The purposes of this study were two-fold: 1) to evaluate the effect of partial defoliation on chlorophyll distribution and percentage green coverage, and 2) to investigate the effect of total defoliation on recovery of 10 turfgrass species.

Turfgrass species under examination were: (Pennisetum clandestinum) Hochst. cv. (Chiov.); St. Augustinegrass (Stenotaphrum secundatum) (Walt.) Kuntze; Paspalum vaginatum SW.; tall fescue (Festuca arundinacea Schreb. cv. Alta); crabgrass (Echinochloa oryzae) Munro.) Hack.; bermudagrass (Cynodon dactylon) (L.) Pears cvs. Santa Ana and Suwannee; zoysiagrass (Zosia japonica x Z. tenuifolia) Wildl. ex. Trin. cv. Emerald; zoysiagrass (Zosia matrella) (L.) Merr.; perennial ryegrass (Lolium perenne) (L.).

Cool season species (tall fescue and perennial ryegrass) were seeded and warm species were vegetatively propagated. Grasses were grown in polystyrene foam containers (27 cm deep, 26 cm long, and 21 cm wide) with the soil level 3 cm below the container edge.

Each mowing and species treatment was replicated 4 times. Green coverage was evaluated in 2 ways: 1) visual rating; 2) measuring the ratio between reflected turf; one is a controlled defoliation by mowing which reduces the leaf area index (LAI); the second is defoliation as a result of attack by pests, defoliation, drought, heavy wear, and misuse of chemicals. Data concerning response of turfgrass species to partial or total defoliation are needed in order to formulate maintenance programs.

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light in the far red (FR) and red (R) band. The FR/R ratio from 1.5–3.5 is correlated with 0–100% green coverage, respectively (4). Measurements were taken with an IL 150 Plant Growth Photometer. Chlorophyll content was determined by the colorimetric method described by Mackinney (9). Sheared clippings were weighed and samples minced in a blender and transferred immediately to an extraction vial.

In one experiment, all grasses were sheared weekly to a height of 3 cm for 10 months using pruning shears. After this, 2 treatments were imposed for a further 6 weeks; in one the weekly shearing level was raised to 6 cm while in the other it was raised to 6 cm. One week after the last shearing the 4 replicates of each species per treatment were sheared as normal. Percentage green cover of the sheared containers was then assessed; the grasses were subsequently sheared to ground level (in 2 layers each 3 cm thick in the case of the 6 cm treatment) and chlorophyll content of all layers assayed. In a 2nd experiment, the same species were grown for 12 months with weekly shearing to 3 cm and then sheared to 0.5 cm above the ground in September. Measurements of the FR/R ratio were obtained, together with a visual assessment of the percentage green cover, 5, 13 and 26 days after shearing.

The results (Table 1) from the first experiment showed that chlorophyll content of the lower layer was less than for the upper layer or layers. Two significantly different groups were observed, one with a much lower chlorophyll content in the lower level which included kikuyu-grass and the bermudagrasses, and the others (with the exception of tall fescue) having intermediate values. In the 1st group, the low-shearing, treatment contained less than 8% of the chlorophyll after normal shearing, resulting in a reduction of percent green cover to 60% or less. When sheared to 6 cm these species still lost more than 80% of their chlorophyll at each shearing, although there was no reduction in percent green cover.

In the second experiment (Table 2), the kikuyu-grass, bermudagrasses and Paspalum vaginatum showed rapid recovery from shearing to 0.5 cm. The high FR/R ratios obtained with these grasses only 13 days after shearing confirmed their rapid recovery. Three significantly different groups with slow to fast recovery rates were shown.

The proposed guideline for the timing of mowing is that no more than 30–40% of the leaf area should be removed at any one time (5, 8). In our experiments removal of 75–85% of the chlorophyll did not reduce the turf green cover. If the total chlorophyll content is in correlation with LAI then the guideline cited may not be accurate and in some cases much more than 30–40% of the LAI can be removed without damage.

According to the chlorophyll distribution, 2 groups of turfgrasses were found: one with 8% or less of the total chlorophyll remaining after shearing and the other with 14% or more (in the low shearing treatment). The first comprised mainly species with low shade tolerance (LST), while the second included those with high shade tolerance (HST).

For the LST grasses, this same pattern of chlorophyll distribution was found 7 weeks after doubling the cutting height, although there was a much higher content in the level below the shearing line. This chlorophyll increase was to a level where the scalping phenomenon did not occur and was similar in this respect to the low shearing treatment of the HST grasses. Work by Biran et al. (3) suggested that the observed change in the chlorophyll content, following a change in the mowing height, might be a temporary one.

The effects of total and partial defoliation were completely different. The differences between the recovery rates from complete defoliation found in our experiments have previously been similarly listed by Youngner et al. (13) for a few species. The 3 species of the LST group possessed the ability for fast recovery. The two C₄ species, tall fescue and perennial ryegrass, did not recover.
It has been demonstrated that defoliation might stop canopy (1) and root (10) growth and reduce the carbohydrate reserves (11). This effect is lower when reserves are higher (6). During the experiments high temperatures prevailed (average maximum daily temperature 34.5°C). This usually increased the dark respiration and decreased the apparent photosynthesis of C3 species under normal ambient CO2 concentrations (12) resulting in low carbohydrate reserves which might explain the failure of C3 species to recover from the treatment. The C4 species (except centipedegrass) fall into groups with 2 different recovery rates. The differences between them are probably due to differences in growth rate (2) rather than carbohydrate reserves.

Mowing is the most fundamental practice utilized in turfgrass culture in which timing and height are important in order to maintain acceptable grass quality (2). Our experiments showed that HST species could be mown less frequently than LST species and that C3 species are more susceptible to very low mowing than are C4 ones.

### Literature Cited


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**Green Coverage and Color Evaluation of Turfgrass by Means of Light Reflection**

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Additional index words: chlorophyll, turfgrass quality

**Abstract.** Light reflectance and chlorophyll content of 10 turfgrass species grown under different conditions indicated that the ratio between the far red (FR) (peak at 732 nm) and red (R) (peak at 640 nm) components of the light reflected from the grass surface correlated with the percentage green cover in an incompletely covered sward, and the intensity of color where coverage was complete. A simple, practical method for measuring these 2 parameters is proposed, using a Plant Growth Photometer capable of measuring the FR/R ratio.

Turfgrasses are grown for both aesthetic and functional purposes. The major components of their aesthetic appeal are percentage green cover and color, but they are difficult to measure objectively.

Color matching techniques such as those of Munsell or the Royal Horticultural Society (7), depend upon matching between small color plates and a uniformly colored surface such as a petal or leaf. These methods cannot easily be used for evaluation of a non-uniformly colored surface such as turfgrass, which requires an integration of different shades.

Correlations between the visual rating of the color and chlorophyll content have been reported (3, 6, 9, 10). Others have correlated visual color rating with reflected light from grasses. Two methods for measurement of light were used. One used a lightmeter with greatest sensitivity in the green band (maximum at 555 nm) (9). The second measured reflected light at 2 wavelengths, 675 nm (R) and 745 nm (FR), by a spectrophotometer and calculated the FR/R ratio (2). A high level of reflected light in the first method and low FR/R ratio in the second were correlated with a lighter green color. The methods proposed in all cited work are applicable only for established lawns with 100% green cover. Less mature, newly cut, droughted, or diseased lawns may have less than 100% cover. The reflected light curve from dead plant residue or bare soil is different from that of a fresh green canopy mainly in the infrared part of the spectrum (4, 5), and no simple method has been proposed to evaluate the differences.

The purpose of the present study was to evaluate methods for rating of green coverage and the color by means of light reflectance and chlorophyll content. Turfgrass species under examination were: kikuyugrass (Pennisetum clandestinum Hochst. cv. Chiov.); St. Augustin­grass (Stenotaphrum secundatum [Walt.] Kunze); Paspalum vaginatum Sw.; tall fescue (Festucu arundinacea Schreb. cv. Alta); centipedegrass (Eremochloa ophiuroides Munro) Hack.); bermudagrass (Cynodon dactylon [L.] Pers. cvs. Santa Ana and Suwannee); zoysiagrass (Zozia japonica var. Tenufolia Willid. ex. Trin. cv. Emerald); zoysiagrass (Zozia matrella [L.] Merr.); perennial ryegrass (Lolium perenne L.).

Cool season species (tall fescue and perennial ryegrass) were seeded and warm species were vegetatively propagated. Grasses were grown in polystyrene foam containers (27 cm deep, 26 cm long, and 21 cm wide) with the soil level 3 cm below the container edge. Regular weekly hand-shearing using pruning shears was carried out down to the level of the container rim, thus leaving a 3-cm layer of turfgrass. Within each treatment there were 4 replicate containers. Measurements of reflected light in the R (peak at 640 nm) and FR (peak at 732 nm) bands were taken with the IL 150 Plant Growth Photometer1 mounted horizontally 12 cm

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