60	2.50	2.35	2.23	2.15	2.08	1.98
a	b	c	d	e	f	g	h

Duncan at .05 = .88.

Members of groups underlined are not significantly different.

TABLE XLVIII

INCREASE IN WIDTH OF BUXUS SEMPERVIRENS WHEN PLANTS WERE SET IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location-	White Structure	Brown Structure
Knoxville	2.22	2.13
Spring Hill	2.03	2.34
Jackson	2.38	2.31
Springfield	2.47	2.63
Crossville	2.41	2.34

2.63	2.47	2.41	2.38	2.34	2.34	2.31	2.22	2.13	2.03
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 1.00.

Members of groups underlined are not significantly different.

TABLE XLIX

MEAN ON THE WEEKLY MAXIMUM TEMPERATURES FROM APRIL 1, 1967 TO APRIL 1, 1968 AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	79.5	79.0
East	95.0	88.3
South	97.6	92.1
West	98.1	90.1

98.1	97.6	95.0	92.1	90.1	88.3	79.5	79.0
a	b	c	d	e	f	g	h

Duncan at .05 = 3.1.

Members of groups underlined are not significantly different.

TABLE L

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM APRIL 1, 1967 TO APRIL 1, 1968 AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	79.3
East	91.7
South	94.9
West	94.1

94.9	94.1	91.7	79.3
a	b	c	d

Duncan at .05 = 2.1.

Members of groups underlined are not significantly different.

TABLE LI

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM APRIL 1, 1967 TO APRIL 1, 1968 IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	90.6	84.5
Spring Hill	98.9	89.8
Jackson	91.0	90.3
Springfield	93.0	87.3
Crossville	89.4	84.7

98.9	93.0	91.0	90.6	90.3	89.8	89.4	87.3	84.7	84.5
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 3.2.

Members of groups underlined are not significantly different.

TABLE LII

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM APRIL 1, 1967 TO APRIL 1, 1968 IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	87.5
Spring Hill	94.5
Jackson	90.7
Springfield	90.2
Crossville	87.0

94.5	90.7	90.2	87.5	87.0
a	b	c	d	e

Duncan at .05 = 2.3.

Members of groups underlined are not significantly different.

TABLE LIII

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM JUNE 21, 1967 TO SEPTEMBER 22, 1967 AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE OR BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	91.3	90.7
East	107.9	100.6
South	107.9	102.3
West	109.3	100.4

109.3	107.9	107.9	102.3	100.6	100.4	91.3	90.7
a	b	c	d	e	f	g	h

Duncan at .05 = 2.5.

Members of groups underlined are not significantly different.

TABLE LIV

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM JUNE 21, 1967 TO SEPTEMBER 22, 1967 AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White and Brown Structures
North	91.0
East	104.2
South	105.1
West	104.9

105.1	104.9	104.2	91.0
a	b	c	d

Duncan at .05 = 1.8.

Members of groups underlined are not significantly different.

TABLE LV

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM JUNE 21, 1967 TO SEPTEMBER 22, 1967 IN WHITE OR BROWN STRUCTURE AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	100.1	96.6
Spring Hill	112.1	104.3
Jackson	103.8	98.6
Springfield	102.7	97.7
Crossville	101.9	95.3

112.1	104.3	103.8	102.7	101.9	100.1	98.6	97.7	96.6	95.3
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 2.8.

Members of groups underlined are not significantly different.

TABLE LVI

MEAN OF THE WEEKLY MAXIMUM TEMPERATURES FROM JUNE 21, 1967 TO SEPTEMBER 22, 1967 IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	98.3
Spring Hill	108.2
Jackson	101.2
Springfield	100.2
Crossville	98.6

108.2	101.2	100.2	98.6	98.3
a	b	c	d	e

Duncan at .05 = 2.0.

Members of groups underlined are not significantly different.

TABLE LVII

MEAN OF THE WEEKLY MINIMUM TEMPERATURES FROM DECEMBER 26, 1967 TO MARCH 22, 1968 AT DIFFERENT DIRECTIONAL EXPOSURES IN WHITE AND BROWN STRUCTURES

Direction	White Structure	Brown Structure
North	14.0	14.4
East	15.0	14.4
South	15.2	15.5
West	14.5	14.6

15.5	15.2	15.0	14.6	14.5	14.4	14.4	14.0
a	b	c	d	e	f	g	h

Duncan at .05 = 2.6.

Members of groups underlined are not significantly different.

TABLE LVIII

MEAN OF THE WEEKLY MINIMUM TEMPERATURES FROM DECEMBER 26, 1967 TO MARCH 22, 1967 IN WHITE OR BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White Structure	Brown Structure
Knoxville	15.7	17.0
Spring Hill	16.3	14.6
Jackson	16.9	15.8
Springfield	12.1	12.4
Crossville	12.5	13.8

17.0	16.0	16.3	15.8	15.7	14.6	13.8	12.5	12.4	12.1
a	b	c	d	e	f	g	h	i	j

Duncan at .05 = 3.1.

Members of groups underlined are not significantly different.

TABLE LIX

MEAN OF THE WEEKLY MINIMUM TEMPERATURES FROM DECEMBER 26, 1967 TO MARCH 22, 1968 IN WHITE AND BROWN STRUCTURES AT DIFFERENT LOCATIONS IN THE STATE

Location	White and Brown Structures
Knoxville	16.3
Spring Hill	15.5
Jackson	16.4
Springfield	12.3
Crossville	13.1

16.4	16.3	15.5	13.1	12.3
a	b	c	d	e

Duncan at .05 = 2.2.

Members of groups underlined are not significantly different.

VITA

The author was born in Putnam County, Tennessee on December 21, 1943. His parents were Willard and Agnes Johnson who live at Baxter, Tennessee. His father has operated a wholesale nursery at Baxter since 1945. The author attended Upperman High School in Baxter and graduated in 1961. He received a Bachelor of Science degree in Business Management at Tennessee Polytechnic Institute in June 1965. While at Tech he was a member of the Society of Business Management and the Society of Business. He accepted an assistantship January 1, 1966 from the Department of Horticulture at The University of Tennessee, Knoxville, where he pursued his Master of Science degree in Horticulture. As a requirement of the assistantship he worked with five of the Agricultural Experiment Stations of the University in different parts of the state.

He married on August 26, 1966 to the former Sarah Frances Stout of Buffalo Valley, Tennessee.