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REFLECTANCE OF LITTER ACCUMULATION LEVELS AT FIVE WAVELENGTHS WITHIN THE 0.5- TO 2.5-μm WAVEBAND

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16. Abstract
Reflectance was measured for 1-m^2 range grass plots with two canopy treatments (standing and clipped) and four levels of litter accumulation and for grain sorghum with two canopy treatments. Reflectance was significantly higher at the 0.65- to 1.65-, and 2.20- μm wavelengths for both grass and grain sorghum canopies when the canopies were clipped and the resulting litter was removed. The natural accumulation of litter under the grass canopy did not significantly affect reflectance. The 1.65- and 2.20- μm wavelength reflectances of the live grass and the intact litter were 21.8% and 16.2%, respectively, and those of grain sorghum were 21.8% and 16.5%, respectively.

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REFLECTANCE OF LITTER ACCUMULATION LEVELS AT FIVE WAVELENGTHS WITHIN THE 0.5- TO 2.5- μm WAVEBAND

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Reflectance of Litter Accumulation Levels at Five Wavelengths Within the 0.5- to 2.5-μm Waveband

The quantity of biomass on the soil surface is important to a range or farm manager in determining the capacity or duration of a grazing period and protecting the soil from water and wind erosion. The deduction of biomass levels from reflectance measurements would allow the range manager to base grazing decisions on data that are more current, more representative of the area being grazed, and that are available in a more timely manner than is possible with conventional methods. Data with these attributes would reduce the odds that the range would sustain damages due to overgrazing.

Pearson and Miller (5) found that over the 0.35- to 0.80-μm waveband, percent reflectance increased as biomass decreased, bare soil had a higher reflectance than dead vegetation, and green vegetation had a lower reflectance than either the bare soil or the dead vegetation.

Leamer et al. (3) reported that bare soil had a higher reflectance than green vegetation at all wavelengths (WL) between 0.50 and 2.50 μm except those between 0.75 and 1.30 μm, at which green vegetation had higher reflectances. The important WL for determining percent cover for two wheat cultivars from reflectance data were 0.65 to 0.75, 0.90, 1.10, 1.65, and 2.2 μm. However, the linear correlation coefficients for the relation between percent cover and reflectance at the 1.65- and 2.20-μm WL were higher than those at other WL throughout more of the growing season.

Gausman et al. (2) reported that for five out of six crops reflectance differences between dead leaves and bare soils were greatest for WL from 0.75 to 1.35 μm.

Standing sugarcane residue (sugarcane killed by frost) and soil were less reflective than bare soil or soil covered with littered residue (1). The standing sugarcane residue was less reflective than the littered residue because of shadows in the field of view.

Our main objective was to determine the effect of plant litter accumulations beneath perennial grass canopies on reflectances at the 0.55-, 0.65-, 0.85-, 1.65-, and 2.20-μm WL.

MATERIALS AND METHODS

A coastal range site located on a Galveston sand (Typic Udipsamments) with a native vegetation canopy consisting mainly of the bunch grass seascoast blue stem *(Andropogon scoparies* var. *lilloralis)* was selected for one study site. The site had not been grazed for about 20 years and a large quantity of litter had built up between the soil surface and the grass canopy.

A randomized complete block design, replicated four times, with four treatments applied to each of four 1-m^2 plot areas was used. Treatments and order of application were: (1) live vegetation and litter intact (LLI); (2) live vegetation intact, with one-half of litter removed (LIHLR); (3) live vegetation intact, with all litter removed (LIALR); and (4) live vegetation clipped, with litter and live vegetation removed (LLR) (Fig. 1).

Reflectance spectra for all studies were taken with an Exotech Model 20 field spectroradiometer (3). (Mention of company or trademark is for the reader's benefit and does not constitute endorsement of a particular product by the U. S. Department of Agriculture over others that may be commercially available.) One spectrum each for incoming and outgoing radiation was taken for each treatment on each plot; 60 seconds were required to complete both spectra. Reflectance readings were taken from a circular area about 30 cm in diameter within each 1-m^2 plot by positioning the instrument directly over the center of the plots at a height of 1 m above ground. Reflectance measurements were made during the same time period (1030-0230) each day. Outgoing radiation was ratioed to incoming radiation to calculate percent reflectance.

An F ratio was calculated for each of five WL (0.55, 0.65, 0.85, 1.65, and 2.20 μm) to test for significance among treatment means, and means for each wavelength were compared with Duncan's multiple range test ($p = 0.05$).

The 3 canopy components, inflorescences and stems, standing green, and standing brown biomass were determined by clipping the canopy at ground level in 20 quadrats (each 50 cm by 50 cm) and separating the clippings into the 3 components. The 20 quadrats were located next to the 1-m^2 areas used for making canopy reflectance measurements.

The other study site was four 1-m^2 plot areas planted to grain sorghum [*Sorghum bicolor* (L.) Moench] on Hidalgo sandy clay loam (Typic Calciustolls). The plants emerged about September 21, 1978, with populations of 228, 261, 270, and 300 plants/plot.

Reflectance was measured on October 18, 1978, when the plants were about 30 cm tall. After reflectance of plants was measured, the plants were clipped and removed from the plot area. The reflectance of the remaining stubble and the now-exposed dry, crusted soil surface was then measured.

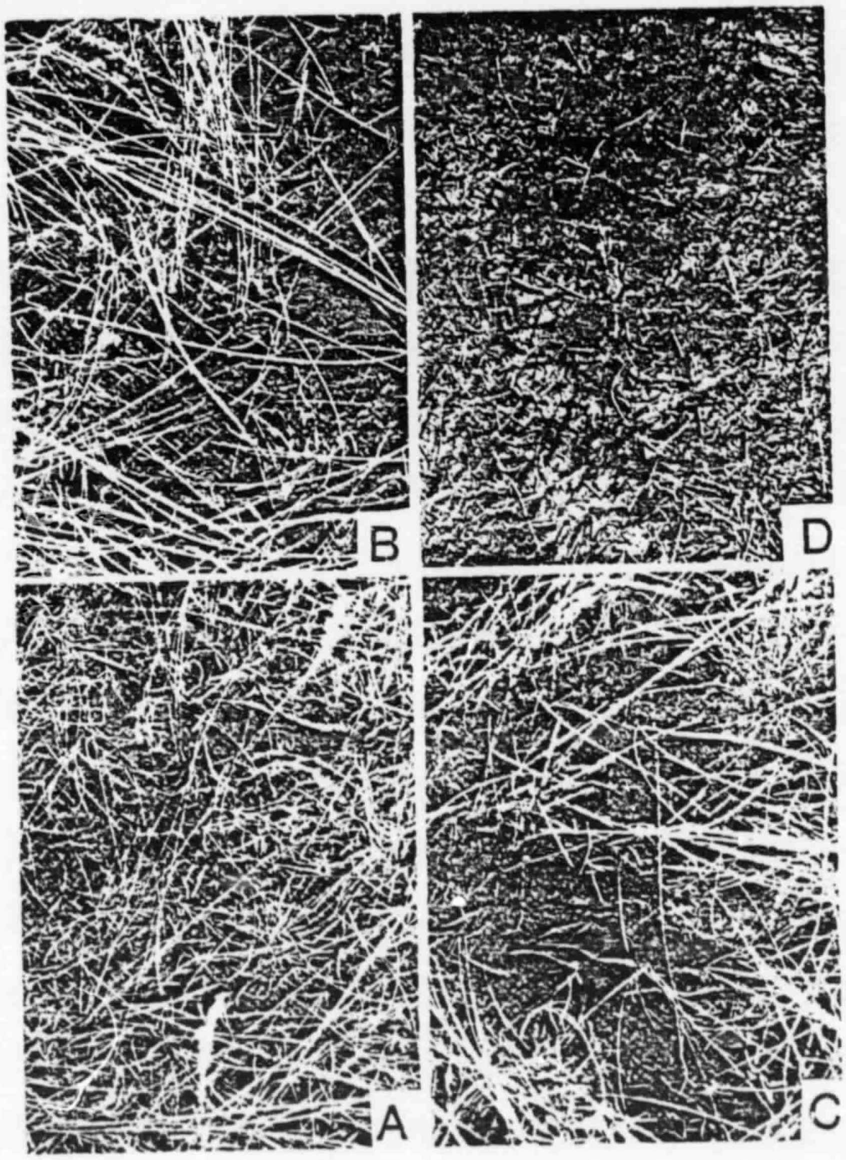

Fig. 1. Grass plot, showing the four treatments: A - live vegetation and litter intact (LLI); B - live vegetation intact, one-half of litter removed (LIHLR); C - live vegetation intact, all litter removed (LIALR); D - live vegetation clipped, with clipping and litter removed (LLR).

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Student's t test ($p = 0.01$) was used to compare reflectance means for plants with those for stubble and exposed soil at the 1.65- and 2.20-μm wavelengths (6).

RESULTS AND DISCUSSION

The appearance of the 1 m^2 grass plots on the coastal sand range site is shown in Fig. 1.

Reflectance spectra associated with the four treatments (LLI, LIHLR, LIALR, LLR) applied to the 1-m^2 plots on the coastal sand range site for the 0.50- to 0.70-μm, 0.75- to 1.30-μm, 1.50- to 1.75-μm, and 2.00- to 2.50-μm wavebands are shown in Fig. 2. The LLR treatment had the highest reflectance for all except the 0.75- to 0.90-μm portion of the 0.75- to 1.30-μm waveband, in which it

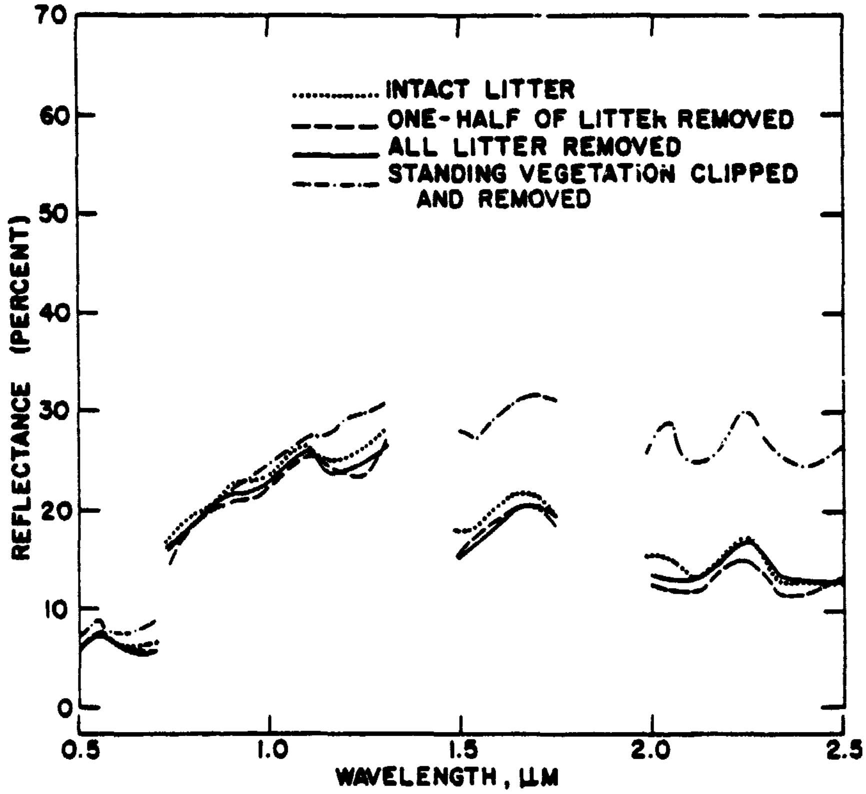

Fig. 2. Spectrophotometrically measured reflectances for the four grass plot treatments: LLI - live vegetation and litter intact; LIHLR - live vegetation intact, one-half of litter removed; LIALR - live vegetation intact, all litter removed; LLR - live vegetation clipped, with clipping and litter removed.

was lower than or equal to the other treatment reflectances. Resulting spectra were as expected, except for the 0.75- to 1.30-μm waveband, for which the reflectance spectra in the 0.75- to 1.10-μm waveband were expected to be much higher, similar to those of live wheat plants (3). However, the vegetation spectra resembled the spectrum for bare soil. The standing vegetation biomass that was clipped, removed from the plots, and oven dried was 29.1% inflorescences and stems, 26.4% standing brown biomass, and 44.5% standing green biomass. It is speculated that the 55.5% nongreen biomass (29.1% inflorescences and stems, and 26.4% standing brown biomass) and shadows (Fig. 1) caused the reflectance for this waveband to be low. This conclusion is supported by the work of Gausman et al. (2), in which dead leaves did not have the characteristically high reflectance of live vegetation in this waveband.

The reflectance levels for vegetation in the 1.10- to 1.30-μm waveband were expected to be similar to those for LLR treatment (Fig. 2) and those for crop residues (1). However, they resembled the spectra for live wheat plants (3).

The 44.5% green biomass probably absorbed sufficient radiation to cause this decrease in reflectance. This is supported by Myers et al. (4), who showed that as leaves are stacked deeper over the spectrophotometer's port, the rate of absorptance for the 1.20-μm WL is higher than that for the 1.10- and 1.30-μm WL's.

The F ratios for 0.65-, 1.65-, and 2.20-μm WL's were significant ($p = 0.05$), while those for the 0.55- and 0.85-μm WL's were not.

Duncan's multiple range test indicated that the reflectance mean for the LLR treatment was higher than and different from all other means, which were alike (Table 1). This was true for all WL with significant F ratios. Since reflectance means for the LLI, LIHLR, and LIALR treatment were statistically alike, it is highly probable that the litter accumulation had no effect on reflectances, and when the quantity (50% or more) of shadow present within the plot area (Fig. 1) is considered, it seems likely that shadows caused reflectances for the three treatments to be alike. For the 0.65-μm WL, Pearson and Miller (5) and Leamer et al. (3) attributed this result to the very efficient absorption of incident radiation by the vegetation, causing a lower reflectance.

The decrease in reflectance for the 1.65- and 2.20-μm WL was also observed by Leamer et al. (3), who attributed this decrease chiefly to a lower-reflecting vegetative canopy that obscured a higher-reflecting soil background. Shadows and plant water contents were also contributing factors.

The calculated t values for the 1.65- and 2.20-μm WL's indicated that reflectances for clipped grain sorghum plots were significantly ($p = 0.01$) higher than those for unclipped plots (Table 2). These results are also attributed chiefly to a low-reflecting vegetation canopy that obscured a high-reflecting soil surface, along with the influence of shadows.

The percent reflectances at the 1.65- and 2.20-μm WL's of grass plots with the LLI treatment were 21.8% and 16.2%, respectively, while those of plots with a grain sorghum canopy were 21.8% and 16.5%, respectively. Therefore, it appears that the species and condition (green or semigreen) of the vegetative canopy did not influence the reflectances for these two WL's.

The shape of the reflectance curve for the 2.00- to 2.50-μm waveband differed widely for the LLR grass plots and for the clipped sorghum plots. The curve for the LLR grass plots was bimodal (Fig. 2), whereas the curve for the clipped grain sorghum plots was bell shaped, with low reflectances for the 2.00- and

Table 1. Percent mean reflectances measured at 3 wavelengths for a grass canopy with 3 levels of litter established under the canopy and for grass canopy clipped with clipping and litter removed.

Treatment	Wavelengths		
	0.65 µm	1.65 µm	2.20 µm
		(Percent)	
LLR^z	7.68 a^y	30.98 A	27.55 A
LLI	6.27 b	21.85 B	16.02 B
LIHLR	5.72 b	20.52 B	15.30 B
LIALR	5.6[illegible] b	20.38 B	14.73 B

^{y} Significant at the 0.05 or 0.01 levels, respectively. All percent mean reflectances followed by a common letter are not significantly different.

^{z} LLR–live vegetation clipped, with clipping and litter removed;
LLI–live vegetation and litter intact;
LIHLR–live vegetation intact, one-half of litter removed;
LIALR–live vegetation intact, all litter removed.

Table 2. Percent mean reflectances measured at 3 wavelengths for a sorghum canopy and for sorghum stubble.

Treatment	Wavelengths		
	0.65 µm	1.65 µm	2.20 µm
		(Percent)	
Canopy	18.5	29.4	30 48
Stubble^z	17.7	21.9	16.45
Found t^y	0.82NS	7.33*	21.93*

^{z} Canopy clipped with clippings removed.
^{y} Required $t_{.05(6)} = 2.45$
* = Significant at the 0.05 level. NS = Not significant.

2.50-µm WL and a high reflectance for the 2.30-µm WL. The differences between these spectra were probably due to a moderate wetness of the soil surface and a dark, decaying organic residue remaining on the stubble after the removal of the grass canopy and litter.

Reflectances at 1.65- and 2.20-µm WL were higher from plots where the canopy was clipped and the litter was removed than from plots with vegetation and litter. Species (grain sorghum or grass) or condition (green or semigreen) of the canopy had no significant effect on the level of reflectance for these two WL.

The level of litter that accumulated between the plant canopy and the soil surface had no effect on level of reflectance at the 0.65-, 1.65-, and 2.20-μm WL. More research is needed to satisfactorily account for the unusual reflectance spectra for grass canopy and litter in the 1.10- to 1.30-μm waveband and for that associated with the *LLR* treatment in the 2.00- to 2.50-μm waveband.

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LITERATURE CITED

1. Gausman, H. W., A. H. Gerbermann, C. L. Wiegand, R. W. Leamer, R. R. Rodriguez, and J. R. Noriega. 1975. Reflectance differences between crop residue and bare soils. Soil Sci. Amer. Proc. 39:752-755.
2. Gausman, H. W., R. R. Rodriguez, and C. L. Wiegand. 1976. Spectrophotometric reflectance differences between dead leaves and bare soil. J. Rio Grande Valley Hort. Soc. 30:103-107.
3. Leamer, R. W., J. R. Noriega, and C. L. Wiegand. 1978. Seasonal changes in reflectances of two wheat cultivars. Agron. J. 70:113-118.
4. Myers, V. I., C. L. Wiegand, M. D. Heilman, and J. R. Thomas. 1966. Remote Sensing in Soil and Water Conservation Research. Proc. Fourth Symp. on Remote Sens. of Environ. pp. 801-813.
5. Pearson, R. L., and L. D. Miller. 1972. Remote mapping of standing crop biomass for estimation of the productivity of the short-grass prairie, Pawnee National Grassland, Colo. Proc. 8th Intl. Symp. Remote Sens. Environ. pp. 1355-1379.
6. Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York. 481 p.
7. Stewart, G., and S. S. Hutchins. 1936. The point observation-plot (square foot density) method of vegetation survey. Amer. Soc. Agron. J. 28:714-726.