EFFECT OF THREE LIGHT INTENSITIES ON
EIGHT TURF TYPE BERMUDAGRASSES
(*CYNODON* L.C. RICH)

By

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EIGHT TURF TYPE BERMUDAGRASSES

(CYNODON L.C. RICH)

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CHAPTER I

INTRODUCTION

It has been estimated that between 20-25% of all cultured turf is under some degree of shade (Wilkinson, 1974). Bermudagrass (Cynodon spp. L.C. Rich), is the most widely used turfgrass in the Southern United States for home lawns, institutions, and recreational facilities. Tree canopies, north sides of buildings, and other man made structures limits the use of bermudagrass as a ground cover. Although very few turfgrasses perform adequately in dense shade, some selections of bermudagrass have shown a tendency for more shade tolerance than others.

Shade influences the turfgrass environment in such a way as to affect the quality of a desirable turf. Turfgrass quality is the product of uniformity, density, color, and texture; therefore, evaluation of turfgrass quality can be complex. Poor quality turfgrass may be a result of one or more of these factors as influenced by a reduction in photosynthesis, as a result of reduced light intensity.

Bermudagrass performance in reduced light may also be influenced by altered light quality of incident radiation by the sun. A change in the spectral composition may change the growth characteristics by way of an altered environment.

Some other factors affecting bermudagrass in a shaded condition might be restricted wind movement by dense shrub or tree plantings, increasing the relative humidity. Tree root competition by shallow rooted ornamentals, disease and insect pests, are all natural turfgrass environmental shade factors.

Altering the cultural practices of turfgrass management can change the effect of shade, but response to reduced light is also dependent on the species and variety grown.

In this investigation, eight selections of bermudagrass, U-3, Sunturf, Tifgreen, Tifway, Common, Fuller's selection, 6-X-149, and A-10112, were subjected to no-shade, 47%, and 73% shade by way of saran shade screens, in natural sunlight. The purpose of this experiment was to determine if differences in shade tolerance existed among eight bermudagrass selections under three levels of sunlight.

CHAPTER II

REVIEW OF LITERATURE

Solar radiation is the energy source for plant life; therefore, growth and developmental processes are dependent on the amount of solar energy that can be converted into chemical energy. Beard (1973), said that "Mowed turfs are capable of abosrbing and converting to chemical energy only 1 to 2% of the total incident radiant energy".

Several major turfgrasses were ranked by Youngner (1962), as being either high or low for shade tolerance. Of these species; improved bermudagrass and common bermudagrass ranked lower than all other species for estimated shade tolerance. The cool season grasses, red fescue, bentgrass, tall fescue, and meadow fescue all ranked high for shade tolerance, but Kentucky bluegrass and perennial ryegrass ranked low. Of the warm season grasses, zoysiagrass and St. Augustinegrass ranked high for shade tolerance with zoysiagrass the higher of the two. In a study by Burton and Deal (1963), on shade tolerance of southern grasses, St. Augustinegrass was rated the highest above zoysiagrass, Bahiagrass (*Paspalum notatum*), centipedegrass (*Eremochloa ophiuroides*), and bermudagrass. Again bermudagrass was ranked the lowest for shade tolerance of the major turfgrass species.

A difference in varieties among species for turfgrass quality was observed by Juska (1963), in a shade tolerance study on eleven varieties of bentgrass. Using plastic shade screens which excluded 30% of the light intensity, a significant difference was shown between varieties for turf quality. The varieties were not significant between themselves, but were significant when ranked into groups by quality performance.

Bermudagrass also showed a difference for shade tolerance among varieties, in a study by McBee and Holt (1966). In testing six warm season turfgrasses, Pensacola bahiagrass (Paspalum notatum); Common St. Augustinegrass (Stenotaphrum secundatum); 'Tifway' bermudagrass (Cynodon sp.); 'No Mow' bermudagrass, FB-137 (Cynodon sp. Florida selection); Meyer zoysia (Zoysia japonica); and Q-2 bermudagrass (Cynodon sp. Kansas selection), the difference between the variety No-Mow and the other bermudagrasses was significant for two levels of shade and full sunlight. Under shade screens of 35%, 60%, and 100% incident light, bermudagrass density was affected most by reduced light, and appeared to be more open and upright under lower levels of shade. During this two year study, the variety No-Mow produced a higher quality sod under lower levels of shade than the other bermudagrasses, and Q-2 was omitted from the experiment during the second year. No-Mow had a higher turf quality and a less hummocky appearance at the intermediate shade level, and exhibited more shade tolerance than St. Augustinegrass. Other researchers have shown that turfgrasses differ by variety in their response to shade and sunlight by a change in color, and density (Beard, 1965; Juska and Hanson, 1969, Wilkinson and Beard, 1974; Wood, 1969).

Light Intensity

The incorporation of CO_2 into carbohydrates is the main function of photosynthesis. A reduction in light intensity will reduce the amount of CO_2 uptake and limit carbohydrate production. Carbohydrate reserves are utilized in plant respiration. The production of carbohydrates in an unshaded situation exceeds respiration rates. Under reduced light intensities, the utilization of carbohydrates by respiration may exceed the production by photosynthesis resulting in deterioration of turfgrass quality (Wilkinson, 1974). If photosynthesis equals respiration rates, a compensation point is reached. Increase the light on a single leaf and it will use more and more CO_2 for photosynthesis. At some point, a saturation effect occurs where additional light will not increase photosynthesis (Madison, 1971).

In an investigation by Burnside and Bohning (1957), on light intensity versus the compensation and saturation points of sun-plants and shade-plants, the leaves of sun-plants had higher compensation points and became light saturated at higher light intensities than shade-plants. The light curves for photosynthesis of sun-plants resembled the light curves of shade-plants in dense shade levels. The saturation and compensation points seem to depend upon the environmental light condition during growth periods.

Alexander and McCloud (1962), measured net photosynthesis as influenced by light intensity, utilizing the uptake of CO_2 of both isolated leaves and plant communities of an improved strain of bermudagrass (*Cynodon dactylon* (L.) Pers.) under various clipping regimes. Light saturation was achieved at 2500-3000 foot-candles compared to average mid-day sunlight intensities of about 10,000 foot-candles for isolated leaves. The compensation point for an isolated bermudagrass leaf was measured at 300 foot-candles, and it was noted that leaf deterioration would occur at levels lower than the compensation point. They also noted that in complete darkness, the respiration rate would equal only about one-sixth of the photosynthetic potential of an isolated leaf. Beard (1973), stated that the compensation point for most turfgrasses is between 2-5% of full sunlight. Beard expressed the measurements for the compensation point of bermudagrass to be about 0.03 cal./cm.^{2}/min., and the saturation point for individual leaves to be about 0.45 cal./ cm^2/min. Light reported without cloud cover in temperate regions can be around 1.5 cal./cm.^{2}/min. at mid-day.

The angle of incident radiation on a turfgrass community will effect photosynthesis differently than a single leaf. The solar radiation is either absorbed, reradiated, or reflected at longer wave lengths in a cultured turfgrass community. In an investigation by Moss (1964), on optimum lighting of leaves, reflectors of aluminum foil beneath mature maize (Zea mays L.) were used to check the significance of a crop yield by reflected solar radiation on a level surface. The reflectors below the maize did not increase photosynthesis. The author went on to report, photosynthesis measurements were made at varying light intensities on both below and above leaves of plants. The species tested were maize (Zea mays L.), sugar cane (Saccharum officiarum L.), sunflower (Heliainthus annuus L.), and tobacco (Nictiana tabacum L.). The monocotyledons, sugar cane and maize responded alike to incident radiation on either leaf surface, but the dicotyledons differed in response to light on the lower leaf surfaces. One-half the saturation level of light on both leaf surfaces performed nearly as well as with saturation of only the top leaf surface, for all four species tested.

In bermudagrass community, the diurnal range effects of ambient light intensities will be the product of inter-leaf interference as well as orientation of the incoming radiation on the individual swards of plant. According to Alexander and McCloud (1962), light intensities between 2500-3000 foot-candles are required for saturation of individual bermudagrass leaves, but in a plant community, the partial shading, angle of the leaf, and reflected light on the underside of leaves will require a higher intensity to saturate the leaves at the top. This partial shading effect has been expressed as a product of Leaf Area Index, or LAI of a plant community. Leaf Area Index will equal the photosynthetic rate of a plant canopy per unit area, but does not mean that LAI of 5-7 will pass enough light through six layers of leaves to be effective on the seventh (Madison, 1971).

In an experiment of leaf areas and angles on corn (*Zea mays* L.), Duncan (1971) reported that leaf area and angle must be considered together, and that the highest yield in his experiment, was from a vertical arrangement of the top layer of leaves, and a horizontal arrangement for the lower layer of leaves. He also observed that the higher the leaf area index, the higher the number of layers of vertical leaves were required for maximum photosynthesis. The lowest photosynthetic efficiency of plant canopies observed in the corn was with horizontal layers of leaves at the top and LAI values of over 3.0, or with all vertical leaves with LAI values under 3.0.

Hart and Lee (1971), and Woledge (1972), carried out extensive research on the degradation in photosynthesis by the aging of grass leaves. Hart and Lee conducted experiments on the net CO_2 exchange rates (NCE) of 'Coastal' bermudagrass (*Cynodon dactylon* (L.) Pers.) in varying light intensities in two growth chamber studies and on outdoor grown potted plants. They found that the NCE rate of the bermudagrass leaves was highest at collar emergence and decreased with age. High light intensities decreased the NCE rate more rapidly, although the initial NCE rate was higher. They also observed that plants grown outdoors had a much higher initial NCE rate than those grown in chambers, but declined more rapidly with age, which they concluded was the result of higher light intensities on the leaves of plants grown outdoors. Woledge (1972), in a series of four experiments on *Lolium temulentum*, L. and *Lolium perenne* L. found that rates of net photosynthesis of grass leaves grown in bright lights decreased as they aged.

In a greenhouse study, Wilson (1962), used sod composed of red fescue (*Festuca rubra*), orchardgrass (*Dactylis glomerata*), and white clover (*Trifolium repens*) for a test on clipping on herbage yield at various light intensities. After using light intensities of 1800-600-200 foot-candles, and by clipping the sod to either a 2 or 4 inch stubble each time it approached 10 inches, the dry weight was measured. As the light intensity decreased, the dry weight decreased for orchardgrass and white clover, while the red fescue remained constant. The report suggested that light, and not clipping *per se* was a more important factor in competition.

Several morphological responses have been attributed to light intensity on turfgrass performance. Some physiological responses listed by Beard (1973) for plants grown at low light intensities are as follows:

1. Higher chlorophyll content.
2. Lower respiration rate.
3. Lower compensation point.
4. Lower carbohydrate reserves.
5. Lower carbohydrate-to-nitrogen ratio.
6. Reduced transpiration rate.
7. Higher tissue moisture content.
8. Lower osmotic pressure.

Youngner (1959, 1961), stated that low light intensities favor the production of chlorophyll and high intensities increase the rate of chlorophyll breakdown by photo-oxidation. Youngner found the dormancy of the variety U-3 of Cynodon dactylon is associated with light intensity interactions with low temperature. The temperature-light effect was found to be below 50°F and light above 7000 foot-candles for reduced growth rate and discoloration which was a figure averaged over time. If night time temperatures reached 34°F and the day time temperature jumped to 70°F, then growth would still continue. The breakdown of chlorophyll by high light intensities exceeding the rate of chlorophyll synthesis in low temperatures, creates a situation for turfgrass discoloration or winter dormancy. Youngner (1961) also showed similar effects for Zoysia matrella, Zoysia japonia, and Zoysia tenuifolia with temperatures slightly higher and light intensities lower than those found for U-3 bermudagrass.

An investigation by Schmidt and Blaser (1969) observed this temperature-light effect on cool-season grasses in a study on Cohansey bentgrass (Agrostis paulustris Huds.), where low light intensities decreased carbohydrate reserves, and higher temperatures decreased the rate of top growth. At high rates of nitrogen fertilizer applied at low light intensities, higher rates of photosynthesis occurred, but less root development and decreased carbohydrates as stored energy were reported. Liberal nitrogen fertilizer applications later inhibited root growth. Further studies by Schmidt and Blaser (1969), on growth and metabolism of 'Tifgreen' bermudagrass (Cynodon spp.), confirm similar responses to nitrogen and low light intensity.

A light intensity reduction study on Coastal bermudagrass (Cynodon dactylon), by Barton et al. (1962), showed that as the fertility level increased and the light intensity decreased, the forage yield, plant density, and leaf area would also decrease. They observed an increase in moisture content, crude protein, true protein, phosphorus, calcium and magnesium contents with low levels of nitrogen fertilizer under low levels of light intensity.

In addition to noticing an increase in moisture content in reduced light intensity on Poa pratensis and Festuca rubra, Wilkinson and Beard (1974), mentioned other physiological features of the turfgrasses studied under shade. A decrease in leaf width, an increase in leaf length, decreased dry weight, higher chlorophyll contents, and a lighter color rating were all observed under shade. Winstead and Ward (1974) made similar observations on Tiflawn bermudagrass (Cynodon dactylon (L.) Pers.) and St. Augustinegrass (Stenotaphrum secundatum (Walt.) Kuntze) under full sun and 70% shade. They also noted an increase in internode length. Other investigators have reported similar observations of the physiology of turfgrass grown under reduced light intensities (Juska, 1963; Wood, 1969; and Youngner, 1959).

Light Quality

According to Beard (1973), turfgrass response to light quality is similar to other species in responses to blue, or red light. Generally blue light, about 435 mu influences compact growth, mesocotyl elongation, and has more effects on chlorophyll "a" than red light. Red light promotes elongated stems, leaf enlargement, rhizome development and seed germination, where as infra-red light inhibits seed germination. Ward, (1969) with reference to light quality, separates the solar spectrum into three segments of infra-red (greater than 0.7u), visible light (0.4u for blue to 0.7u for red) and ultraviolet (below 0.4u).

The solar radiation will usually be equivalent to about 52% infra-red, 44% visible, and 4% ultraviolet.

A light response to unfolding of the grass leaf was investigated by Virgin (1960). Grass leaf unfolding was caused by both greater growth of cells of the upper part of the mesoctyl as well as turgidity of the upper cells. Red light was found to induce this, and infra-red light inhibited the response which was reversible. Measurement of the spectrum showed a dominance of infra-red at low intensities in wave lengths of 710 mu-730 mu, with 710 mu amounts higher. The red action spectrum was at 660 mu and 600 mu, with traces to 540 mu. Although red is important for leaf enlargement, the blue end of the spectrum is more important for dense turfgrass growth according to McBee (1969).

The ultraviolet radiation reflectance, transmittance, and absorptance by plant leaf epidermis was investigated by Gausman et al. (1975) on several species of plants with varying leaf thicknesses. They separated ultraviolet light into three wave lengths, A, B, and C; and defined them as having wave lengths of 370-400 mu for A, 280-320 mu for B, and 200-280 mu for C. Their results showed that higher amounts of ultraviolet A was absorbed by plant epidermis, and not transmitted. In reference to ultraviolet B, high amounts were found to grossly malform plant leaves; also as ultraviolet B was increased, dry weight, leaf size and height of test plants decreased. Of the species tested, the plants with the thick epidermal surfaces absorbed greater amounts of total ultraviolet radiation.

Four selections of bermudagrass were tested by McBee (1969), at two different variations in light quality. The varieties used were 'Tifdwarf', a vegetative mutant of 'Tifgreen' (X *Cynodon* *dactylon* X

C. transvaalensis), 'Tifway' (X C. transvaalensis X C. dactylon), 'Floraturf' (FB-137, Cynodon sp.), and Common (Cynodon dactylon (L.) Pers.; local sprigs). Light chambers filtered to produce light of either 600-675 mu or wave lengths below 575 mu were set to eleven hour light cycles at 29.5°C and thirteen hours of darkness at 18.3°C with a relative humidity of about 60%. McBee found that the shorter wave lengths yielded better performance of all varieties except Common, and the selection Floraturf had the largest percentage of coverage in both chambers. Observations were made of blue light minimizing elongation and red enhancing the effect. If a growth mechanism was involved, Floraturf seemed not to be as sensitive to various wave lengths. In the same report, McBee compared light performance of the bermudagrasses under Post Oak (Quercus stellata) canopies and found similar responses to relative light. It was found that the light quality decreases from the perimeter to trunk and the greatest reduction was in the blue part of the spectrum, with also a great reduction in 600 mu and an increase in infra-red radiation as the shade became more dense.

Two kinds of shade under tree canopies are described by Vezina et al. (1966). These are "green shade" under a dense deciduous tree canopy, and "blue shade" under a less dense shade effect of tree canopies. Dense "green shade" occurs where the primary sources of shade are transmittance and reflection, in which the green and yellow light is reflected by the leaves and the red and blue light absorbed. According to Anderson (1964), the near infra-red wavelengths longer than 700 mu are also much higher under deciduous tree canopies. "Blue shade" under less dense canopies, reduces the red wavelengths much more than the blue as reported by Vezina et al. Confierous trees do not effect the light quality as much as deciduous trees and usually act more like neutral fiters on the light quality (Beard, 1973).

The response to shade under deciduous trees in field experiments compared to saran shade screen light quality was investigated by Gaskin (1965). The report stated that dense shade removed more blue light than red in spectral composition of incident radiation which filtered through a deciduous tree canopy. By the use of various saran shade screens and a color temperature meter for light quality, Gaskin reported that the shade under saran shade screens was similar to the shade of deciduous tree canopies up to about 75% shade.

Environmental Responses

The influence of disease as a shade tolerance factor was suggested by Beard (1965), after an investigation of factors in the adaptation of turfgrass to shade. The evaluations of shade tolerance were made on 'Pennlawn' red fescue (Festuca rubra), Merion and Common Kentucky bluegrasses (Poa pratensis L.), roughstalk bluegrass, Kentucky 31 tall fescue (Festuca arundinacea Schreb.) and 'Norlea' and Common perennial ryegrasses (Lolium perenne L.) and these grasses were mixed in eight combinations. Pennlawn red fescue showed infestations of leafspot (Helminthosporium sativum PKB.) resulting in thinning of the turf. The Kentucky bluegrasses showed a gradual build up of powdery mildew (Erysiphe graminis D.C.), Roughstalk bluegrass performed well and the tall fescue and the perennial ryegrasses showed no recovery during the second growing season after snow mold during the first winter after establishment. The performance of the varieties was measured under canopies of sugar maples (Acer saccharum Mersh), with only 5% incident light. The adaptability to shade seemed to be influenced by the disease resistance in this particular study where the environment for disease under shade culture existed.

Despite adverse conditions associated with shade, turfgrass quality can be improved by certain cultural practices. First of all, a selection of shade tolerant species and variety well adapted to the soil and climate would be the most important consideration. Second, modifications of thinning underbrush and low limbs for non-restricted air movement would decrease chances of disease. Third, avoid excessive nitrogen applications which could favor shoot growth over root growth, placing further stress on carbohydrate reserves. Fourth, a higher mowing height would provide a greater leaf area for absorption at lower light intensities (Wilkinson, 1974).

CHAPTER III

METHODS AND MATERIALS

This investigation was conducted on the Agronomy Research Station at Stillwater, Oklahoma. The research period extended from July 2, 1976 to October 12, 1976. Eight bermudagrass selections were evaluated at three levels of solar radiation, to determine differences in shade tolerance (Cynodon L.C. Rich).

The bermudagrass varieties selected were 'U-3' bermudagrass (Cynodon dactylon), 'Sunturf' (C. magennissii), 'Tifgreen' (Cynodon dactylon X C. tranvaalensis), 'Tifway' (C. dactylon X C. transvaalensis), Common (Cynodon dactylon; local sprigs) Fuller's selection (Cynodon spp.) and two experimental selections 6-X-149 (Cynodon spp.) and A-10112 (Cynodon spp.). The bermudagrass selections were placed under three levels of light intensity (shade levels), full sunlight, 47% shade and 73% shade. This was achieved through use of saran shade screens, and replicated three times.

The experiment was arranged in a split plot design. The main plots were varieties with levels of light intensity as sub-plots. The treatments were randomized and replicated three times. The replications were in a line east to west over the test area. The main plots were 1.54 m (5 ft) wide by 4.62 m (15 ft) long, and the subplots 1.54 m (5 ft) square. These were marked in 1 m areas for evaluation purposes by permanent markers at the four corners of each subplot. The soil type was a Kirkland silt loam, with a pH of 5.7 and was high in levels of potassium. It had less than a two percent slope.

The 47% and 73% saran screens were stretched over one-half inch interior diameter P.V.C. pipe frames five feet square. These were placed on notched wooden stakes placed six inches above the soil surface, and fastened by soft wire in such a way as to permit removal for mowing. The screens were placed on the corresponding subplot within one week after initial establishment.

The plots were sprigged July 2, 1976, at a rate of 9 bushels per 1000 sq. ft. The sprigs were scattered by hand over a harrowed seed bed. They were then rototilled into the soil surface, rolled with a water filled roller, and watered with portable irrigation pipe with fixed risers and impulse sprinklers. Water was applied as needed during a one month establishment period, after which, water was applied at less frequent intervals.

Fertilizer was applied as ammonium phosphate (18-46-0), at the rate of 0.5 lbs N/1000 sq. ft. every two weeks starting one month after sprigging. A preemergence herbicide, Dacthal, was applied with a two gallon compression sprayer for crabgrass control on July 5, 1976. All other weeds were removed by hand prior to evaluation periods.

Evaluations were begun on August 5, 1976, approximately one month after establishment and ended October 12, 1976. The major evaluation was made on turf quality, which is a measure of color and density. These evaluations were made by ocular estimates on six dates approximately two weeks apart. The method of scoring was based on a scale of 1 to 10, with 10 being best and 1, the poorest quality.

The plots were mowed first on September 6, 1976, at which time the clippings were oven dried and weighed. A Jacobsen '21 Manor' mower was set to a height of 3.81 centimeters with a cardboard box modification taped to the standard grass catcher for gathering the clippings. After oven drying at 100^{o}C, the clippings were weighed on an Ainsworth Electronic balance, model number A-200, and the grams per meter plot converted to kilograms per hectare.

Light readings for the entire solar spectrum under the saran shade screens were made by the use of a Star Pyronometer light sensor attached to a physcrometric microvoltmeter, and the readings were converted to Langleys, by dividing by 8.38 mv. as calibrated at the factory for the sensor. These readings were made on one replication per reading date for all subplot treatments.

CHAPTER IV

RESULTS AND DISCUSSION

In this experiment, turfgrass quality, turfgrass clipping weight, and light intensity were measured. Both turfgrass quality and clipping weight were analyzed by variety, shade level, and date of scoring. The light intensity was analyzed by variety differences and shade level. Turfgrass quality was the primary interest in this investigation, and was used as a measure of performance for the varieties. The clipping weight was analyzed as a growth factor, and light intensity was analyzed to show performance of the saran shade screens for each treatment.

As shown in Appendix Table I for turfgrass quality, significant differences were noted for variety, shading, dates, variety x dates interaction, and shading x dates interaction. Variety x shading interaction was not significant. In the analysis of variance of the split-plot design used, error terms were designated Error A, Error B and Error C for clarity.

As shown in Appendix Table IV, Tifgreen had the largest means and U-3 the smallest and the two were found to be significantly different as determined by Duncan's Multiple Range test. The varieties could be split into two groups. There were no significant differences in turf quality among the varieties Sunturf, 6-X-149, Fuller's Sel., and Tifgreen. However, they were significantly different in turf quality from the varieties U-3, Common, A-10112, and Tifway.

A significant difference in Turfgrass quality was observed under different light intensities. The lowest quality was determined under the 73% shade, and the highest turf quality was full sunlight. This indicates that decreasing the light intensity for these bermudagrasses would decrease the turf quality. It was noted that a general thinning of the turf, taller and more spindly plants, was observed as the shade level increased.

The turf quality by date interaction was shown to be significantly different between the first and last scoring dates as shown in Table IV. There were significant differences in turf quality as the season advanced. An exception was noted in September, where there were no differences in turf quality between the first and last scoring dates.

There were significant differences in the shading x date interaction as indicated in Appendix Table I. The three levels of shade are shown graphically in Figure 1 for six dates of scoring turfgrass quality. These dates are referred to as time intervals of T1 through T6. As previously mentioned, the initial establishment of the experiment was July 2, and T1 is August 5, approximately one month later. It should be noted that the turf quality for full sunlight and 47% shade level are nearly the same for T1. By time interval three, a difference is observed where turf quality in full sunlight steadily increased in nearly a straight line, and the same in T3 as in T2. The turf quality in full sunlight tends to level off in its rate of increase by T4. The values for turf quality in 47% shade and full sunlight continue nearly parallel till T6. The 73% shade level showed very little increase from T1 to T6.

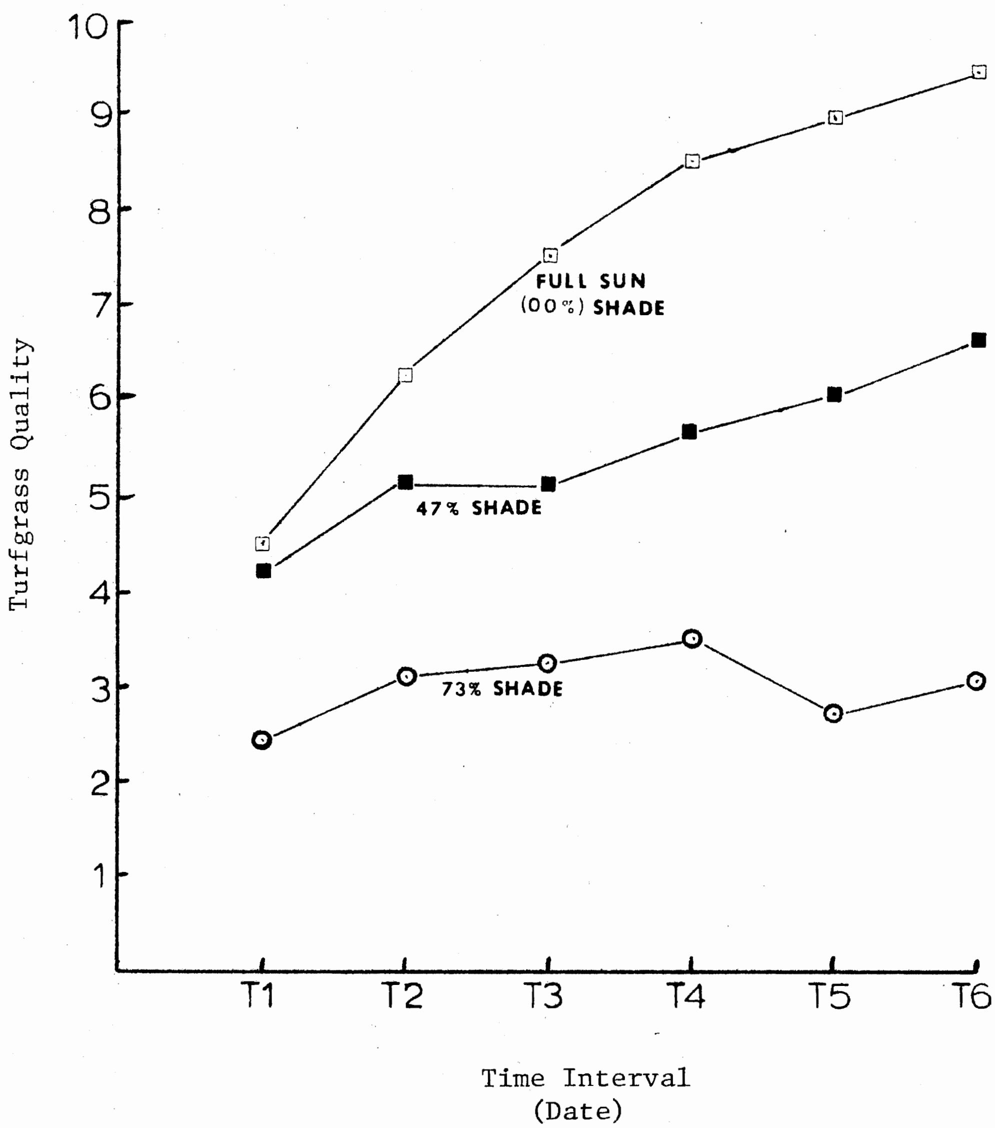

Figure 1. The Mean Effect of Shading X Date Interaction for Turfgrass Quality Under Three Light Intensities.

T1 = Aug. 6
T2 = Aug. 19
T3 = Aug. 26
T4 = Sept. 5
T5 = Sept. 20
T6 = Oct. 11

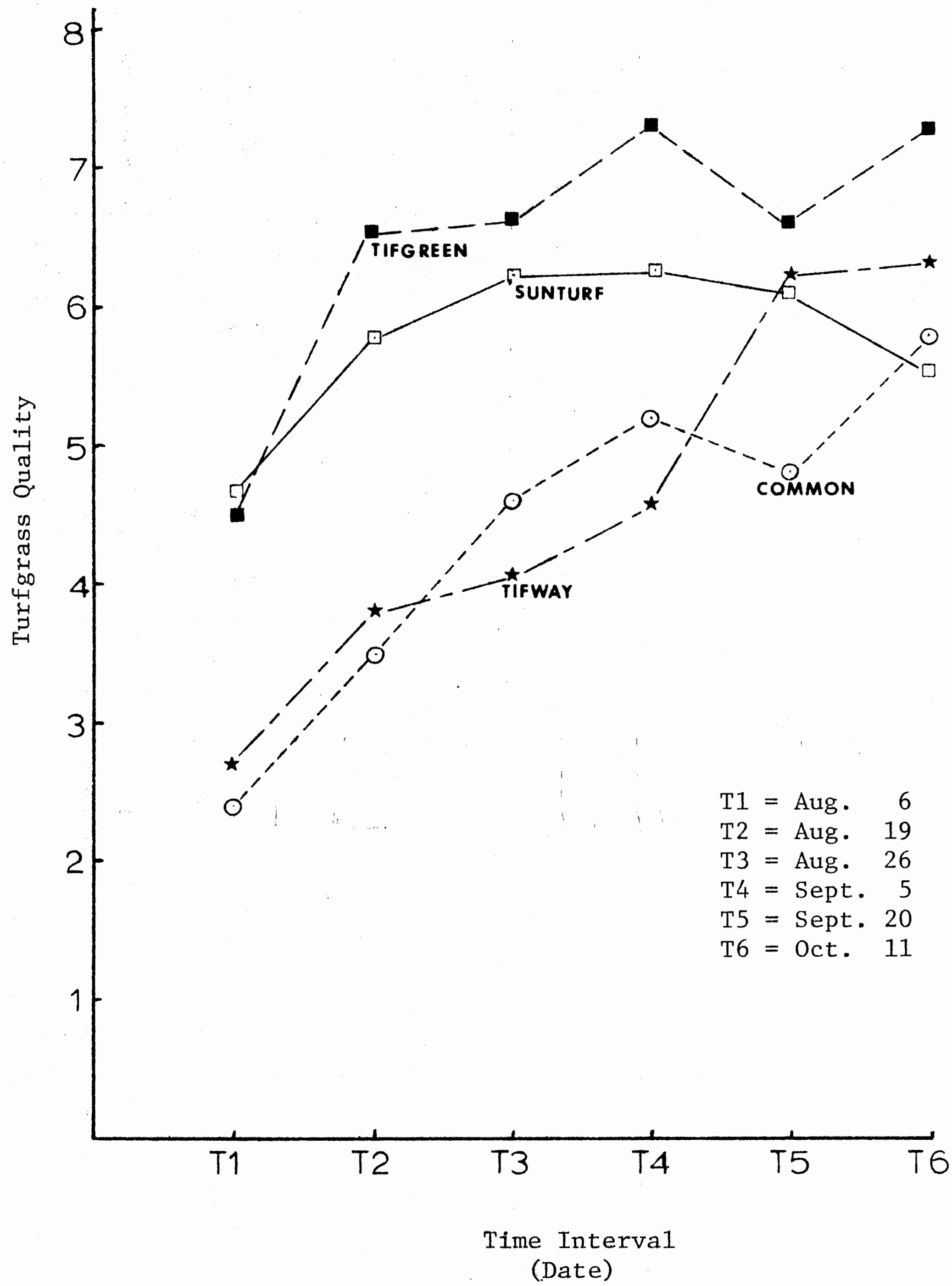

Figure 2. The Mean Effect of Variety X Date Interaction for Turfgrass Quality of Tifgreen, Sunturf, Common, and Tifway Bermudagrasses.

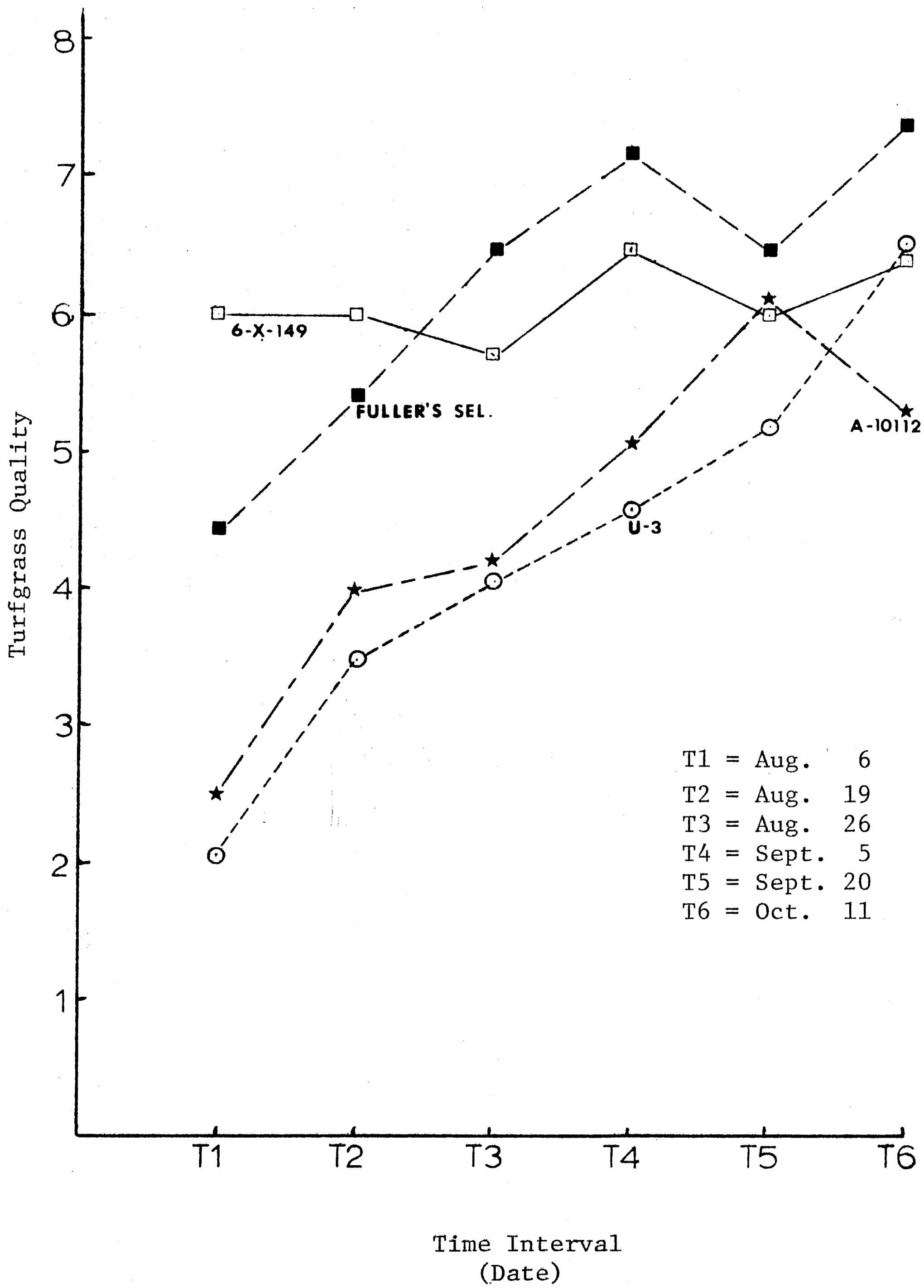

Figure 3. The Mean Effect of Variety X Date Interaction for Turfgrass Quality of 6-X-149, Fuller's Selection, A-10112, and U-3 Bermudagrasses.

The near paralleling effect of the 47% and 73% shade levels as opposed to the rapid increase of full sunlight gave the significant difference in the analysis of variance for turf quality.

Highly significant differences in variety x date interaction were observed as shown in Table I. As graphically shown in Figures 2 and 3, the increase in turf quality ratings by time intervals are not straight lines for each variety. Grouped together though, a pattern exists where four varieties can be ranked together. Tifgreen, Fuller's Sel., 6-X-149, and Sunturf all had similar responses to time intervals, and conversely U-3, A-10112, Tifway and Common were also similar in results. It might be noted that Tifgreen and Fuller's Sel., were nearly identical and ranked the highest for turf quality at T6. A decline at T5 was apparent for Tifgreen, Fuller's Sel. and Common, while Sunturf and A-10112 declined in turf quality at T6. Removal of a large amount of top growth at the first clipping, and early cool temperatures were two of the reasons for a fluctuation in turf quality at T5 and T6.

There were no significant differences for the variety x shading interactions, as shown in Appendix Table I. This is graphically illustrated for the means in Figures 4 and 5. Generally, the higher the means for turfgrass quality in full sunlight for all varieties, the higher the sunlight for the 47% and 73% shade levels. This effect would perhaps account for a lack of interaction in variety x shading.

Highly significant differences were evident in clipping weights for variety, shading, and dates, as shown in Appendix Table II. Interactions for variety x shading, variety x date, and shading x date also were significantly different. Variety means for clipping weight ranked in order from the smallest to the largest showed U-3 to be the least and

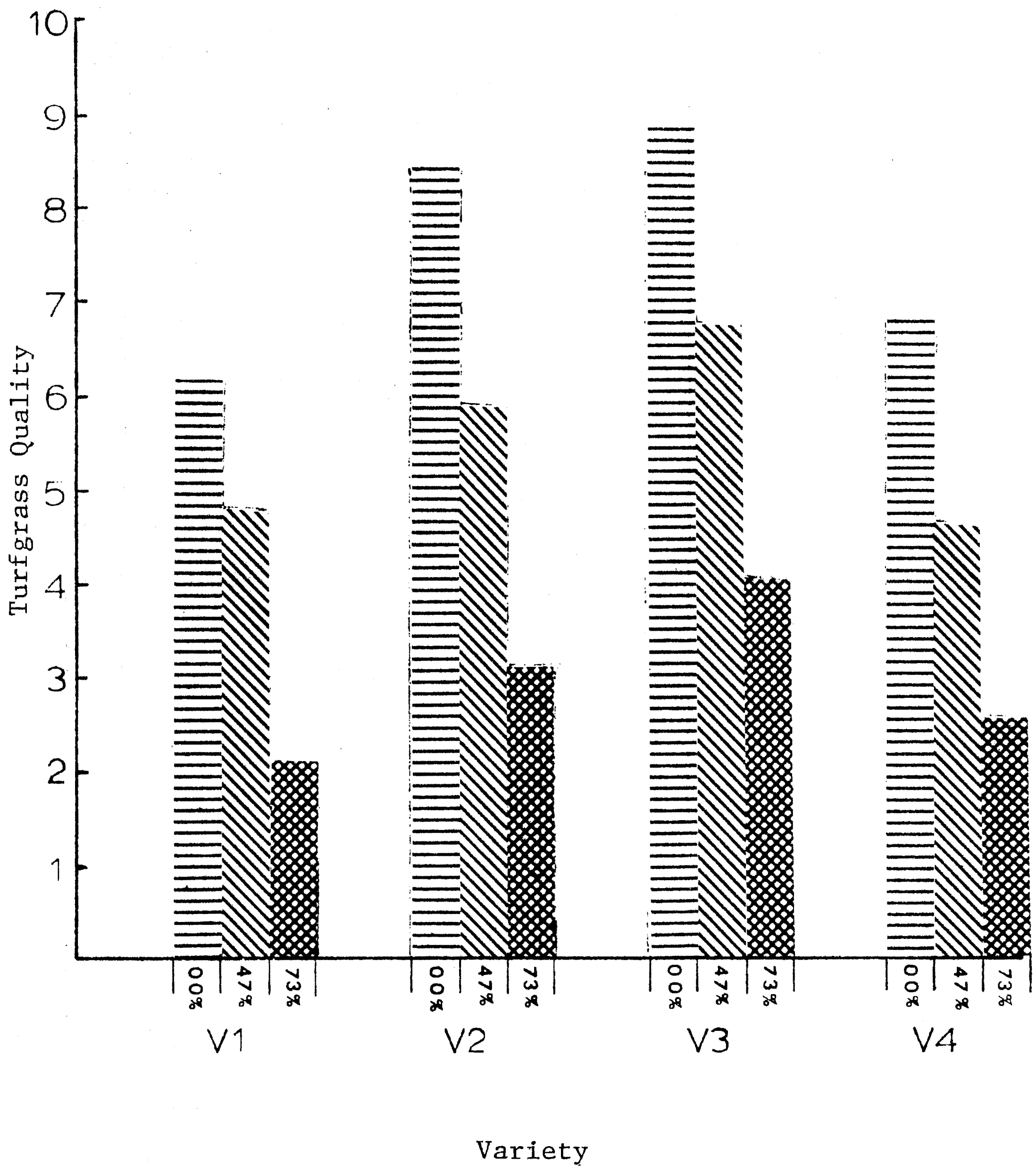

Figure 4. The Mean Effect of Variety X Shading Interaction for Turfgrass Quality of U-3, Sunturf, Tifgreen, Tifway, Bermudagrasses.

V1 = U-3
V2 = Sunturf
V3 = Tifgreen
V4 = Tifway

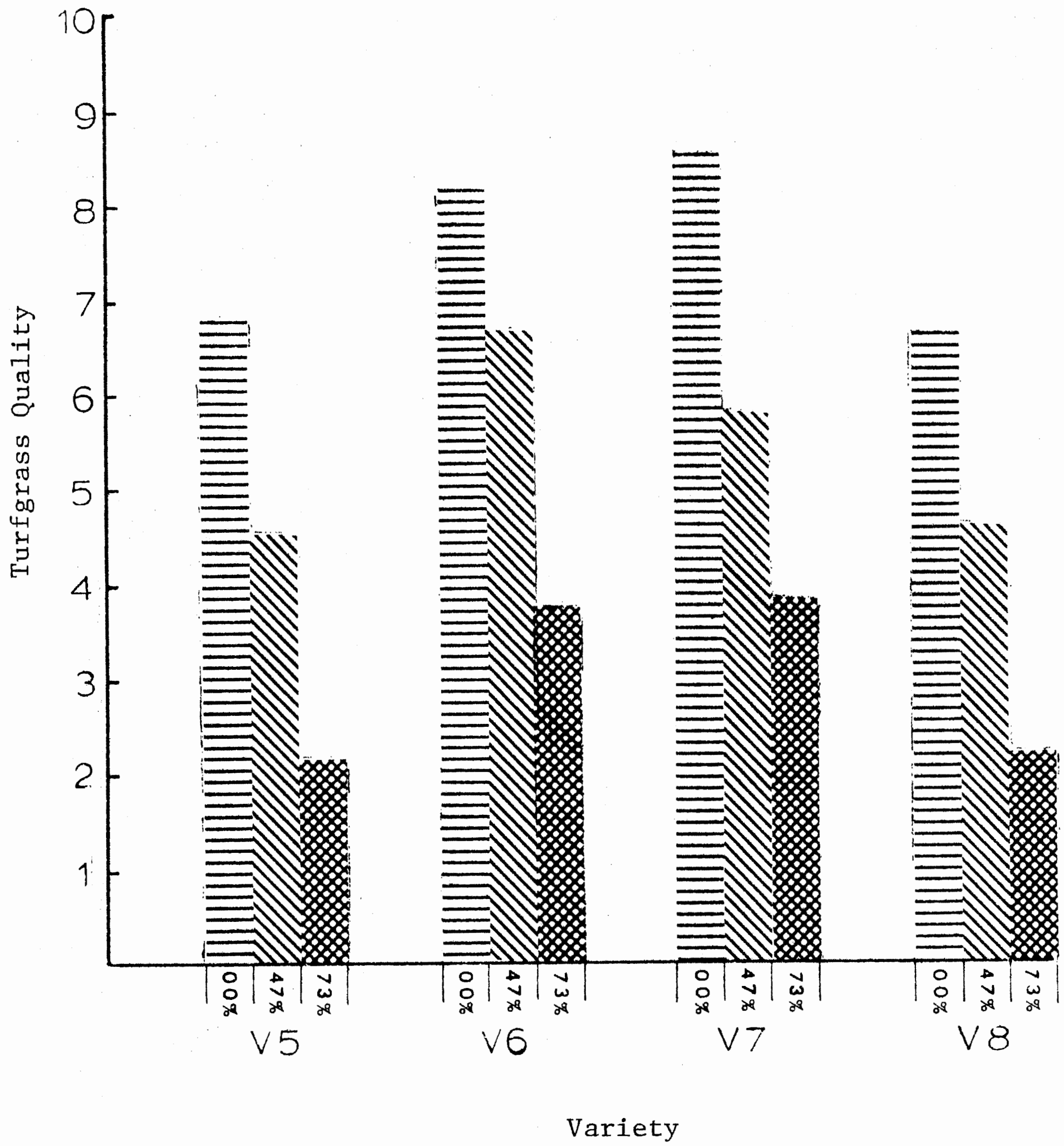

Figure 5. The Mean Effect of Variety X Shading Interaction for Turfgrass Quality of Common, Fuller's Sel., 6-X-149, and A-10112 Bermudagrasses.

V5 = Common
V6 = Fuller's Sel.
V7 = 6-X-149
V8 = A-10112

exceeded by Fuller's Sel., Tifgreen, Tifway, Common, A-10112, Sunturf, and 6-X-149 as shown in Table V. There were no significant differences among 6-X-149, Sunturf, and A-10112 for clipping weights. Likewise, there were no significant differences among Sunturf, A-10112, and Common, or for A-10112, Common, and Tifway. In a comparision of Common and 6-X-149, there were significant differences in clipping weight, but not between the other varieties. The greatest amount of clippings by weight came from varieties A-10112, Sunturf, and 6-X-149. It is interesting to note that only one of the three varieties with the highest clipping weight, was in the more shade tolerant of the two groups for turf quality.

There was little difference in clipping weights between full sunlight and 47% shade level, but a significant difference was noted for the 73% shade level as shown by Duncan's Multiple Range Test in Table V. This would seem obvious by the observance of more spindly plants, and less dense turf under the 73% shade screens.

There were highly significant differences in clipping weights by dates as shown in Table V. The order of means from smallest to largest was October 11, September 24, and September 6. A possible reason for the significant difference in dates could have been the large amount of turfgrass clippings on the first date, and slower growth due to environmental changes for the October clipping.

The analysis of variance for light intensity shows no significant differences for variety, or variety x shading interactions, as shown in Appendix Table III. The shading for light intensity was highly significant.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of this study was to evaluate the performance of eight varieties of bermudagrass in three levels of light intensity. Turfgrass quality was evaluated for density and color in the same scoring. It was noted that very little change in color was observed during the course of this experiment. Turfgrass clipping weight and light intensity evaluations were also investigated.

For turfgrass quality, a significant difference was found for varieties. A Duncan's Multiple Range Test indicated that there was little difference among two groups of varieties for turf quality. The more shade tolerant group from the smaller to largest means were Sunturf, 6-X-149, Fuller's, and Tifgreen. The least shade tolerant group means were U-3, Common, A-10112, and Tifway.

The tables for the analysis of variance also showed significant difference for shading levels, dates, variety x dates interaction and shading x date interactions. The shade levels means in the order of highest to lowest were 73% shade, 47% shade and full sunlight as shown by a Duncan's Multiple Range Test. Turf quality increases with dates as the season advanced, except in September where no differences in turf quality existed.

The analysis of variance for variety x dates interactions was not significant. The graphic results indicated that as the shade level increased, the turf quality decreased at nearly the same rates for all the varieties.

Turfgrass clippings showed highly significant differences for variety, shading, dates, variety x dates interaction, variety x shading interaction, and shading x dates interactions in the analysis of variance tables. Late season clippings, cool weather during September, and variations in growth rates gave the highly significant differences in clipping weights.

The light intensities for the shade treatments were not significantly different as shown by the analysis for variance table.

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APPENDIX

TABLE I

ANALYSIS OF VARIANCE FOR TURFGRASS QUALITY
OF VARIETY, SHADING, AND DATE

Source	Degress of Freedom	Mean Squares	F
Replication	2	10.42	
Variety	7	45.72	18.66**
Error A	14	2.45	
Shading	2	758.33	608.92**
Variety X Shading	14	1.34	1.07NS
Error B	32	1.24	
Date	5	67.84	86.76**
Variety X Date	35	3.31	4.24**
Shading X Date	10	20.54	26.33**
Variety X Shading X Date	70	0.72	
Error C	240	0.78	
Total (Corrected)	431	6.61	

NS - Not Significant
** - Exceeds 1% level of significance

TABLE II

ANALYSIS OF VARIANCE FOR TURFGRASS CLIPPING WEIGHTS OF VARIETY, SHADING, LIGHT INTENSITY, AND DATE

Source	Degrees of Freedom	Mean Square	F
Replication	2	27585.84	
Variety	7	985820.29	14.39**
Error A	14	136986.46	
Shading	2	1199865.33	18.34**
Variety X Shading	14	224399.17	3.43**
Error B	32	64521.52	
Date	2	6732289.10	
Variety X Date	14	467440.14	97.60**
Shading X Date	4	2484081.85	3.6**
Variety X Shading X Date	28	160119.64	
Error C	96	68974.26	
Total (Corrected)	215	267713.85	

** Exceeds 1% level of significance

TABLE III

ANALYSIS OF VARIANCE FOR LIGHT INTENSITY
OF SHADING UNDER THREE LEVELS

Source	Degrees of Freedom	Means Squares	F
Replication	2	8801.40	
Variety	7	6.39	1.330NS
Error A	14	4.81	
Shading	2	33060.41	248.666**
Variety X Shading	14	4.21	.032NS
Error B	32	132.95	
Total (Corrected)	71	1241.54	

NS - Not Significant
** - Exceeds 1% level of significance

TABLE IV

DUNCANS MULTIPLE RANGE TEST OF THE MEANS FOR
VARIETIES, SHADE LEVELS, AND DATES
FOR TURFGRASS QUALITY

Variety:	U-3	Common	A10112	Tifway	Sunturf	6-X-149	Fuller's	Tifgreen
Means:	4.37	4.44	4.55	4.66	5.81	6.12	6.27	6.51

* 0.05 level

* 0.01 level

Shade Level:	73%	47%	00%
Means:	2.98	5.48	7.56

*All levels significant

Dates:	Aug. 6	Aug. 19	Aug. 26	Sept. 5	Sept. 20	Oct. 11
Means:	3.69	4.86	5.29	5.88	5.97	6.37

* Same for both 0.05 and 0.01 levels

** Any two means not underscored by the same line are significantly different.

** Any two means underscored by the same line are not significantly different.

TABLE V

DUNCANS MULTIPLE RANGE TEST OF THE MEANS
FOR VARIETIES, SHADE LEVELS, AND DATES
FOR TURFGRASS CLIPPING WEIGHTS

Variety:	U-3	Fuller's	Tifgreen	Tifway	Common	A10112	Sunturf	6-X-149
Means:	145.12	218.77	236.07	298.80	343.72	506.74	533.47	706.34

* 0.05 level

* 0.01 level

Shade Level:	73%	00%	47%
Means:	228.5	416.55	475.79

* Same for both 0.05 and 0.01 levels

Date:	Oct. 11	Sept. 24	Sept. 6
Means:	42.78	432.25	645.86

* Significant at all levels

** Any two means not underscored by the same line are significantly different.

** Any two means underscored by the same line are not significantly different.

TABLE VI

DUNCANS MULTIPLE RANGE TEST OF THE MEANS FOR VARIETIES FOR LIGHT INTENSITY

Variety:	Fuller's	Common	U-3	A10112	Tifgreen	Tifway	Sunturf	6-X-149
Means:	64.90	65.41	65.81	66.61	66.63	66.85	66.96	67.31

* All varieties are not significant at 0.05 level

** Any two means not underscored by the same line are significantly different.

** Any two means underscored by the same line are not significantly different.

VITA[2]

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