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LEAF REFLECTANCE-NITROGEN-CHLOROPHYLL RELATIONS AMONG THREE SOUTH TEXAS WOODY RANGELAND PLANT SPECIES

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Leaf Reflectance-Nitrogen-Chlorophyll Relations Among Three South Texas Woody Rangeland Plant Species

Leaf reflectance within the 0.40- to 0.75-μm waveband is influenced primarily by chlorophyll (chl) pigments (2, 3, 13). Reflectance can be used to: evaluate turf color (3), estimate the nitrogen (N) status of sweet pepper leaves (14), measure amounts of biomass or vegetation density (15, 16), and demonstrate leaf spectral and color-infrared film image differences among shrubs and woody plant species (5, 8, 9).

Leaf reflectance measurements have not been used to estimate the N or chl status of rangeland plants. A pilot study (7) indicated that leaf N concentration of six of seven rangeland species decreased as the season progressed from March to June or October. Visible light reflectance at the 0.55-μm wavelength of five of these species decreased as N concentration decreased; reflectance at this wavelength is affected by chl concentration (13). In crop plants the leaf visible light reflectance increased (decreased chl) and was inversely correlated with leaf N concentration (2, 13). This difference between rangeland and crop plants may have been caused by variation in leaf maturation or senescence (11), effects of salinity on leaf chl concentration (6), or chl may have a different dependence on leaf N content (14).

Our objective, therefore, was to make additional reflectance measurements to further evaluate their possible use to predict leaf N concentrations of three highly important south Texas rangeland woody plant species. The capability to estimate leaf N concentration using reflectance measurements would be a quick method of evaluating forage protein (N x 6.25) content, which is highly important for livestock and wildlife production.

MATERIALS AND METHODS

Three woody plant species common on south Texas rangelands, nomenclature after Correll and Johnston (4), were used in this study: Hackberry (*Celtis laevigata* Willd.), honey mesquite (*Prosopis glandulosa* Torr. var.), and live oak (*Quercus virginiana* Mill.). Hackberry is a major species on bottomland range sites. Live oak is abundant on deep sands and grows in formations ranging from dense, uniform stands to frequent thickets or motts in underbrush. Honey mesquite is a dominant species throughout the area and grows on a variety of sites (deep sands, sandy loams, clay loams, heavy clays).

Leaves of these species were collected once during spring (March) and once during summer (July) to measure their spectral reflectance and to determine their chl and N concentrations. Leaves from each of 12 trees of each species were collected from all portions of tree canopies for both spring and summer measurements. Detached leaves were thoroughly mixed and enclosed immediately in air-tight plastic bags and stored on ice to minimize dehydration during transport to the laboratory.

At each collection, two leaves from each of the 12 trees of each plant species were used to measure spectral reflectance. Total leaf chl and N concentrations (10) were determined in duplicates for each of the 12 trees of each species. The means of these measurements and determinations were used to represent each tree of each species.

Total diffuse reflectance of upper (adaxial) surface of single leaves over the 0.4 to 0.7-μm visible light waveband was measured with a Beckman Model DK-2A spectrophotometer, equipped with a reflectance attachment. (Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the USDA over others that may be commercially available.) These data have been corrected for decay of the barium sulfate standard to give absolute radiometric data (1). Reflectance data given in this study are for the 0.55-μm wavelength because it is most sensitive to a change in leaf reflectance caused by a difference in pigment concentration (13).

The t-test (12) was used to test statistical differences between means of leaf N and between leaf chl concentrations for spring and summer for each of the three plant species. Linear correlations of reflectance with leaf N and chl and N with chl were calculated. Deviations from linear regression were also tested.

RESULTS AND DISCUSSION

Leaf Reflectance

The mean reflectance value for the limey-green colored leaves of the three woody plant species during spring was 16.4%. Leaf reflectance among the plant species showed that hackberry (17.6%) and mesquite (17.0%) were significantly higher than live oak (14.6%). In summer, the plant species leaves, which had become darker green, absorbed more light, thus significantly ($p = 0.01$) reducing the three species' mean reflectance value to about 8.1%–a reflectance decrease of 50.6% from spring to summer. In summer leaf reflectance of hackberry (8.0%) and mesquite (7.1%) were significantly lower than that of live oak (9.3%).

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Leaf N and Chl Concentrations

Table 1 shows both spring and summer leaf N and chl concentrations of the three woody plant species. Mesquite and hackberry had 94 and 37% higher N concentration in the spring and 132 and 84% higher N concentration in the summer, respectively, than did live oak. Leaf N concentrations of hackberry, mesquite, and live oak decreased 34, 41, and 50% from spring to summer, respectively.

Table 1. The leaf nitrog: : (:', and total chlorophyll (chl) concentration of the three woody :' ,nt species during the spring (March) and summer (July) of 1979.

Species	Nitrogen Spring	Nitrogen Summer	Diff.	Chlorophyll Summer	Chlorophyll Spring	Diff.
	..........%	....		..........Mg/g	....	
Hackberry	3.93	2.61	1.32*	2.91	1.78	1.13*
Live Oak	2.87	1.42	1.45*	1.73	1.01	0.72*
Mesquite	5.57	3.29	2.28*	2.28	0.90	1.38*
Mean	4.12	2.44		2.31	1.23	

* Significant at the 1% probability level.

Leal chl concentration was highest for hackberry in both spring and summer. Hackberry leaves had 68 and 28% higher leaf chl concentrations than did live oak and mesquite in summer, respectively; whereas, in spring, leaf chl concentrations were 76 and 98% higher, respectively. From spring to summer, leaf chl concentrations of hackberry, mesquite, and live oak increased 63, 71, and 153%, respectively.

Leaf Reflectance vs N and Chl Concentrations

Linear correlations of reflectance with N and chl, and N with chl were not statistically significant (p = 0.05) for the three species in the spring, except for hackberry which had a 0.38 coefficient of determination for the correlation of reflectance with N. The other coefficients of determination were below 0.19. In summer, no correlations were statistically significant (p = 0.05) for any of the three woody plant species. The coefficients of determination were all below 0.31. The deviations from linear regression were not statistically significant.

The relationship between leaf reflectance and leaf N and chl concentrations, however, showed that the leaf reflectance was positively related to leaf N concentration and inversely related to leaf chl concentration. For example, during spring leaf reflectances and N concentrations were high but leaf chl

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concentrations were low; whereas, in summer leaf reflectances and N concentrations were low but chl concentrations were high. These findings substantiated results from our previous pilot study (7) since woody species' leaf N concentrations do not agree with crop plant results where reflectance was inversely correlated with leaf N concentration (14). However, according to our results, leaf spectral reflectance measurements cannot be used to predict leaf N concentration for woody plant species.

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