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The Determination of Greenness Indices and the Relationships Between Greenness and Leaf Area Index and Total Dry Weight of Seven Crops

by

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INTRODUCTION

Leaf area index (LAI) and total dry weight (DWT) are used often by researchers for monitoring and recording crop growth and development. Field measurement of LAI and DWT is tedious and time consuming, sample dependent, and subject to sampling biases. Overall LAI and DWT are especially difficult to estimate for non-uniform crop stands. Remote sensing techniques have potential for non-destructive estimation of crop growth parameters such as LAI and DWT that would require less labor and time, be subject to fewer sampling errors, and could be applied to large geographical areas.

Some research has already been conducted to determine the relationships between satellite-, air-, and ground-based spectral data (including data from a wide variety of electromagnetic wavebands and linear combinations of these data) and various crop growth parameters. Each study has suggested various methods of spectral data transformation. The idea of a four-dimensional "greenness index" involving LANDSAT multispectral scanner (MSS) data was developed by Kauth and Thomas (1976). Since then, greenness indices for ground-based reflectance data have been developed over wheat (*Triticum aestivum* L.) canopies (Rice et al., 1980; Jackson, 1983).

The purpose of this study was to apply the greenness concept to ground-based reflectance data taken over seven crops (sweet and field corn (*Zea mays* L.), grain sorghum (*Sorghum bicolor* (L.) Moench.), pearl millet (*Pennisetum americanum* L.), pinto bean (*Phaseolus vulgaris* L.), soybean (*Glycine max* (L.)

Merr.), and sunflower (*Helianthus annus* L.)) near Manhattan, Kansas in 1981 and 1982 to determine reflectance data-LAI and DWT relationships, and to see if these relationships were crop-specific or could be more generally applied to several crops.

LITERATURE REVIEW

Leaf area index (LAI) is the ratio of the total leaf area of a plant canopy to the land area on which that canopy is growing. Leaf area index is used in crop models for estimation of yield (Hodges et al., 1979), dry matter accumulation (Heilman et al., 1976; Hodges et al., 1979), evapotranspiration, photosynthesis, plant vigor, disease, soil salinity, and moisture stress. Field measurement of LAI is tedious and time consuming. Leaf area index measurements are very sample dependent, so are subject to biases in sample selection or error due to non-uniform crop stands. Remote sensing techniques have potential for non-destructive LAI estimates that would require less labor and time, be subject to fewer sampling errors, and could be applied to large geographical areas.

Reflectance and radiance measurements in the visible and near-infrared regions of the electromagnetic spectrum are indicative of the amount of vegetation present (Blair and Baumgardner, 1977). Low spectral reflectance and radiance (high absorptance) in the visible region of the spectrum (0.4 - 0.7 μm) is due to absorption by leaf pigments (primarily the chlorophylls, but carotenoids, xanthophylls, and anthocyanins also have an effect) and is inversely related to the *in situ* chlorophyll density (Gates et al., 1965; Tucker et al., 1975). High spectral reflectance and radiance in the near-infrared (0.7 - 1.3 μm) is due to the refractive index discontinuities among cell structures in leaves (Gausman, 1977) and is directly related to green leaf density (Gates et al., 1965; Tucker et al., 1975).

At any given wavelength, once asymptotic levels of spectral reflectance or radiance have been reached, further increases in the vegetational density or biomass will have no change on the canopy spectral properties at that wavelength. This is because the canopy is of sufficient density and thickness to prevent penetration of incident spectral irradiance with additional (and canopy lower level) biomass. The contribution of the soil spectra to the total (soil + vegetation) spectra is then minimal at that wavelength (Tucker and Miller, 1977). This asymptotic spectral reflectance or radiance is reached at two to three times lower levels of vegetation (LAI, fresh biomass, dry biomass, etc.) in the 0.63 to 0.69 μm (red) region than in the 0.75 to 1.00 μm (near-infrared) region (Tucker, 1977).

Various linear combinations and ratios of spectral reflectance or radiance data have been used to estimate such crop growth parameters as LAI, fresh and dry biomass, percent soil cover, and intercepted photosynthetically active radiation. Jordan (1969) used a ratio of 0.8 um/0.675 μm energy reaching a forest floor to determine the LAI of forest canopies. Colwell (1974) concluded that a ratio of near-infrared/red radiance somewhat normalized the effect of soil background spectral differences. Holben et al. (1980), relating red and near-infrared radiances and several crop growth parameters of soybean, found the most significant correlation to be between the near-infrared/red ratio and green wet leaf biomass, green dry leaf biomass, and green LAI ($r = 0.93$, 0.92, and 0.92, respectively).

Most of the work relating spectral properties of a crop canopy to crop growth has used satellite-collected data from the LANDSAT multispectral scanners (MSS) or data from spectroradiometers (ground- or air-based) that stimulate the MSS wavebands. Multispectral scanner wavebands are those four spectral regions shown in Fig. 1 as bands MSS4 (0.5 - 0.6 µm), MSS5 (0.6 - 0.7 µm), MSS6 (0.7 - 0.8 µm), and MSS7 (0.8 - 1.1 µm). Kanemasu (1974) found a reflectance ratio of MSS4/MSS5 to be better at indicating crop growth than the MSS6 reflectance using ground-based data collected from wheat, sorghum, and soybean. Wiegand et al. (1973) had LANDSAT MSS5 and MSS6 data collected over cotton (*Gossypium hirsutum* L.), sorghum, and corn. They found band 6 alone to be superior to the MSS5/MSS6 ratio and the (MSS6 - MSS5) difference at correlating with LAI of mature sorghum and corn. The sorghum and corn data were combined since a single linear relation fit both crops. A quadratic relation using the (MSS6 - MSS5) difference was the best indicator of cotton vegetation density. Maxwell (1976) found the most significant variables for monitoring rangeland were the MSS7/MSS5 ratio or the MSS5 data. The ratio reduced random frustrations caused by source variations and atmospheric conditions. Pollock and Kanemasu (1979) used LANDSAT data in an emperical model derived by Kanemasu et al. (1977):

$$LAI = 2.677 - 3.694(MSS4/MSS5) - 2.309(MSS4/MSS6) + 5.751[MSS4/(2 \times MSS7)] + 0.43(MSS5/MSS6) - 2.692[MSS5/(2 \times MSS7)] + 3.071\{(MSS4/MSS5) - [MSS4/(2 \times MSS7)][MSS4/MSS5]\}$$

where MSS4, MSS5, MSS6, and MSS7 represent LANDSAT MSS data for each corresponding waveband, to estimate leaf area in Kansan wheat

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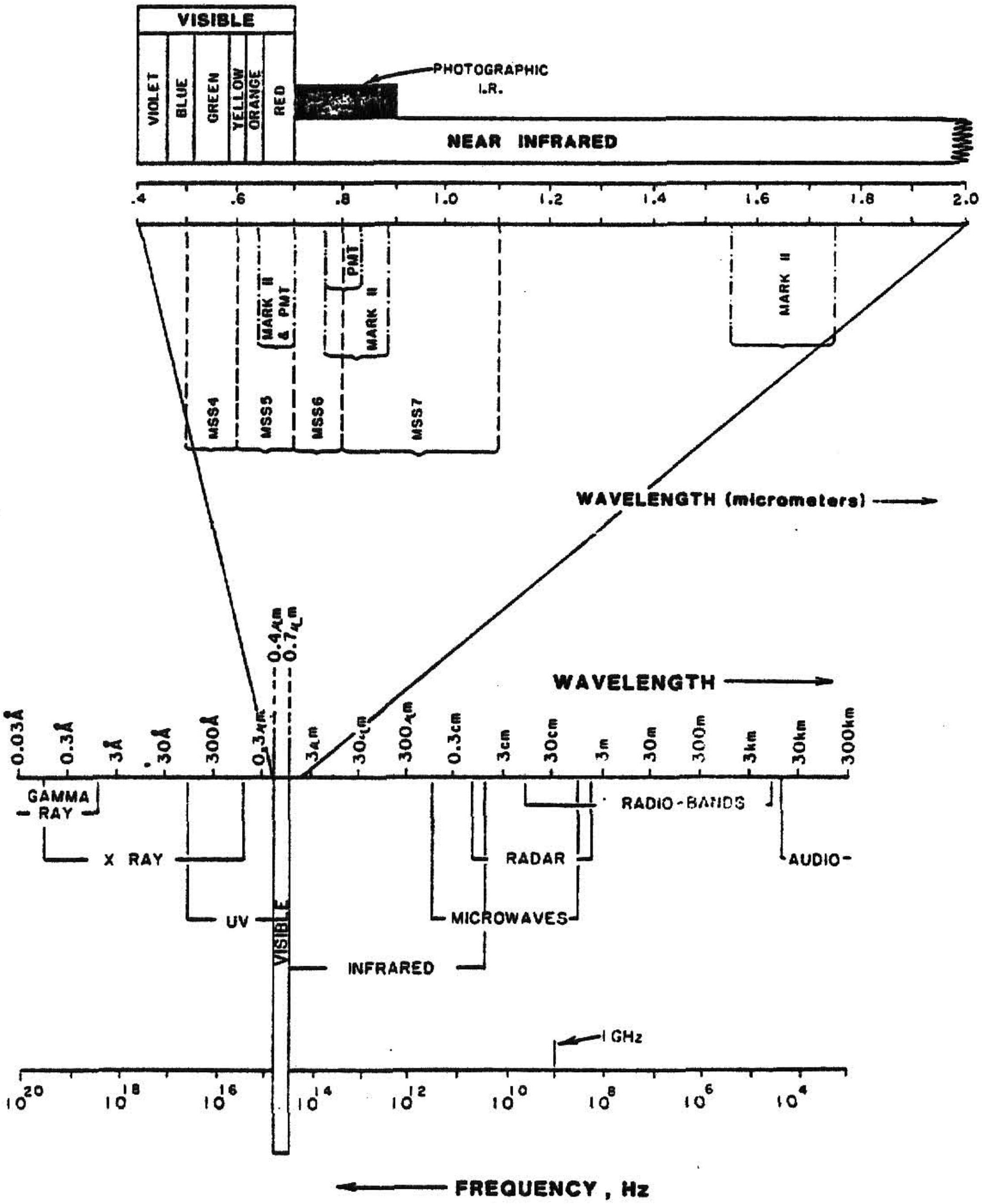


Fig. 1. The electromagnetic spectrum (from Jackson et al., 1980).

fields. They found that their model worked well for LAI values above 0.5 and poorly at values below 0.5 (overall $R^2 = 0.68$).

Rouse et al. (1973), using LANDSAT-1 MSS5 and MSS7 radiance data, developed the "band ratio parameter" (BRP), later termed the "vegetation index" (VI).

$$VI = (MSS5 - MSS7)/(MSS5 + MSS7)$$

This normalization procedure was used to eliminate seasonal sun angle differences and to minimize the effect of atmospheric attenuation. To avoid working with negative values and the possibility that the ratio variance would be proportional to the mean values, they developed the "transformed vegetation index" (TVI).

$$TVI = (VI)^{0.5} + 0.5$$

There was a high correlation between TVI and moisture content ($R^2 = 0.99$) and green biomass of vegetation ($R^2 = 0.89$) (Rouse et al., 1973). Ashley and Rea (1975), monitoring forested and agricultural areas of the eastern United States, found the VI represented seasonal vegetational changes better than the individual MSS5 or MSS7 data. The VI increased with increases in foliage and decreased with senescence.

Kauth and Thomas (1976) transformed LANDSAT MSS four band data into linear combinations representing four orthagonal unit vectors in four space. The four transformations or indices developed were "soil brightness" (SBI), "greenness" (GVI), "yellowness" (YI), and "non-such" (NS).

$$SBI = 0.433(MSS4) + 0.632(MSS5) + 0.586(MSS6) + 0.264(MSS7)$$

$$GVI = -0.290(MSS4) - 0.562(MSS5) + 0.600(MSS6) + 0.491(MSS7)$$

$$YI = -0.829(MSS4) + 0.522(MSS5) - 0.039(MSS6) + 0.194(MSS7)$$

$$NS = 0.223(MSS4) + 0.012(MSS5) - 0.543(MSS6) + 0.810(MSS7)$$

The SBI is that area of 4-space in which soil data are found. The value derived from the greenness index (GVI), or greenness value, for a given vegetation point in 4-space, would be the orthogonal distance from the vegetation point to the soil space, and is indicative of the amount of green vegetation present. Shifts in yellowness and non-such are diagnostic of the physical state of the atmosphere (Kauth and Thomas, 1976). Jackson et al. (1983) showed that yellowness and non-such are essentially independent of vegetational changes and that yellowness is sensitive to haze conditions and non-such is sensitive to water vapor absorption.

Soil brightness and greenness indices were used by Thompson and Wehmanen (1979) to develop the "green index number" (GIN) which was effective in monitoring water stress over large areas of semi-arid wheat-growing regions in Australia and the U. S. S. R. Badwar and Thompson (1983) developed a model using LANDSAT MSS data and the spectral greenness of Kauth and Thomas (1976) to estimate spectral emergence of small grains at the pixel (field) level.

Richardson and Wiegand (1977) developed two-dimensional indices to describe LANDSAT red (MSS5) and near-infrared (MSS6 or MSS7) data. They found that data for bare soil, cloud tops, and cloud shadows followed a highly predictable linear relation (soil background lines) when MSS5 and MSS6 data were plotted ($R^2 = 0.986$) or when MSS5 and MSS7 data were plotted ($R^2 = 0.974$). Vegetation data collected over sorghum were found to lie away from the soil line. The perpendicular distance from a vegetation point to the soil line was indicative of the amount of vegetation present (measured as LAI). They developed two "perpendicular vegetation indices".

$$PVI = \left[(Rgg5 - Rp5)^2 + (Rgg7 - Rp7)^2\right]^{0.5}$$

$$PVI6 = \left[(Rgg5 - Rp5)^2 + (Rgg6 - Rp6)^2\right]^{0.5}$$

where Rp represents the reflectance of a candidate vegetation point for LANDSAT band MSS5, MSS6, or MSS7 and Rgg is the soil background reflectance corresponding to the candidate vegetation point. The highest correlation was between MSS6 data and LAI ($r = 0.877$). Correlations of LAI with vegetation indices were highest for PVI6 ($r = 0.812$) and GVI ($r = 0.808$). They concluded that vegetation indices are more capable of making temporal (season-to-season) comparisons of vegetation amounts and conditions than independent waveband data (Richardson and Wiegand, 1977).

Deering (1978) reported the VI6 and TVI6 (VI and TVI calculated using MSS6 in place of MSS7) were slightly more significant with respect to green biomass of rangeland than PVI or GVI. Wiegand et al. (1979) found TVI, GVI, and PVI to all be significantly linearly correlated ($r = 0.70$ to 0.95) with measured LAI of winter wheat from LAI $\cong 0.3$ until senescence.

Tucker (1979) compared the capability of various ratios and indices using green and red bands with similar ratios and indices using near-infrared and red bands and found the near-infrared-red combinations to be much more significantly related to crop growth parameters of grass than the green-red combinations. Aase and Siddoway (1980) reported that the vegetation indices of VI, VI6, PVI, and PVI6 provided more adequate year-to-year comparisons of winter wheat vegetation amounts and conditions than simple ratios or individual MSS bands. All indices were linearly related to LAI and leaf dry matter and adequately delineated differences in ground cover (stand densities) to determine winterkill and make decisions concerning the necessity for reseeding of spring grains in Montana.

Aase and Siddoway (1981) also showed that general relationships existed between seasonal dry matter accumulation of winter wheat and the vegetation indices through the end of tillering, but after tillering, the relationships collapsed due to increased contribution to the dry weight by non-leafy material (stem, head, grain, etc.).

Soil brightness and greenness indices similar in form to those of Kauth and Thomas (1976) but using ground-based reflectance data for wheat rather than LANDSAT MSS digital counts were developed by W. A. Malila and J. Gleason in 1977 and first published by Rice et al. (1980). These indices are called "reflectance brightness" (RBI) and "reflectance greenness" (RGI):

$$RBI = 0.32362(RF_1) + 0.48521(RF_2) + 0.56304(RF_3) + 0.60949(RF_4)$$

$$RGI = -0.48935(RF_1) - 0.61249(RF_2) + 0.17289(RF_3) + 0.59538(RF_4)$$

where RF_1, RF_2, RF_3, and RF_4 represent reflectance factor data for radiometer bands corresponding to MSS4, MSS5, MSS6, and MSS7 wavebands. These indices were later applied to soybean to develop temporal-spectral profile models and to study vegetation detection thresholds (Rice et al., 1980).

For Kollenkark et al. (1982), soil color and moisture strongly affected ground-collected soybean canopy reflectance data corresponding to the individual MSS wavebands. The near-infrared/red reflectance ratio and the reflectance greenness (RGI) were less affected than the individual bands by changes in soil background. Leaf area index and percent soil cover were more highly related to the ratios and greenness than either fresh or dry biomass and the relations determined relating growth parameters to reflectance greenness were:

$$\% \text{ soil cover} = -12.79 + 5.47(RGI) - 0.065(RGI)^2 \qquad R^2=0.98$$

$$LAI = 0.143 + 0.02(RGI) + 0.0046(RGI)^2 \qquad R^2=0.86$$

$$\text{total fresh biomass} = 89.59 - 16.07(RGI) + 3.99(RGI)^2 \qquad R^2=0.81$$

$$\text{total dry biomass} = 28.13 - 7.476(RGI) + 0.986(RGI)^2 \qquad R^2=0.74$$

They also found that greenness increased asymptotically once LAI values reached 5.0 for soybeans. Greenness is better correlated with LAI and soil cover than fresh or dry biomass because LAI and soil cover are primarily functions of the green leaves of a canopy. Total fresh and dry biomass are functions of the green leaves as well as stems, pods, seeds, and other plant structures that are not spectrally detectable (Kollenkark et al., 1982).

Hatfield et al. (1982b) related reflectance greenness and the MSS7/MSS5 reflectance ratio to LAI in multiple planting date and irrigation frequencies in wheat. There were more variations in the relationship of the ratio to LAI over differing planting dates and irrigation frequencies. Greenness values saturated and plateaued for LAI values above 4 and did not return to the origonal bare soil level after complete senescence. Hatfield et al. (1982a) found a better relationship between reflectance greenness and intercepted photosynthetically active radiation than between greenness and LAI in wheat, although separate models were needed for the growth phase and the senescence phase of the growing season.

Daughtry et al. (1983) compared the abilities of reflectance greenness and LAI to estimate solar radiation intercepted (SRI) and found that reflectance greenness was able to estimate SRI better than LAI. Greenness increased asymptotically for LAI values above approximately 5. Since 90% of the incoming solar radiation should be intercepted by corn canopies once LAI reaches approximately 3.0 (Linvill et al., 1978), the importance of accurately estimating LAI greater than 5.0 for corn canopies is diminished. Greenness estimated SRI was then used in a model involving meteorological data to estimate corn yields with $R^2 = 0.68$ (Daughtry et al., 1983).

Jackson (1983) described a method for calculating the coefficients for n-space indices by using an approach similar to that of Kauth and Thomas (1976). To calculate soil brightness and greenness coefficients for reflectance measurements, only three data points are required: one reflectance measurement taken over wet bare soil, one over dry soil, and one over green vegetation. He demonstrated his method by determining reflectance brightness and greenness for wheat.

$$\text{Jackson's RBI} = 0.3285(RF_1) + 0.3731(RF_2) + 0.5779(RF_3) + 0.6473(RF_4)$$

$$\text{Jackson's RGI} = -0.4480(RF_1) - 0.6896(RF_2) + 0.0670(RF_3) + 0.5650(RF_4)$$

Though this greenness index and that published by Rice et al. (1980) were determined over wheat canopies, and most of the work relating greenness values to crop growth parameters involved wheat, some applications have been made to soybean and corn (Rice et al., 1980; Kollenkark et al., 1982).

An understanding of the reflectance properties of the leaves of different species would help determine which crops have similar greenness-crop growth parameter relationships. Near-infrared reflectance is affected by refractive index discontinuities within leaves. The most important discontinuity is the cell wall/air space interface, although discontinuities among cellular constituents also affect near-infrared reflectance (Gausman, 1974). Differences in cell wall/air space arrangements are most determined by leaf mesophyll arrangements. A leaf with a compact mesophyll structure reflects less light than a leaf with a "spongy mesophyll" because there are fewer hydrated cell wall/intercellular air space interfaces to refract the light (Gausman et al., 1970). Mesophyll arrangements for the crops involved in this study are described in Table 1.

Sinclair et al. (1971) found trends in reflectance differences between monocotyledons and dicotyledons. For example, soybean reflectances were significantly greater than those of the monocotyledons, yet the differences were less than 5%.

They found reflectance spectra of fresh green leaves very similar, regardless of the species.

Table 1. Scientific names and leaf mesophyll arrangements of crops involved in this study. (from Gausman et al., 1973, and Esau, 1965)

Crop	Scientific name	Mesophyll arrangement*	Additional structural characteristics
Corn (field and sweet)	*Zea mays* L.	Compact	Bulliform cells, hairs upper epidermis.
Grain Sorghum	*Sorghum bicolor* (L.) Moench.	Compact	Bulliform cells.
Pearl Millet	*Pennisetum americanum* L.	Compact	Bulliform cells.
Pinto Bean	*Phaseolus vulgaris* L.	Dorsiventral	Very porous mesophyll.
Soybean	*Glycine max* (L.) Merr.	Dorsiventral	Porous mesophyll.
Sunflower	*Helianthus annuus* L.	Isolateral	Hairs upper and lower epidermis.

*Definitions of mesophyll arrangements used are:

Dorsiventral, a usually porous (many intercellular air spaces) mesophyll with palisade parenchyma cells in its upper part and spongy parenchyma cells on the lower.

Isolateral, a porous mesophyll that tends to have long narrow cells throughout.

Compact, comprised of relatively compact chlorenchyma with few intercellular spaces (nonporous mesophyll).

MATERIALS AND METHODS

This research was conducted on the Ashland Evapotranspiration Research site near Manhattan, Kansas in 1982. An independent test was made with data collected in 1981. A description of the 1981 plots and conditions is given by Hattendorf (1982).

For the 1982 study, the soil was Eudora silt loam, a coarse-silty, mixed, mesic Fluventic Hapludoll. Eudora soils are well drained, neutral to moderately alkaline, friable and easily worked. They are naturally fertile and have medium or high available moisture capacity. They were formed in coarse silt loam or loam alluvium (Jantz et al., 1975).

The plot design was randomized complete block with six crops (field corn, pearl millet, grain sorghum, pinto bean, sunflower, and soybean) and three replications per crop. Two remaining plots of a 4 by 5 grid were planted to sweet corn. Table 2 lists the scientific names and varieties of the crops grown. Fig. 2 shows the 1982 plot arrangement. Plots were 14 m long and 12 m wide with 3 m alleys between plots. There were 16 rows per plot and the row spacing was 0.762 m.

On 3 May, the entire plot area was fertilized with 205 kg/ha of actual N in the form of ammonium nitrate. On 5 May, Treflan™ (a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine) was preplant applied to the soybean, pinto bean, and sunflower plots which were disked immediately after application. A Lasso™ (2-chloro-2',6'-diethyl-N[methoxymethyl] acetanilide) + Bladex™(2-[[4-chloro-6- [ethylamino] -s-triazin-2-yl] -amino] -

Table 2. Scientific names and varieties of crops grown in 1981 and 1982.

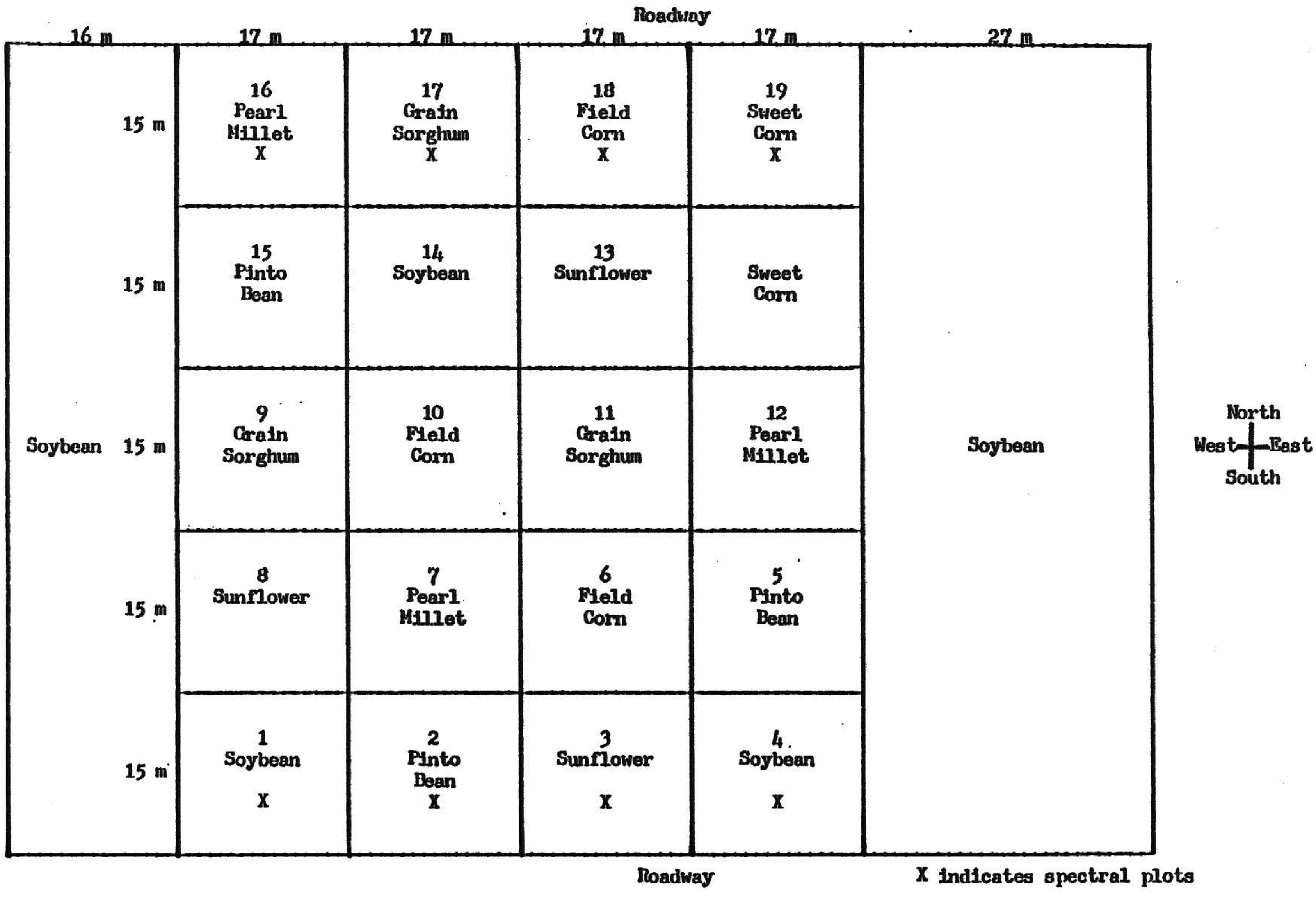
Crop	Scientific name	Variety/hybrid
Field Corn	*Zea mays* L.	PV76S
Grain Sorghum	*Sorghum bicolor* (L.)Moench	PV535GR
Pearl Millet	*Pennisetum americanum* L.	79-2094/78-7088 in 1981 81-1107/78-7088 in 1982
Pinto Bean	*Phaseolus vulgaris* L.	UI114
Soybean	*Glycine max* (L.) Merr.	Cumberland
Sunflower	*Helianthus annuus* L.	IS907
Sweet Corn*	*Zea mays* L.	Merit

*No LAI data were collected for sweet corn in 1981.

Table 3. Planting dates for crops in 1981 and 1982.

Crop	Planting date for: 1981	1982
Field Corn	21 May	20 May
Grain Sorghum	2 June	11 June
Pearl Millet	2 June	11 June
Pinto Bean	22 May	20 May
Soybean	22 May	20 May
Sunflower	22 May	20 May
Sweet Corn	21 May	20 May

Figure 2. Plot arrangement for 1982, Manhattan, Kansas, showing plot dimensions, plot numbers, and crops.



2-methyl-propionitrile) tank mix was applied to all corn plots immediately after planting. Milogard™(2-chloro-4, 6 bis [isopropylamino]-s-triazine) was applied to the sorghum and millet plots immediately after planting. Table 3 lists the planting dates for both years.

Two neutron access tubes of O.D. 4.13 cm and wall thickness of 0.09 cm were centrally located in each plot. Neutron probe data were collected with a Troxler 2601 series probe approximately every 10 days to a depth of 3.05 m in 15 cm increments. Concurrently, two gravimetric samples were taken from the 0 to 76 mm layer of each plot. The samples were weighed, dried 48 hours at 105 C, and weighed again for the determination of water content by weight. Water content data were used in a water-use study not involved in the analysis presented here.

Periodically throughout the season, stomatal resistance measurements were taken using a transient porometer, canopy temperature was measured with an infrared field thermometer, and small leaf samples were collected from nonspectral locations for determination of leaf water potential, osmotic potential, and turgor pressure using thermocouple psychrometers and a dew point microvoltmeter. Those data are also not involved in this analysis.

Spectral reflectance data were collected with an Exotech 4-band radiometer, Model 100A, equipped to simulate the four LANDSAT multispectral scanner (MSS) bands MSS4 (0.5 - 0.6 μm), MSS5 (0.6 - 0.7 μm), MSS6 (0.7 - 0.8 μm), and MSS7 (0.8 - 1.1 μm). Those plots over which spectral data were collected are indicated in Fig. 2.

The radiometer was mounted on a boom truck modeled after LARS (Bauer et al., 1980). The boom was held at a 45^{o} angle so that the instrument was aimed over the crop canopy in the vertical nadir position, 7.4 m above the ground. After 16 July, the boom angle was 43^{o} and the instrument was 7.2 m above the ground. Calibrations were taken over a barium sulfate panel of size 1.2 x 1.2 m approximately every 15 to 20 minutes. Reflectances were calculated using bidirectional reflectance factors measured at an irradiance zenith angle of 10^{o}.

Reflectance data were collected only during clear sunny periods. For each set of data collected, three observations were taken per plot, with the exception of the first two sets taken in 1981, when only one observation per plot was taken. On several dates, more than one data set was collected, so for each date, the mean of all reflectance measurements collected over any one crop for one waveband was used as the reflectance value for that date, crop, and waveband.

Plant samples were taken from a nonspectral plot approximately once each week for the determination of above ground fresh mass, dry mass, and green leaf area index (LAI). Early in the season, 2 or 3 m of row were sampled, but as plant size increased, the sampling length was reduced to 1 m. Green leaf area, in cm^2, was obtained with a Type AAM5 Hayashi Denko leaf area meter. Leaf area index was calculated by dividing the total area of green leaves in the sample by the ground area, in cm^2, represented by that sample site. Fresh mass was recorded for the entire sample. The plants were separated into leaves, stems, and reproductive parts, dried at 80 C for one week, and weighed to determine dry mass of plant parts. Fresh and dry mass were converted to Mg/ha.

Stepwise multiple regression analysis (MAXR option) was conducted by the Statistical Analysis System (SAS Institute Staff, 1979) on LAI and above ground dry weight to day of year/100 to determine the field predicted values of LAI and dry weight for each date that spectral data were collected.

A modified form of the procedure described by Jackson (1983) was used to calculate the coefficients for 4-space soil brightness and greenness for the 1982 reflectance data. Greenness values were calculated for each date that spectral data were collected. Multiple regression analyses (GLM and STEPWISE procedures) were conducted by SAS to determine relationships between greenness values and LAI and dry weight.

RESULTS AND DISCUSSION

Because measurement of leaf area index (LAI) and above ground total dry weight (DWT) did not coincide with the dates that spectral data were collected, equations were needed that would estimate LAI and DWT from the day of the year. Leaf area index and DWT were each regressed against the first through the fourth order of day of year/100 (D) by using step-wise multiple regression analysis (MAXR option) of the Statistical Analysis System (SAS Institute Staff, 1979). For all crops, the equations derived when regressing LAI against D over the entire growing season estimated LAI very well at the beginning and end of the season, but always underestimated LAI during mid-season when LAI values were at their peak. Leaf area index was again regressed against the first through the fourth powers of D, but separate equations were derived for data up to maximum LAI (inclusive) and after maximum LAI (inclusive). These two-equation models estimated LAI as well during mid-season as they did during earlier and later parts of the season. The models for DWT showed no such seasonal biases when derived over the entire growing season. The two-equation models for estimating LAI and the equations for estimating DWT from D are given in Table 4.

Leaf area index and DWT data were plotted against D along with the model estimates. There were still a few values for early-season grain sorghum and millet and end-of-season soybean that were best estimated from a hand-drawn curve through the actual data points. Those hand estimated values are listed in

Table 4. Regression equations for leaf area index (LAI) and above ground dry weight (DWT) (measured in Mg/ha) against day of year/100 (D) for 1982.

Crop	Equation*	R^2	N	Range of D	Model significance
Field Corn	$LAI = 117 - 149D + 47.3D^2$	0.99	9	1.54 - 1.95	0.0001
	$LAI - 23.9 - 9.09D$	0.88	10	1.95 - 2.59	0.0001
	(a) $DWT = 2100 - 4110D + 2960D^2 - 931D^3 + 109D^4$	0.95	18	1.54 - 2.59	0.0001
Grain sorghum	$LAI = 184 - 212D + 61.3D^2$	0.98	8	1.73 - 2.07	0.0001
	$LAI = 15.6 - 5.05D$	0.79	11	2.07 - 2.94	0.0003
	$DWT = 254 - 379D + 181D^2 - 27.1D^3$	0.98	18	1.73 - 2.94	0.0001
Pearl millet	$LAI = -8.45 + 0.856D^4$	0.94	8	1.73 - 2.07	0.0001
	$LAI = 20.9 - 6.84D$	0.86	10	2.07 - 2.94	0.0001
	$DWT = -22.0 + 7.35D^3 - 2.00D^4$	0.94	17	1.73 - 2.94	0.0001
Pinto bean	$LAI = 88.9 - 114D + 36.7D^2$	0.99	9	1.54 - 1.95	0.0001
	$LAI = 39.6 - 17.8D$	0.94	7	1.93 - 2.22	0.0003
	$DWT = 104 - 192D^2 + 139D^3 - 27.5D^4$	0.98	14	1.54 - 2.22	0.0001

*All independent variables significant at the 0.05 level except where noted.
(a)All independent variables significant at the 0.10 level.

Table 4. (continued)

Crop	Equation*	R^2	N	Range of D	Model significance
Soybean	$LAI = 42.0 - 53.3D + 16.9D^2$	0.99	12	1.54 - 2.11	0.0001
	$LAI = 7.54 - 0.149D^2$	0.89	8	2.11 - 2.70	0.0005
	$DWT = 183 - 286D + 144D^2 - 23.3D^3$	0.97	19	1.54 - 2.70	0.0001
Sunflower	$LAI = 101 - 130D + 41.8D^2$	0.98	8	1.54 - 1.93	0.0001
	$LAI = 12.7 - 2.07D^2$	0.94	10	1.93 - 2.44	0.0001
	$DWT = 654 - 1070D + 570D^2 - 98.8D^3$	0.95	17	1.54 - 2.44	0.0001
Sweet Corn	$LAI = 114 - 146D + 46.6D^2$	0.97	8	1.54 - 1.93	0.0002
	$LAI = 8.71 - 0.241D^4$	0.91	9	1.93 - 2.44	0.0001
	$DWT = 2500 - 4990D + 3670D^2 - 1180D^3 + 140D^4$	0.97	16	1.54 - 2.44	0.0001

*All independent variables significant at the 0.05 level.

Table 5. Exceptions from regression equations (see Table 4) for indicated days of the year/100 (D) when LAI and/or DWT were predicted from field data for regression against greenness.

Crop	D	LAI	DWT(Mg/ha)
Grain sorghum	1.84	---	0.105
	1.88	---	0.499
Pearl millet	1.80	0.05	0.098
	1.84	0.85	0.295
	1.88	1.56	0.623
	1.97	---	2.23
Soybean	2.45	2.30	---
	2.53	0.88	---
	2.63	0.13	---
	2.65	0.10	---
	2.70	0.00	---

Table 5. With those exceptions, LAI and DWT were estimated from the models given in Table 4 for each date spectral data were collected. I called these the field estimated values of LAI and DWT.

To determine coefficients for soil brightness and greenness from the four-band reflectance data, a modified form of the procedure described by Jackson (1983) was used. Jackson's method uses only two four-dimensional data points collected over bare soil to determine the soil brightness coefficients. Those two points should preferably differ considerably in reflectance (one taken over wet soil and one over dry soil). The soil brightness coefficients are determined from the equation for the line through those two points. I modified the Jackson (1983) procedure by using all soil data collected (i.e., N = 17 for Eudora silt loam in 1982) and deriving a set of coefficients by using the linear equation for each possible pair of two soil points. In the case of the Eudora soil, I had 136 possible soil data pairs, so I determined 136 sets of coefficients and then calculated the mean of all 136 coefficient estimates for each waveband. The estimated mean values and standard errors of the means for soil brightness coefficients are given in Table 6. Along with those I estimated for the Eudora and Muir soils are those previously published by Rice et al. (1980) and Jackson (1983). The determined soil brightness index for the Eudora soil is

$$SBI_E = 0.3296(RF_1) + 0.4111(RF_2) + 0.5082(RF_3) + 0.6414(RF_4).$$

The next step was to calculate the reflectance greenness coefficients for each crop using the 1982 data. To accomplish

Table 6. Coefficients for four band reflectance soil brightness.

Manhattan, Kansas:

Soil, Year	Number of observations	Number of observation pairs	Mean coefficients and standard errors of means for: RF1	SE1	RF2	SE2	RF3	SE3	RF4	SE4*
Eudora, 1982	17	136	0.3296	0.0090	0.4111	0.0108	0.5082	0.0077	0.6414	0.0115
a)Muir, 1981-82	17	21	0.4015	0.0220	0.4762	0.0179	0.5053	0.0184	0.5640	0.0271

Equations of others:

Source	Coefficients for: RF1	RF2	RF3	RF4
Rice et al., 1980	0.32362	0.48521	0.56304	0.60949
Jackson, 1983	0.3285	0.3731	0.5779	0.6473

*RF1, RF2, RF3, and RF4 represent reflectance factor data for radiometer bands corresponding to MSS4, MSS5, MSS6, and MSS7 LANDSAT wavebands and SE1, SE2, SE3, and SE4 represent the standard errors of the means for the mean coefficients.

a)The Muir soil brightness index was determined only for comparison with the Eudora index and was not used in any determinations or calculations.

this, Jackson (1983) used the determined soil brightness coefficients and one four-dimensional data point taken over green vegetation. The Gram-Schmidt process (Freiberger, 1960) is used to determine the unit vector orthogonal to soil brightness and in the direction of the green vegetation data. The 1982 crop reflectance data were taken from an Eudora soil location, so I used the Eudora SBI for the greenness index calculations. I modified Jackson's procedure by using all data collected over each crop. Greenness coefficients were determined for each waveband by using each of the data points, resulting in a greenness index for each point. Each greenness index was tested for orthogonality by calculating the dot product of the greenness and soil brightness indices. If the absolute value of this dot product was less than 0.05, then the indices were considered orthogonal. Only those N indices that were orthogonal to the soil brightness index were used to calculate estimated mean values and standard errors of the means for each waveband for each crop. Those coefficients formed the "individual greenness indices" for each crop. I calculated an "overall greenness index" by using the same technique on all reflectance data taken over all crops (N = 76). The coefficients for each crop's individual greenness and the overall greenness are listed in Table 7 along with those previously published by Rice et al. (1980) and Jackson (1983). The overall greenness index was calculated and included in further analyses to determine if the ability to estimate LAI and DWT from spectral reflectance greenness depends upon having indices derived for each crop specifically or if a more general index, derived over

Table 7. Coefficients for four band reflectance greenness.

Manhattan, Kansas:

Crop	N	RF1	SE1	RF2	SE2	RF3	SE3	RF4	SE4*
		Mean coefficients and standard errors of means for:							
Field corn	11	-0.4676	0.0033	-0.6724	0.0038	0.1781	0.0075	0.5442	0.0071
Grain sorghum	16	-0.4495	0.0033	-0.6762	0.0031	0.1998	0.0104	0.5463	0.0049
Pearl millet	15	-0.4602	0.0019	-0.6585	0.0038	0.1340	0.0125	0.5777	0.0060
Pinto bean	5	-0.4539	0.0096	-0.6860	0.0037	0.2795	0.0076	0.4942	0.0106
Soybean	13	-0.4771	0.0088	-0.6506	0.0113	0.2169	0.0151	0.5442	0.0077
Sunflower	7	-0.4335	0.0047	-0.7054	0.0093	0.2951	0.0099	0.4750	0.0092
Sweet corn	9	-0.4645	0.0092	-0.6751	0.0038	0.2123	0.0084	0.5304	0.0097
All crops combined, 'overall'	76	-0.4596	0.0025	-0.6710	0.0030	0.2021	0.0070	0.5399	0.0043

Equations of others:

Source	Coefficients for:	RF1	RF2	RF3	RF4
Rice et al., 1980		-0.48935	-0.61249	0.17289	0.59538
Jackson, 1983		-0.4480	-0.6896	0.0670	0.5650

*RF1, Rf2, RF3, and RF4 represent reflectance factor data for radiometer bands corresponding to MSS4, MSS5, MSS6, and MSS7 LANDSAT wavebands and SE1, SE2, SE3, and SE4 represent the standard errors of the means for the mean coefficients.

several crops, can be used. The indices from Rice et al. (1980) were included because they are currently used by a number of agencies (Kanemasu, 1983).

For each date that spectral data were collected, the reflectance values were transformed through the individual greenness index, for each respective crop, to determine the individual greenness (IG) value for that date. Reflectance values were also transformed through the overall greenness index and the greenness index published by Rice et al. (1980) to determine "OG" and "RG" values, respectively, for each crop and date.

To determine the relationship between LAI and reflectance greenness, for each crop, regression analysis (GLM procedure) was conducted by SAS on the field estimated values of LAI against IG, OG, and RG values by using 1982 data. Strong linear relationships were found (model significance < 0.001) but intercepts were not significantly different from zero ($p > 0.05$). The GLM procedure was again performed (NOINT option) to find the no-intercept models that estimate LAI from greenness values for each crop. The results are numerical values I have termed "crop factors" that, when multiplied by the greenness value, estimate LAI ($R^2 \geq 0.94$). Crop factors were determined for each crop using each of the possible greenness values (IG, OG, and RG). Table 8 lists the crop factors, their standard errors, and R^2 values for each crop and greenness combination.

Figures 3, 4, and 5 show the leaf area index values predicted from spectral data (by multiplying the appropriate crop factor by the IG, OG, and RG values, respectively) plotted

Table 8. Crop factors for predicting leaf area index (LAI) using reflectance greenness.

Crop	N	Individual greenness			Overall greenness			Greenness from Rice et al., 1980		
		R^2	Crop factor	SE	R^2	Crop factor	SE	R^2	Crop factor	SE
Field corn	16	0.98	0.204	0.0076	0.98	0.199	0.0076	0.98	0.186	0.0073
Grain sorghum	22	0.98	0.185	0.0061	0.98	0.187	0.0061	0.98	0.173	0.0060
Pearl millet	22	0.96	0.220	0.0102	0.96	0.218	0.0102	0.95	0.203	0.0098
Pinto bean	11	0.95	0.118	0.0085	0.95	0.120	0.0086	0.95	0.112	0.0082
Soybean	20	0.95	0.107	0.0059	0.95	0.109	0.0060	0.94	0.103	0.0057
Sunflower	16	0.95	0.126	0.0075	0.95	0.127	0.0076	0.95	0.119	0.0070
Sweet corn	15	0.99	0.176	0.0046	0.99	0.175	0.0046	0.99	0.163	0.0046
Grass crops	75	0.97	0.198	0.0044	0.97	0.197	0.0043	0.96	0.183	0.0042
Broadleaf crops	47	0.94	0.115	0.0042	0.94	0.117	0.0042	0.94	0.110	0.0040

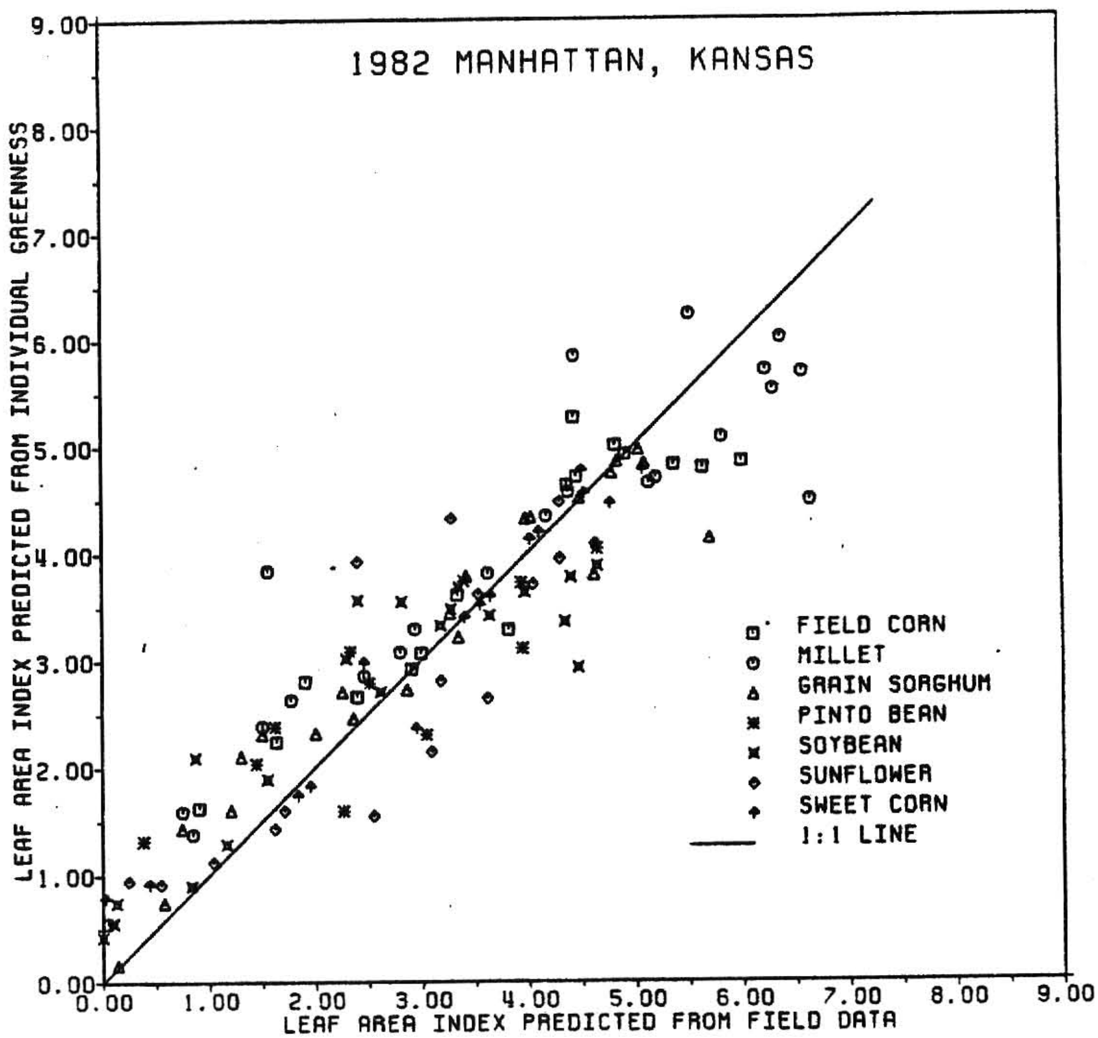


Fig. 3. Leaf area index (LAI) values predicted from spectral data (by multiplying the appropriate crop factor by the individual greenness) against the field estimated values of LAI.

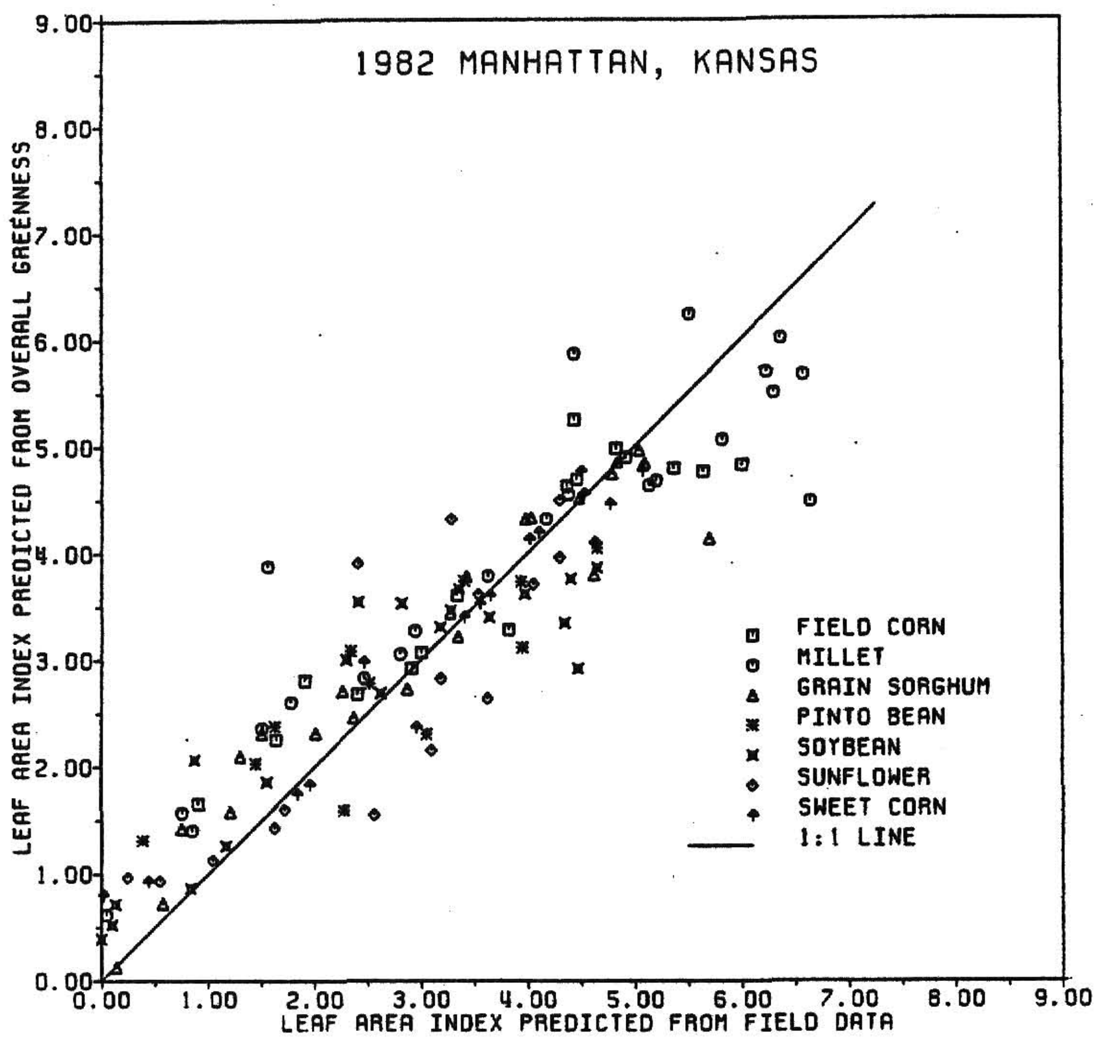


Fig. 4. Leaf area index (LAI) values predicted from spectral data (by multiplying the appropriate crop factor by the overall greenness) against the field estimated values of LAI.

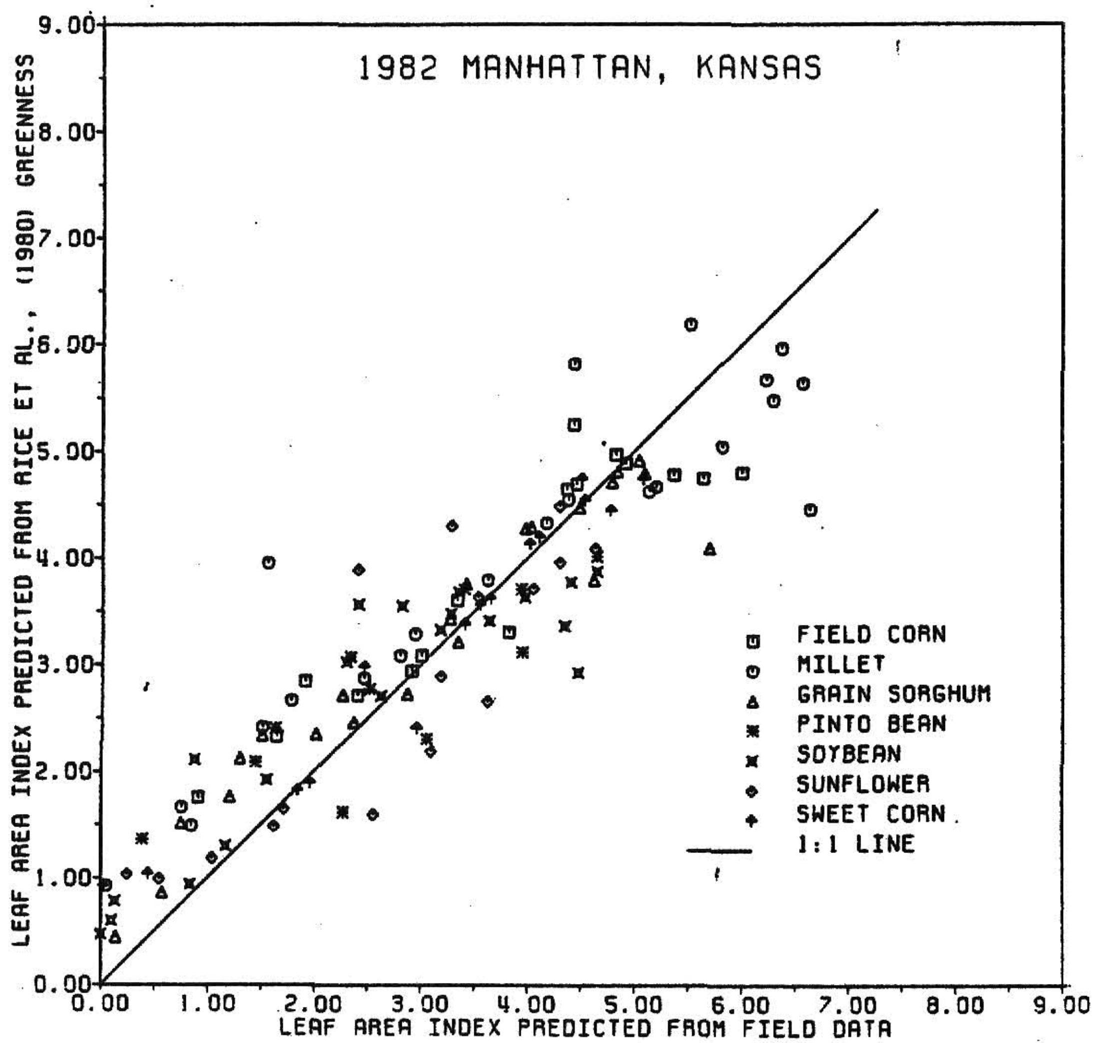


Fig. 5. Leaf area index (LAI) values predicted from spectral data (by multiplying the appropriate crop factor by the greenness from Rice et al. (1980)) against the field estimated values of LAI.

against the field estimated values of LAI. Judging from the results in Tables 7 and 8 and the strong similarities between Fig. 3, 4, and 5, models using the more general overall greenness, or that of Rice et al. (1980), were just as effective at estimating LAI as those models using individual greenness. It is, therefore, not necessary to use specific greenness coefficients for each of these crops.

I noticed similarities among the crop factors for the four grass crops (i.e., for overall greenness, crop factors = 0.199, 0.187, 0.218, and 0.175 for field corn, grain sorghum, pearl millet, and sweet corn, respectively) and then similar values among the broadleaf crops (0.120, 0.109, and 0.127 for pinto bean, soybean, and sunflower, respectively). This was not totally unexpected, as Wiegand et al. (1973) had found a single relation to fit both corn and sorghum spectral data in estimating LAI and Sinclair et al. (1970) had found trends in reflectance differences between monocotyledons and dicotyledons. I repeated the GLM procedures, grouping all data for the grasses, then all broadleaf crops, to determine generalized crop factors. Those are also listed in Table 8.

To demonstrate the ability of the "crop factor x greenness" concept to estimate LAI over the entire growing season, Fig. 6 through 12 show the leaf area index estimates from spectral data (by multiplying overall greenness x the crop-specific factor and overall greenness x the more general grass or broadleaf factor) along with the actual field measured LAI data, plotted against the day of the year for each crop. During mid-

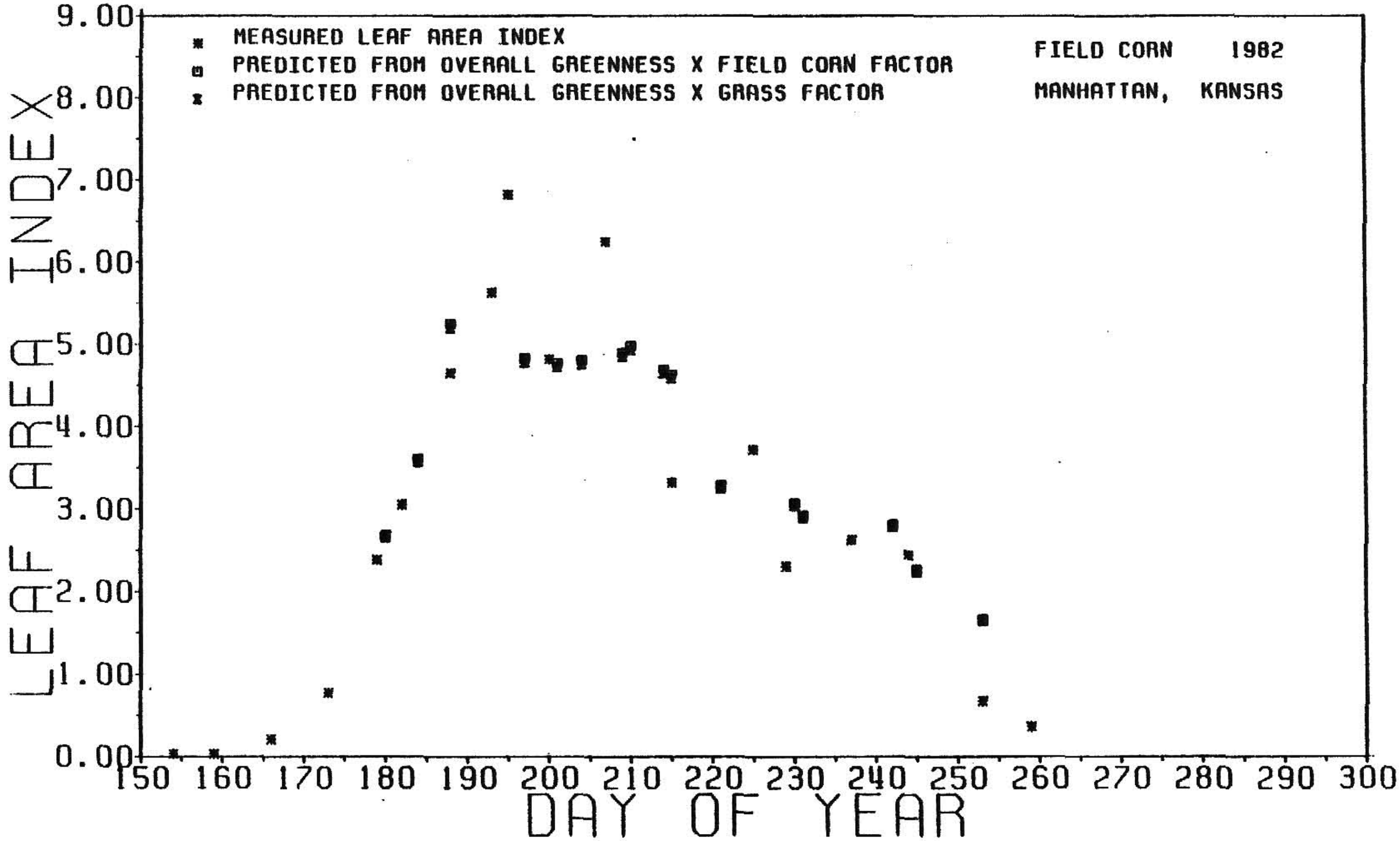


Fig. 6. Spectrally estimated LAI and field measured LAI of field corn plotted against the day of the year, using 1982 determined models on 1982 data.

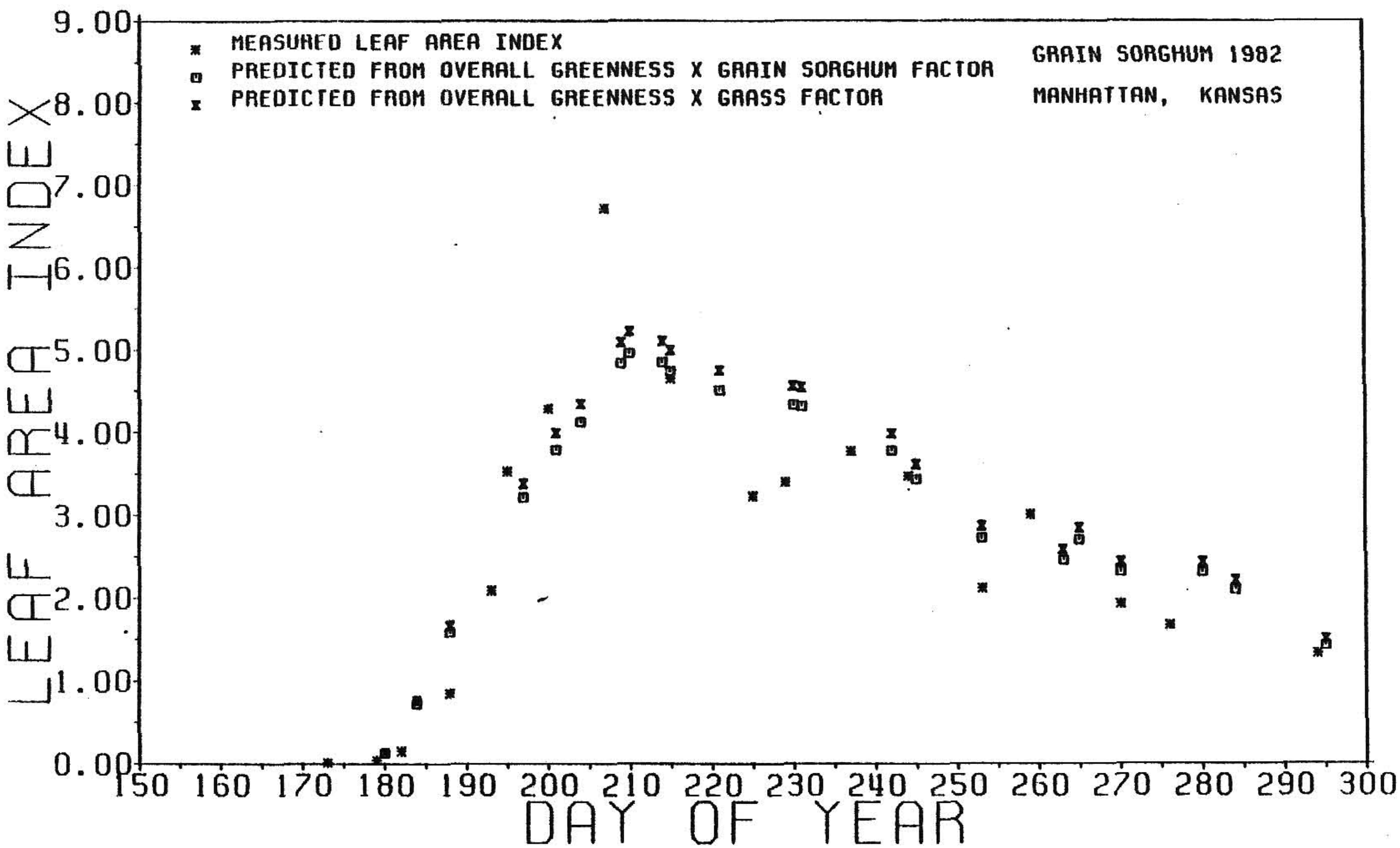


Fig. 7. Same as Fig. 6, but for grain sorghum.

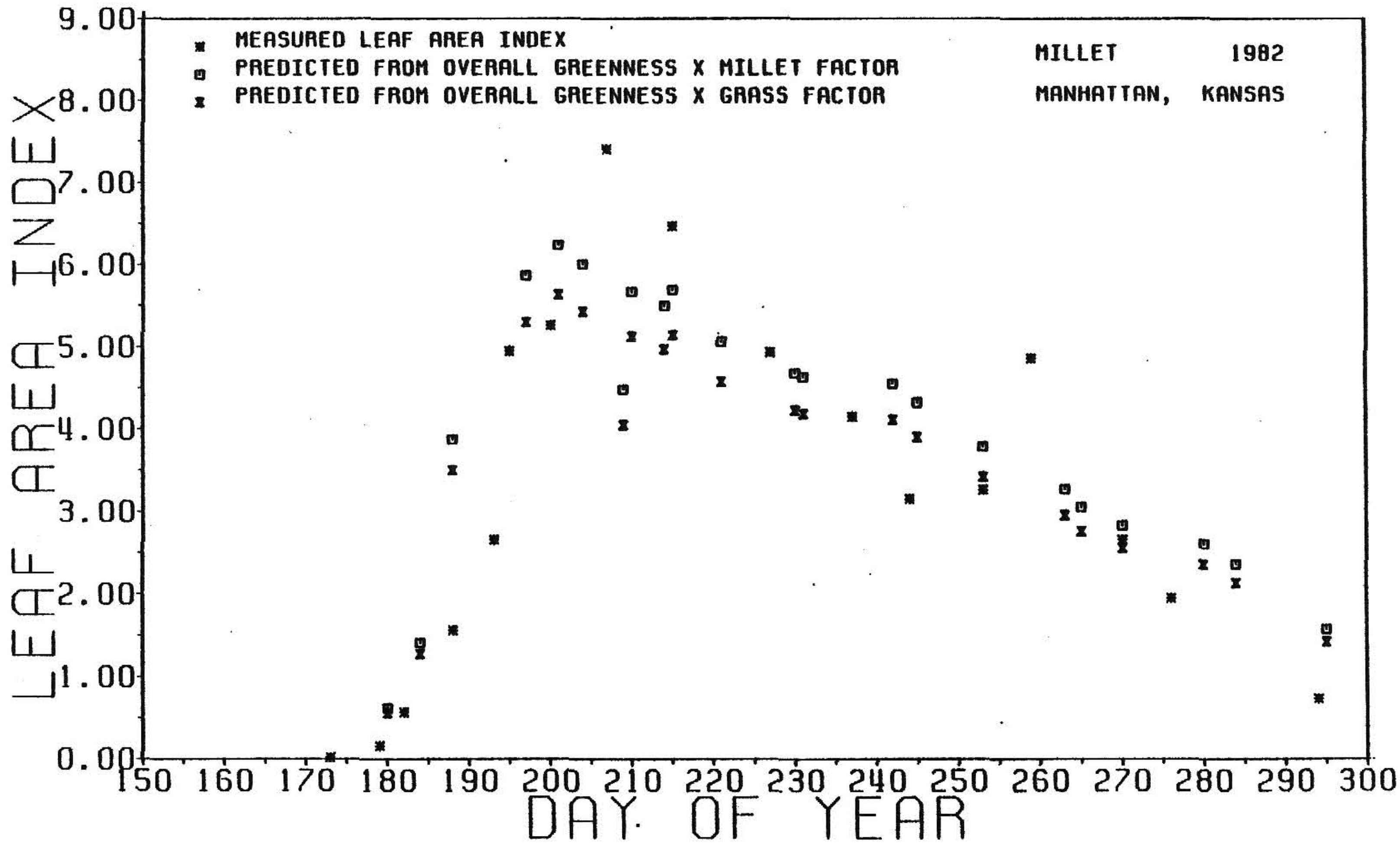


Fig. 8. Same as Fig. 6, but for pearl millet.

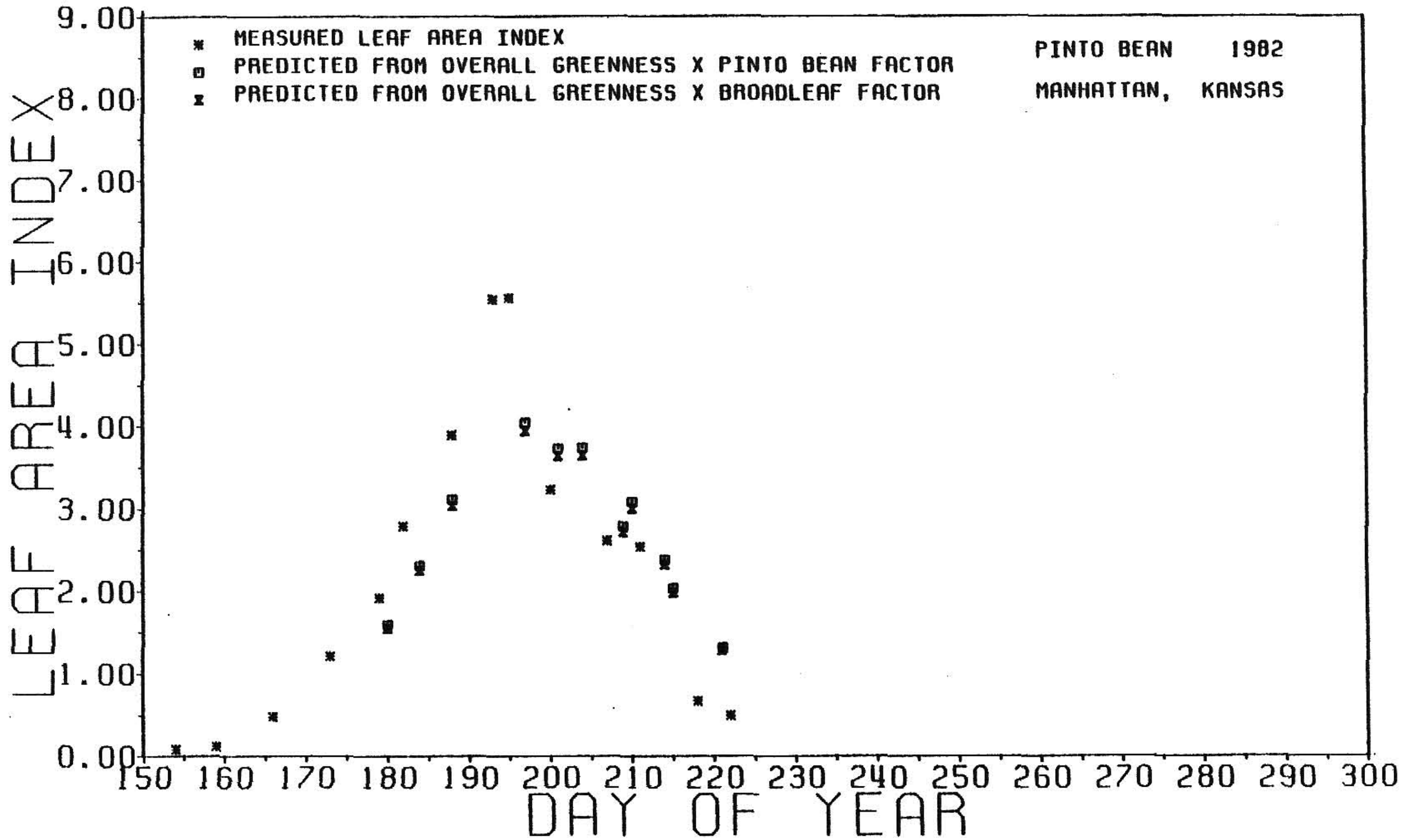


Fig. 9. Same as Fig. 6, but for pinto bean.

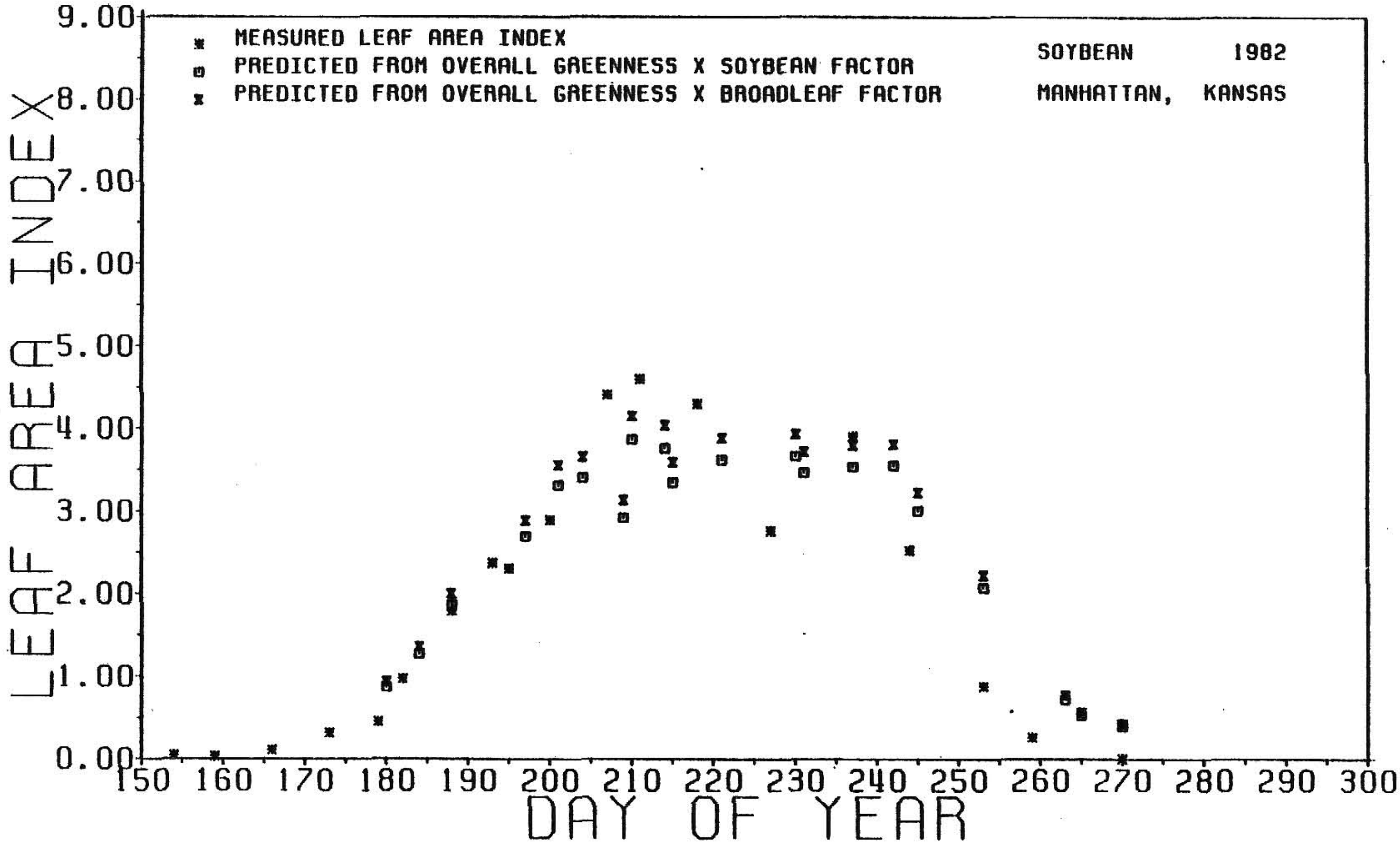


Fig. 10. Same as Fig. 6, but for soybean.

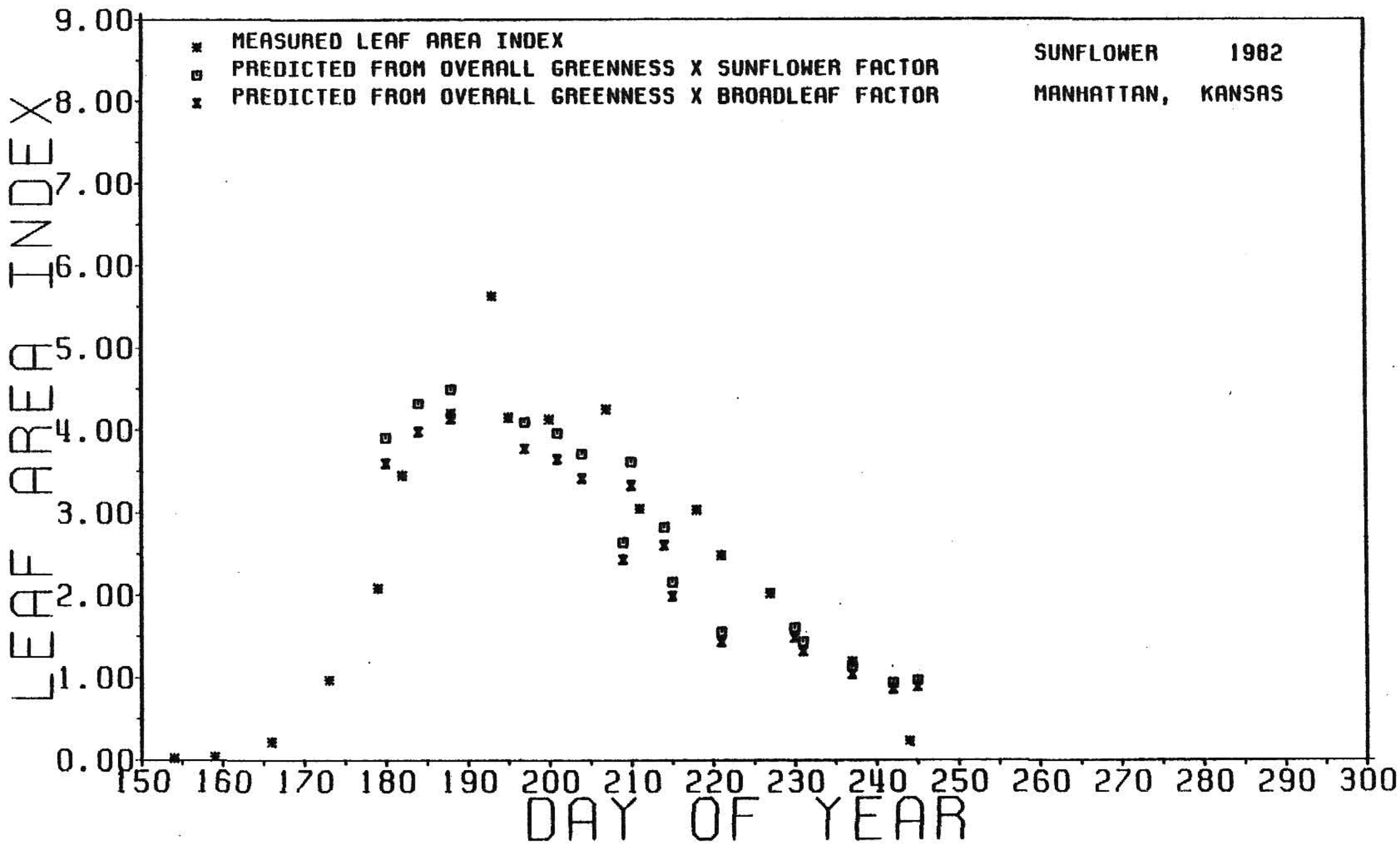


Fig. 11. Same as Fig. 6, but for sunflower.

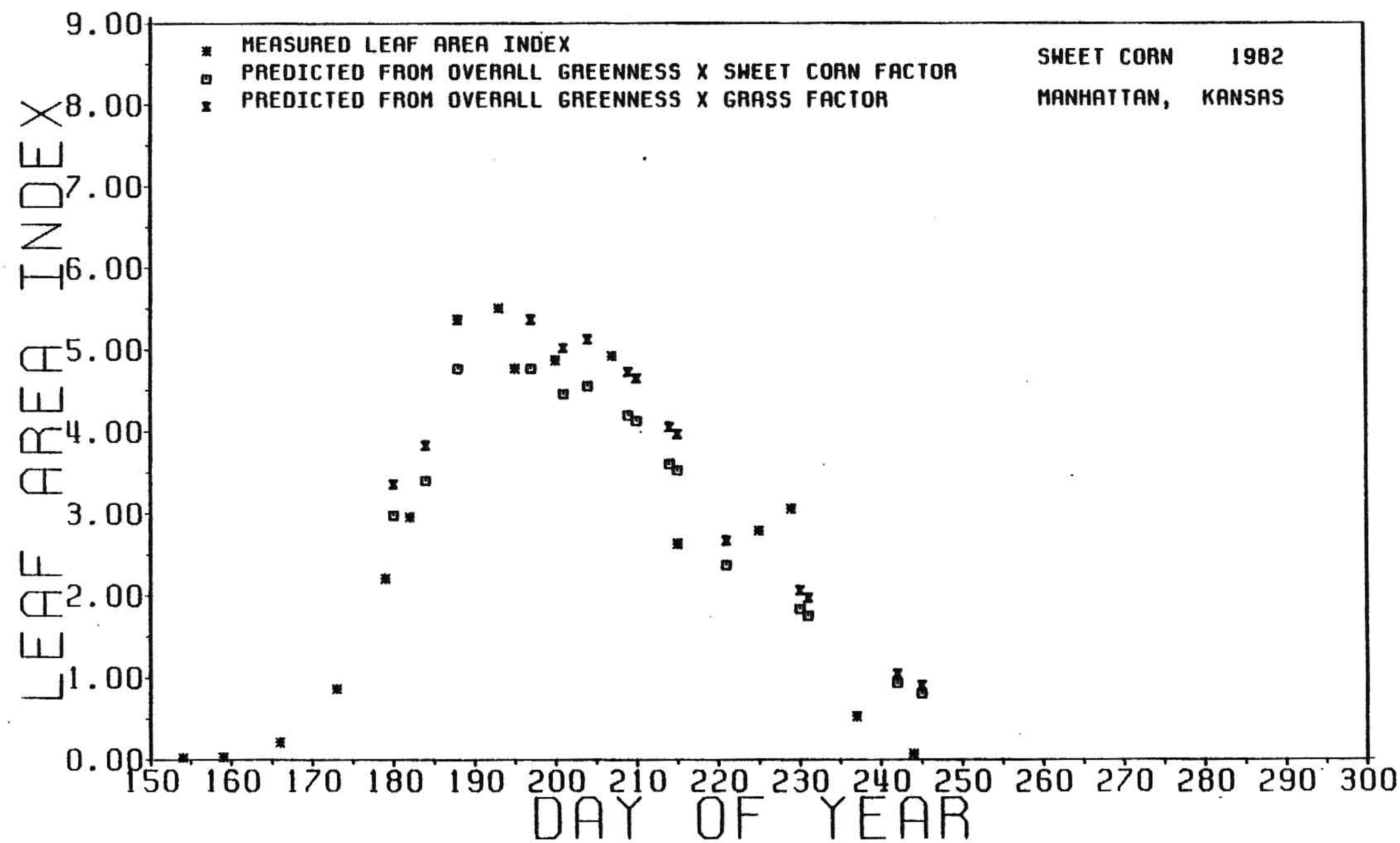


Fig. 12. Same as Fig. 6, but for sweet corn.

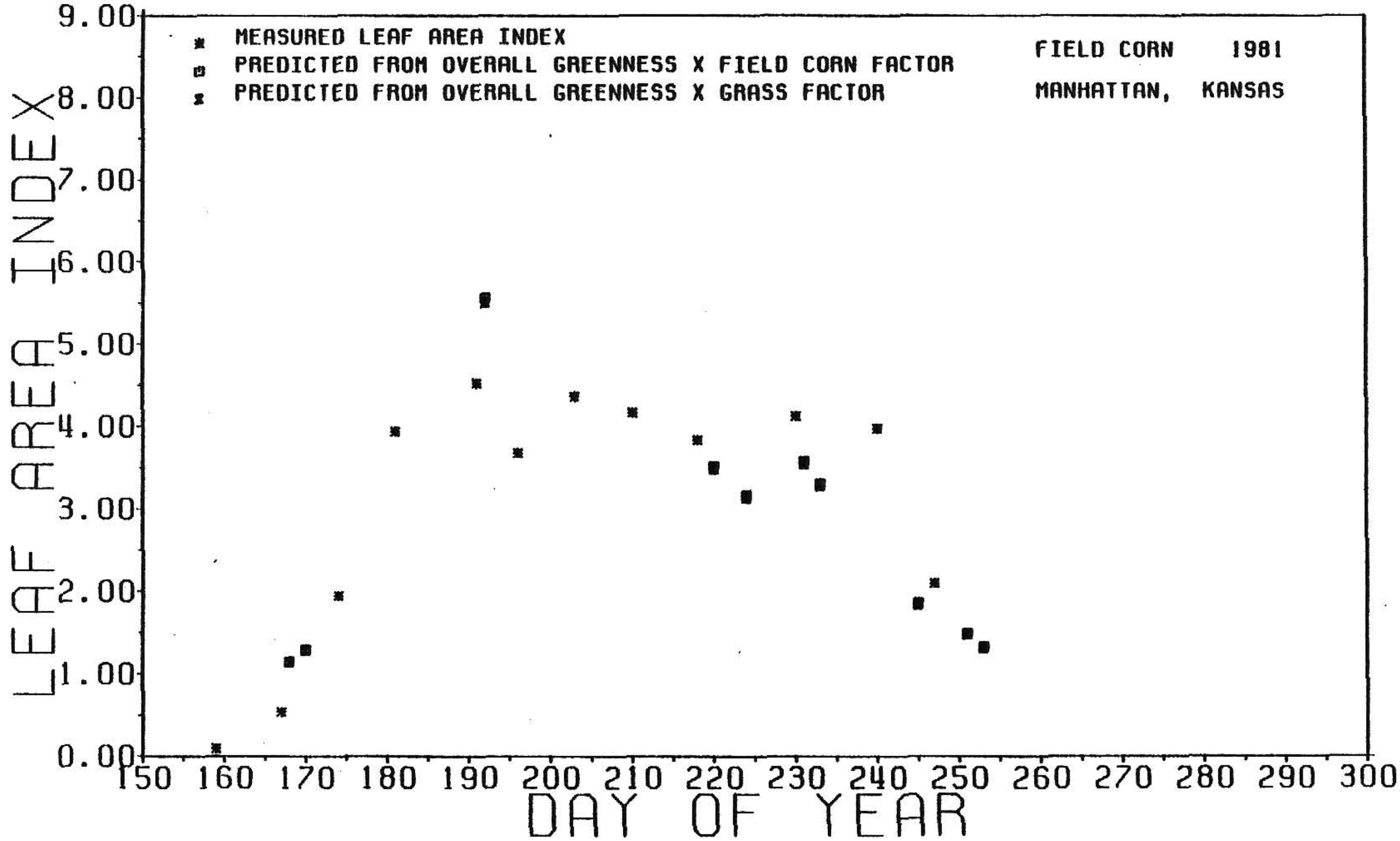


Fig. 13. Spectrally estimated LAI and field measured LAI for field corn plotted against the day of the year, using 1982 determined models on 1981 data.

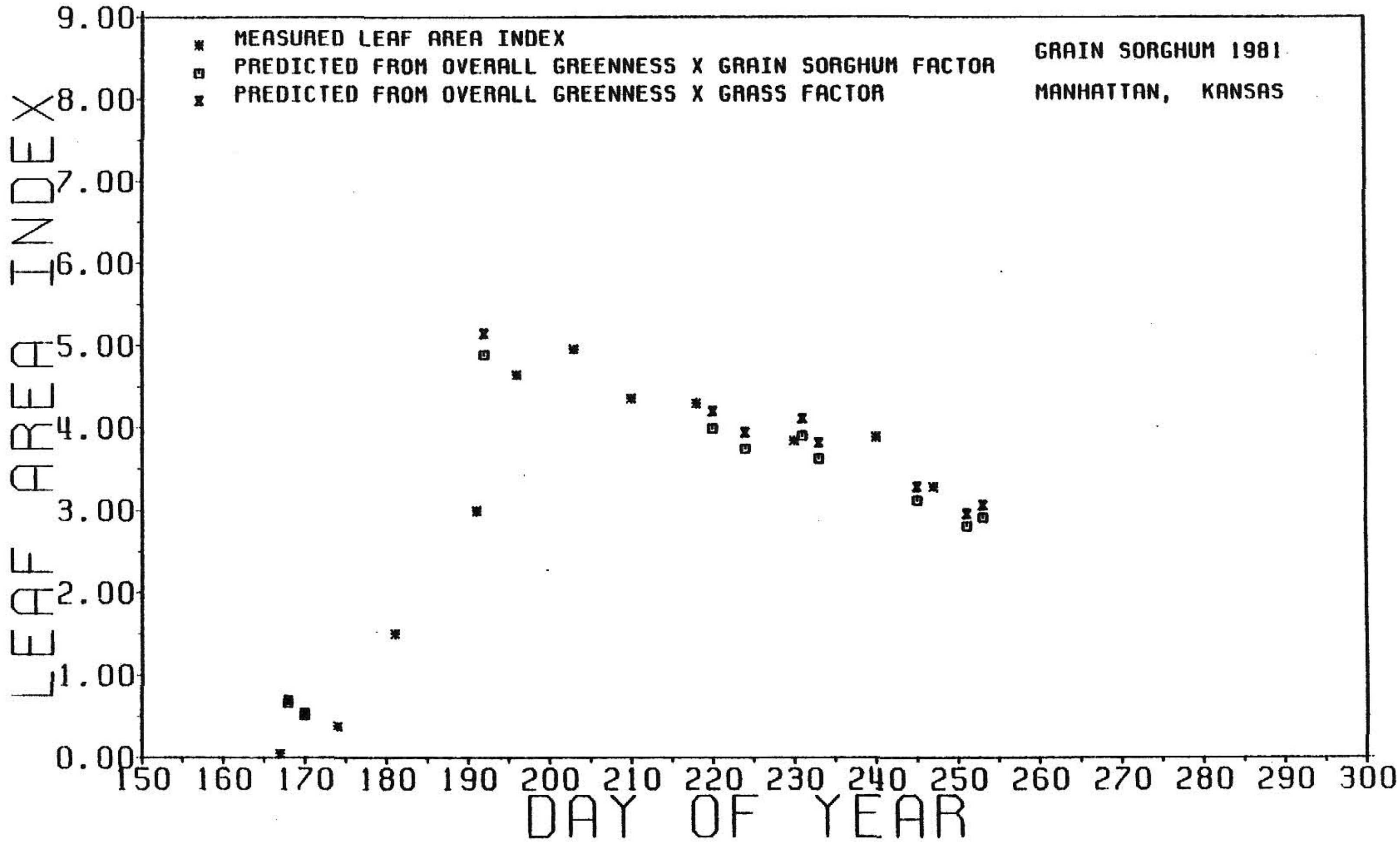


Fig. 14. Same as Fig. 13, but for grain sorghum.

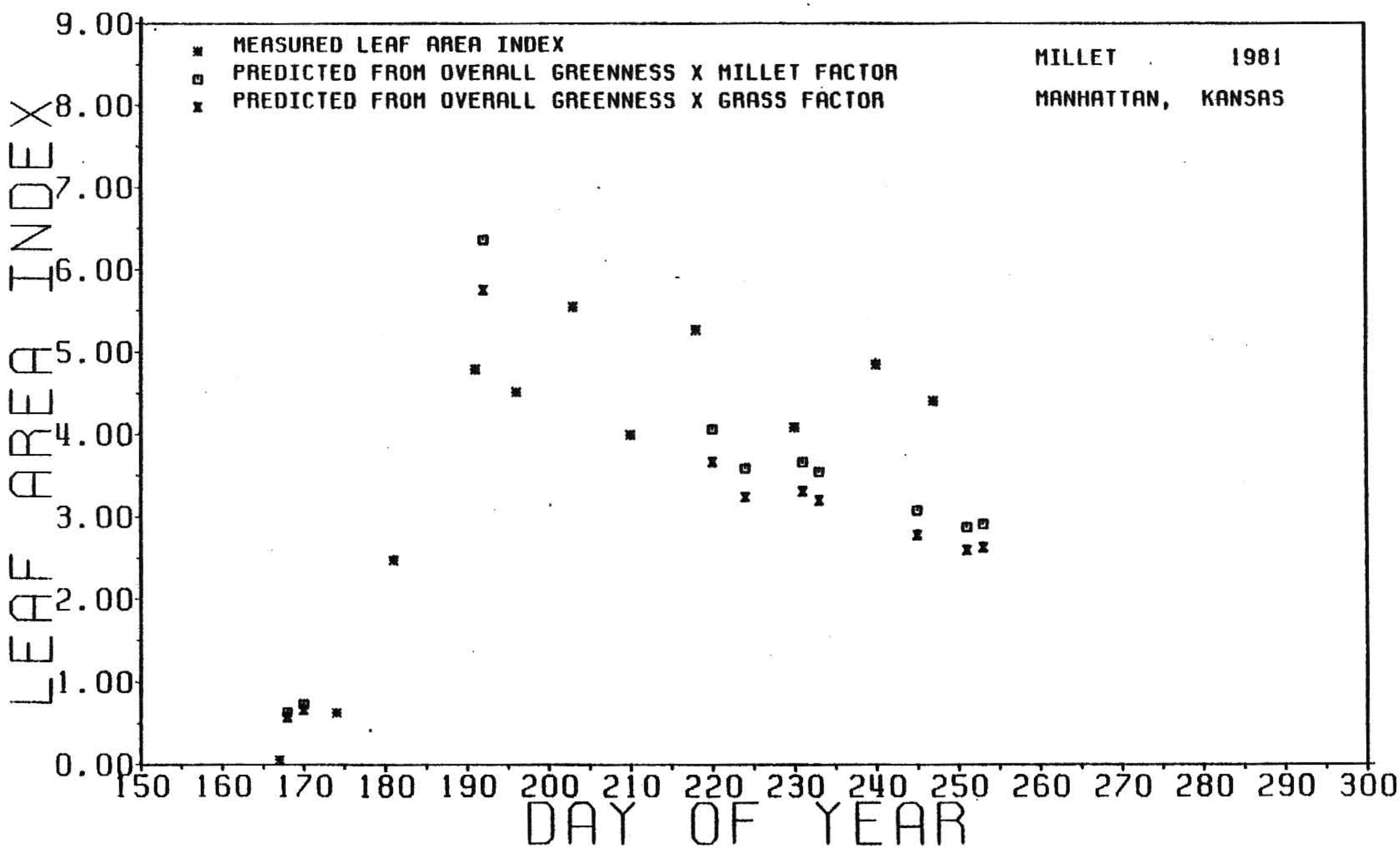


Fig. 15. Same as Fig. 13, but for pearl millet.

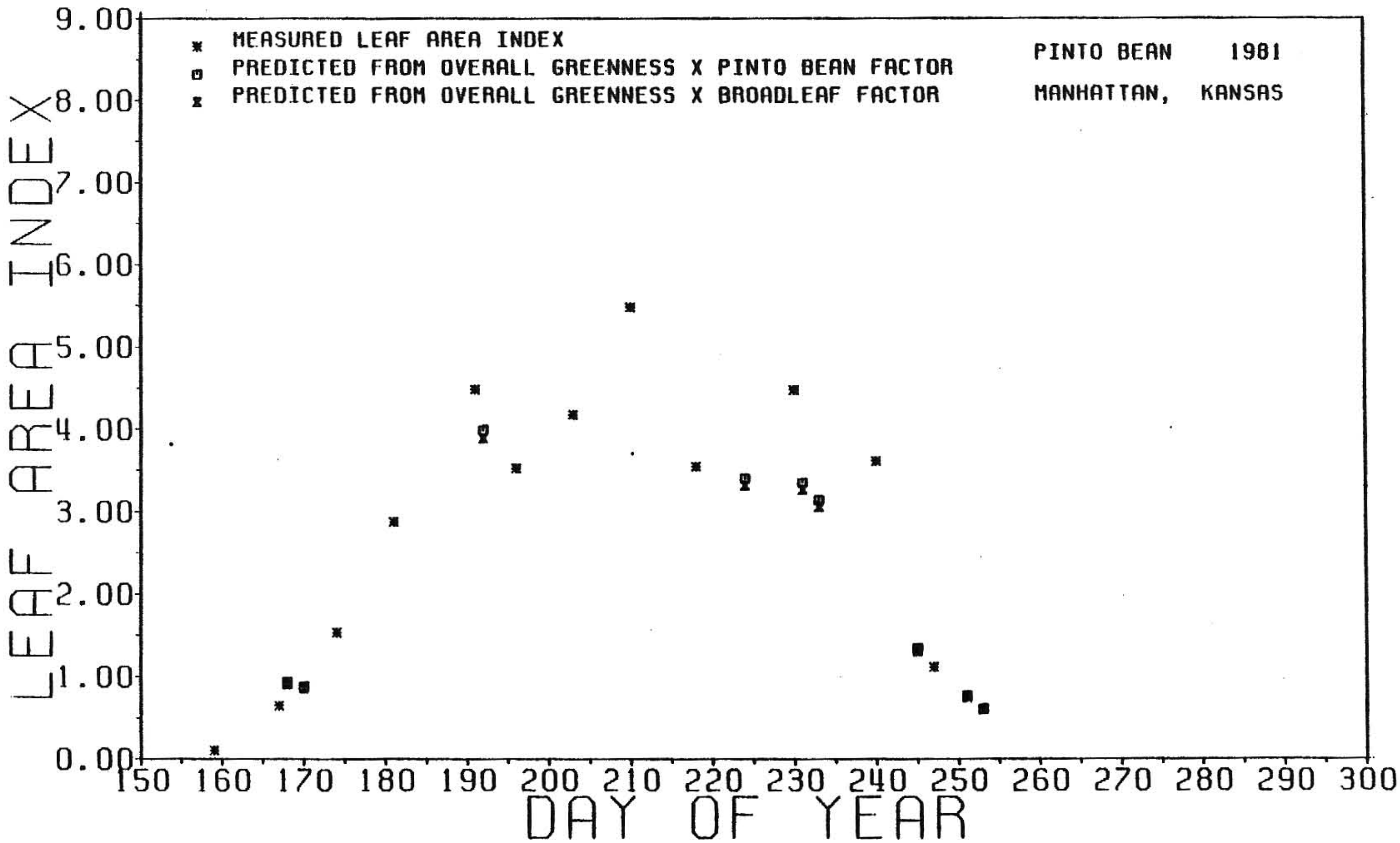


Fig. 16. Same as Fig. 13, but for pinto bean.

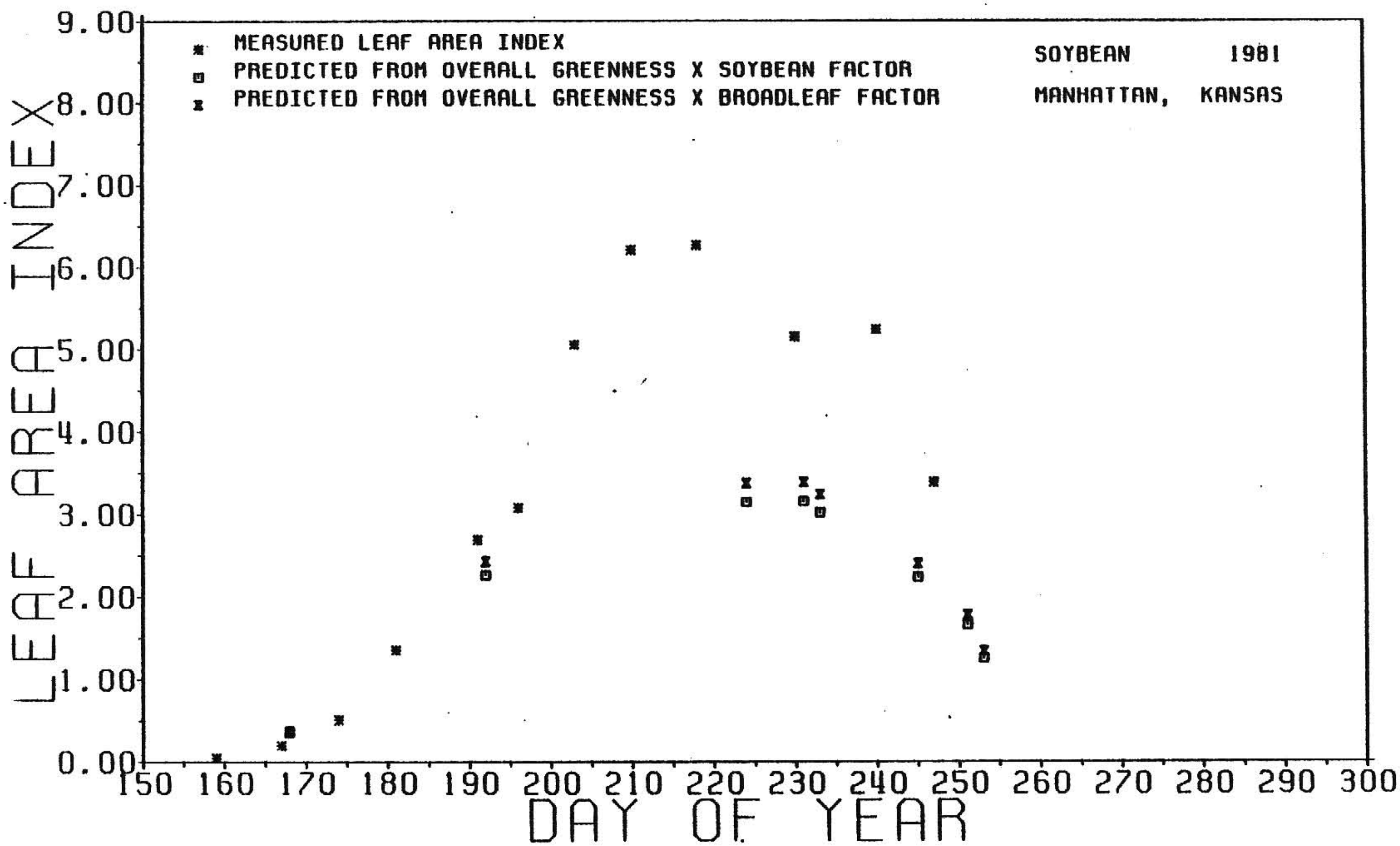


Fig. 17. Same as Fig. 13, but for soybean.

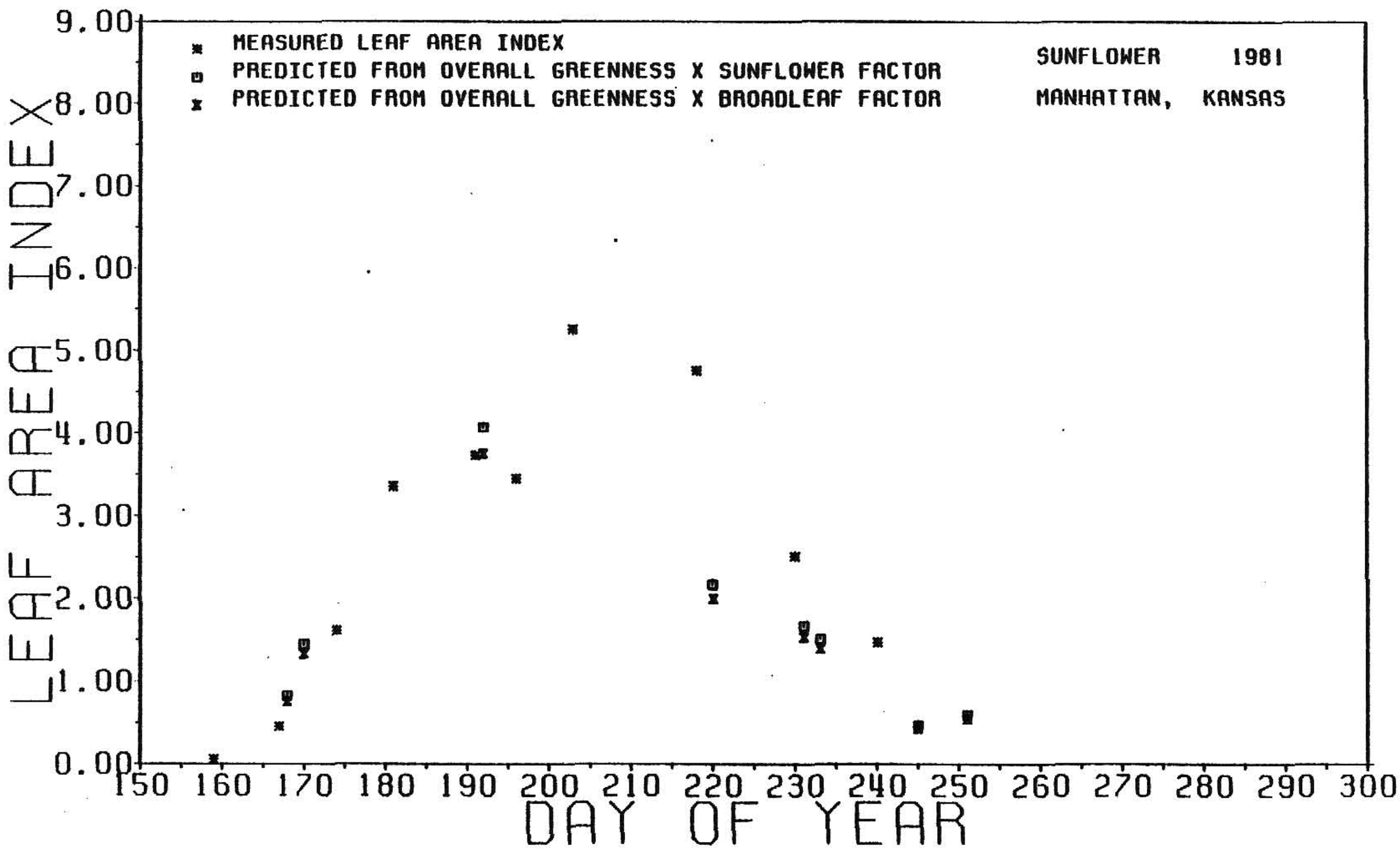


Fig. 18. Same as Fig. 13, but for sunflower.

season, greenness estimated LAI values tended to reach saturation levels. These levels varied from LAI values of 5.0 - 6.5 in the grass crops and 4.0 - 5.0 in the broadleaf crops. At the end of the season, as field measured green LAI reached zero for field corn, sweet corn, pinto bean, soybean, and sunflower, greenness estimated LAI stayed slightly higher than zero (0.4 - 1.0). This was due to plant dry matter still present, but no longer green, so that the soil was not completely bare.

As an independent test, Fig. 13 through 18 show spectrally estimated LAI and field measured LAI plotted against day of the year for each crop, using the 1982 determined models on 1981 data. No field data had been collected on sweet corn in 1981. Unfortunately, due to weather and field conditions, no spectral data were taken for days 193 - 219 in 1981. Again, the crop factor x greenness concept estimated LAI quite well, particularly for grain sorghum and field corn.

Pearl millet showed considerable variability in both the actual and spectral LAI values for both years. In the 1982 figure for millet, Fig. 8, greenness estimated LAI had a more stable trend through the season than field measured LAI. Pearl millet tends to vary considerably in growth rate, tillering, heading, and is even difficult to plant at an even rate. There was considerable variability in LAI within plots. Since field measured LAI was taken from only one location in a plot each time data were collected, but greenness LAI was estimated as the mean of three or more observations (at differing loca-

Table 9. Regression equations for above ground dry weight (DWT) (measured in Mg/ha) predicted from field data equations (see Table 4) against reflectance individual greenness (IG), overall greenness (OG), and greenness published by Rice et al. (1980) (RG) through the entire 1982 growing season.

Crop	N	R^2	Equations*	Model significance
Grain sorghum	22	0.51	$DWT = -1.51 + 0.349(IG)^2 - 0.0263(IG)^3 + 0.000513(IG)^4$	0.0043
	22	0.51	$DWT = -1.41 + 0.356(OG)^2 - 0.0271(OG)^3 + 0.000535(OG)^4$	0.0041
	22	0.49	$DWT = -2.85 + 0.325(RG)^2 - 0.0228(RG)^3 + 0.000417(RG)^4$	0.0060
Pearl millet	22	0.46	$DWT = -3.18 + 2.22(IG) - 0.0713(IG)^2$	0.0030
	22	0.45	$DWT = -3.30 + 2.21(OG) - 0.0704(OG)^2$	0.0034
	22	0.55	$DWT = -24.9 + 6.73(RG) - 0.347(RG)^2 + 0.00523(RG)^3$	0.0021
Sunflower	16	0.69	$DWT = 0.708 + 1.08(IG) - 0.0286(IG)^2$	0.0005
	16	0.68	$DWT = 0.727 + 1.08(OG) - 0.0287(OG)^2$	0.0006
	16	0.67	$DWT = 0.0495 + 1.06(RG) - 0.0263(RG)^2$	0.0008
Sweet cron	15	0.52	$DWT = -16.3 + 7.42(RG) - 0.545(RG)^2 + 0.00101(RG)^4 - 0.0000219(RG)^5$	0.0892
Grass crops	75	0.38	$DWT = -2.26 + 0.675(IG)^2 - 0.0803(IG)^3 + 0.00335(IG)^4 - 0.0000478(IG)^5$	0.0001
	75	0.38	$DWT = -2.49 + 0.678(OG)^2 - 0.0799(OG)^3 + 0.00331(OG)^4 - 0.0000466(OG)^5$	0.0001
	75	0.38	$DWT = -5.79 + 0.685(RG)^2 - 0.0746(RG)^3 + 0.00287(RG)^4 - 0.0000377(RG)^5$	0.0001

*All independent variables significant at the 0.05 level.

tions within a plot) for each date, greenness may be a better estimator of overall pearl millet LAI than the field measurements. Likewise, im 1982, greenness estimated LAI for grain sorghum had a more stable trend through the season than field measurements.

There were some problems in greenness estimating soybean LAI for days 220 - 245 and sunflower LAI for days 220 - 223 in 1981. This could be due to variability between the 1 m sampling locations and the spectral data collection locations.

I attempted to determine relationships between the greenness values and DWT over the entire season. For each crop, stepwise multiple regression (MAXR option) was conducted by SAS on the field estimated values of DWT against IG, OG, and RG values to the first through the fifth order. For field corn, pinto bean, and soybean, no significant models could be determined ($p > 0.1$) by using any of the greenness possibilities. For sweet corn, one model was determined by using the greenness from Rice et al. (1980) that was barely significant ($p = 0.09$). The other greenness values were not significantly related to sweet corn DWT. Significant models were developed for grain sorghum, pearl millet, and sunflower by using each of the greenness possibilities. Those had R^2 values between 0.45 and 0.69, and are presented in Table 9. I also determined greenness-DWT relations for the grass crops combined (also in Table 9) but there were no significant models for the broadleaf crops combined. Kollenkark et al. (1982) also determined that greenness is better correlated to LAI than DWT because DWT includes stems, pods, seeds, etc. that are not spectrally detectable. Aase and Siddoway (1981) had similar problems in determining relationships between seasonal dry matter accumulation of winter wheat and vegetation indices. They could determine such relationships up to tillering, but after this stage, the relationships collapsed due to increased contribution to the dry weight by non-leafy material.

Models that could estimate DWT during the first part of the season, when the plant matter present is due almost entirely to leafy material, might be possible to determine. I chose the date of maximum leaf area to be the cut-off point for these first-of-season models. Because only three to eight data points were taken for each crop prior to maximum leaf area, I believed I did not have sufficient data to determine crop-specific greenness-DWT models, but that I could use the combined grass data and combined broadleaf data to determine general models for early season. Using SAS regression techniques (STEPWISE and GLM procedures), only the first order greenness values were significant ($p < 0.05$) and intercepts were not significantly different from zero ($p > 0.05$). The no-intercept models for estimating DWT from greenness resulted in general DWT crop factors for grass crops and broadleaf crops presented in Table 10. Those DWT crop factors, multiplied by appropriate greenness values, estimate dry weight in Mg/ha ($R^2 \geq 0.91$). Fig. 19 shows the dry weight estimated from spectral data (by multiplying the grass or broadleaf crop factor by the overall greenness values) plotted against the field estimated values of DWT.

Table 10. Crop factors for predicting above ground vegetation dry weight (DWT) (measured in Mg/ha) up to maximum LAI by using reflectance greenness.

Crop	N	Individual greenness			Overall greenness			Greenness from Rice et al., 1980		
		R^2	Crop factor	SE	R^2	Crop factor	SE	R^2	Crop factor	SE
Broadleaf crops	14	0.96	0.099	0.0053	0.97	0.101	0.0053	0.96	0.095	0.0050
Grass crops	18	0.92	0.151	0.0110	0.92	0.150	0.0109	0.91	0.139	0.0106

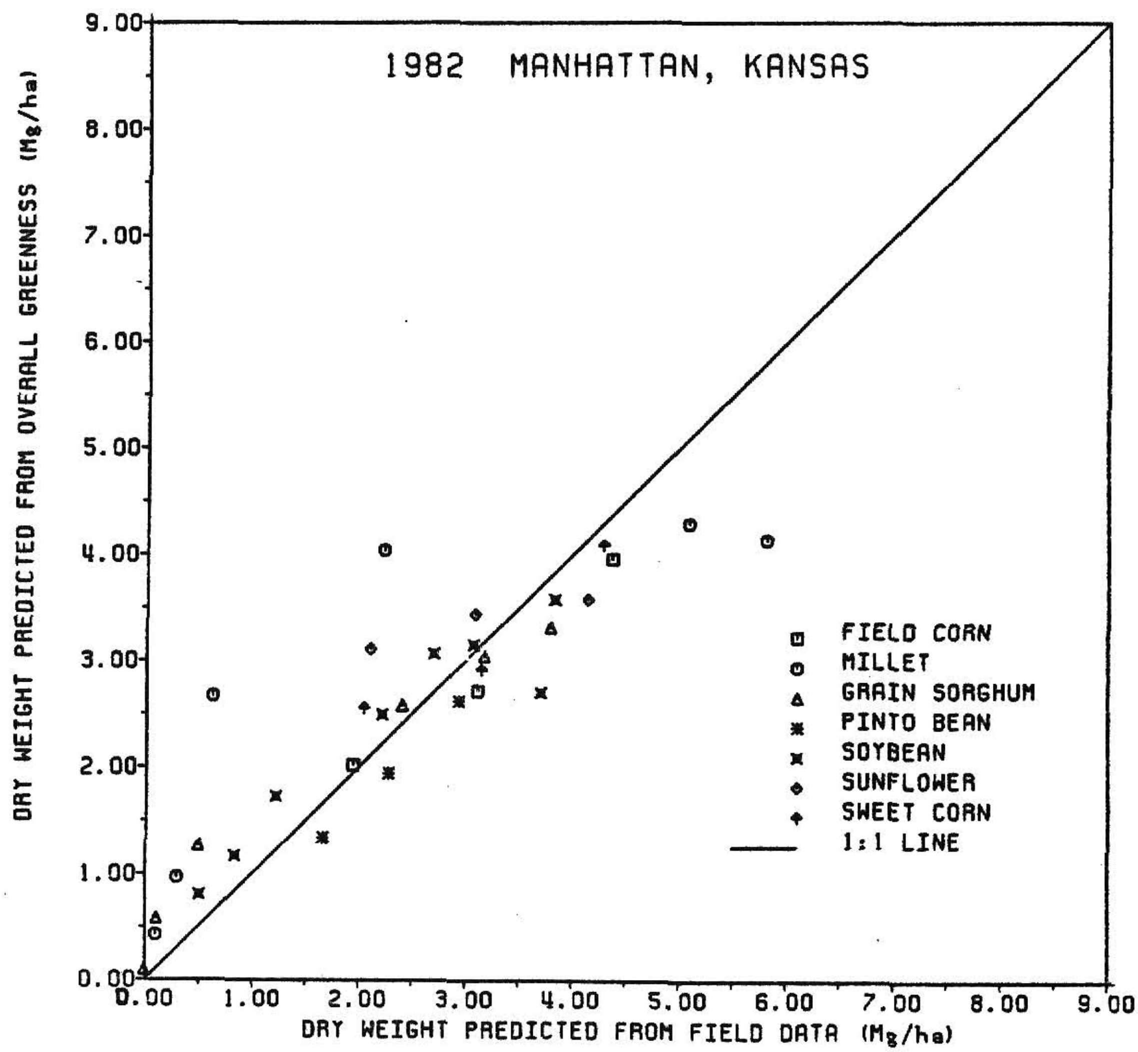


Fig. 19. Total dry weight (DWT) values predicted from spectral data (by multiplying the appropriate dry weight crop factor, grass or broadleaf, by the overall greenness values) against field estimated values of DWT for 1982, until maximum leaf area.

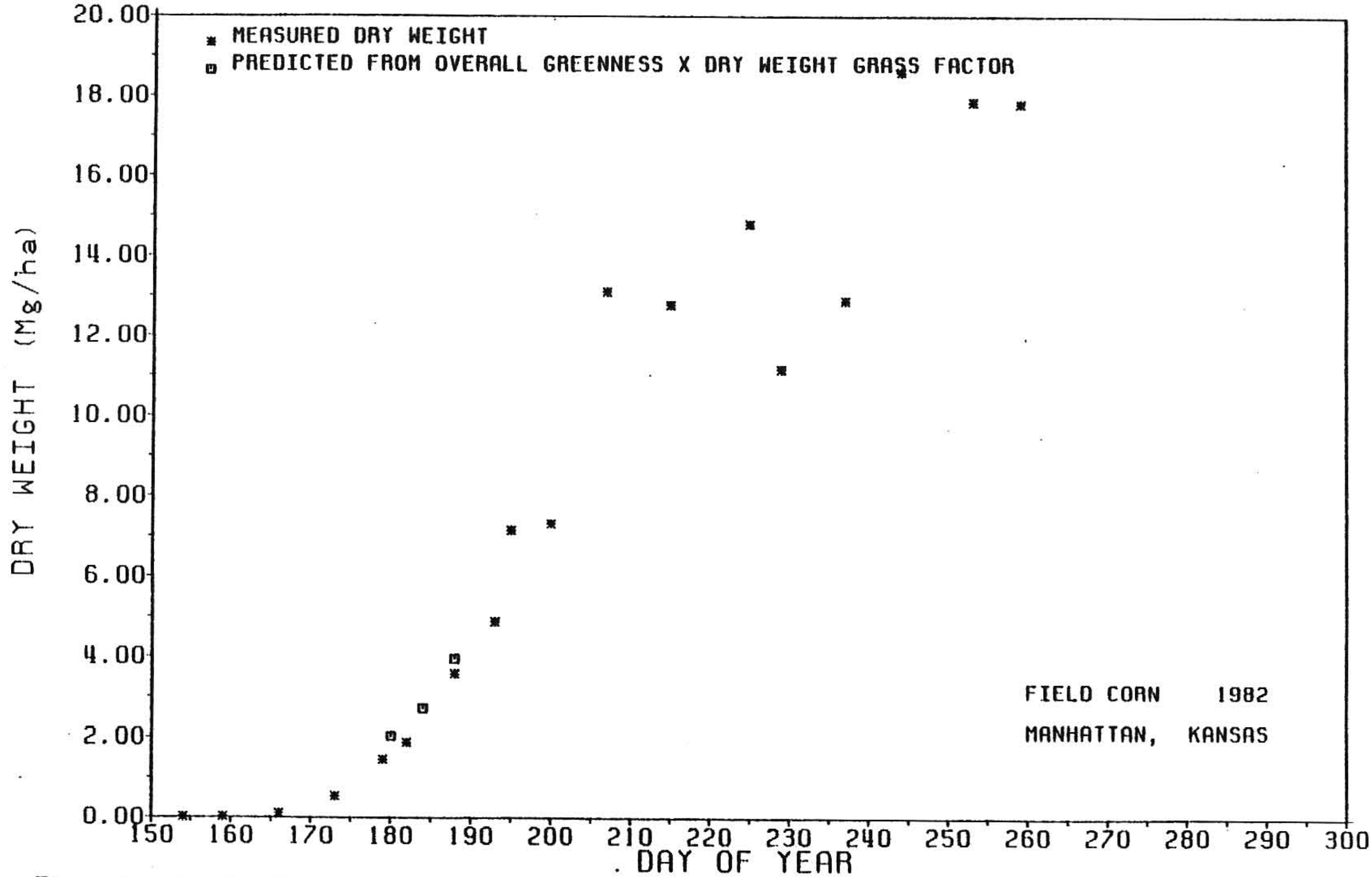


Fig. 20. Spectrally estimated DWT until maximum LAI and field measured DWT over the entire season for field corn, plotted against the day of the year, using 1982 models on the 1982 data.

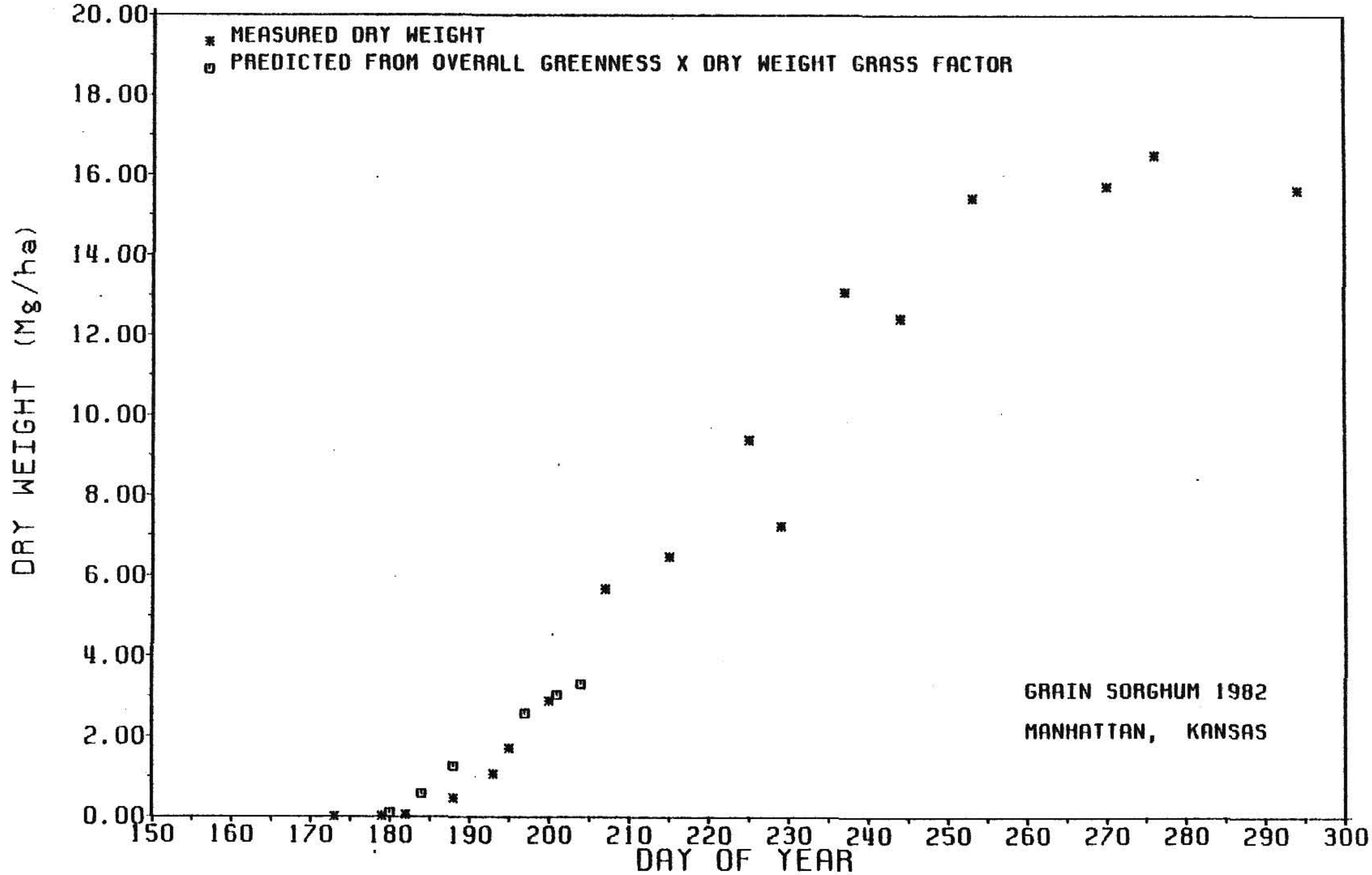


Fig. 21. Same as Fig. 20, but for grain sorghum.

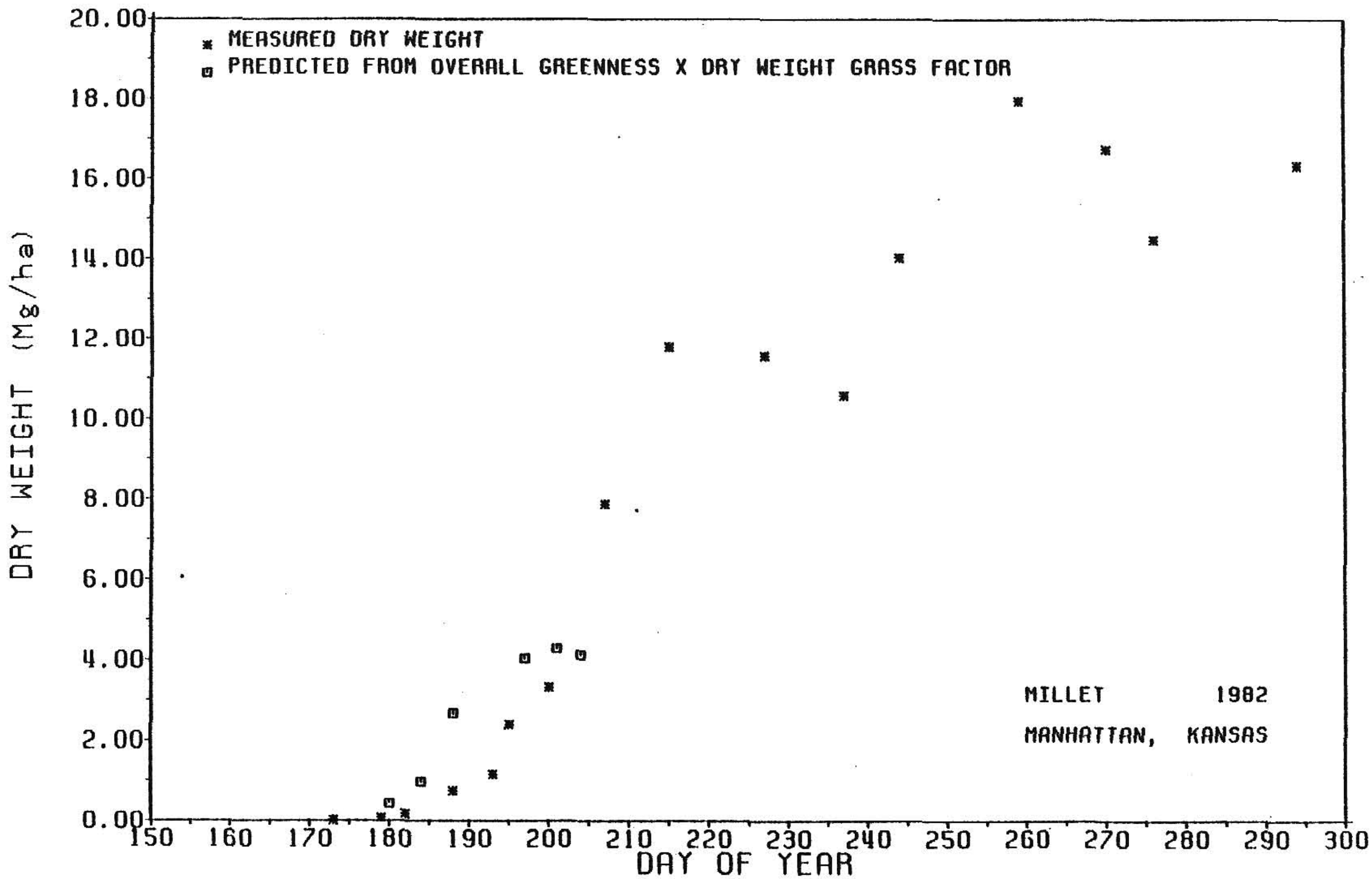


Fig. 22. Same as Fig. 20, but for pearl millet.

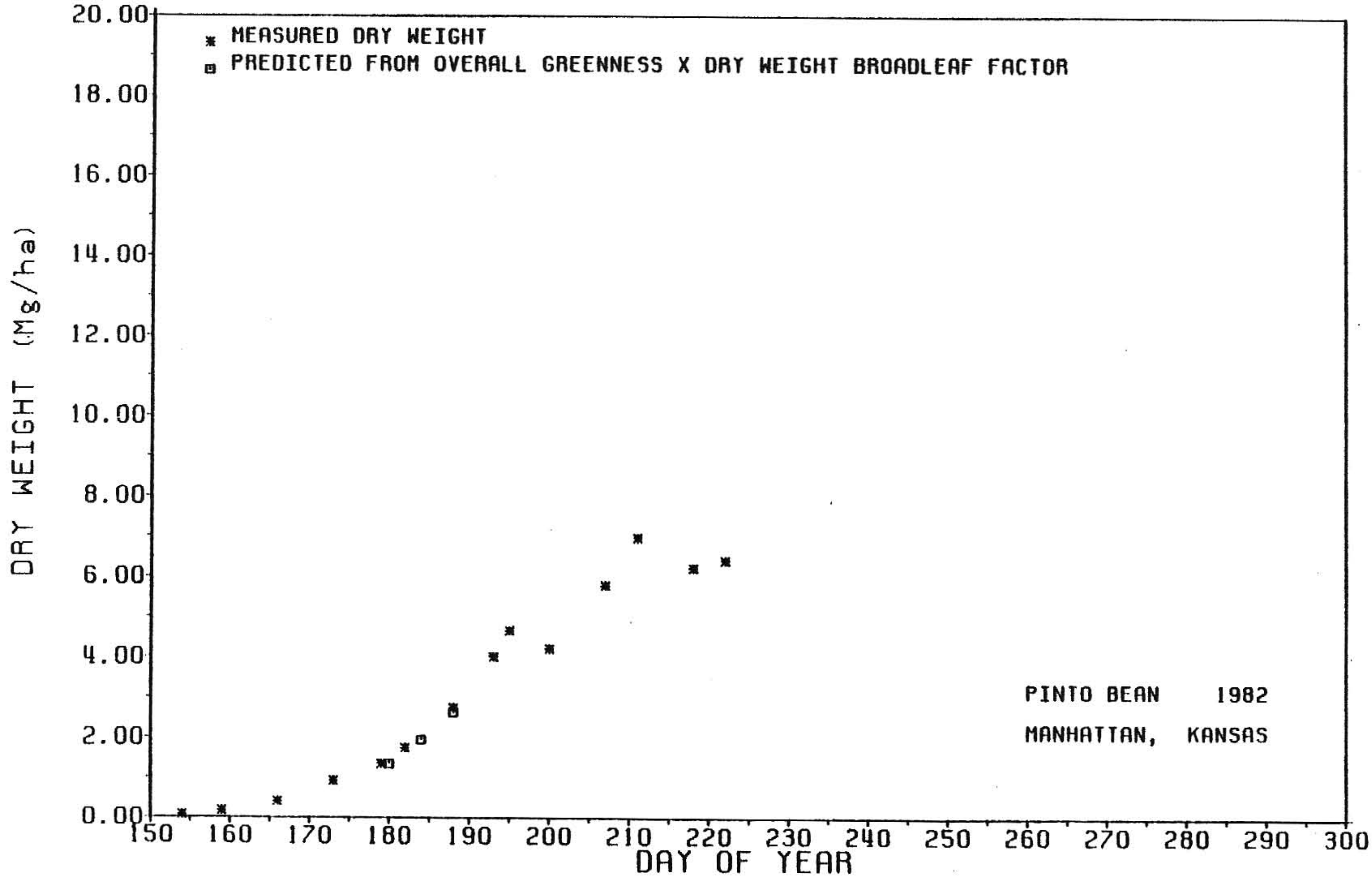


Fig. 23. Same as Fig. 20, but for pinto bean.

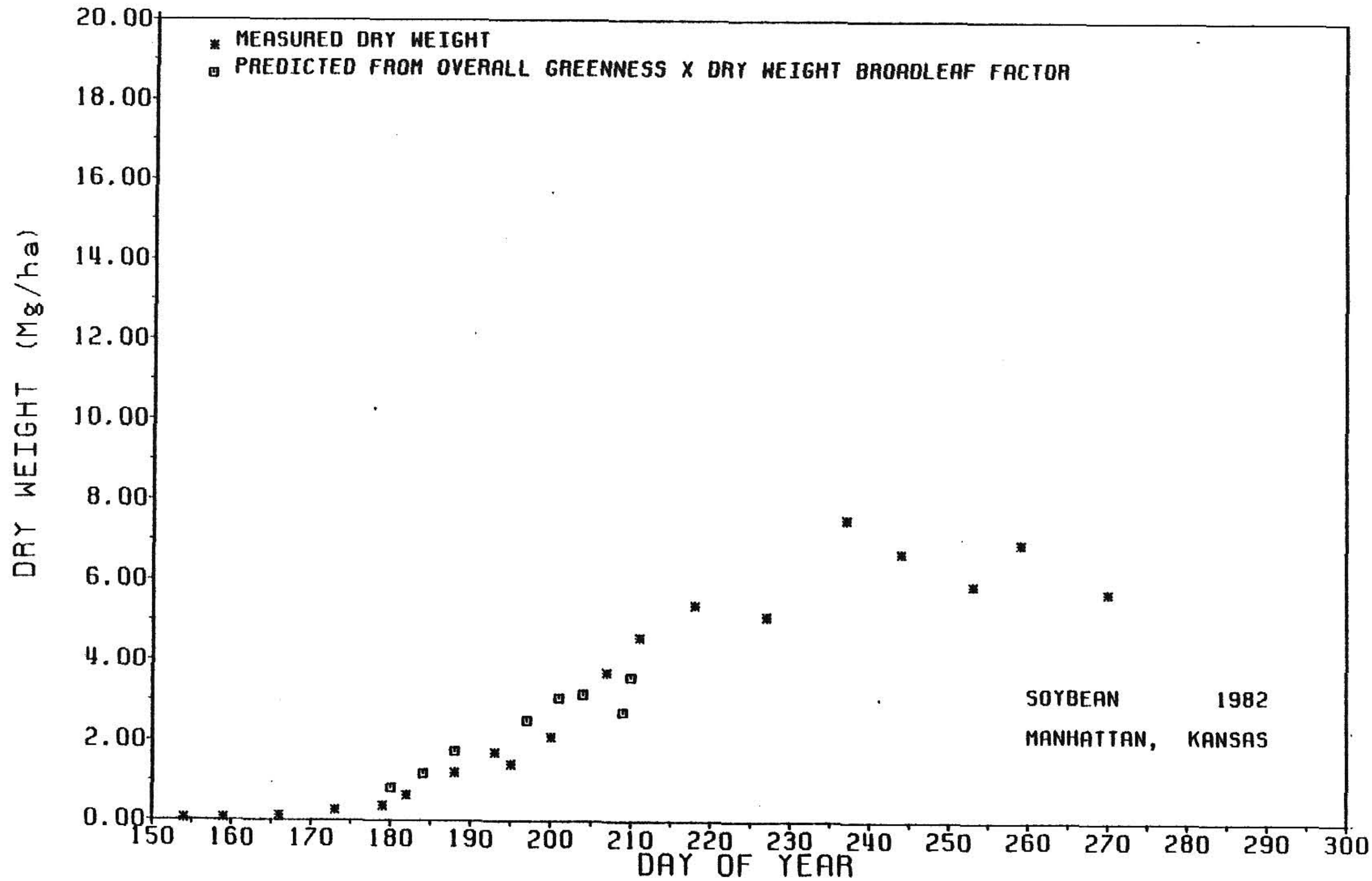


Fig. 24. Same as Fig. 20, but for soybean.

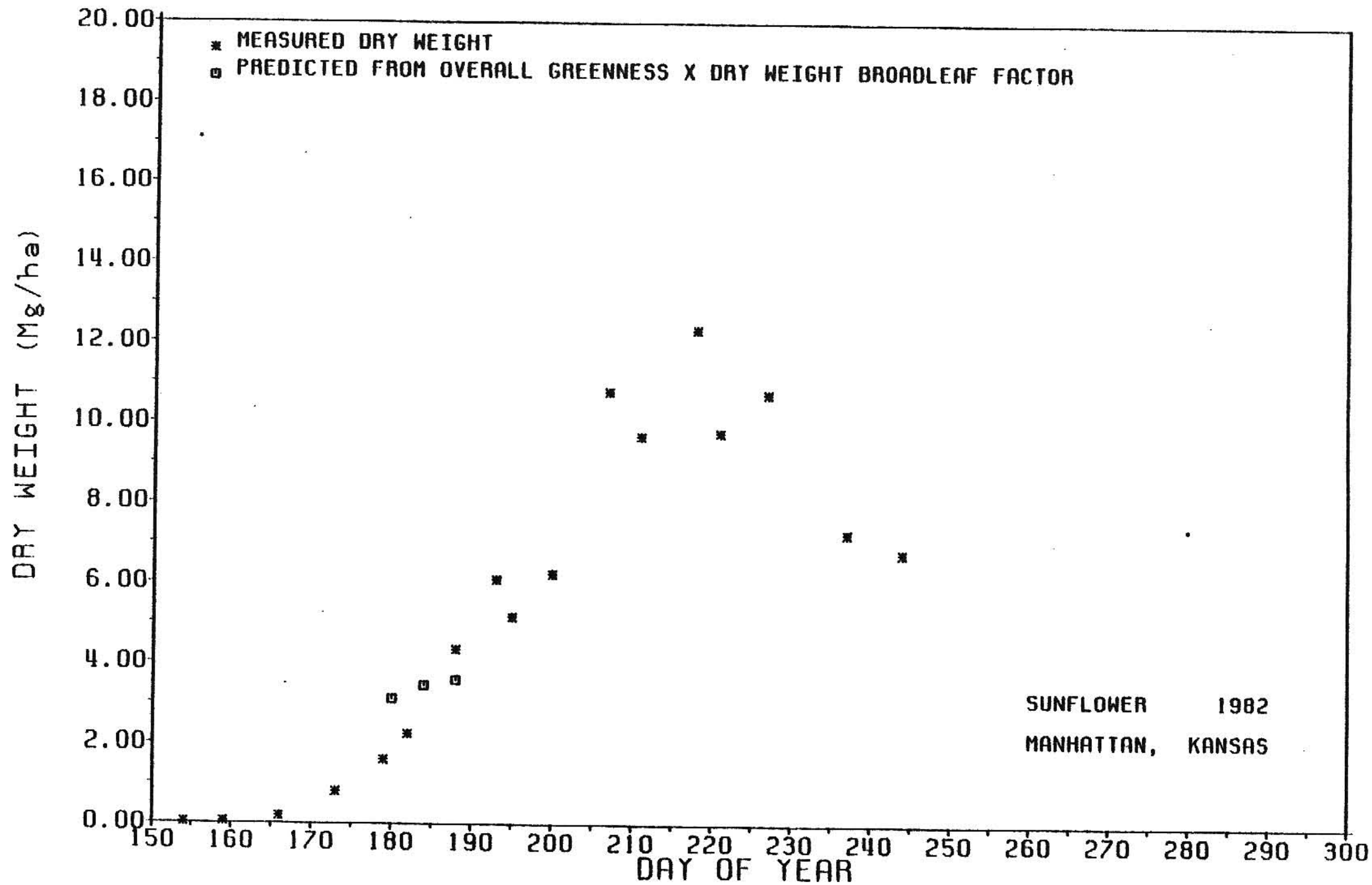


Fig. 25. Same as Fig. 20, but for sunflower.

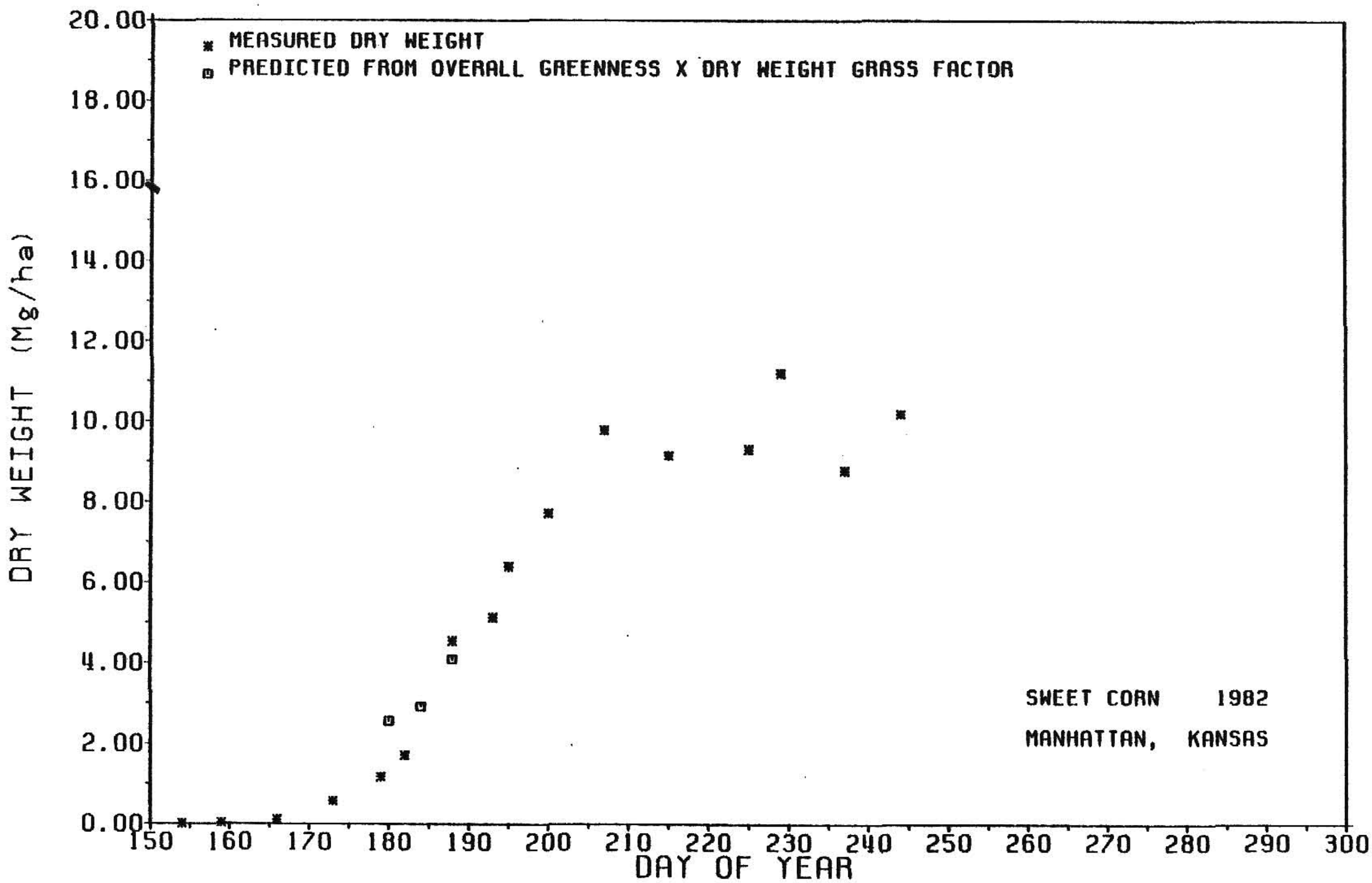


Fig. 26. Same as Fig. 20, but for sweet corn.

Fig. 20 through 26 show the DWT spectral estimates for the first of the season (until maximum leaf area) along with actual field measured DWT values for the entire season, plotted against the day of the year for each crop. The greenness models estimated DWT quite well, but unfortunately, only concern a small part of the growing season.

As an independent test on the general dry weight crop models that were determined in 1982, Fig. 27 through 32 show spectrally estimated DWT until maximum leaf area, along with actual field measured DWT values for the 1981 season, plotted against the day of the year for each crop. For the small part of the season included, greenness estimated DWT very well for all crops examined except for day 224 in soybean and day 192 in sunflower. On those dates, I also had difficulty in estimating soybean and sunflower LAI from greenness. This may also indicate differences between the vegetation densities of the plant sampling sites and the spectral data sites.

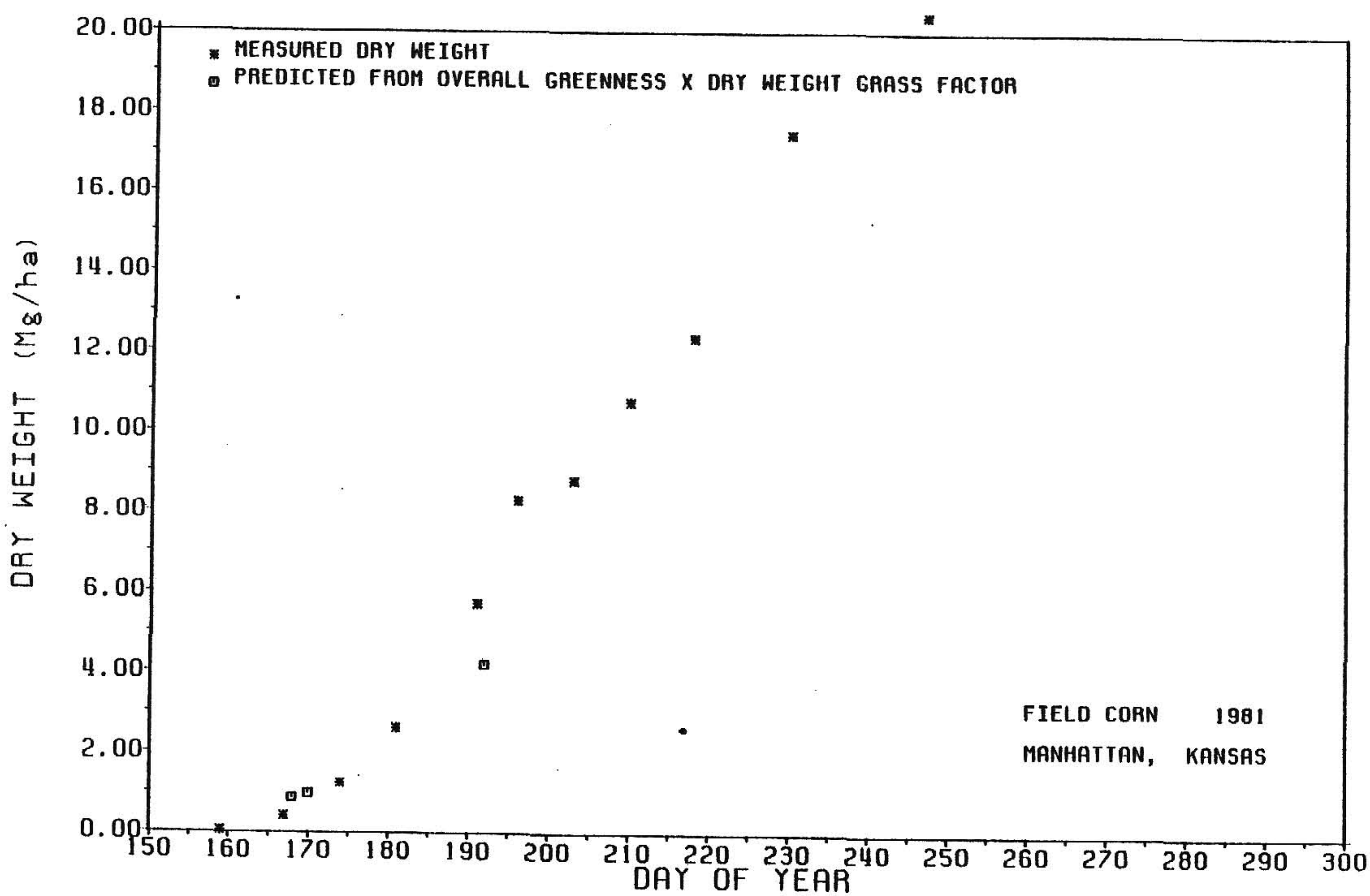


Fig. 27. Spectrally estimated DWT until maximum LAI and field measured DWT over the entire season for field corn, plotted against the day of the year, using 1982 models on the 1981 data.

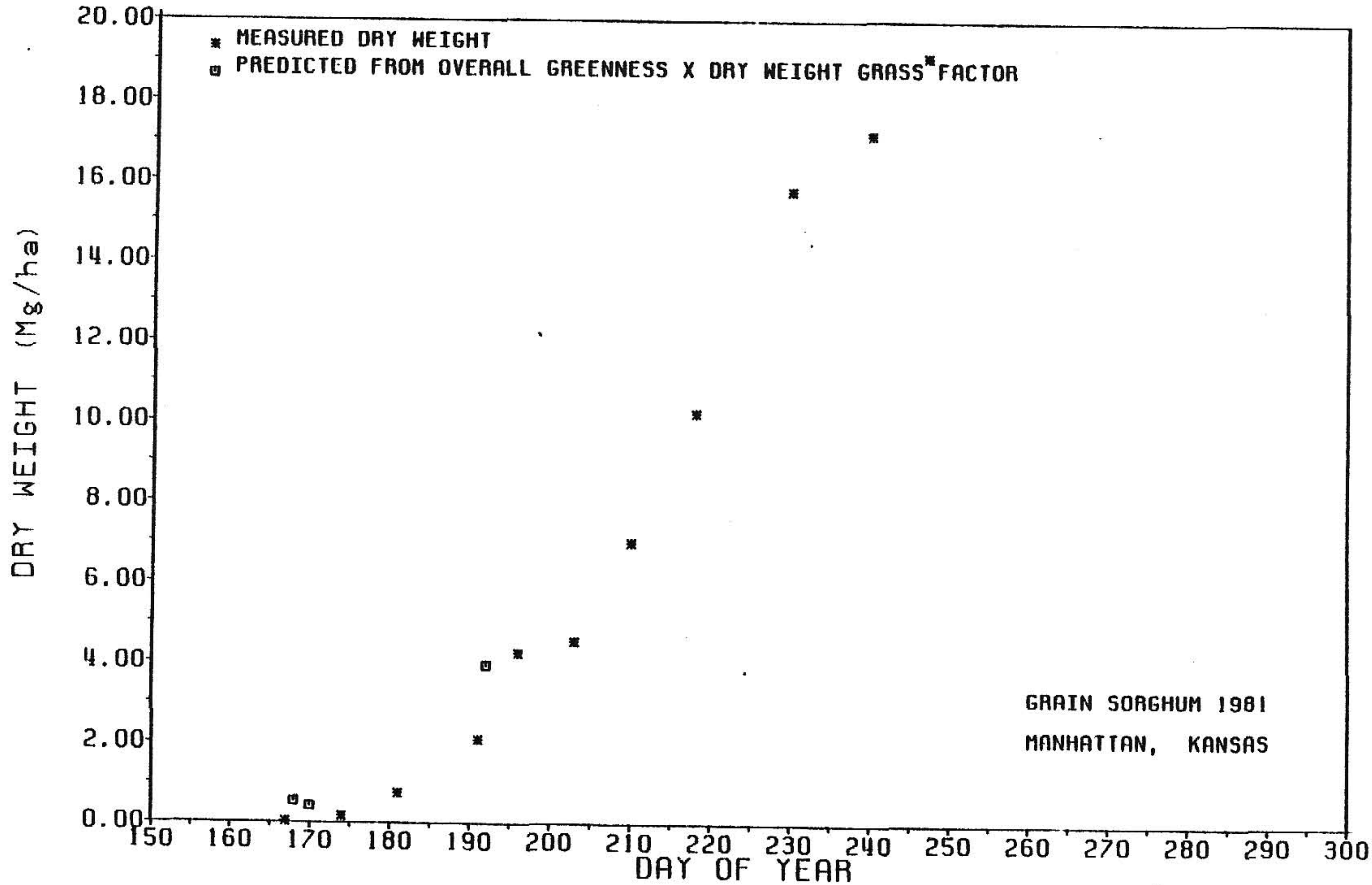


Fig. 28. Same as Fig. 27, but for grain sorghum.

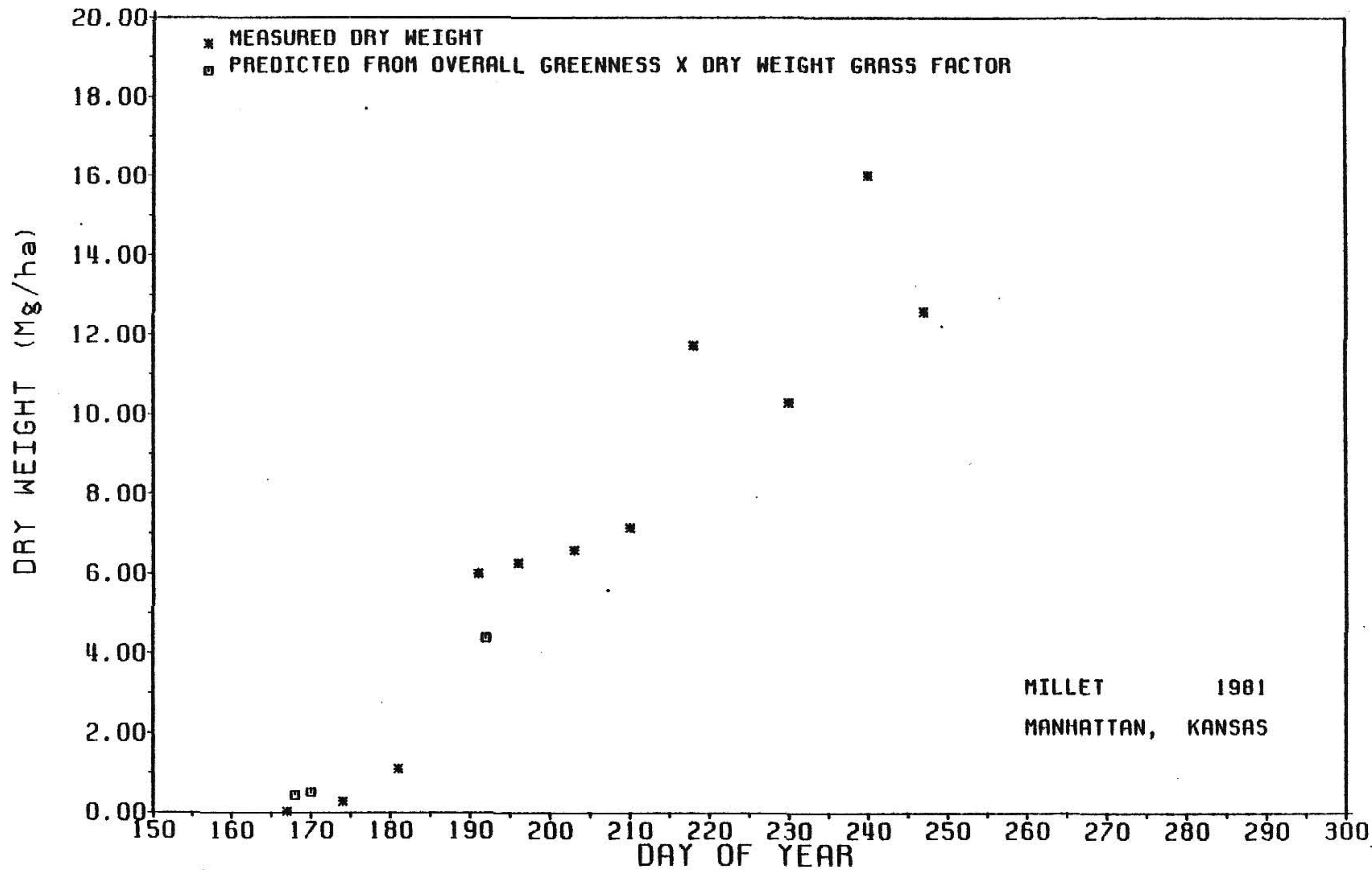


Fig. 29. Same as Fig. 27, but for pearl millet.

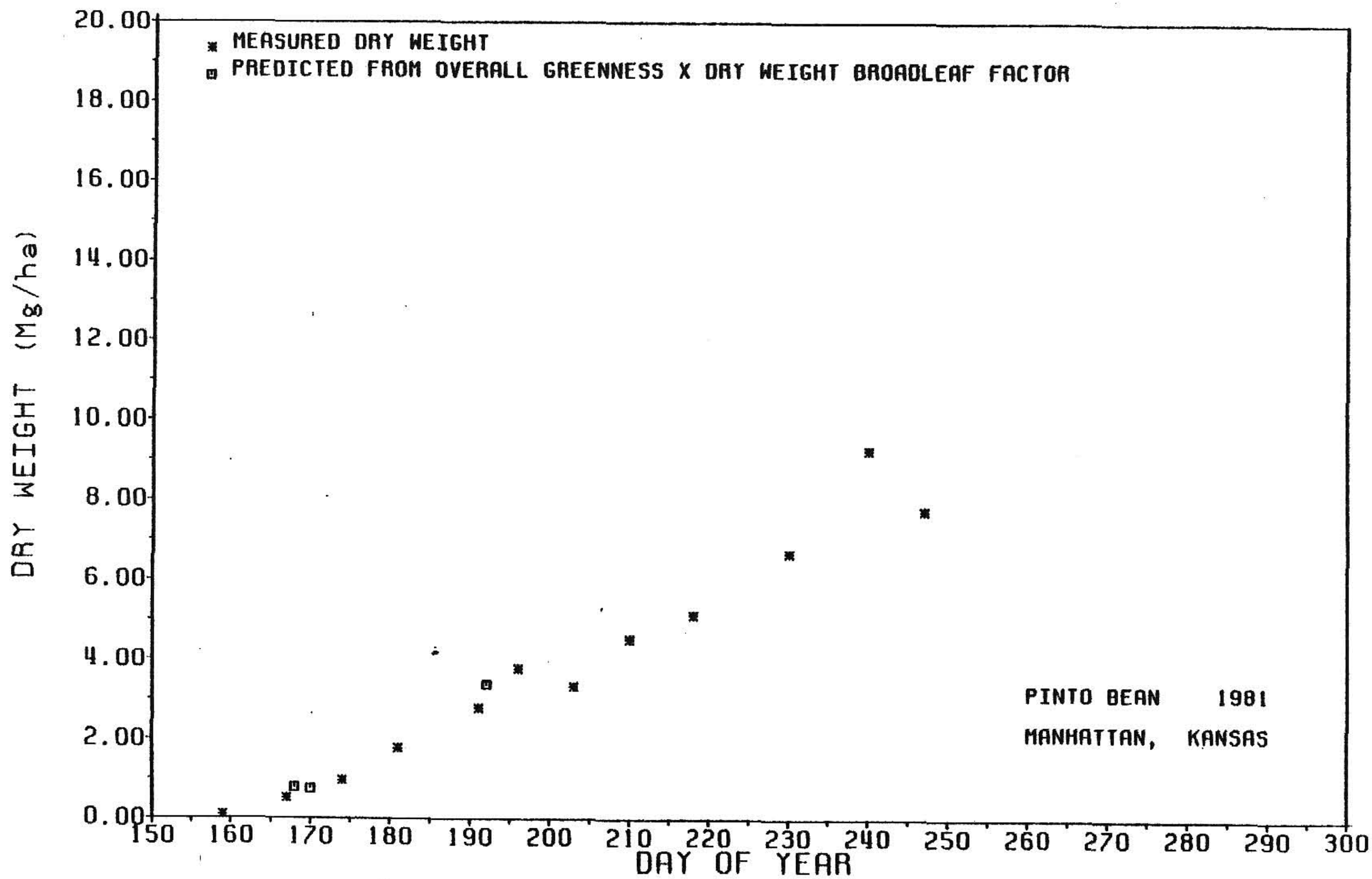


Fig. 30. Same as Fig. 27, but for pinto bean.

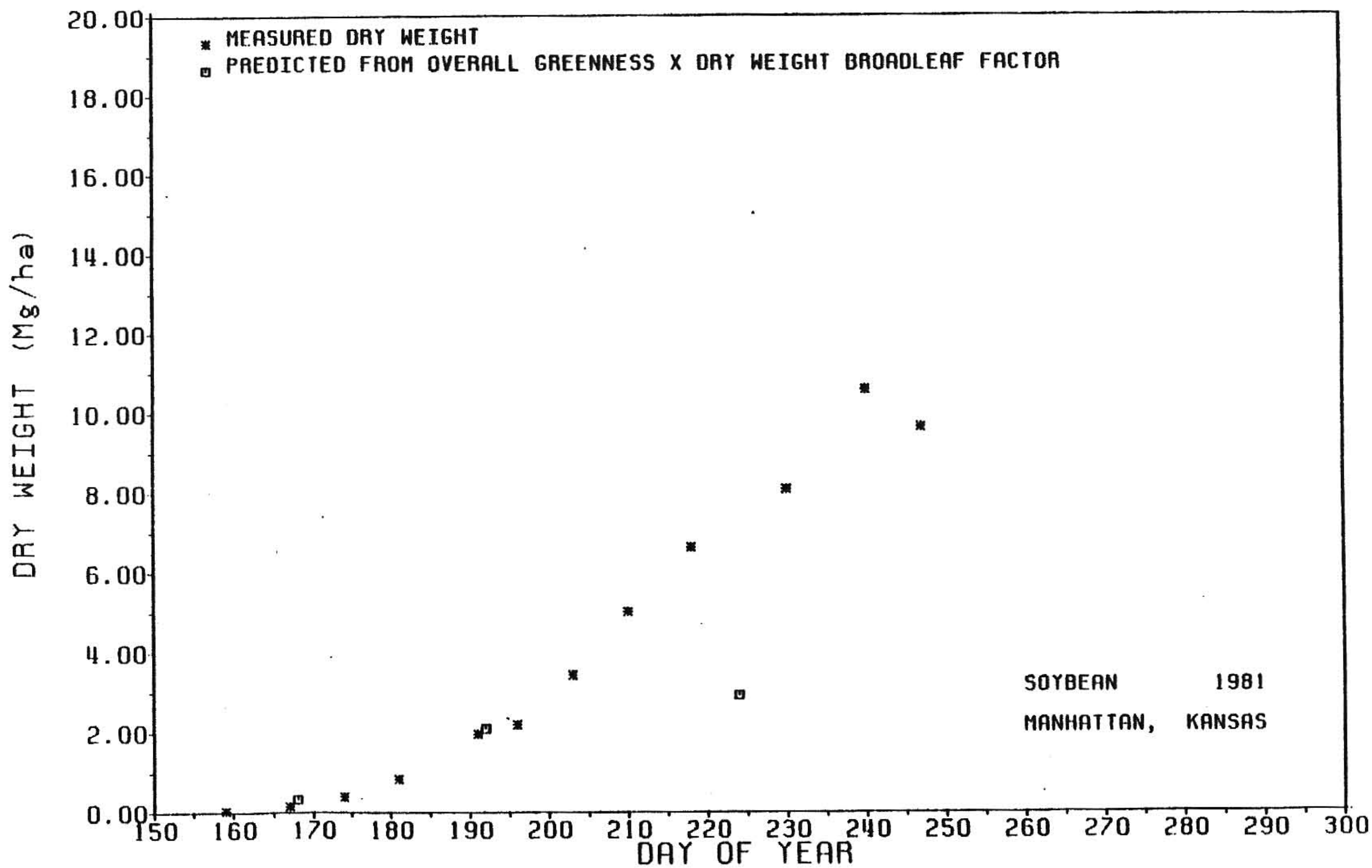


Fig. 31. Same as Fig. 27, but for soybean.

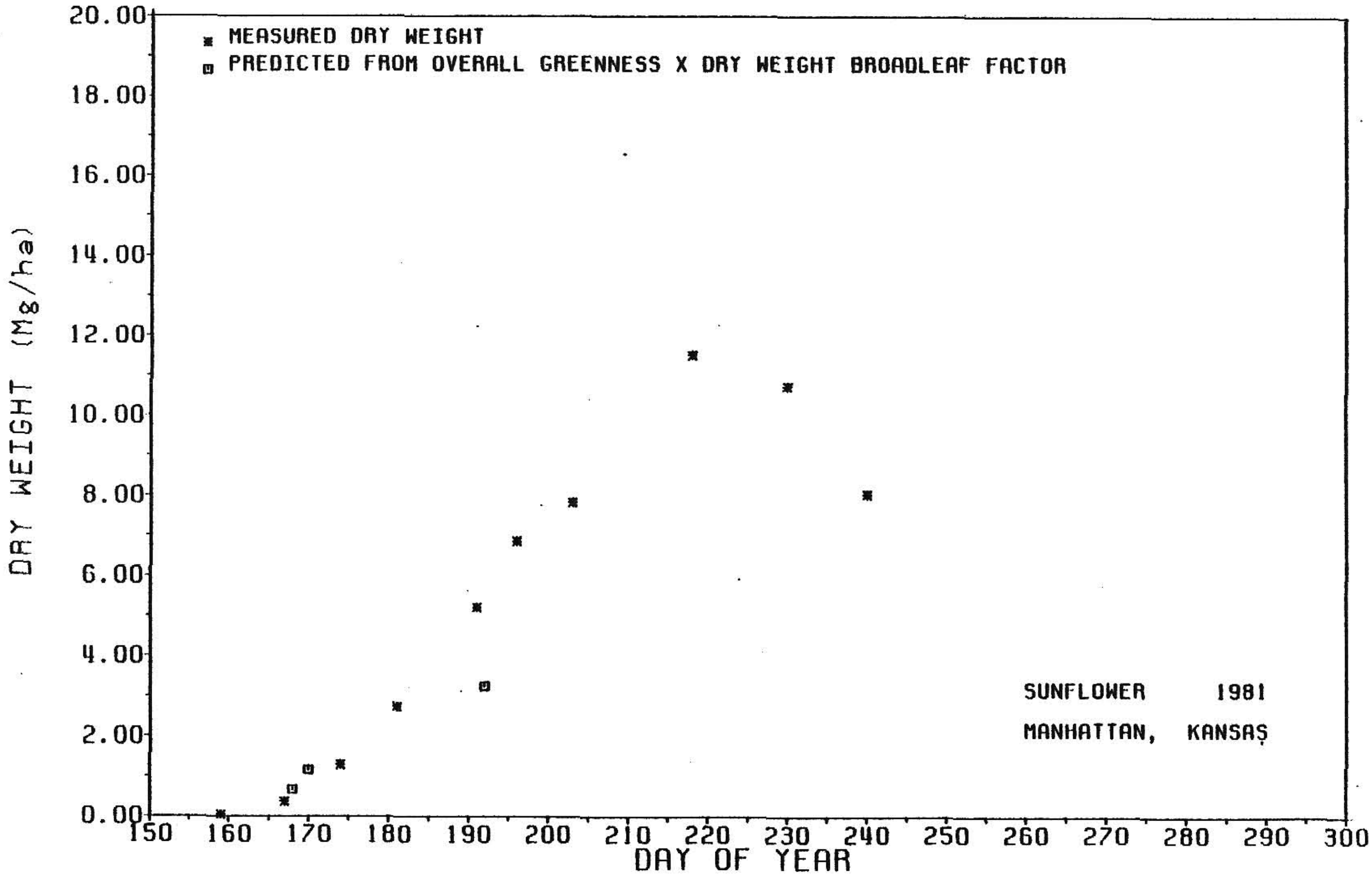


Fig. 32. Same as Fig. 27, but for sunflower.

SUMMARY AND CONCLUSIONS

By using a modified form of the procedure described by Jackson (1983), four-dimensional reflectance greenness indices were determined for each of seven crops (field and sweet corn, grain sorghum, pearl millet, pinto bean, soybean, and sunflower) and an overall greenness index was determined from the data of all crops combined. Greenness values were highly correlated with the 1982 leaf area index (LAI) values, whether the index used was derived for the specific crop involved, for all crops combined, or in an independent study (Rice et al., 1980). For each crop examined, the relationship between greenness and LAI was significant ($p < 0.01$) and linear, with the slope equal to what I have termed the "crop factor". The intercepts were not significantly different from zero ($p > 0.05$). The resulting numerical crop factors, when multiplied by the greenness values, estimated LAI with $R^2 \geq 0.94$. The seven crops were grouped into grass and broadleaf classes and the data used to determine general crop factors. When multiplied by greenness values, the grass and broadleaf factors are able to estimate 1982 LAI values with $R^2 \geq 0.94$.

The greenness indices and crop factors determined with 1982 data were applied to an independent data set from 1981 (involving a different row direction and soil type) and estimated LAI quite well, particularly for grain sorghum and field corn. There were tendencies in both seasons for greenness estimated LAI to reach saturation levels. Those levels varied from LAI values of 5.0 to 7.0 in the grass crops and 4.0 to 5.0 in the broadleaf crops.

Significant relationships could not be determined between greenness values and total dry weight (DWT) over the entire 1982 growing season. This is because DWT includes stems, pods, seeds, and other plant parts that are not spectrally detectable. Significant relationships were determined between greenness and DWT for the grass and broadleaf classes up until maximum leaf area ($p < 0.05$). These relationships were linear, and their intercepts were not significantly different from zero ($p > 0.05$). The resulting DWT crop factors, multiplied by appropriate greenness values, estimated total dry weight in Mg/ha with $R^2 \geq 0.91$. The 1982 determined crop factors for DWT until maximum leaf area were applied to the 1981 data and estimated DWT quite well for the small part of the season concerned.

The greenness x crop factor concept is a simple but effective method of transforming remotely sensed spectral data into estimations of DWT until maximum leaf area or LAI that are not so labor or time consuming or prone to sampling biases as conventional field measurements of DWT and LAI. Remote sensing of greenness would allow research on a wide assortment of crop models requiring LAI or DWT as an input to be applied to larger areas or at more frequent intervals than conventional sampling techniques.

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APPENDIX

The following notes apply to Tables 3A, 4A, 5A, and 6A.

TIME = time of day, Central Standard Time.

MSS4, MSS5, MSS6, and MSS 7 = percent reflectance for the respective wavebands.

SOLAR AZIMUTH = angle between sun and direction South, in degrees.

SOLAR ELEVATION = angle between sun and horizon, in degrees.

Table 1A.

1981 VEGETATION MASS AND GREEN LEAF AREA INDEX

DAY OF YEAR	CROP	ABOVE GROUND DRY MASS MG/HA	VEGETATION LEAF AREA INDEX
159	FIELD CORN	0.04	0.09
167	FIELD CORN	0.41	0.54
174	FIELD CORN	1.23	1.94
181	FIELD CORN	2.61	3.93
191	FIELD CORN	5.71	4.52
196	FIELD CORN	8.28	3.67
203	FIELD CORN	8.78	4.36
210	FIELD CORN	10.75	4.16
218	FIELD CORN	12.35	3.83
230	FIELD CORN	17.45	4.12
240	FIELD CORN	24.93	3.97
247	FIELD CORN	20.43	2.09
167	PEARL MILLET	0.03	0.06
174	PEARL MILLET	0.28	0.63
181	PEARL MILLET	1.09	2.48
191	PEARL MILLET	6.00	4.79
196	PEARL MILLET	6.26	4.51
203	PEARL MILLET	6.59	5.55
210	PEARL MILLET	7.15	3.99
218	PEARL MILLET	11.73	5.27
230	PEARL MILLET	10.29	4.08
240	PEARL MILLET	16.02	4.85
247	PEARL MILLET	12.59	4.40
159	PINTO BEAN	0.08	0.10
167	PINTO BEAN	0.51	0.65
174	PINTO BEAN	0.95	1.53
181	PINTO BEAN	1.76	2.87
191	PINTO BEAN	2.77	4.48
196	PINTO BEAN	3.75	3.52
203	PINTO BEAN	3.31	4.17
210	PINTO BEAN	4.50	5.48
218	PINTO BEAN	5.11	3.54
230	PINTO BEAN	6.66	4.47
240	PINTO BEAN	9.24	3.61
247	PINTO BEAN	7.72	1.11
167	GRAIN SORGHUM	0.02	0.05
174	GRAIN SORGHUM	0.17	0.38
181	GRAIN SORGHUM	0.74	1.50
191	GRAIN SORGHUM	2.07	2.99
196	GRAIN SORGHUM	4.23	4.64
203	GRAIN SORGHUM	4.52	4.95
210	GRAIN SORGHUM	6.98	4.35
218	GRAIN SORGHUM	10.20	4.29
230	GRAIN SORGHUM	15.75	3.84
240	GRAIN SORGHUM	17.15	3.88

Table 1A.

1981 VEGETATION MASS AND GREEN LEAF AREA INDEX

DAY OF YEAR	CROP	ABOVE GROUND DRY MASS MG/HA	VEGETATION LEAF AREA INDEX
247	GRAIN SORGHUM	19.10	3.28
159	SOYBEAN	0.03	0.04
167	SOYBEAN	0.15	0.20
174	SOYBEAN	0.39	0.51
181	SOYBEAN	0.83	1.35
191	SOYBEAN	1.96	2.69
196	SOYBEAN	2.19	3.08
203	SOYBEAN	3.43	5.06
210	SOYBEAN	5.01	6.21
218	SOYBEAN	6.63	6.27
230	SOYBEAN	8.09	5.15
240	SOYBEAN	10.58	5.24
247	SOYBEAN	9.63	3.39
159	SUNFLOWER	0.03	0.06
167	SUNFLOWER	0.36	0.45
174	SUNFLOWER	1.28	1.61
181	SUNFLOWER	2.73	3.36
191	SUNFLOWER	5.20	3.73
196	SUNFLOWER	6.86	3.45
203	SUNFLOWER	7.83	5.25
218	SUNFLOWER	11.52	4.76
230	SUNFLOWER	10.72	2.51
240	SUNFLOWER	8.03	1.47

Table 2A.

1982 VEGETATION MASS AND GREEN LEAF AREA INDEX

DAY OF YEAR	CROP	----ABOVE GROUND VEGETATION---- FRESH MASS MG/HA	DRY MASS MG/HA	LEAF AREA INDEX
154	FIELD CORN	.	0.01	0.03
159	FIELD CORN	.	0.02	0.03
166	FIELD CORN	.	0.10	0.21
173	FIELD CORN	.	0.53	0.77
179	FIELD CORN	15.57	1.44	2.38
182	FIELD CORN	23.48	1.86	3.05
188	FIELD CORN	36.49	3.57	4.65
193	FIELD CORN	54.24	4.88	5.63
195	FIELD CORN	73.17	7.15	6.82
200	FIELD CORN	57.26	7.33	4.81
207	FIELD CORN	82.25	13.11	6.25
215	FIELD CORN	63.90	12.77	3.32
225	FIELD CORN	72.73	14.80	3.72
229	FIELD CORN	50.20	11.17	2.30
237	FIELD CORN	51.35	12.89	2.62
244	FIELD CORN	56.82	18.60	2.44
253	FIELD CORN	44.05	17.85	0.67
259	FIELD CORN	37.02	17.80	0.36
173	PEARL MILLET	.	0.01	0.02
179	PEARL MILLET	0.66	0.07	0.16
182	PEARL MILLET	2.13	0.17	0.57
188	PEARL MILLET	6.71	0.74	1.56
193	PEARL MILLET	11.82	1.15	2.66
195	PEARL MILLET	26.49	2.38	4.95
200	PEARL MILLET	30.97	3.32	5.26
207	PEARL MILLET	63.20	7.88	7.41
215	PEARL MILLET	64.85	11.79	6.47
227	PEARL MILLET	57.23	11.57	4.93
237	PEARL MILLET	50.08	10.58	4.15
244	PEARL MILLET	54.99	14.04	3.15
253	PEARL MILLET	50.62	.	3.26
259	PEARL MILLET	73.54	17.95	4.86
270	PEARL MILLET	.	16.74	2.66
276	PEARL MILLET	46.27	14.48	1.95
294	PEARL MILLET	39.83	16.34	0.73
154	PINTO BEAN	.	0.05	0.08
159	PINTO BEAN	.	0.16	0.12
166	PINTO BEAN	.	0.40	0.48
173	PINTO BEAN	.	0.91	1.21
179	PINTO BEAN	9.80	1.34	1.92
182	PINTO BEAN	13.25	1.74	2.79
188	PINTO BEAN	17.34	2.73	3.89
193	PINTO BEAN	31.46	4.01	5.54
195	PINTO BEAN	38.47	4.66	5.56
200	PINTO BEAN	30.58	4.21	3.23

Table 2A.

1982 VEGETATION MASS AND GREEN LEAF AREA INDEX

DAY OF YEAR	CROP	----ABOVE GROUND VEGETATION---- FRESH MASS MG/HA	DRY MASS MG/HA	LEAF AREA INDEX
207	PINTO BEAN	27.99	5.78	2.61
211	PINTO BEAN	32.05	6.98	2.54
218	PINTO BEAN	18.31	6.22	0.67
222	PINTO BEAN	14.61	6.41	0.49
154	SWEET CORN	.	0.01	0.02
159	SWEET CORN	.	0.02	0.03
166	SWEET CORN	.	0.10	0.21
173	SWEET CORN	.	0.57	0.86
179	SWEET CORN	13.04	1.17	2.21
182	SWEET CORN	22.35	1.71	2.96
188	SWEET CORN	43.17	4.54	5.37
193	SWEET CORN	48.14	5.13	5.51
195	SWEET CORN	49.51	6.40	4.77
200	SWEET CORN	54.70	7.72	4.87
207	SWEET CORN	62.18	9.78	4.92
215	SWEET CORN	39.54	9.15	2.63
225	SWEET CORN	40.13	9.30	2.79
229	SWEET CORN	45.29	11.19	3.06
237	SWEET CORN	32.58	8.78	0.53
244	SWEET CORN	25.14	10.18	0.07
173	GRAIN SORGHUM	.	0.00	0.01
179	GRAIN SORGHUM	0.17	0.02	0.04
182	GRAIN SORGHUM	0.49	0.04	0.15
188	GRAIN SORGHUM	3.76	0.46	0.85
193	GRAIN SORGHUM	10.43	1.06	2.09
195	GRAIN SORGHUM	19.76	1.70	3.53
200	GRAIN SORGHUM	26.47	2.89	4.29
207	GRAIN SORGHUM	44.57	5.68	6.72
215	GRAIN SORGHUM	43.90	6.47	4.65
225	GRAIN SORGHUM	43.25	9.38	3.23
229	GRAIN SORGHUM	40.85	7.23	3.40
237	GRAIN SORGHUM	55.37	13.06	3.77
244	GRAIN SORGHUM	48.54	12.42	3.47
253	GRAIN SORGHUM	42.40	15.42	2.12
259	GRAIN SORGHUM	54.29	.	3.01
270	GRAIN SORGHUM	.	15.71	1.93
276	GRAIN SORGHUM	41.85	16.49	1.67
294	GRAIN SORGHUM	35.21	15.62	1.33
154	SOYBEAN	.	0.04	0.04
159	SOYBEAN	.	0.05	0.03
166	SOYBEAN	.	0.11	0.11
173	SOYBEAN	.	0.25	0.32
179	SOYBEAN	2.12	0.36	0.45
182	SOYBEAN	3.93	0.63	0.97
188	SOYBEAN	6.45	1.19	1.79

Table 2A.

1982 VEGETATION MASS AND GREEN LEAF AREA INDEX

DAY OF YEAR	CROP	----ABOVE GROUND VEGETATION---- FRESH MASS MG/HA	DRY MASS MG/HA	LEAF AREA INDEX
193	SOYBEAN	10.11	1.69	2.37
195	SOYBEAN	9.30	1.40	2.30
200	SOYBEAN	11.29	2.09	2.89
207	SOYBEAN	18.46	3.69	4.40
211	SOYBEAN	22.18	4.56	4.59
218	SOYBEAN	27.73	5.37	4.29
227	SOYBEAN	23.04	5.10	2.76
237	SOYBEAN	33.31	7.52	3.90
244	SOYBEAN	27.35	6.68	2.52
253	SOYBEAN	19.76	5.88	0.88
259	SOYBEAN	19.95	6.92	0.26
270	SOYBEAN	.	5.70	0.00
154	SUNFLOWER	.	0.01	0.02
159	SUNFLOWER	.	0.04	0.04
166	SUNFLOWER	.	0.19	0.22
173	SUNFLOWER	.	0.79	0.97
179	SUNFLOWER	20.26	1.59	2.08
182	SUNFLOWER	36.02	2.23	3.45
188	SUNFLOWER	48.99	4.33	4.20
193	SUNFLOWER	66.81	6.08	5.63
195	SUNFLOWER	60.80	5.15	4.15
200	SUNFLOWER	62.66	6.23	4.13
207	SUNFLOWER	85.31	10.76	4.25
211	SUNFLOWER	65.05	9.66	3.04
218	SUNFLOWER	79.21	12.32	3.03
221	SUNFLOWER	65.72	9.75	2.48
227	SUNFLOWER	64.83	10.72	2.02
237	SUNFLOWER	37.83	7.24	1.19
244	SUNFLOWER	28.86	6.76	0.23

Table 3A.

BARE SOIL REFLECTANCE FOR 1981

DAY OF YEAR	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
231	1120	6.03	8.36	11.26	17.55	55.80	50.72
233	1059	5.41	7.40	10.80	15.01	60.75	46.85

Table 4A.

BARE SOIL REFLECTANCE FOR 1982

DAY OF YEAR	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
197	853	7.39	9.54	12.86	17.40	85.39	40.01
197	853	7.33	9.57	12.91	17.46	85.39	40.01
197	845	6.34	8.30	10.12	13.89	86.74	38.46
197	935	6.51	8.35	11.41	16.24	77.57	48.05
197	935	6.46	8.33	11.38	16.19	77.57	48.05
197	935	6.46	8.35	11.41	16.24	77.57	48.05
197	936	6.10	7.81	10.62	14.96	77.36	48.24
197	1016	6.83	8.92	12.00	16.96	68.08	55.63
197	1016	6.30	8.10	10.90	15.35	68.08	55.63
197	1103	8.68	11.32	15.33	21.13	52.98	63.57
197	1104	7.24	9.28	12.50	17.18	52.59	63.73
197	1203	10.22	13.09	18.01	23.89	21.29	70.72
197	1203	9.19	11.81	16.44	22.36	21.29	70.72
197	1301	10.85	13.94	18.86	24.97	-20.60	70.79
197	1301	10.52	13.55	18.74	25.05	-20.60	70.79
197	1407	10.99	14.09	19.43	25.81	-54.86	62.77
197	1408	11.30	14.73	19.57	26.05	-55.24	62.61
197	1459	7.76	9.78	14.10	19.20	-70.58	53.80
197	1459	8.80	11.34	16.23	21.71	-70.58	53.80
201	1008	10.33	13.19	18.65	24.85	69.20	53.67
201	1008	12.07	15.61	22.38	29.74	69.20	53.67
204	846	6.80	8.56	12.76	18.02	85.18	37.82
204	847	7.29	9.25	13.56	18.62	85.01	38.01
204	916	9.72	12.70	17.10	22.69	79.78	43.58
204	917	8.60	11.01	15.05	20.07	79.59	43.77
204	1003	7.29	9.32	13.02	17.84	69.66	52.35
204	1005	8.12	10.21	14.13	19.13	69.17	52.72
204	1045	11.60	14.95	19.79	25.52	57.65	59.65
204	1046	11.58	14.88	19.11	24.56	57.31	59.81
204	1228	10.77	13.77	18.58	24.04	3.37	70.38
204	1229	14.01	17.81	22.74	28.78	2.67	70.39
204	1328	11.95	15.26	20.29	26.11	-35.22	67.07
204	1329	13.99	17.67	23.13	29.16	-35.75	66.96
204	1424	13.00	16.69	21.92	27.91	-58.72	59.06
204	1425	14.19	17.95	23.37	29.38	-59.05	58.90
204	1525	13.87	17.87	23.38	29.50	-74.74	48.19
204	1526	11.86	14.98	20.24	25.86	-74.96	48.00
209	937	9.23	12.08	16.00	21.33	74.22	46.86
209	938	8.78	11.38	15.34	20.68	74.00	47.05
209	1214	11.92	15.21	19.58	25.16	12.39	68.87
209	1215	11.45	14.67	18.80	24.38	11.74	68.91
209	1428	10.21	13.20	17.40	22.56	-58.50	57.56
209	1428	9.20	11.89	15.80	20.60	-58.50	57.56
210	934	9.59	12.51	16.59	21.91	74.57	46.16
210	935	8.84	11.47	15.30	20.32	74.35	46.35
214	1018	10.53	13.48	17.39	22.69	62.63	53.47
214	1019	9.64	12.37	16.06	21.27	62.35	53.64
214	1156	11.64	14.78	18.76	23.99	22.35	66.61
214	1200	10.99	13.89	17.77	22.91	20.04	66.89
215	1305	12.51	16.24	19.20	24.38	-20.04	66.59
215	1306	11.99	15.48	18.57	23.73	-20.62	66.52
215	1419	11.12	14.01	17.99	22.91	-53.74	57.80
215	1420	10.52	13.31	17.19	22.10	-54.08	57.64
215	1546	10.21	13.04	16.92	21.86	-76.16	42.49
215	1547	8.99	11.46	15.30	19.94	-76.36	42.30
215	1700	8.24	10.53	14.37	18.71	-89.21	28.29

Table 4A.

BARE SOIL REFLECTANCE FOR 1982

DAY OF YEAR	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
215	1701	7.07	8.91	12.36	16.46	-89.37	28.09
221	1040	12.83	16.17	21.77	28.17	53.36	55.79
221	1041	11.62	14.85	20.04	26.34	53.03	55.94
230	913	10.61	13.22	19.60	26.07	72.23	39.10
230	913	8.33	10.51	15.37	21.13	72.23	39.10
231	845	11.64	14.51	19.95	25.81	77.35	33.70
231	846	9.52	11.96	16.89	22.72	77.16	33.89
231	1236	14.66	18.18	24.61	30.90	-3.52	62.80
231	1237	12.12	15.19	20.50	26.50	-4.05	62.79
242	918	13.57	17.24	22.45	28.84	66.53	37.80
242	919	12.89	16.46	21.93	28.54	66.31	37.97
245	922	14.16	17.94	23.55	29.97	64.44	37.90
245	923	12.75	16.38	21.66	28.43	64.22	38.07
245	1018	14.40	18.31	23.70	30.23	50.17	47.03
245	1020	13.00	16.40	22.11	28.89	49.59	47.33
245	1152	15.07	19.08	24.42	30.91	15.33	57.04
245	1153	14.06	17.72	23.00	29.56	14.89	57.09
245	1250	14.93	18.87	24.29	30.96	-11.42	57.42
245	1251	13.99	17.66	22.89	29.58	-11.87	57.38
245	1401	14.62	18.44	23.60	29.75	-40.10	51.34
245	1401	13.69	17.25	22.30	28.47	-40.10	51.34
245	1617	12.99	16.12	22.24	28.14	-74.20	29.07
245	1618	11.60	14.63	19.79	26.18	-74.38	28.88
253	832	6.51	8.49	10.77	14.14	71.55	27.34
263	821	7.13	8.79	13.08	17.29	69.83	23.35
265	941	12.64	16.11	22.10	28.46	51.98	36.42
265	945	11.00	14.14	18.93	25.12	50.99	37.03
265	1016	12.09	15.14	21.84	28.41	42.73	41.40
265	1018	10.80	13.72	18.71	24.93	42.16	41.67
265	1146	12.71	16.11	21.89	28.08	12.53	49.57
265	1147	11.61	14.78	19.55	25.58	12.15	49.62
265	1238	13.26	16.87	22.16	28.37	-7.66	49.99
265	1240	11.78	14.98	19.59	25.72	-8.43	49.94
265	1343	13.37	16.86	22.56	28.77	-31.17	45.75
265	1344	11.88	15.08	19.80	25.81	-31.49	45.65
265	1438	12.95	16.19	22.76	29.13	-47.42	38.97
265	1439	12.35	15.75	20.55	26.83	-47.68	38.83
270	1045	6.86	8.91	11.42	15.06	32.32	43.30
270	1046	6.85	8.87	11.32	14.99	32.00	43.41
280	1006	14.48	18.20	24.74	31.55	40.34	35.76
280	1007	14.03	17.95	22.94	29.36	40.08	35.88

Table 5A.

REFLECTANCE FOR 1981

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
168	8	FIELD CORN	1548	5.84	8.46	9.61	22.57	-72.52	56.38
170	8	FIELD CORN	1352	4.25	6.90	7.56	21.42	-19.76	73.43
192	8	FIELD CORN	1601	1.92	4.14	1.85	56.97	-72.44	53.89
192	8	FIELD CORN	1601	1.81	4.06	1.96	55.35	-72.44	53.89
192	8	FIELD CORN	1601	2.19	4.90	1.92	62.08	-72.44	53.89
220	8	FIELD CORN	1515	2.17	3.64	2.68	37.48	-51.12	57.42
220	8	FIELD CORN	1515	2.07	3.50	2.55	36.47	-51.12	57.42
220	8	FIELD CORN	1515	2.26	3.81	2.71	40.37	-51.12	57.42
224	8	FIELD CORN	1136	2.10	3.64	2.61	33.07	53.76	54.71
224	8	FIELD CORN	1136	2.10	3.72	2.64	36.83	53.76	54.71
224	8	FIELD CORN	1136	2.08	3.63	2.60	34.52	53.76	54.71
231	8	FIELD CORN	1105	2.18	3.68	3.28	37.26	59.98	48.26
231	8	FIELD CORN	1105	2.05	3.59	3.04	38.26	59.98	48.26
231	8	FIELD CORN	1105	2.09	3.65	3.45	39.69	59.98	48.26
233	8	FIELD CORN	1054	2.16	4.00	3.56	39.43	62.02	46.00
233	8	FIELD CORN	1054	1.94	3.60	3.52	35.23	62.02	46.00
233	8	FIELD CORN	1054	1.93	3.43	3.34	33.49	62.02	46.00
233	8	FIELD CORN	1550	1.93	3.18	3.42	32.94	-58.22	48.34
233	8	FIELD CORN	1550	1.83	3.07	3.21	34.02	-58.22	48.34
233	8	FIELD CORN	1550	2.26	3.94	3.73	38.40	-58.22	48.34
245	8	FIELD CORN	1416	2.71	4.56	5.64	25.99	-22.91	56.21
245	8	FIELD CORN	1416	2.47	4.09	5.36	20.13	-22.91	56.21
245	8	FIELD CORN	1416	2.44	4.23	5.17	22.06	-22.91	56.21
251	8	FIELD CORN	1003	2.65	4.95	7.04	21.67	66.45	33.49
251	8	FIELD CORN	1003	2.15	3.98	5.86	19.92	66.45	33.49
251	8	FIELD CORN	1003	2.51	4.44	6.04	22.55	66.45	33.49
251	8	FIELD CORN	1107	2.78	5.23	6.61	22.12	51.10	44.09
251	8	FIELD CORN	1107	2.61	4.56	6.61	19.33	51.10	44.09
251	8	FIELD CORN	1108	2.16	3.75	5.40	16.16	50.83	44.24
251	8	FIELD CORN	1244	3.00	4.81	6.52	19.47	17.26	54.79
251	8	FIELD CORN	1245	2.95	4.48	6.83	16.63	16.84	54.85
251	8	FIELD CORN	1245	2.71	4.08	6.39	15.54	16.84	54.85
253	8	FIELD CORN	1247	3.09	5.03	7.39	18.76	15.43	54.25
253	8	FIELD CORN	1248	2.82	4.65	7.10	17.47	15.01	54.31
253	8	FIELD CORN	1249	3.34	5.49	7.86	19.05	14.59	54.35
169	15	PEARL MILLET	1549	9.05	12.41	15.75	22.62	-72.77	56.20
170	15	PEARL MILLET	1353	6.07	9.23	11.88	18.42	-20.53	73.36
192	15	PEARL MILLET	1602	2.67	6.12	2.95	62.37	-72.68	53.71
192	15	PEARL MILLET	1602	2.47	5.95	2.84	60.86	-72.68	53.71
192	15	PEARL MILLET	1602	2.74	6.20	3.06	65.16	-72.68	53.71
220	15	PEARL MILLET	1516	2.43	4.16	2.92	40.55	-51.46	57.26
220	15	PEARL MILLET	1516	2.52	4.33	3.04	40.50	-51.46	57.26
220	15	PEARL MILLET	1516	2.61	4.48	3.08	41.58	-51.46	57.26
224	15	PEARL MILLET	1138	2.25	4.01	2.84	35.58	53.12	55.02
224	15	PEARL MILLET	1138	2.60	4.69	3.27	37.81	53.12	55.02
224	15	PEARL MILLET	1138	2.40	4.37	2.94	37.11	53.12	55.02
231	15	PEARL MILLET	1107	2.33	4.07	3.39	37.96	59.44	48.59
231	15	PEARL MILLET	1107	2.11	3.72	3.19	34.49	59.44	48.59
231	15	PEARL MILLET	1107	2.14	3.82	3.13	37.24	59.44	48.59
233	15	PEARL MILLET	1055	2.19	4.04	3.35	35.96	61.77	46.17
233	15	PEARL MILLET	1055	2.54	4.66	3.83	37.64	61.77	46.17
233	15	PEARL MILLET	1055	2.13	3.89	3.21	33.22	61.77	46.17
233	15	PEARL MILLET	1548	2.27	4.00	3.55	35.75	-57.67	48.67
233	15	PEARL MILLET	1548	2.35	4.07	3.77	36.40	-57.67	48.67
233	15	PEARL MILLET	1548	2.11	3.69	3.38	35.61	-57.67	48.67
245	15	PEARL MILLET	1417	2.17	3.91	3.52	31.32	-23.33	56.13

Table 5A.

REFLECTANCE FOR 1981

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
245	15	PEARL MILLET	1417	2.31	4.15	3.80	32.05	-23.33	56.13
245	15	PEARL MILLET	1417	2.32	4.15	3.80	31.92	-23.33	56.13
251	15	PEARL MILLET	1004	1.53	2.88	2.87	26.94	66.24	33.66
251	15	PEARL MILLET	1004	1.93	3.58	3.41	30.67	66.24	33.66
251	15	PEARL MILLET	1005	1.90	3.50	3.56	28.56	66.03	33.84
251	15	PEARL MILLET	1115	1.97	3.64	3.44	28.88	48.85	45.27
251	15	PEARL MILLET	1115	2.37	4.41	4.06	33.19	48.85	45.27
251	15	PEARL MILLET	1115	2.30	4.16	3.98	31.16	48.85	45.27
251	15	PEARL MILLET	1245	2.30	3.82	3.73	28.45	16.84	54.85
251	15	PEARL MILLET	1245	2.19	3.80	3.61	29.50	16.84	54.85
251	15	PEARL MILLET	1245	2.30	3.92	4.08	28.17	16.84	54.85
253	15	PEARL MILLET	1249	2.25	3.90	3.80	29.03	14.59	54.35
253	15	PEARL MILLET	1249	2.60	4.50	4.58	31.45	14.59	54.35
253	15	PEARL MILLET	1251	2.55	4.51	4.53	31.29	13.75	54.45
168	7	PINTO BEAN	1547	6.10	9.39	9.76	27.55	-72.28	56.57
170	7	PINTO BEAN	1351	7.10	11.09	13.13	28.52	-18.98	73.49
192	7	PINTO BEAN	1558	1.81	6.08	1.83	75.58	-71.72	54.45
192	7	PINTO BEAN	1558	1.59	5.54	1.65	72.36	-71.72	54.45
192	7	PINTO BEAN	1558	1.50	5.22	1.80	59.71	-71.72	54.45
220	7	PINTO BEAN	1514	2.31	6.12	2.67	.	-50.77	57.57
220	7	PINTO BEAN	1514	2.22	5.90	2.56	.	-50.77	57.57
220	7	PINTO BEAN	1514	2.24	5.92	2.54	.	-50.77	57.57
224	7	PINTO BEAN	1135	2.20	6.11	2.53	61.35	54.08	54.55
224	7	PINTO BEAN	1135	2.12	5.81	2.42	59.61	54.08	54.55
224	7	PINTO BEAN	1135	2.03	5.79	2.30	61.06	54.08	54.55
231	7	PINTO BEAN	1103	2.10	5.48	2.76	60.02	60.51	47.92
231	7	PINTO BEAN	1103	1.98	5.13	2.67	55.69	60.51	47.92
231	7	PINTO BEAN	1103	2.07	5.62	2.76	61.60	60.51	47.92
233	7	PINTO BEAN	1053	2.16	5.53	2.92	57.55	62.28	45.83
233	7	PINTO BEAN	1053	2.09	5.39	2.85	54.02	62.28	45.83
233	7	PINTO BEAN	1053	2.01	5.37	2.73	57.85	62.28	45.83
233	7	PINTO BEAN	1551	1.91	4.64	2.63	54.76	-58.49	48.18
233	7	PINTO BEAN	1551	2.08	5.02	2.93	51.40	-58.49	48.18
233	7	PINTO BEAN	1551	2.23	5.39	2.99	57.37	-58.49	48.18
245	7	PINTO BEAN	1414	2.47	5.67	4.65	31.08	-22.05	56.36
245	7	PINTO BEAN	1414	2.96	6.02	5.85	26.63	-22.05	56.36
245	7	PINTO BEAN	1414	2.81	6.06	5.59	27.33	-22.05	56.36
251	7	PINTO BEAN	1002	3.02	5.80	6.33	21.62	66.66	33.31
251	7	PINTO BEAN	1003	3.60	6.42	7.96	19.60	66.45	33.49
251	7	PINTO BEAN	1106	3.48	6.22	7.08	20.83	51.38	43.94
251	7	PINTO BEAN	1107	3.67	6.53	7.78	20.21	51.10	44.09
251	7	PINTO BEAN	1244	3.63	5.93	7.31	18.90	17.26	54.79
251	7	PINTO BEAN	1244	3.98	6.25	8.22	17.64	17.26	54.79
253	7	PINTO BEAN	1244	4.63	6.94	9.56	18.75	16.67	54.09
253	7	PINTO BEAN	1246	4.83	7.00	9.82	18.17	15.84	54.20
168	16	GRAIN SORGHUM	1551	8.98	12.40	16.01	23.61	-73.25	55.83
170	16	GRAIN SORGHUM	1355	5.57	8.31	10.89	16.08	-22.04	73.22
192	16	GRAIN SORGHUM	1603	2.89	6.68	3.18	63.13	-72.91	53.52
192	16	GRAIN SORGHUM	1603	2.23	5.42	2.74	46.91	-72.91	53.52
192	16	GRAIN SORGHUM	1603	2.61	6.02	3.00	60.80	-72.91	53.52
220	16	GRAIN SORGHUM	1517	2.81	5.23	3.40	48.13	-51.81	57.11
220	16	GRAIN SORGHUM	1517	2.83	5.23	3.37	46.74	-51.81	57.11
220	16	GRAIN SORGHUM	1517	3.08	5.90	3.77	.	-51.81	57.11
224	16	GRAIN SORGHUM	1139	2.77	5.65	3.58	47.28	52.79	55.17
224	16	GRAIN SORGHUM	1139	2.53	4.98	2.95	42.41	52.79	55.17
224	16	GRAIN SORGHUM	1139	2.62	5.36	3.26	44.51	52.79	55.17

Table 5A.

DAY OF YEAR	PLOT	CROP	REFLECTANCE FOR 1981 TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
231	16	GRAIN SORGHUM	1108	2.49	5.17	3.95	46.96	59.17	48.76
231	16	GRAIN SORGHUM	1108	2.53	5.08	4.15	45.54	59.17	48.76
231	16	GRAIN SORGHUM	1108	2.39	4.84	3.83	43.86	59.17	48.76
232	16	GRAIN SORGHUM	1057	2.26	4.64	3.83	41.17	61.26	46.51
232	16	GRAIN SORGHUM	1057	2.37	4.83	3.99	41.40	61.26	46.51
232	16	GRAIN SORGHUM	1057	2.40	5.02	4.04	42.64	61.26	46.51
233	16	GRAIN SORGHUM	1547	2.51	4.89	4.21	44.25	-57.40	48.83
233	16	GRAIN SORGHUM	1547	2.44	4.65	3.92	42.41	-57.40	48.83
233	16	GRAIN SORGHUM	1547	2.55	4.95	4.33	42.50	-57.40	48.83
245	16	GRAIN SORGHUM	1418	2.35	4.38	4.14	36.38	-23.75	56.05
245	16	GRAIN SORGHUM	1418	2.30	4.39	4.24	35.89	-23.75	56.05
245	16	GRAIN SORGHUM	1418	2.23	4.26	3.97	37.73	-23.75	56.05
251	16	GRAIN SORGHUM	1005	1.90	3.71	3.96	32.02	66.03	33.84
251	16	GRAIN SORGHUM	1005	1.95	3.75	4.25	33.19	66.03	33.94
251	16	GRAIN SORGHUM	1006	1.74	3.44	3.81	31.20	65.82	34.02
251	16	GRAIN SORGHUM	1116	2.27	4.26	4.15	34.79	48.56	45.42
251	16	GRAIN SORGHUM	1116	2.17	4.10	3.85	33.39	48.56	45.42
251	16	GRAIN SORGHUM	1116	2.34	4.41	4.26	32.77	48.56	45.42
251	16	GRAIN SORGHUM	1246	2.38	4.14	4.32	33.68	16.42	54.91
251	16	GRAIN SORGHUM	1246	2.32	4.09	4.28	31.77	16.42	54.91
251	16	GRAIN SORGHUM	1246	2.31	4.11	4.17	33.43	16.42	54.91
253	16	GRAIN SORGHUM	1251	2.30	4.13	4.36	32.73	13.75	54.45
253	16	GRAIN SORGHUM	1252	2.45	4.47	4.49	34.25	13.32	54.49
253	16	GRAIN SORGHUM	1252	2.49	4.59	4.59	36.82	13.32	54.49
168	1	SOYBEAN	1546	7.95	10.77	13.54	20.98	-72.03	56.75
192	1	SOYBEAN	1556	2.00	5.97	4.18	41.53	-71.23	54.81
192	1	SOYBEAN	1556	1.98	4.83	2.29	46.33	-71.23	54.81
192	1	SOYBEAN	1556	1.91	4.59	1.97	49.19	-71.23	54.81
220	1	SOYBEAN	1513	1.97	3.98	2.04	.	-50.42	57.72
220	1	SOYBEAN	1513	1.98	3.90	2.04	.	-50.42	57.72
220	1	SOYBEAN	1513	2.21	4.28	2.26	.	-50.42	57.72
224	1	SOYBEAN	1135	2.03	4.11	2.05	58.62	54.08	54.55
224	1	SOYBEAN	1135	2.18	4.38	2.24	62.09	54.08	54.55
224	1	SOYBEAN	1135	1.95	3.92	1.95	58.08	54.08	54.55
231	1	SOYBEAN	1101	1.93	3.78	2.39	59.17	61.03	47.59
231	1	SOYBEAN	1101	1.98	3.79	2.43	59.27	61.03	47.59
231	1	SOYBEAN	1101	1.83	3.62	2.32	58.64	61.03	47.59
233	1	SOYBEAN	1051	1.85	3.78	2.36	56.49	62.78	45.48
233	1	SOYBEAN	1051	1.95	3.96	2.51	57.47	62.78	45.48
233	1	SOYBEAN	1051	2.09	4.28	2.62	60.55	62.78	45.48
233	1	SOYBEAN	1554	2.16	4.14	2.78	61.77	-59.30	47.68
233	1	SOYBEAN	1554	1.81	3.37	2.27	49.99	-59.30	47.68
233	1	SOYBEAN	1554	1.84	3.53	2.36	54.54	-59.30	47.68
245	1	SOYBEAN	1413	1.95	4.97	3.16	43.00	-21.62	56.43
245	1	SOYBEAN	1413	1.79	4.53	2.66	41.86	-21.62	56.43
245	1	SOYBEAN	1413	2.05	5.16	3.03	48.90	-21.62	56.43
251	1	SOYBEAN	1000	2.20	6.23	4.30	40.44	67.08	32.95
251	1	SOYBEAN	1000	2.47	6.45	5.18	38.34	67.08	32.95
251	1	SOYBEAN	1001	2.18	5.82	4.06	39.16	66.87	33.13
251	1	SOYBEAN	1105	2.23	6.04	4.74	33.85	51.65	43.79
251	1	SOYBEAN	1105	2.15	5.87	4.23	39.33	51.65	43.79
251	1	SOYBEAN	1106	2.48	6.32	5.05	35.72	51.38	43.94
251	1	SOYBEAN	1242	2.30	5.75	4.70	31.48	17.68	54.74
251	1	SOYBEAN	1243	2.13	5.09	4.24	29.38	17.68	54.74
251	1	SOYBEAN	1243	2.06	5.17	3.75	34.47	17.68	54.74
253	1	SOYBEAN	1242	2.71	6.36	6.23	28.64	17.50	53.98

Table 5A.

REFLECTANCE FOR 1981

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
253	1	SOYBEAN	1243	2.90	6.56	6.84	28.44	17.09	54.04
253	1	SOYBEAN	1244	2.74	6.84	6.71	30.93	16.67	54.09
168	6	SUNFLOWER	1555	6.19	9.09	10.57	24.63	-74.20	55.08
170	6	SUNFLOWER	1349	5.83	10.09	10.29	34.71	-17.42	73.62
192	6	SUNFLOWER	1606	2.27	6.27	2.40	61.21	-73.61	52.97
192	6	SUNFLOWER	1606	2.98	8.21	3.54	76.28	-73.61	52.97
192	6	SUNFLOWER	1606	2.77	7.64	3.17	71.45	-73.61	52.97
220	6	SUNFLOWER	1524	2.94	5.68	3.64	37.84	-54.15	56.03
220	6	SUNFLOWER	1524	3.38	6.81	4.14	42.26	-54.15	56.03
220	6	SUNFLOWER	1524	3.20	6.28	3.90	41.86	-54.15	56.03
231	6	SUNFLOWER	1115	3.26	6.39	5.33	32.90	57.23	49.91
231	6	SUNFLOWER	1115	2.97	5.98	4.89	32.34	57.23	49.91
231	6	SUNFLOWER	1115	3.21	6.64	5.21	33.68	57.23	49.91
233	6	SUNFLOWER	1103	3.18	6.84	5.25	36.13	59.70	47.52
233	6	SUNFLOWER	1103	2.79	5.90	4.41	30.49	59.70	47.52
233	6	SUNFLOWER	1103	2.91	6.02	5.01	28.30	59.70	47.52
233	6	SUNFLOWER	1559	2.67	5.13	4.64	24.96	-60.61	46.84
233	6	SUNFLOWER	1559	2.55	4.66	4.37	24.25	-60.61	46.84
233	6	SUNFLOWER	1559	2.94	5.86	4.33	34.91	-60.61	46.84
245	6	SUNFLOWER	1422	3.65	5.50	7.39	14.72	-25.42	55.73
245	6	SUNFLOWER	1422	3.56	4.92	7.42	12.86	-25.42	55.73
245	6	SUNFLOWER	1422	3.55	5.16	7.25	13.23	-25.42	55.73
251	6	SUNFLOWER	1008	5.18	8.06	10.28	19.58	65.40	34.37
251	6	SUNFLOWER	1009	5.05	7.73	9.97	19.10	65.18	34.55
251	6	SUNFLOWER	1009	4.47	6.61	9.12	16.81	65.18	34.55

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
180	18	FIELD CORN	1218	5.33	5.16	21.60	29.91	9.97	73.69
180	18	FIELD CORN	1220	5.40	5.39	19.41	26.22	8.34	73.75
180	18	FIELD CORN	1220	5.13	4.90	20.45	28.41	8.34	73.75
184	18	FIELD CORN	1028	4.00	3.44	21.91	31.63	66.88	59.20
184	18	FIELD CORN	1029	4.04	3.47	22.05	33.21	66.59	59.38
184	18	FIELD CORN	1029	3.86	3.32	22.80	33.67	66.59	59.38
188	18	FIELD CORN	951	5.02	4.28	33.61	53.19	75.66	52.04
188	18	FIELD CORN	952	5.05	4.45	30.79	48.67	75.44	52.22
188	18	FIELD CORN	952	5.16	4.45	33.32	51.73	75.44	52.22
188	18	FIELD CORN	1236	5.03	4.28	28.31	42.99	-3.59	73.10
188	18	FIELD CORN	1237	4.83	4.23	27.64	42.78	-4.38	73.09
188	18	FIELD CORN	1238	5.45	4.80	29.22	44.18	-5.17	73.07
197	18	FIELD CORN	840	3.48	2.66	27.18	41.53	87.57	37.49
197	18	FIELD CORN	840	3.15	2.38	26.02	41.01	87.57	37.49
197	18	FIELD CORN	841	3.19	2.49	24.58	37.81	87.40	37.69
197	18	FIELD CORN	932	3.28	2.57	26.25	39.83	78.18	47.48
197	18	FIELD CORN	933	3.27	2.50	27.49	42.97	77.97	47.67
197	18	FIELD CORN	933	3.07	2.35	25.16	38.77	77.97	47.67
197	18	FIELD CORN	1012	3.47	2.68	27.07	42.04	69.13	54.91
197	18	FIELD CORN	1012	3.19	2.52	25.44	40.20	69.13	54.91
197	18	FIELD CORN	1012	3.28	2.59	25.90	40.16	69.13	54.91
197	18	FIELD CORN	1101	3.62	2.73	27.13	40.82	53.76	63.26
197	18	FIELD CORN	1101	3.45	2.63	27.32	41.97	53.76	63.26
197	18	FIELD CORN	1102	3.63	2.84	26.35	39.77	53.38	63.42
197	18	FIELD CORN	1200	3.43	2.72	26.58	40.49	23.29	70.50
197	18	FIELD CORN	1200	3.39	2.74	26.07	39.97	23.29	70.50
197	18	FIELD CORN	1201	3.18	2.50	24.62	37.28	22.63	70.58
197	18	FIELD CORN	1259	3.52	2.73	28.11	42.65	-19.23	70.92
197	18	FIELD CORN	1259	3.86	3.00	29.35	44.88	-19.23	70.92
197	18	FIELD CORN	1300	3.70	2.93	28.02	42.21	-19.92	70.85
197	18	FIELD CORN	1405	3.48	2.63	27.04	40.66	-54.11	63.09
197	18	FIELD CORN	1406	3.83	2.99	29.21	44.53	-54.49	62.93
197	18	FIELD CORN	1406	3.22	2.52	25.79	39.67	-54.49	62.93
197	18	FIELD CORN	1456	3.90	3.08	29.58	45.14	-69.84	54.35
197	18	FIELD CORN	1457	3.67	2.95	28.07	43.68	-70.09	54.16
197	18	FIELD CORN	1457	3.09	2.48	24.69	38.79	-70.09	54.16
201	18	FIELD CORN	1004	3.18	2.61	25.02	39.56	70.20	52.94
201	18	FIELD CORN	1005	2.92	2.27	26.46	42.27	69.95	53.12
201	18	FIELD CORN	1005	3.31	2.84	25.27	40.04	69.95	53.12
204	18	FIELD CORN	841	3.54	2.78	26.20	40.84	86.03	36.85
204	18	FIELD CORN	842	3.52	2.80	27.49	42.89	85.86	37.05
204	18	FIELD CORN	842	2.84	2.21	26.50	41.98	85.86	37.05
204	18	FIELD CORN	920	4.12	3.47	29.11	45.15	79.01	44.34
204	18	FIELD CORN	920	2.98	2.38	24.54	40.12	79.01	44.34
204	18	FIELD CORN	921	3.26	2.71	25.32	40.24	78.81	44.53
204	18	FIELD CORN	1011	3.65	3.01	27.23	43.12	67.65	53.80
204	18	FIELD CORN	1012	3.26	2.61	25.30	40.54	67.39	53.97
204	18	FIELD CORN	1013	3.30	2.68	25.34	40.02	67.12	54.15
204	18	FIELD CORN	1049	3.66	2.97	26.47	40.94	56.28	60.30
204	18	FIELD CORN	1049	3.11	2.47	25.52	40.29	56.28	60.30
204	18	FIELD CORN	1050	3.40	2.76	25.40	39.72	55.93	60.46
204	18	FIELD CORN	1232	3.94	3.17	26.70	40.94	0.56	70.41
204	18	FIELD CORN	1233	3.19	2.59	25.90	41.31	-0.14	70.41
204	18	FIELD CORN	1233	3.59	2.92	26.37	41.35	-0.14	70.41
204	18	FIELD CORN	1332	3.59	2.91	27.16	42.02	-37.31	66.61
204	18	FIELD CORN	1333	3.51	2.87	26.38	41.89	-37.83	66.49

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
204	18	FIELD CORN	1333	3.06	2.51	23.98	38.27	-37.83	66.49
204	18	FIELD CORN	1429	3.41	2.72	26.67	41.89	-60.32	58.23
204	18	FIELD CORN	1429	3.55	2.87	26.86	42.88	-60.32	58.23
204	18	FIELD CORN	1430	3.15	2.53	24.61	38.97	-60.63	58.06
204	18	FIELD CORN	1530	3.42	2.82	27.12	42.01	-75.80	47.25
204	18	FIELD CORN	1530	3.20	2.58	27.08	42.62	-75.80	47.25
204	18	FIELD CORN	1531	2.73	2.22	22.92	36.85	-76.01	47.06
209	18	FIELD CORN	955	4.79	3.99	34.18	52.70	70.16	50.18
209	18	FIELD CORN	956	3.59	3.02	27.95	44.43	69.92	50.36
209	18	FIELD CORN	958	3.72	3.13	28.77	46.22	69.44	50.73
209	18	FIELD CORN	1229	4.54	3.96	27.04	41.92	2.49	69.24
209	18	FIELD CORN	1231	4.04	3.45	26.79	42.31	1.15	69.25
209	18	FIELD CORN	1232	3.58	3.15	24.68	39.21	0.48	69.26
209	18	FIELD CORN	1440	4.20	3.53	26.46	40.65	-62.14	55.54
209	18	FIELD CORN	1442	3.73	3.13	27.00	42.23	-62.72	55.20
209	18	FIELD CORN	1443	2.80	2.38	22.46	35.30	-63.00	55.03
210	18	FIELD CORN	949	4.02	3.46	26.78	41.97	71.26	48.94
210	18	FIELD CORN	950	3.36	2.87	26.24	41.46	71.03	49.12
210	18	FIELD CORN	952	4.03	3.40	29.65	46.43	70.56	49.49
214	18	FIELD CORN	918	4.62	4.20	26.91	41.35	76.66	42.58
214	18	FIELD CORN	919	3.72	3.15	26.23	41.50	76.46	42.77
214	18	FIELD CORN	920	3.47	3.02	25.64	40.69	76.26	42.96
214	18	FIELD CORN	1026	4.58	4.07	26.45	40.83	60.34	54.83
214	18	FIELD CORN	1027	3.68	3.22	25.95	41.82	60.04	55.00
214	18	FIELD CORN	1028	3.72	3.33	26.63	42.54	59.74	55.17
214	18	FIELD CORN	1206	5.10	4.70	26.01	38.94	16.48	67.25
214	18	FIELD CORN	1208	4.52	3.84	28.42	44.04	15.27	67.35
214	18	FIELD CORN	1209	4.40	3.76	28.51	44.77	14.67	67.40
215	18	FIELD CORN	1312	6.05	5.86	24.26	35.76	-24.02	66.08
215	18	FIELD CORN	1313	5.84	5.22	30.87	46.80	-24.57	66.00
215	18	FIELD CORN	1314	5.23	4.54	28.68	44.07	-25.12	65.92
215	18	FIELD CORN	1427	6.15	5.82	28.07	41.26	-56.38	56.53
215	18	FIELD CORN	1428	5.78	5.16	30.47	46.89	-56.69	56.37
215	18	FIELD CORN	1429	5.41	4.54	31.47	48.13	-57.01	56.20
215	18	FIELD CORN	1553	5.85	5.46	29.19	43.01	-77.55	41.17
215	18	FIELD CORN	1554	5.55	4.95	29.86	46.11	-77.74	40.98
215	18	FIELD CORN	1555	4.12	3.61	25.27	39.55	-77.93	40.79
215	18	FIELD CORN	1707	5.83	6.00	26.93	40.21	-90.31	26.93
215	18	FIELD CORN	1708	6.00	5.85	31.49	47.75	-90.47	26.74
215	18	FIELD CORN	1708	4.55	4.18	26.95	41.29	-90.47	26.74
221	18	FIELD CORN	1045	4.64	5.24	18.14	26.73	51.69	56.56
221	18	FIELD CORN	1045	4.17	3.94	22.24	33.86	51.69	56.56
221	18	FIELD CORN	1046	3.65	3.19	21.94	33.72	51.34	56.71
230	18	FIELD CORN	928	4.00	4.29	16.05	23.17	69.03	41.84
230	18	FIELD CORN	930	3.56	3.39	18.79	27.52	68.59	42.20
230	18	FIELD CORN	930	4.00	3.69	24.11	36.92	68.59	42.20
231	18	FIELD CORN	855	3.95	4.13	15.59	21.81	75.45	35.58
231	18	FIELD CORN	856	4.09	3.87	20.48	29.75	75.26	35.77
231	18	FIELD CORN	857	3.41	3.18	21.83	33.49	75.07	35.96
231	18	FIELD CORN	1248	4.46	4.98	15.93	22.80	-9.88	62.53
231	18	FIELD CORN	1249	4.46	4.50	21.29	30.76	-10.40	62.49
231	18	FIELD CORN	1251	3.52	3.30	20.81	31.36	-11.45	62.42
242	18	FIELD CORN	929	4.34	4.99	15.27	22.12	64.07	39.73
242	18	FIELD CORN	929	3.52	3.95	15.27	23.26	64.07	39.73
242	18	FIELD CORN	931	4.67	4.66	25.06	39.76	63.61	40.08
245	18	FIELD CORN	933	5.02	6.31	15.50	23.77	61.93	39.80

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
245	18	FIELD CORN	934	4.13	5.14	14.14	22.03	61.69	39.97
245	18	FIELD CORN	935	4.17	4.37	19.26	31.34	61.45	40.14
245	18	FIELD CORN	1025	5.03	6.27	14.51	21.48	48.10	48.06
245	18	FIELD CORN	1027	4.79	5.88	15.60	23.42	47.49	48.34
245	18	FIELD CORN	1028	4.83	5.62	20.02	32.37	47.18	48.48
245	18	FIELD CORN	1159	5.97	7.22	17.41	25.28	12.18	57.36
245	18	FIELD CORN	1159	5.88	7.13	19.41	28.00	12.18	57.36
245	18	FIELD CORN	1200	4.25	4.83	15.80	24.87	11.73	57.40
245	18	FIELD CORN	1256	6.25	7.84	17.41	24.82	-14.13	57.16
245	18	FIELD CORN	1257	5.93	7.18	19.81	29.35	-14.58	57.11
245	18	FIELD CORN	1258	4.44	4.99	16.74	26.18	-15.03	57.06
245	18	FIELD CORN	1410	5.45	6.87	16.31	24.44	-43.12	50.18
245	18	FIELD CORN	1411	5.82	7.58	17.66	25.83	-43.44	50.04
245	18	FIELD CORN	1412	4.26	4.62	17.89	29.44	-43.77	49.91
245	18	FIELD CORN	1625	5.47	6.65	18.00	26.12	-75.68	27.57
245	18	FIELD CORN	1626	5.02	5.72	18.51	27.06	-75.86	27.38
245	18	FIELD CORN	1627	4.95	5.52	19.09	29.68	-76.04	27.19
253	18	FIELD CORN	908	6.06	7.98	15.95	22.43	64.30	33.79
253	18	FIELD CORN	910	6.69	8.53	20.26	28.48	63.87	34.14
253	18	FIELD CORN	911	5.26	7.04	14.15	21.11	63.65	34.32
180	16	PEARL MILLET	1215	13.42	16.59	22.75	28.40	12.39	73.58
180	16	PEARL MILLET	1215	17.39	21.71	28.82	35.38	12.39	73.58
180	16	PEARL MILLET	1216	16.40	20.37	28.29	35.20	11.58	73.62
184	16	PEARL MILLET	1024	5.74	6.38	12.15	15.92	68.00	58.49
184	16	PEARL MILLET	1025	6.56	7.61	16.48	21.94	67.73	58.67
184	16	PEARL MILLET	1025	6.08	6.50	16.61	22.19	67.73	58.67
188	16	PEARL MILLET	945	9.70	10.52	30.65	42.45	76.95	50.91
188	16	PEARL MILLET	946	9.35	9.58	35.01	49.45	76.74	51.10
188	16	PEARL MILLET	947	8.77	8.96	33.12	46.45	76.53	51.28
188	16	PEARL MILLET	1232	8.75	9.42	23.54	31.86	-0.40	73.13
188	16	PEARL MILLET	1233	8.31	8.35	27.38	37.91	-1.20	73.13
188	16	PEARL MILLET	1233	7.64	7.57	25.85	36.22	-1.20	73.13
197	16	PEARL MILLET	836	4.66	3.32	29.90	44.27	88.22	36.72
197	16	PEARL MILLET	836	4.93	3.49	33.20	49.35	88.22	36.72
197	16	PEARL MILLET	837	5.36	3.75	35.03	51.10	88.06	36.91
197	16	PEARL MILLET	928	4.77	3.56	29.01	42.42	78.97	46.72
197	16	PEARL MILLET	928	4.77	3.46	32.19	48.44	78.97	46.72
197	16	PEARL MILLET	929	5.25	3.79	33.42	49.13	78.78	46.91
197	16	PEARL MILLET	1008	4.69	3.57	28.57	42.17	70.14	54.18
197	16	PEARL MILLET	1008	4.83	3.50	31.67	47.12	70.14	54.18
197	16	PEARL MILLET	1008	5.39	3.91	33.97	50.03	70.14	54.18
197	16	PEARL MILLET	1058	5.05	3.82	28.98	41.58	54.90	62.79
197	16	PEARL MILLET	1058	5.13	3.69	33.11	48.43	54.90	62.79
197	16	PEARL MILLET	1059	5.14	3.76	31.90	46.51	54.53	62.95
197	16	PEARL MILLET	1158	5.25	3.93	30.91	44.88	24.60	70.35
197	16	PEARL MILLET	1158	5.21	3.87	33.01	48.75	24.60	70.35
197	16	PEARL MILLET	1158	5.77	4.30	33.19	47.52	24.60	70.35
197	16	PEARL MILLET	1255	5.71	4.39	30.93	44.10	-16.45	71.16
197	16	PEARL MILLET	1256	5.86	4.35	34.51	49.70	-17.16	71.10
197	16	PEARL MILLET	1256	6.12	4.50	35.19	50.64	-17.16	71.10
197	16	PEARL MILLET	1402	5.39	4.10	30.32	43.37	-52.95	63.56
197	16	PEARL MILLET	1402	5.30	3.91	33.47	48.94	-52.95	63.56
197	16	PEARL MILLET	1403	5.57	4.12	33.98	49.63	-53.34	63.40
197	16	PEARL MILLET	1454	5.22	3.97	30.08	43.24	-69.33	54.71
197	16	PEARL MILLET	1454	5.12	3.83	33.23	49.38	-69.33	54.71
197	16	PEARL MILLET	1455	5.29	3.94	33.20	48.67	-69.59	54.53

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
201	16	PEARL MILLET	1000	4.55	3.61	31.73	48.48	71.16	52.21
201	16	PEARL MILLET	1001	4.39	3.38	31.82	48.80	70.92	52.39
201	16	PEARL MILLET	1001	4.79	3.62	33.28	50.24	70.92	52.39
204	16	PEARL MILLET	839	4.34	3.22	30.35	45.67	86.36	36.47
204	16	PEARL MILLET	839	4.41	3.32	31.41	48.32	86.36	36.47
204	16	PEARL MILLET	840	3.97	2.97	29.17	45.28	86.20	36.66
204	16	PEARL MILLET	917	4.56	3.44	31.38	47.50	79.59	43.77
204	16	PEARL MILLET	918	4.66	3.43	33.51	51.27	79.39	43.96
204	16	PEARL MILLET	918	5.30	3.96	35.21	53.78	79.39	43.96
204	16	PEARL MILLET	1005	4.76	3.58	31.92	48.39	69.17	52.72
204	16	PEARL MILLET	1007	4.92	3.65	33.77	52.14	68.67	53.08
204	16	PEARL MILLET	1007	5.02	3.79	34.02	52.32	68.67	53.08
204	16	PEARL MILLET	1046	4.25	3.25	28.75	43.70	57.31	59.81
204	16	PEARL MILLET	1046	4.33	3.29	29.83	46.02	57.31	59.81
204	16	PEARL MILLET	1047	4.36	3.30	30.41	46.93	56.97	59.97
204	16	PEARL MILLET	1230	4.69	3.52	30.70	46.06	1.96	70.40
204	16	PEARL MILLET	1230	4.50	3.45	29.49	45.19	1.96	70.40
204	16	PEARL MILLET	1230	4.54	3.47	30.35	46.18	1.96	70.40
204	16	PEARL MILLET	1330	4.76	3.58	31.16	47.31	-36.28	66.84
204	16	PEARL MILLET	1330	4.88	3.74	32.14	49.25	-36.28	66.84
204	16	PEARL MILLET	1330	4.64	3.52	31.50	48.67	-36.28	66.84
204	16	PEARL MILLET	1426	4.27	3.26	29.47	44.79	-59.37	58.73
204	16	PEARL MILLET	1426	4.40	3.37	30.39	46.57	-59.37	58.73
204	16	PEARL MILLET	1427	4.37	3.29	30.11	46.15	-59.69	58.56
204	16	PEARL MILLET	1527	4.06	3.14	29.02	44.29	-75.17	47.82
204	16	PEARL MILLET	1527	4.33	3.27	30.08	45.91	-75.17	47.82
204	16	PEARL MILLET	1528	4.67	3.52	32.36	49.33	-75.38	47.63
209	16	PEARL MILLET	941	4.58	3.56	31.79	48.66	73.35	47.61
209	16	PEARL MILLET	944	1.99	1.37	11.89	16.64	72.69	48.16
209	16	PEARL MILLET	946	3.80	3.15	28.51	45.81	72.24	48.53
209	16	PEARL MILLET	1217	4.82	3.88	30.84	47.62	10.44	68.98
209	16	PEARL MILLET	1219	4.96	4.13	31.09	48.58	9.13	69.05
209	16	PEARL MILLET	1221	4.86	4.04	31.37	49.43	7.81	69.10
209	16	PEARL MILLET	1430	1.21	0.91	7.50	10.86	-59.13	57.23
209	16	PEARL MILLET	1431	1.30	0.96	7.82	11.27	-59.44	57.06
209	16	PEARL MILLET	1433	3.98	3.15	27.96	43.78	-60.06	56.73
210	16	PEARL MILLET	937	4.34	3.59	29.35	45.97	73.93	46.72
210	16	PEARL MILLET	939	4.14	3.40	28.52	44.90	73.49	47.09
210	16	PEARL MILLET	940	3.96	3.38	27.94	45.01	73.28	47.28
214	16	PEARL MILLET	908	3.85	3.16	26.11	42.08	78.61	40.69
214	16	PEARL MILLET	909	3.77	3.14	26.53	42.59	78.42	40.88
214	16	PEARL MILLET	910	4.00	3.43	28.08	45.83	78.23	41.07
214	16	PEARL MILLET	1020	3.81	3.29	25.96	42.45	62.07	53.81
214	16	PEARL MILLET	1021	4.17	3.60	28.52	46.63	61.78	53.99
214	16	PEARL MILLET	1022	3.74	3.15	26.53	43.90	61.50	54.16
214	16	PEARL MILLET	1200	4.04	3.46	26.31	42.15	20.04	66.89
214	16	PEARL MILLET	1202	4.22	3.67	27.99	45.80	18.86	67.01
214	16	PEARL MILLET	1202	4.37	3.71	28.53	46.16	18.86	67.01
215	16	PEARL MILLET	1307	4.72	4.13	27.81	43.64	-21.19	66.46
215	16	PEARL MILLET	1308	5.11	4.44	29.49	46.16	-21.76	66.38
215	16	PEARL MILLET	1308	5.02	4.25	30.11	47.50	-21.76	66.38
215	16	PEARL MILLET	1421	4.37	3.68	27.30	43.10	-54.41	57.49
215	16	PEARL MILLET	1422	4.81	4.12	29.91	47.31	-54.74	57.33
215	16	PEARL MILLET	1423	4.58	3.80	29.58	46.88	-55.08	57.17
215	16	PEARL MILLET	1548	4.48	3.89	27.93	44.25	-76.56	42.12
215	16	PEARL MILLET	1549	4.51	3.94	28.58	45.36	-76.76	41.93

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
215	16	PEARL MILLET	1550	4.59	3.99	30.44	47.99	-76.96	41.74
215	16	PEARL MILLET	1702	4.62	4.20	29.39	45.84	-89.52	27.90
215	16	PEARL MILLET	1703	4.24	3.89	28.15	45.06	-89.68	27.70
215	16	PEARL MILLET	1703	4.98	4.34	34.22	53.29	-89.68	27.70
221	16	PEARL MILLET	1042	3.82	3.23	24.39	38.81	52.70	56.10
221	16	PEARL MILLET	1043	3.90	3.27	24.93	39.48	52.36	56.25
221	16	PEARL MILLET	1043	4.05	3.41	27.26	44.36	52.36	56.25
230	16	PEARL MILLET	915	3.57	3.13	21.64	34.82	71.81	39.47
230	16	PEARL MILLET	916	4.10	3.54	24.79	39.91	71.61	39.65
230	16	PEARL MILLET	919	3.60	3.13	23.81	39.97	70.98	40.20
231	16	PEARL MILLET	848	3.39	2.86	20.54	32.70	76.79	34.27
231	16	PEARL MILLET	849	3.27	2.84	21.72	35.14	76.60	34.45
231	16	PEARL MILLET	850	3.50	3.06	23.18	38.48	76.41	34.64
231	16	PEARL MILLET	1238	4.09	3.69	24.33	38.82	-4.58	62.77
231	16	PEARL MILLET	1241	4.37	3.87	25.94	41.29	-6.18	62.72
231	16	PEARL MILLET	1243	3.90	3.51	25.05	40.88	-7.24	62.67
242	16	PEARL MILLET	921	4.01	3.83	23.06	37.47	65.87	38.33
242	16	PEARL MILLET	922	4.05	3.65	22.74	36.20	65.65	38.50
242	16	PEARL MILLET	924	3.88	3.49	24.18	39.89	65.20	38.86
245	16	PEARL MILLET	924	3.61	3.31	19.98	32.78	63.99	38.25
245	16	PEARL MILLET	929	3.31	3.11	19.69	33.17	62.85	39.11
245	16	PEARL MILLET	930	3.85	3.61	23.60	40.05	62.62	39.29
245	16	PEARL MILLET	1020	3.79	3.67	21.14	35.83	49.59	47.33
245	16	PEARL MILLET	1022	4.03	3.78	21.78	35.96	49.00	47.62
245	16	PEARL MILLET	1023	3.81	3.43	21.91	36.56	48.70	47.77
245	16	PEARL MILLET	1154	3.99	3.83	21.71	36.03	14.44	57.14
245	16	PEARL MILLET	1155	4.39	4.07	23.11	37.53	13.99	57.19
245	16	PEARL MILLET	1156	4.71	4.20	25.46	41.17	13.54	57.24
245	16	PEARL MILLET	1251	4.30	4.09	22.92	37.88	-11.87	57.38
245	16	PEARL MILLET	1252	4.21	3.90	22.82	37.40	-12.33	57.34
245	16	PEARL MILLET	1253	3.98	3.56	22.49	37.10	-12.78	57.29
245	16	PEARL MILLET	1403	4.69	4.59	22.86	37.09	-40.78	51.09
245	16	PEARL MILLET	1404	3.76	3.64	21.11	35.11	-41.12	50.96
245	16	PEARL MILLET	1405	3.77	3.60	21.90	37.20	-41.46	50.83
245	16	PEARL MILLET	1619	4.17	4.16	21.87	35.99	-74.57	28.69
245	16	PEARL MILLET	1620	3.72	3.56	20.26	33.36	-74.75	28.51
245	16	PEARL MILLET	1621	4.31	3.94	23.30	37.75	-74.94	28.32
253	16	PEARL MILLET	859	3.07	2.83	17.09	27.88	66.20	32.21
253	16	PEARL MILLET	900	3.55	3.52	19.97	33.19	65.99	32.39
253	16	PEARL MILLET	901	3.61	3.50	20.33	34.88	65.78	32.57
263	16	PEARL MILLET	838	2.66	2.62	13.50	22.59	66.57	26.40
263	16	PEARL MILLET	839	2.93	2.79	15.50	25.84	66.38	26.58
263	16	PEARL MILLET	840	4.12	4.17	21.44	36.26	66.18	26.76
265	16	PEARL MILLET	947	3.97	4.16	18.41	30.32	50.49	37.33
265	16	PEARL MILLET	948	2.57	2.77	12.95	22.63	50.24	37.47
265	16	PEARL MILLET	949	3.02	3.11	14.37	24.89	49.98	37.62
265	16	PEARL MILLET	1018	3.10	3.47	15.14	26.75	42.16	41.67
265	16	PEARL MILLET	1019	3.51	3.77	17.21	29.21	41.87	41.79
265	16	PEARL MILLET	1020	3.14	3.38	15.64	27.07	41.58	41.92
265	16	PEARL MILLET	1147	3.89	4.31	16.77	27.56	12.15	49.62
265	16	PEARL MILLET	1148	3.89	4.19	17.39	28.28	11.77	49.66
265	16	PEARL MILLET	1148	3.39	3.60	16.36	27.54	11.77	49.66
265	16	PEARL MILLET	1240	3.88	4.34	16.17	25.90	-8.43	49.94
265	16	PEARL MILLET	1241	3.63	4.00	16.39	27.05	-8.82	49.91
265	16	PEARL MILLET	1242	3.58	3.88	16.98	28.47	-9.20	49.88
265	16	PEARL MILLET	1344	4.05	4.61	17.44	29.15	-31.49	45.65

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
265	16	PEARL MILLET	1345	3.73	4.07	17.11	27.83	-31.82	45.55
265	16	PEARL MILLET	1346	3.41	3.71	16.66	27.80	-32.14	45.44
265	16	PEARL MILLET	1440	3.59	4.25	16.95	29.30	-47.94	38.68
265	16	PEARL MILLET	1441	4.00	4.36	18.47	29.86	-48.20	38.54
265	16	PEARL MILLET	1441	3.41	3.76	16.30	27.59	-48.20	38.54
270	16	PEARL MILLET	1127	3.29	3.96	13.87	23.86	18.28	46.78
270	16	PEARL MILLET	1128	3.94	4.61	16.65	28.00	17.92	46.84
270	16	PEARL MILLET	1129	3.77	4.34	16.28	28.17	17.57	46.90
280	16	PEARL MILLET	1008	2.93	3.93	11.75	20.61	39.81	36.01
280	16	PEARL MILLET	1009	3.72	4.72	15.14	25.64	39.55	36.13
280	16	PEARL MILLET	1010	4.63	5.98	18.08	31.10	39.28	36.25
284	16	PEARL MILLET	1035	2.76	3.66	11.05	19.13	31.20	37.81
284	16	PEARL MILLET	1038	3.55	4.59	14.09	24.22	30.34	38.11
284	16	PEARL MILLET	1040	3.97	5.15	15.62	27.00	29.76	38.30
295	16	PEARL MILLET	1230	3.79	5.50	10.78	18.49	-6.11	38.77
295	16	PEARL MILLET	1231	4.04	5.87	11.18	18.99	-6.42	38.74
295	16	PEARL MILLET	1231	4.35	6.38	12.75	21.99	-6.42	38.74
180	2	PINTO BEAN	1208	6.37	5.61	28.26	38.54	17.88	73.22
180	2	PINTO BEAN	1208	5.82	5.71	18.04	25.24	17.88	73.22
180	2	PINTO BEAN	1209	5.81	5.91	16.87	23.04	17.11	73.28
184	2	PINTO BEAN	1020	4.94	4.00	28.28	38.67	69.09	57.77
184	2	PINTO BEAN	1020	5.26	4.53	23.66	32.69	69.09	57.77
184	2	PINTO BEAN	1020	5.17	4.24	25.13	35.53	69.09	57.77
188	2	PINTO BEAN	931	6.95	5.53	42.88	61.02	79.81	48.25
188	2	PINTO BEAN	932	7.97	7.46	34.68	50.22	79.61	48.44
188	2	PINTO BEAN	933	7.30	6.44	38.35	55.67	79.41	48.63
188	2	PINTO BEAN	1226	6.58	5.93	30.70	41.98	4.37	73.09
188	2	PINTO BEAN	1227	7.10	6.37	28.52	39.47	3.58	73.11
188	2	PINTO BEAN	1227	6.71	5.52	32.63	44.73	3.58	73.11
197	2	PINTO BEAN	830	5.30	3.68	40.20	55.71	89.19	35.56
197	2	PINTO BEAN	831	5.47	3.85	36.82	51.79	89.03	35.75
197	2	PINTO BEAN	831	5.89	4.15	40.77	56.17	89.03	35.75
197	2	PINTO BEAN	920	5.94	4.21	46.75	65.80	80.52	45.19
197	2	PINTO BEAN	920	6.11	4.27	47.14	66.65	80.52	45.19
197	2	PINTO BEAN	921	5.66	4.00	40.66	56.34	80.33	45.39
197	2	PINTO BEAN	1000	5.48	3.94	44.01	62.06	72.08	52.72
197	2	PINTO BEAN	1001	5.70	3.99	43.70	61.55	71.84	52.90
197	2	PINTO BEAN	1001	5.75	4.08	41.64	58.37	71.84	52.90
197	2	PINTO BEAN	1053	5.16	3.70	40.28	57.24	56.73	61.99
197	2	PINTO BEAN	1054	5.18	3.64	40.48	57.62	56.37	62.15
197	2	PINTO BEAN	1054	5.31	3.77	38.20	53.42	56.37	62.15
197	2	PINTO BEAN	1151	5.31	3.75	41.98	58.89	29.04	69.73
197	2	PINTO BEAN	1152	5.71	4.04	41.30	58.12	28.42	69.83
197	2	PINTO BEAN	1152	5.63	4.08	39.47	55.08	28.42	69.83
197	2	PINTO BEAN	1250	6.90	5.46	46.45	68.82	-12.90	71.40
197	2	PINTO BEAN	1250	6.96	5.69	41.24	61.19	-12.90	71.40
197	2	PINTO BEAN	1251	5.65	4.43	33.46	47.94	-13.62	71.36
197	2	PINTO BEAN	1355	5.38	4.02	39.99	56.72	-50.11	64.62
197	2	PINTO BEAN	1355	5.68	4.20	38.03	53.59	-50.11	64.62
197	2	PINTO BEAN	1356	5.65	4.25	37.30	52.26	-50.52	64.47
197	2	PINTO BEAN	1449	5.41	4.11	38.46	54.16	-68.04	55.61
197	2	PINTO BEAN	1450	5.70	4.35	36.89	52.22	-68.30	55.43
197	2	PINTO BEAN	1450	5.75	4.40	38.10	53.34	-68.30	55.43
201	2	PINTO BEAN	949	5.51	4.16	39.64	56.23	73.70	50.18
201	2	PINTO BEAN	949	5.71	4.38	37.49	53.19	73.70	50.18
201	2	PINTO BEAN	950	5.85	4.50	36.81	51.45	73.48	50.37

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
204	2	PINTO BEAN	833	5.87	4.16	42.75	59.76	87.86	35.31
204	2	PINTO BEAN	833	6.09	4.30	40.63	56.44	87.86	35.31
204	2	PINTO BEAN	834	6.07	4.42	38.74	53.25	87.20	35.50
204	2	PINTO BEAN	908	5.81	4.11	40.30	56.17	81.28	42.05
204	2	PINTO BEAN	909	6.02	4.21	41.52	57.40	81.10	42.24
204	2	PINTO BEAN	909	6.26	4.61	39.86	55.17	81.10	42.24
204	2	PINTO BEAN	955	5.63	4.01	39.36	54.97	71.58	50.89
204	2	PINTO BEAN	955	5.58	3.94	38.89	54.40	71.58	50.89
204	2	PINTO BEAN	957	5.89	4.35	37.23	51.71	71.11	51.26
204	2	PINTO BEAN	1036	5.68	4.27	38.21	53.06	60.55	58.15
204	2	PINTO BEAN	1037	5.71	4.04	38.78	53.70	60.24	58.32
204	2	PINTO BEAN	1037	6.06	4.45	37.64	51.88	60.24	58.32
204	2	PINTO BEAN	1206	5.71	4.20	37.22	51.22	18.36	69.58
204	2	PINTO BEAN	1220	5.61	4.07	36.14	50.34	8.94	70.21
204	2	PINTO BEAN	1221	5.81	4.48	33.62	46.00	8.24	70.24
204	2	PINTO BEAN	1321	5.83	4.26	38.84	54.51	-31.39	67.81
204	2	PINTO BEAN	1321	5.99	4.48	37.39	52.54	-31.39	67.81
204	2	PINTO BEAN	1321	6.15	4.65	36.85	50.76	-31.39	67.81
204	2	PINTO BEAN	1418	5.65	4.01	40.05	55.41	-56.72	60.05
204	2	PINTO BEAN	1419	5.97	4.39	37.94	52.70	-57.06	59.88
204	2	PINTO BEAN	1419	6.05	4.56	36.97	50.71	-57.06	59.88
204	2	PINTO BEAN	1519	5.74	4.18	41.20	57.22	-73.43	49.31
204	2	PINTO BEAN	1519	5.94	4.38	38.96	54.15	-73.43	49.31
204	2	PINTO BEAN	1520	6.28	4.70	38.38	52.66	-73.65	49.12
209	2	PINTO BEAN	919	6.27	4.64	38.51	52.43	77.91	43.48
209	2	PINTO BEAN	920	4.96	3.59	25.85	34.16	77.71	43.67
209	2	PINTO BEAN	922	2.82	2.00	12.43	15.28	77.32	44.05
209	2	PINTO BEAN	1159	6.10	4.63	36.13	49.75	21.80	68.01
209	2	PINTO BEAN	1201	6.40	5.20	32.30	44.68	20.58	68.15
209	2	PINTO BEAN	1202	6.51	5.52	31.65	43.34	19.97	68.22
209	2	PINTO BEAN	1416	6.08	4.65	35.51	48.61	-54.51	59.50
209	2	PINTO BEAN	1417	6.75	5.43	34.15	46.49	-54.86	59.35
209	2	PINTO BEAN	1417	6.59	5.56	32.16	43.54	-54.86	59.35
210	2	PINTO BEAN	921	6.16	4.94	34.73	47.57	77.24	43.72
210	2	PINTO BEAN	922	6.43	5.20	33.66	46.65	77.04	43.91
210	2	PINTO BEAN	923	6.63	5.60	33.66	46.24	76.84	44.10
214	2	PINTO BEAN	855	6.96	6.09	31.57	43.80	81.03	38.21
214	2	PINTO BEAN	856	7.12	6.50	31.18	43.64	80.85	38.40
214	2	PINTO BEAN	858	7.18	7.07	29.34	40.61	80.49	38.78
214	2	PINTO BEAN	1006	7.12	6.63	29.91	41.16	65.84	51.38
214	2	PINTO BEAN	1007	7.44	7.02	30.07	41.70	65.58	51.56
214	2	PINTO BEAN	1008	7.61	7.98	28.25	39.01	65.32	51.73
214	2	PINTO BEAN	1142	8.36	8.32	30.07	41.19	30.04	65.41
214	2	PINTO BEAN	1143	8.22	8.38	30.21	41.84	29.51	65.51
214	2	PINTO BEAN	1146	7.93	8.61	27.49	37.91	27.91	65.78
215	2	PINTO BEAN	1254	9.18	10.18	27.73	37.95	-13.52	67.21
215	2	PINTO BEAN	1255	8.93	10.02	26.98	36.96	-14.12	67.16
215	2	PINTO BEAN	1256	8.99	10.67	26.26	36.12	-14.73	67.12
215	2	PINTO BEAN	1410	9.06	9.83	30.02	41.35	-50.57	59.18
215	2	PINTO BEAN	1410	8.64	9.34	29.14	40.39	-50.57	59.18
215	2	PINTO BEAN	1411	8.89	10.25	27.84	38.25	-50.93	59.03
215	2	PINTO BEAN	1537	8.78	9.68	29.31	40.37	-74.32	44.18
215	2	PINTO BEAN	1538	7.96	8.67	27.62	38.50	-74.53	43.99
215	2	PINTO BEAN	1539	8.05	9.18	26.72	37.13	-74.74	43.81
215	2	PINTO BEAN	1650	9.01	9.49	32.68	45.59	-87.60	30.22
215	2	PINTO BEAN	1651	8.03	8.16	32.00	44.17	-87.76	30.03

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
215	2	PINTO BEAN	1651	8.89	9.83	30.64	42.22	-87.76	30.03
221	2	PINTO BEAN	1035	6.80	8.16	20.82	28.24	54.97	55.00
221	2	PINTO BEAN	1035	6.75	7.70	21.63	29.34	54.97	55.00
221	2	PINTO BEAN	1036	7.27	8.85	20.70	27.98	54.65	55.16
180	19	SWEET CORN	1221	5.80	4.87	28.29	38.51	7.53	73.78
180	19	SWEET CORN	1222	5.83	5.53	22.45	30.27	6.71	73.80
180	19	SWEET CORN	1222	5.52	4.93	23.48	31.71	6.71	73.80
184	19	SWEET CORN	1030	4.33	3.36	26.52	39.18	66.30	59.56
184	19	SWEET CORN	1030	3.68	2.95	21.60	31.98	66.30	59.56
184	19	SWEET CORN	1031	4.45	3.65	23.40	33.02	66.01	59.74
188	19	SWEET CORN	953	5.68	4.43	38.12	59.26	75.22	52.41
188	19	SWEET CORN	954	4.74	3.80	31.80	48.85	74.99	52.60
188	19	SWEET CORN	955	5.35	4.36	33.01	49.82	74.77	52.79
188	19	SWEET CORN	1239	5.77	4.61	32.65	48.05	-5.97	73.06
188	19	SWEET CORN	1239	5.45	4.45	30.43	45.94	-5.97	73.06
188	19	SWEET CORN	1240	5.73	5.07	27.19	39.48	-6.76	73.03
197	19	SWEET CORN	842	5.24	4.25	33.30	48.60	87.24	37.88
197	19	SWEET CORN	842	5.76	4.63	37.32	54.87	87.24	37.88
197	19	SWEET CORN	843	5.01	3.94	32.16	46.98	87.07	38.07
197	19	SWEET CORN	934	5.44	4.44	33.45	48.75	77.77	47.86
197	19	SWEET CORN	934	5.58	4.44	35.52	52.26	77.77	47.86
197	19	SWEET CORN	935	4.49	3.54	31.30	47.14	77.57	48.05
197	19	SWEET CORN	1014	4.97	4.06	30.38	44.28	68.61	55.27
197	19	SWEET CORN	1015	4.95	3.89	29.96	44.01	68.35	55.45
197	19	SWEET CORN	1015	4.80	3.82	28.88	42.42	68.35	55.45
197	19	SWEET CORN	1102	5.08	4.14	33.01	48.79	53.38	63.42
197	19	SWEET CORN	1103	4.57	3.54	30.02	44.13	52.98	63.57
197	19	SWEET CORN	1103	4.96	3.87	31.82	46.98	52.98	63.57
197	19	SWEET CORN	1201	5.49	4.56	33.63	49.30	22.63	70.58
197	19	SWEET CORN	1202	5.28	4.26	32.43	47.34	21.96	70.65
197	19	SWEET CORN	1202	5.00	4.01	30.62	45.57	21.96	70.65
197	19	SWEET CORN	1300	6.14	5.02	36.36	52.72	-19.92	70.85
197	19	SWEET CORN	1300	5.68	4.65	32.98	47.79	-19.92	70.85
197	19	SWEET CORN	1301	5.38	4.32	32.25	48.09	-20.60	70.79
197	19	SWEET CORN	1406	5.71	4.62	36.80	53.94	-54.49	62.93
197	19	SWEET CORN	1407	4.97	3.82	32.99	48.14	-54.86	62.77
197	19	SWEET CORN	1407	5.06	4.01	30.96	46.29	-54.86	62.77
197	19	SWEET CORN	1457	5.88	4.86	35.95	52.82	-70.09	54.16
197	19	SWEET CORN	1458	4.68	3.87	29.84	44.08	-70.34	53.98
197	19	SWEET CORN	1458	4.73	3.85	30.16	44.80	-70.34	53.98
201	19	SWEET CORN	1007	4.70	4.33	29.76	45.44	69.45	53.49
201	19	SWEET CORN	1007	4.70	4.38	29.83	45.58	69.45	53.49
201	19	SWEET CORN	1007	4.75	4.40	29.76	45.48	69.45	53.49
204	19	SWEET CORN	843	5.92	5.11	32.42	47.90	85.69	37.24
204	19	SWEET CORN	843	6.66	6.03	34.79	52.43	85.69	37.24
204	19	SWEET CORN	843	5.18	4.55	29.31	44.53	85.69	37.24
204	19	SWEET CORN	921	5.60	4.83	31.36	46.92	78.81	44.53
204	19	SWEET CORN	922	6.16	5.46	34.01	51.49	78.62	44.72
204	19	SWEET CORN	922	4.79	4.29	28.12	43.61	78.62	44.72
204	19	SWEET CORN	1014	5.50	4.70	30.81	45.71	66.86	54.33
204	19	SWEET CORN	1015	5.96	5.10	33.36	49.88	66.60	54.51
204	19	SWEET CORN	1016	5.20	4.51	27.53	41.18	66.33	54.69
204	19	SWEET CORN	1050	5.95	5.06	32.77	48.68	55.93	60.46
204	19	SWEET CORN	1051	5.98	5.15	33.24	49.61	55.58	60.62
204	19	SWEET CORN	1051	5.60	4.94	28.43	42.60	55.58	60.62
204	19	SWEET CORN	1234	5.68	4.95	32.20	48.40	-0.84	70.40

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
204	19	SWEET CORN	1234	6.23	5.30	33.38	48.47	-0.84	70.40
204	19	SWEET CORN	1235	5.40	4.70	29.42	44.04	-1.55	70.40
204	19	SWEET CORN	1334	6.24	5.39	33.89	50.02	-38.33	66.37
204	19	SWEET CORN	1334	6.37	5.35	33.59	48.81	-38.33	66.37
204	19	SWEET CORN	1335	5.96	5.21	31.20	46.34	-38.84	66.25
204	19	SWEET CORN	1430	6.39	5.50	35.18	51.95	-60.63	58.06
204	19	SWEET CORN	1431	5.96	5.03	32.51	47.42	-60.94	57.89
204	19	SWEET CORN	1431	5.24	4.63	28.43	42.48	-60.94	57.89
204	19	SWEET CORN	1532	6.08	5.34	33.66	50.03	-76.22	46.88
204	19	SWEET CORN	1532	6.03	5.05	33.30	48.22	-76.22	46.88
204	19	SWEET CORN	1532	6.52	5.77	33.90	50.45	-76.22	46.88
209	19	SWEET CORN	959	6.83	6.24	35.03	51.06	69.20	50.91
209	19	SWEET CORN	1001	6.25	5.62	33.77	49.99	68.71	51.27
209	19	SWEET CORN	1002	5.61	5.19	28.63	42.34	68.47	51.45
209	19	SWEET CORN	1234	6.94	6.49	33.28	49.15	-0.86	69.25
209	19	SWEET CORN	1238	6.76	6.53	30.20	44.88	-3.54	69.22
209	19	SWEET CORN	1445	5.65	5.08	28.79	42.10	-63.56	54.68
209	19	SWEET CORN	1446	6.12	5.29	29.86	42.75	-63.84	54.50
209	19	SWEET CORN	1448	5.56	5.15	27.32	39.75	-64.39	54.16
210	19	SWEET CORN	953	6.64	6.16	32.51	47.54	70.33	49.67
210	19	SWEET CORN	955	6.34	5.82	31.81	47.07	69.86	50.03
210	19	SWEET CORN	956	5.47	5.18	26.83	39.47	69.62	50.21
214	19	SWEET CORN	922	6.06	5.73	27.68	40.72	75.86	43.33
214	19	SWEET CORN	923	6.20	5.76	29.48	43.27	75.65	43.52
214	19	SWEET CORN	923	5.39	5.26	25.56	38.30	75.65	43.52
214	19	SWEET CORN	1029	7.18	7.11	29.26	42.76	59.44	55.34
214	19	SWEET CORN	1030	6.52	6.35	29.07	43.19	59.14	55.50
214	19	SWEET CORN	1031	5.58	5.66	24.24	36.83	58.84	55.67
214	19	SWEET CORN	1210	8.06	7.80	30.76	43.85	14.06	67.45
214	19	SWEET CORN	1211	6.84	6.62	28.79	42.33	13.44	67.50
214	19	SWEET CORN	1213	5.50	5.45	24.54	36.59	12.21	67.58
215	19	SWEET CORN	1315	7.95	7.95	27.57	39.26	-25.67	65.84
215	19	SWEET CORN	1316	7.86	7.41	29.89	42.59	-26.22	65.75
215	19	SWEET CORN	1317	7.21	6.96	28.00	41.23	-26.76	65.67
215	19	SWEET CORN	1430	7.30	7.64	27.26	39.90	-57.32	56.04
215	19	SWEET CORN	1431	6.49	6.52	26.57	38.55	-57.64	55.88
215	19	SWEET CORN	1431	6.35	6.14	27.98	40.95	-57.64	55.88
215	19	SWEET CORN	1556	7.27	7.48	28.04	40.80	-78.12	40.60
215	19	SWEET CORN	1557	7.18	7.26	28.47	40.94	-78.32	40.41
215	19	SWEET CORN	1558	6.34	6.18	28.23	41.28	-78.51	40.22
215	19	SWEET CORN	1709	7.63	7.96	29.73	43.02	-90.63	26.54
215	19	SWEET CORN	1710	7.14	7.24	30.17	43.43	-90.79	26.35
215	19	SWEET CORN	1711	7.89	8.01	33.27	48.16	-90.94	26.15
221	19	SWEET CORN	1046	6.17	6.94	19.79	28.56	51.34	56.71
221	19	SWEET CORN	1047	5.13	5.34	19.64	28.84	51.00	56.86
221	19	SWEET CORN	1047	4.94	4.95	20.95	30.51	51.00	56.86
230	19	SWEET CORN	932	6.16	7.75	16.70	23.26	68.14	42.56
230	19	SWEET CORN	933	5.63	6.73	16.80	23.20	67.92	42.74
230	19	SWEET CORN	934	5.89	6.15	22.26	31.66	67.69	42.92
231	19	SWEET CORN	858	6.93	9.02	18.50	26.09	74.87	36.14
231	19	SWEET CORN	859	5.44	6.58	16.57	23.42	74.68	36.33
231	19	SWEET CORN	900	5.48	6.19	21.77	30.99	74.48	36.52
231	19	SWEET CORN	1252	7.18	9.50	17.66	23.30	-11.97	62.38
231	19	SWEET CORN	1253	6.19	8.03	16.54	22.91	-12.49	62.34
231	19	SWEET CORN	1254	6.33	7.23	22.25	31.95	-13.01	62.29
242	19	SWEET CORN	933	5.85	9.17	13.76	19.48	63.15	40.42

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
242	19	SWEET CORN	935	5.54	8.42	13.53	19.40	62.68	40.77
242	19	SWEET CORN	938	6.00	9.14	15.88	22.53	61.97	41.28
245	19	SWEET CORN	935	5.94	8.97	13.52	19.19	61.45	40.14
245	19	SWEET CORN	936	5.54	8.33	12.90	18.49	61.22	40.31
245	19	SWEET CORN	936	5.78	8.80	14.11	20.53	61.22	40.31
245	19	SWEET CORN	1030	6.23	9.40	13.88	19.24	46.57	48.77
245	19	SWEET CORN	1031	6.26	9.32	14.25	19.60	46.25	48.91
245	19	SWEET CORN	1032	6.85	10.36	16.34	23.47	45.94	49.05
245	19	SWEET CORN	1201	7.00	10.26	14.89	19.96	11.27	57.44
245	19	SWEET CORN	1202	7.00	10.52	15.31	21.22	10.81	57.48
245	19	SWEET CORN	1202	7.22	10.76	16.68	23.26	10.81	57.48
245	19	SWEET CORN	1259	7.34	10.71	15.27	20.29	-15.48	57.01
245	19	SWEET CORN	1300	6.71	10.14	15.03	21.01	-15.92	56.96
245	19	SWEET CORN	1300	6.84	10.03	16.07	22.37	-15.92	56.96
245	19	SWEET CORN	1414	6.43	9.47	13.59	18.31	-44.41	49.64
245	19	SWEET CORN	1416	6.27	9.48	14.20	19.85	-45.05	49.37
245	19	SWEET CORN	1419	5.24	7.67	13.15	18.62	-46.00	48.95
245	19	SWEET CORN	1628	6.15	9.09	13.38	18.09	-76.22	27.00
245	19	SWEET CORN	1630	5.93	9.30	14.50	21.17	-76.58	26.63
245	19	SWEET CORN	1631	6.27	9.40	15.71	21.74	-76.76	26.44
180	17	GRAIN SORGHUM	1217	18.53	23.30	28.96	35.28	10.78	73.66
180	17	GRAIN SORGHUM	1217	19.09	24.04	29.45	35.61	10.78	73.66
180	17	GRAIN SORGHUM	1218	17.88	22.45	28.13	34.35	9.97	73.69
184	17	GRAIN SORGHUM	1026	12.74	16.09	23.58	29.87	67.45	58.85
184	17	GRAIN SORGHUM	1027	8.52	10.37	16.03	20.88	67.16	59.02
184	17	GRAIN SORGHUM	1027	6.04	6.98	12.15	16.20	67.16	59.02
188	17	GRAIN SORGHUM	948	16.95	20.93	35.96	47.34	76.31	51.47
188	17	GRAIN SORGHUM	949	14.71	17.70	31.75	41.98	76.09	51.66
188	17	GRAIN SORGHUM	950	10.38	12.04	23.89	32.38	75.88	51.85
188	17	GRAIN SORGHUM	1234	14.10	17.44	27.13	34.98	-2.00	73.12
188	17	GRAIN SORGHUM	1235	12.77	15.26	25.59	33.07	-2.79	73.12
188	17	GRAIN SORGHUM	1236	9.78	11.32	20.55	27.25	-3.59	73.10
197	17	GRAIN SORGHUM	837	6.03	5.40	26.75	37.89	88.06	36.91
197	17	GRAIN SORGHUM	839	5.88	5.58	22.44	31.51	87.73	37.30
197	17	GRAIN SORGHUM	839	5.22	4.66	20.93	29.35	87.73	37.30
197	17	GRAIN SORGHUM	930	5.79	5.23	24.81	35.81	78.58	47.10
197	17	GRAIN SORGHUM	930	5.94	5.71	22.76	31.96	78.58	47.10
197	17	GRAIN SORGHUM	930	5.14	4.52	21.18	29.82	78.58	47.10
197	17	GRAIN SORGHUM	1010	5.90	5.32	25.81	36.83	69.63	54.55
197	17	GRAIN SORGHUM	1011	5.95	5.63	23.78	33.36	69.38	54.73
197	17	GRAIN SORGHUM	1011	5.24	4.75	21.22	30.00	69.38	54.73
197	17	GRAIN SORGHUM	1059	6.20	5.59	26.52	37.58	54.53	62.95
197	17	GRAIN SORGHUM	1100	6.25	6.04	23.99	33.57	54.15	63.10
197	17	GRAIN SORGHUM	1100	5.79	5.10	22.65	31.67	54.15	63.10
197	17	GRAIN SORGHUM	1159	6.36	5.99	26.18	37.24	23.95	70.42
197	17	GRAIN SORGHUM	1159	5.80	5.64	23.27	33.06	23.95	70.42
197	17	GRAIN SORGHUM	1159	5.64	4.98	22.22	31.09	23.95	70.42
197	17	GRAIN SORGHUM	1256	7.59	7.34	30.65	43.13	-17.16	71.10
197	17	GRAIN SORGHUM	1257	7.73	7.80	27.04	36.62	-17.85	71.04
197	17	GRAIN SORGHUM	1257	5.80	5.13	23.45	32.39	-17.85	71.04
197	17	GRAIN SORGHUM	1403	7.39	6.96	30.47	43.46	-53.34	63.40
197	17	GRAIN SORGHUM	1404	6.31	5.80	24.42	34.45	-53.73	63.24
197	17	GRAIN SORGHUM	1405	5.75	5.04	23.79	33.62	-54.11	63.09
197	17	GRAIN SORGHUM	1455	7.04	6.81	28.70	41.13	-69.59	54.53
197	17	GRAIN SORGHUM	1456	8.10	8.13	29.14	40.47	-69.84	54.35
197	17	GRAIN SORGHUM	1456	6.00	5.35	24.12	33.65	-69.84	54.35

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
201	17	GRAIN SORGHUM	1002	6.30	5.71	30.07	44.18	70.68	52.58
201	17	GRAIN SORGHUM	1003	7.06	7.25	27.10	38.83	70.44	52.76
201	17	GRAIN SORGHUM	1004	6.11	5.77	26.44	38.27	70.20	52.94
204	17	GRAIN SORGHUM	840	5.55	4.37	30.22	44.56	86.20	36.66
204	17	GRAIN SORGHUM	840	5.69	4.53	28.57	41.92	86.20	36.66
204	17	GRAIN SORGHUM	841	5.11	3.94	28.25	41.30	86.03	36.85
204	17	GRAIN SORGHUM	919	5.74	4.57	31.56	46.60	79.20	44.15
204	17	GRAIN SORGHUM	919	5.34	4.40	26.93	39.39	79.20	44.15
204	17	GRAIN SORGHUM	920	5.16	4.11	26.61	39.01	79.01	44.34
204	17	GRAIN SORGHUM	1010	5.46	4.35	30.19	44.66	67.90	53.62
204	17	GRAIN SORGHUM	1010	5.46	4.49	27.02	39.25	67.90	53.62
204	17	GRAIN SORGHUM	1011	5.30	4.22	26.39	38.46	67.65	53.80
204	17	GRAIN SORGHUM	1047	5.13	4.16	28.08	41.02	56.97	59.97
204	17	GRAIN SORGHUM	1048	5.34	4.47	25.60	36.44	56.63	60.13
204	17	GRAIN SORGHUM	1048	5.25	4.09	27.48	39.70	56.63	60.13
204	17	GRAIN SORGHUM	1231	5.84	4.72	30.55	44.20	1.26	70.40
204	17	GRAIN SORGHUM	1231	5.64	4.78	26.89	38.86	1.26	70.40
204	17	GRAIN SORGHUM	1232	5.52	4.37	27.76	39.88	0.56	70.41
204	17	GRAIN SORGHUM	1331	5.62	4.60	29.88	44.10	-36.80	66.73
204	17	GRAIN SORGHUM	1331	5.46	4.48	27.75	40.21	-36.80	66.73
204	17	GRAIN SORGHUM	1332	5.42	4.29	26.79	38.87	-37.31	66.61
204	17	GRAIN SORGHUM	1427	5.09	4.23	27.67	40.38	-59.69	58.56
204	17	GRAIN SORGHUM	1428	5.19	4.40	25.00	35.47	-60.01	58.40
204	17	GRAIN SORGHUM	1428	5.01	3.94	25.39	36.07	-60.01	58.40
204	17	GRAIN SORGHUM	1528	5.37	4.41	29.47	43.08	-75.38	47.63
204	17	GRAIN SORGHUM	1529	5.56	4.59	27.75	39.46	-75.59	47.44
204	17	GRAIN SORGHUM	1529	5.40	4.27	27.39	38.90	-75.59	47.44
209	17	GRAIN SORGHUM	948	6.10	5.03	35.93	54.06	71.79	48.90
209	17	GRAIN SORGHUM	950	6.81	5.56	38.43	56.96	71.33	49.27
209	17	GRAIN SORGHUM	953	6.35	5.16	36.67	53.97	70.63	49.82
209	17	GRAIN SORGHUM	1223	6.23	5.42	31.20	45.94	6.48	69.15
209	17	GRAIN SORGHUM	1225	6.83	6.18	30.98	44.75	5.15	69.19
209	17	GRAIN SORGHUM	1227	6.23	5.38	30.75	45.11	3.82	69.22
209	17	GRAIN SORGHUM	1435	5.13	4.28	27.97	41.92	-60.66	56.39
209	17	GRAIN SORGHUM	1437	5.43	4.50	27.87	40.60	-61.26	56.05
209	17	GRAIN SORGHUM	1438	5.58	4.54	29.58	43.22	-61.56	55.88
210	17	GRAIN SORGHUM	942	5.64	4.64	32.28	48.13	72.84	47.65
210	17	GRAIN SORGHUM	943	6.33	5.29	33.30	49.47	72.61	47.83
210	17	GRAIN SORGHUM	945	5.81	4.81	31.66	46.91	72.17	48.20
214	17	GRAIN SORGHUM	912	5.91	4.84	32.12	48.05	77.84	41.45
214	17	GRAIN SORGHUM	914	6.76	5.56	33.69	50.04	77.45	41.83
214	17	GRAIN SORGHUM	914	5.80	4.62	31.56	46.90	77.45	41.83
214	17	GRAIN SORGHUM	1023	6.04	4.96	32.85	49.78	61.21	54.33
214	17	GRAIN SORGHUM	1024	6.35	5.36	31.59	47.16	60.92	54.50
214	17	GRAIN SORGHUM	1025	5.86	4.73	31.67	47.54	60.63	54.66
214	17	GRAIN SORGHUM	1204	7.14	5.99	33.44	48.91	17.68	67.14
214	17	GRAIN SORGHUM	1204	6.99	6.07	31.67	46.37	17.68	67.14
214	17	GRAIN SORGHUM	1206	6.06	4.94	31.38	46.25	16.48	67.25
215	17	GRAIN SORGHUM	1310	8.26	7.22	35.05	51.61	-22.90	66.24
215	17	GRAIN SORGHUM	1310	7.92	7.05	33.24	48.26	-22.90	66.24
215	17	GRAIN SORGHUM	1311	6.79	5.68	32.04	46.84	-23.46	66.16
215	17	GRAIN SORGHUM	1424	7.50	6.52	33.32	49.36	-55.40	57.01
215	17	GRAIN SORGHUM	1425	7.13	6.23	31.01	45.17	-55.73	56.85
215	17	GRAIN SORGHUM	1426	6.38	5.26	32.11	47.21	-56.05	56.69
215	17	GRAIN SORGHUM	1551	6.83	5.90	31.48	46.77	-77.15	41.55
215	17	GRAIN SORGHUM	1552	6.47	5.62	30.69	44.87	-77.35	41.36

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
215	17	GRAIN SORGHUM	1552	6.67	5.59	33.85	49.49	-77.35	41.36
215	17	GRAIN SORGHUM	1704	6.63	5.79	33.77	49.81	-89.84	27.51
215	17	GRAIN SORGHUM	1705	6.04	5.18	29.95	43.88	-90.00	27.32
215	17	GRAIN SORGHUM	1706	6.75	5.64	36.38	53.53	-90.16	27.12
221	17	GRAIN SORGHUM	1043	5.60	4.74	30.15	44.91	52.36	56.25
221	17	GRAIN SORGHUM	1044	5.73	4.91	29.63	44.24	52.02	56.40
221	17	GRAIN SORGHUM	1044	5.21	4.25	28.86	43.14	52.02	56.40
230	17	GRAIN SORGHUM	923	5.20	4.40	28.76	43.59	70.12	40.93
230	17	GRAIN SORGHUM	924	5.03	4.20	27.30	41.77	69.91	41.11
230	17	GRAIN SORGHUM	927	4.47	3.74	26.54	40.33	69.25	41.66
231	17	GRAIN SORGHUM	851	5.01	4.22	27.37	41.00	76.22	34.83
231	17	GRAIN SORGHUM	853	4.76	4.03	25.62	38.50	75.84	35.21
231	17	GRAIN SORGHUM	854	4.65	3.85	27.31	41.04	75.65	35.39
231	17	GRAIN SORGHUM	1244	5.73	4.98	29.55	43.98	-7.77	62.65
231	17	GRAIN SORGHUM	1245	5.73	4.84	30.19	45.15	-8.30	62.62
231	17	GRAIN SORGHUM	1247	5.12	4.30	28.79	42.85	-9.35	62.56
242	17	GRAIN SORGHUM	925	4.88	4.53	23.24	35.53	64.98	39.03
242	17	GRAIN SORGHUM	926	5.24	4.57	26.93	40.54	64.75	39.21
242	17	GRAIN SORGHUM	927	4.77	4.08	24.98	37.25	64.53	39.38
245	17	GRAIN SORGHUM	931	4.90	4.69	20.65	31.67	62.39	39.46
245	17	GRAIN SORGHUM	932	3.93	3.69	18.83	29.25	62.16	39.63
245	17	GRAIN SORGHUM	932	4.68	4.11	24.50	36.73	62.16	39.63
245	17	GRAIN SORGHUM	1024	5.04	4.74	22.45	34.89	48.40	47.91
245	17	GRAIN SORGHUM	1024	5.67	5.50	23.68	35.83	48.40	47.91
245	17	GRAIN SORGHUM	1025	4.77	4.27	24.29	36.93	48.10	48.06
245	17	GRAIN SORGHUM	1156	6.38	6.50	22.92	33.87	13.54	57.24
245	17	GRAIN SORGHUM	1158	6.69	6.96	24.33	36.16	12.63	57.32
245	17	GRAIN SORGHUM	1158	5.11	4.68	25.46	38.93	12.63	57.32
245	17	GRAIN SORGHUM	1254	5.07	5.01	21.58	33.89	-13.23	57.25
245	17	GRAIN SORGHUM	1255	5.30	5.01	23.72	36.70	-13.68	57.21
245	17	GRAIN SORGHUM	1256	5.39	4.85	27.03	41.18	-14.13	57.16
245	17	GRAIN SORGHUM	1406	4.93	4.70	22.36	35.21	-41.79	50.70
245	17	GRAIN SORGHUM	1408	4.56	4.24	21.72	33.92	-42.46	50.44
245	17	GRAIN SORGHUM	1409	4.98	4.50	25.76	39.11	-42.79	50.31
245	17	GRAIN SORGHUM	1622	4.80	4.60	22.15	34.93	-75.12	28.13
245	17	GRAIN SORGHUM	1623	4.17	4.03	19.77	31.73	-75.31	27.94
245	17	GRAIN SORGHUM	1624	5.43	5.01	27.27	41.67	-75.49	27.76
253	17	GRAIN SORGHUM	902	3.83	3.72	16.21	24.89	65.57	32.74
253	17	GRAIN SORGHUM	906	3.42	3.52	15.28	24.01	64.73	33.45
253	17	GRAIN SORGHUM	907	4.51	4.56	23.30	36.28	64.51	33.62
263	17	GRAIN SORGHUM	842	2.86	2.78	13.85	22.62	65.78	27.11
263	17	GRAIN SORGHUM	843	3.57	3.60	14.28	21.70	65.58	27.29
263	17	GRAIN SORGHUM	844	4.00	4.28	20.58	32.69	65.38	27.46
265	17	GRAIN SORGHUM	949	3.62	3.72	15.76	24.89	49.98	37.62
265	17	GRAIN SORGHUM	950	3.80	4.09	17.31	26.71	49.73	37.77
265	17	GRAIN SORGHUM	951	4.37	4.75	20.04	31.38	49.47	37.92
265	17	GRAIN SORGHUM	1022	4.30	4.51	19.89	31.33	41.00	42.18
265	17	GRAIN SORGHUM	1023	4.28	4.66	19.52	30.08	40.71	42.31
265	17	GRAIN SORGHUM	1023	4.81	5.24	21.06	32.28	40.71	42.31
265	17	GRAIN SORGHUM	1149	4.74	4.94	19.06	28.59	11.39	49.69
265	17	GRAIN SORGHUM	1150	4.74	4.99	21.03	31.98	11.00	49.73
265	17	GRAIN SORGHUM	1151	3.89	4.17	16.87	25.48	10.62	49.77
265	17	GRAIN SORGHUM	1243	4.53	4.73	18.33	27.83	-9.59	49.84
265	17	GRAIN SORGHUM	1244	4.33	4.61	19.17	28.75	-9.97	49.81
265	17	GRAIN SORGHUM	1244	4.33	4.59	17.68	26.83	-9.97	49.81
265	17	GRAIN SORGHUM	1346	4.39	4.84	18.04	27.85	-32.14	45.44

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
265	17	GRAIN SORGHUM	1347	4.29	4.53	19.96	30.87	-32.47	45.34
265	17	GRAIN SORGHUM	1347	4.62	4.95	19.80	29.77	-32.47	45.34
265	17	GRAIN SORGHUM	1442	4.54	4.92	18.44	27.91	-48.46	38.39
265	17	GRAIN SORGHUM	1443	4.23	4.55	19.83	30.82	-48.72	38.25
265	17	GRAIN SORGHUM	1444	4.71	5.18	21.14	31.88	-48.98	38.10
270	17	GRAIN SORGHUM	1130	5.39	5.77	20.00	29.13	17.21	46.96
270	17	GRAIN SORGHUM	1131	5.87	6.73	17.47	25.17	16.86	47.01
270	17	GRAIN SORGHUM	1132	4.28	4.72	18.21	28.31	16.50	47.07
280	17	GRAIN SORGHUM	1011	4.09	4.28	16.61	25.71	39.01	36.38
280	17	GRAIN SORGHUM	1012	4.67	5.28	14.86	22.13	38.74	36.50
280	17	GRAIN SORGHUM	1012	4.54	5.38	19.71	31.59	38.74	36.50
284	17	GRAIN SORGHUM	1043	4.01	4.24	15.94	24.83	28.88	38.59
284	17	GRAIN SORGHUM	1045	4.11	4.64	13.49	20.46	28.29	38.77
284	17	GRAIN SORGHUM	1047	4.03	4.56	17.06	26.84	27.70	38.95
295	17	GRAIN SORGHUM	1232	5.03	6.89	13.65	22.44	-6.73	38.72
295	17	GRAIN SORGHUM	1232	5.84	8.04	14.55	23.16	-6.73	38.72
295	17	GRAIN SORGHUM	1232	5.34	7.65	13.97	22.83	-6.73	38.72
180	4	SOYBEAN	1204	11.79	13.47	26.17	33.34	20.92	72.97
180	4	SOYBEAN	1205	7.71	7.48	23.39	30.93	20.17	73.03
180	4	SOYBEAN	1205	9.66	10.42	25.68	34.06	20.17	73.03
180	1	SOYBEAN	1209	5.91	6.67	11.97	15.46	17.11	73.28
180	1	SOYBEAN	1210	7.18	8.36	14.80	19.91	16.33	73.34
180	1	SOYBEAN	1210	7.13	8.09	15.28	20.69	16.33	73.34
184	4	SOYBEAN	1015	5.60	5.44	20.12	26.19	70.40	56.86
184	4	SOYBEAN	1016	5.09	4.82	19.69	25.59	70.15	57.04
184	4	SOYBEAN	1017	5.48	4.79	23.18	30.59	69.88	57.22
184	1	SOYBEAN	1021	5.51	5.60	15.32	21.08	68.82	57.95
184	1	SOYBEAN	1021	5.60	5.44	16.92	23.06	68.82	57.95
184	1	SOYBEAN	1022	5.86	5.41	19.77	26.88	68.55	58.13
188	4	SOYBEAN	923	7.34	7.18	29.89	41.35	81.35	46.72
188	4	SOYBEAN	923	7.17	6.96	32.19	44.93	81.35	46.72
188	4	SOYBEAN	925	7.33	7.08	33.20	46.43	80.97	47.11
188	1	SOYBEAN	934	9.19	10.07	27.25	38.98	79.21	48.82
188	1	SOYBEAN	935	9.08	9.98	26.42	38.40	79.01	49.01
188	1	SOYBEAN	936	8.96	9.23	32.88	47.61	78.81	49.20
188	4	SOYBEAN	1220	8.08	8.26	28.13	37.40	9.10	72.96
188	4	SOYBEAN	1221	7.29	7.38	27.79	36.38	8.32	72.99
188	4	SOYBEAN	1222	7.64	7.83	27.12	35.76	7.53	73.01
188	1	SOYBEAN	1229	7.99	8.69	21.66	28.72	1.99	73.12
188	1	SOYBEAN	1229	7.82	8.27	21.96	29.41	1.99	73.12
188	1	SOYBEAN	1230	6.55	6.89	23.85	32.36	1.19	73.13
197	4	SOYBEAN	824	5.26	4.17	34.10	47.70	90.14	34.40
197	4	SOYBEAN	825	4.77	3.71	33.50	47.74	89.98	34.59
197	4	SOYBEAN	828	4.66	3.76	30.04	42.80	89.51	35.17
197	1	SOYBEAN	832	4.66	3.82	29.53	41.11	88.87	35.95
197	1	SOYBEAN	833	4.97	3.96	29.76	40.92	88.71	36.14
197	1	SOYBEAN	833	4.56	3.56	30.89	42.98	88.71	36.14
197	4	SOYBEAN	911	5.31	4.19	36.19	51.37	82.20	43.47
197	4	SOYBEAN	913	5.35	4.32	38.65	55.64	81.84	43.85
197	4	SOYBEAN	914	5.50	4.42	36.32	52.15	81.65	44.05
197	1	SOYBEAN	922	4.69	3.97	28.12	39.93	80.14	45.58
197	1	SOYBEAN	923	4.76	3.89	30.13	42.96	79.95	45.77
197	1	SOYBEAN	923	4.71	3.72	32.72	46.40	79.95	45.77
197	4	SOYBEAN	954	3.84	3.11	23.17	32.69	73.47	51.61
197	4	SOYBEAN	954	3.53	2.81	22.60	32.08	73.47	51.61
197	4	SOYBEAN	954	3.32	2.54	21.99	30.72	73.47	51.61

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
197	1	SOYBEAN	1004	4.79	4.01	29.70	42.82	71.12	53.45
197	1	SOYBEAN	1004	4.70	3.78	31.61	45.46	71.12	53.45
197	1	SOYBEAN	1004	4.60	3.57	33.05	46.94	71.12	53.45
197	4	SOYBEAN	1048	4.69	3.95	27.95	39.38	58.48	61.17
197	4	SOYBEAN	1049	4.58	3.63	30.39	43.94	58.14	61.33
197	4	SOYBEAN	1049	4.45	3.51	30.74	44.40	58.14	61.33
197	1	SOYBEAN	1055	4.48	3.73	27.90	40.88	56.01	62.31
197	1	SOYBEAN	1055	4.27	3.38	26.97	38.60	56.01	62.31
197	1	SOYBEAN	1055	4.05	3.09	29.78	42.62	56.01	62.31
197	4	SOYBEAN	1148	4.81	4.02	28.51	40.15	30.87	69.44
197	4	SOYBEAN	1148	4.49	3.59	29.76	42.44	30.87	69.44
197	4	SOYBEAN	1149	4.38	3.41	30.89	44.34	30.27	69.54
197	1	SOYBEAN	1153	4.92	4.09	28.26	39.41	27.80	69.92
197	1	SOYBEAN	1153	4.56	3.58	31.29	44.03	27.80	69.92
197	1	SOYBEAN	1154	4.76	3.76	30.92	43.37	27.17	70.01
197	4	SOYBEAN	1245	4.83	4.19	28.29	40.41	-9.27	71.59
197	4	SOYBEAN	1246	4.64	3.83	31.18	45.94	-10.00	71.56
197	4	SOYBEAN	1247	5.50	4.65	34.68	51.54	-10.73	71.52
197	1	SOYBEAN	1251	4.54	4.06	24.76	35.54	-13.62	71.36
197	1	SOYBEAN	1252	4.26	3.49	26.97	38.40	-14.33	71.31
197	1	SOYBEAN	1252	4.31	3.44	29.06	41.86	-14.33	71.31
197	4	SOYBEAN	1350	5.45	4.89	30.58	43.09	-47.96	65.35
197	4	SOYBEAN	1350	4.68	3.79	32.74	47.28	-47.96	65.35
197	4	SOYBEAN	1351	4.95	4.03	31.60	45.62	-48.39	65.21
197	1	SOYBEAN	1356	4.40	3.56	29.35	40.89	-50.52	64.47
197	1	SOYBEAN	1357	4.71	3.70	29.86	40.94	-50.94	64.32
197	1	SOYBEAN	1357	4.41	3.40	31.03	43.15	-50.94	64.32
197	4	SOYBEAN	1446	5.62	5.12	31.05	44.05	-67.24	56.15
197	4	SOYBEAN	1447	4.92	4.10	33.64	48.29	-67.51	55.97
197	4	SOYBEAN	1447	5.11	4.36	32.82	46.89	-67.51	55.97
197	1	SOYBEAN	1451	4.80	3.96	30.40	42.39	-68.56	55.25
197	1	SOYBEAN	1451	4.70	3.94	29.15	40.60	-68.56	55.25
197	1	SOYBEAN	1451	4.51	3.57	32.00	44.87	-68.56	55.25
201	4	SOYBEAN	944	4.69	3.93	34.33	50.21	74.80	49.25
201	4	SOYBEAN	944	4.38	3.40	36.55	54.22	74.80	49.25
201	4	SOYBEAN	945	4.47	3.55	36.17	53.36	74.59	49.44
201	1	SOYBEAN	950	4.89	4.10	34.96	51.01	73.48	50.37
201	1	SOYBEAN	951	4.67	3.85	33.65	49.47	73.25	50.55
201	1	SOYBEAN	951	4.37	3.48	34.82	51.25	73.25	50.55
204	4	SOYBEAN	830	4.58	3.57	34.39	49.92	87.85	34.73
204	4	SOYBEAN	831	4.28	3.15	35.84	52.95	87.69	34.92
204	4	SOYBEAN	831	4.49	3.36	35.58	52.27	87.69	34.92
204	1	SOYBEAN	834	4.23	3.15	35.03	50.55	87.20	35.50
204	1	SOYBEAN	834	4.30	3.22	34.82	50.48	87.20	35.50
204	1	SOYBEAN	835	4.29	3.21	34.81	50.97	87.03	35.69
204	4	SOYBEAN	905	4.25	3.21	35.81	52.14	81.83	41.47
204	4	SOYBEAN	906	4.35	3.20	37.58	55.48	81.65	41.66
204	4	SOYBEAN	906	4.17	3.06	36.57	53.75	81.65	41.66
204	1	SOYBEAN	910	4.36	3.25	35.33	50.88	80.91	42.43
204	1	SOYBEAN	911	4.28	3.12	37.25	53.87	80.72	42.62
204	1	SOYBEAN	911	4.34	3.21	37.21	54.10	80.72	42.62
204	4	SOYBEAN	942	4.19	3.16	35.36	51.47	74.50	48.48
204	4	SOYBEAN	944	3.85	2.81	36.14	53.54	74.06	48.86
204	4	SOYBEAN	945	4.04	2.93	36.21	52.86	73.84	49.04
204	1	SOYBEAN	958	3.87	2.85	33.33	48.23	70.87	51.44
204	1	SOYBEAN	959	3.95	2.87	35.26	51.33	70.63	51.62

Table 6A

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
204	1	SOYBEAN	959	4.05	2.96	35.88	52.56	70.63	51.62
204	4	SOYBEAN	1033	4.31	3.26	33.85	48.82	61.48	57.64
204	4	SOYBEAN	1033	4.13	3.04	35.63	51.63	61.48	57.64
204	4	SOYBEAN	1034	4.21	3.08	36.21	52.66	61.17	57.81
204	1	SOYBEAN	1038	3.81	2.90	31.51	45.45	59.93	58.49
204	1	SOYBEAN	1040	4.09	2.95	36.10	52.16	59.29	58.82
204	1	SOYBEAN	1040	4.05	2.93	36.23	52.49	59.29	58.82
204	4	SOYBEAN	1159	4.09	3.06	33.75	49.30	22.83	69.10
204	4	SOYBEAN	1202	4.01	2.98	36.46	53.31	20.93	69.32
204	4	SOYBEAN	1202	4.13	2.98	36.64	53.20	20.93	69.32
204	1	SOYBEAN	1222	3.71	2.77	30.69	44.25	7.55	70.27
204	1	SOYBEAN	1223	3.79	2.77	32.34	46.67	6.86	70.29
204	1	SOYBEAN	1223	3.63	2.64	33.20	48.41	6.86	70.29
204	4	SOYBEAN	1318	3.96	2.91	34.97	50.67	-29.68	68.11
204	4	SOYBEAN	1318	3.88	2.83	36.36	53.50	-29.68	68.11
204	4	SOYBEAN	1318	4.00	2.89	36.30	53.22	-29.68	68.11
204	1	SOYBEAN	1322	3.93	2.89	35.48	52.10	-31.95	67.71
204	1	SOYBEAN	1322	3.93	2.91	35.03	52.06	-31.95	67.71
204	1	SOYBEAN	1323	4.01	2.95	36.41	54.10	-32.51	67.61
204	4	SOYBEAN	1415	3.87	2.88	34.71	50.44	-55.68	60.53
204	4	SOYBEAN	1416	3.76	2.78	35.29	52.17	-56.03	60.37
204	4	SOYBEAN	1417	3.98	2.90	36.07	52.79	-56.38	60.21
204	1	SOYBEAN	1420	3.93	2.88	35.88	52.25	-57.40	59.72
204	1	SOYBEAN	1420	3.93	2.91	35.40	52.17	-57.40	59.72
204	1	SOYBEAN	1420	3.89	2.86	35.49	52.34	-57.40	59.72
204	4	SOYBEAN	1515	3.97	3.02	35.53	51.48	-72.53	50.05
204	4	SOYBEAN	1515	3.87	2.90	35.26	51.53	-72.53	50.05
204	4	SOYBEAN	1516	4.09	3.03	37.20	54.30	-72.76	49.86
204	1	SOYBEAN	1520	3.84	2.95	35.68	53.05	-73.65	49.12
204	1	SOYBEAN	1521	3.85	2.94	35.93	53.18	-73.87	48.94
204	1	SOYBEAN	1521	3.96	3.02	36.73	54.31	-73.87	48.94
209	4	SOYBEAN	855	4.27	3.16	37.61	53.52	82.40	38.90
209	4	SOYBEAN	904	4.38	3.31	41.25	60.69	80.77	40.63
209	4	SOYBEAN	908	4.53	3.31	39.63	56.59	80.02	41.39
209	1	SOYBEAN	925	2.13	1.46	16.60	22.10	76.71	44.61
209	1	SOYBEAN	927	2.22	1.47	17.03	22.49	76.31	44.99
209	1	SOYBEAN	929	1.71	1.12	13.04	17.08	75.90	45.37
209	4	SOYBEAN	1133	4.29	3.32	40.58	60.33	36.21	65.56
209	4	SOYBEAN	1140	3.83	3.00	38.61	58.34	32.59	66.33
209	4	SOYBEAN	1144	4.23	3.15	39.42	58.40	30.44	66.73
209	1	SOYBEAN	1204	4.18	3.14	39.24	57.54	18.74	68.35
209	1	SOYBEAN	1206	4.10	3.07	38.70	56.97	17.49	68.47
209	1	SOYBEAN	1207	3.87	2.94	37.24	55.30	16.86	68.53
209	4	SOYBEAN	1404	2.84	2.12	26.13	37.39	-50.12	61.35
209	4	SOYBEAN	1408	1.26	0.91	11.20	15.65	-51.63	60.74
209	4	SOYBEAN	1409	2.14	1.54	18.85	26.33	-52.00	60.59
209	1	SOYBEAN	1420	4.33	3.34	40.05	58.79	-55.89	58.87
209	1	SOYBEAN	1421	4.18	3.18	39.78	58.74	-56.22	58.71
209	1	SOYBEAN	1422	1.49	1.06	12.44	17.11	-56.56	58.54
210	4	SOYBEAN	913	3.75	2.74	37.49	55.55	78.80	42.20
210	4	SOYBEAN	914	3.55	2.67	38.43	57.95	78.61	42.39
210	4	SOYBEAN	915	3.72	2.74	38.54	57.48	78.42	42.58
210	1	SOYBEAN	925	3.86	2.89	39.15	58.03	76.43	44.47
210	1	SOYBEAN	926	3.95	2.93	40.55	60.08	76.23	44.66
210	1	SOYBEAN	928	3.42	2.56	37.91	57.07	75.82	45.04
214	4	SOYBEAN	845	3.91	2.97	39.03	58.57	82.82	36.29

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
214	4	SOYBEAN	846	3.75	2.89	39.90	61.40	82.65	36.49
214	4	SOYBEAN	848	4.12	3.12	42.25	64.00	82.29	36.87
214	1	SOYBEAN	859	3.96	2.95	40.38	60.90	80.30	38.98
214	1	SOYBEAN	900	3.88	2.94	40.56	61.34	80.12	39.17
214	1	SOYBEAN	901	3.66	2.77	38.48	58.86	79.93	39.36
214	4	SOYBEAN	1000	3.15	2.47	34.93	53.69	67.36	50.31
214	4	SOYBEAN	1001	2.99	2.34	34.26	53.76	67.11	50.49
214	4	SOYBEAN	1002	3.58	2.70	39.04	59.89	66.86	50.67
214	1	SOYBEAN	1010	3.49	2.70	37.06	56.68	64.80	52.08
214	1	SOYBEAN	1011	3.52	2.69	37.93	58.34	64.53	52.26
214	1	SOYBEAN	1012	3.32	2.49	35.74	55.45	64.27	52.43
214	4	SOYBEAN	1134	3.32	2.60	33.30	50.93	34.12	64.59
214	4	SOYBEAN	1134	3.73	2.97	32.61	49.84	34.12	64.59
214	4	SOYBEAN	1136	3.43	2.60	35.11	53.96	33.12	64.80
214	1	SOYBEAN	1147	3.38	2.65	35.13	53.41	27.37	65.87
214	1	SOYBEAN	1148	3.46	2.68	35.51	54.93	26.83	65.96
214	1	SOYBEAN	1149	3.37	2.62	32.41	50.20	26.28	66.05
215	4	SOYBEAN	1238	3.67	3.03	29.91	45.07	-3.60	67.68
215	4	SOYBEAN	1240	3.77	3.13	30.08	45.90	-4.86	67.65
215	4	SOYBEAN	1248	3.61	2.92	30.68	46.69	-9.85	67.45
215	1	SOYBEAN	1257	3.49	2.91	31.77	48.92	-15.33	67.06
215	1	SOYBEAN	1258	3.67	3.05	30.06	46.69	-15.93	67.01
215	1	SOYBEAN	1259	3.72	3.12	29.07	45.00	-16.52	66.96
215	4	SOYBEAN	1404	4.27	3.42	33.26	49.90	-48.34	60.06
215	4	SOYBEAN	1406	4.15	3.39	32.70	49.30	-49.09	59.77
215	4	SOYBEAN	1406	4.10	3.30	33.77	50.98	-49.09	59.77
215	1	SOYBEAN	1412	3.59	2.94	34.00	52.24	-51.29	58.88
215	1	SOYBEAN	1412	3.55	2.92	32.40	50.36	-51.29	58.88
215	1	SOYBEAN	1413	3.60	2.99	31.07	47.61	-51.65	58.73
215	4	SOYBEAN	1531	3.57	2.93	33.60	50.70	-73.05	45.30
215	4	SOYBEAN	1532	3.64	3.00	31.80	48.21	-73.27	45.11
215	4	SOYBEAN	1533	3.72	3.04	33.84	51.70	-73.48	44.92
215	1	SOYBEAN	1540	3.70	3.10	36.18	55.39	-74.95	43.62
215	1	SOYBEAN	1541	3.59	3.00	33.56	52.41	-75.15	43.43
215	1	SOYBEAN	1542	3.86	3.22	32.81	50.27	-75.36	43.24
215	4	SOYBEAN	1645	4.20	3.45	39.96	59.49	-86.78	31.19
215	4	SOYBEAN	1646	3.86	3.17	35.20	52.77	-86.94	31.00
215	4	SOYBEAN	1647	3.99	3.24	37.43	56.26	-87.11	30.80
215	1	SOYBEAN	1653	4.47	3.76	42.33	63.70	-88.08	29.64
215	1	SOYBEAN	1653	4.08	3.34	38.13	57.57	-88.08	29.64
215	1	SOYBEAN	1654	3.82	3.14	36.19	54.67	-88.25	29.45
221	4	SOYBEAN	1031	3.44	2.62	34.96	52.48	56.22	54.37
221	4	SOYBEAN	1032	3.58	2.78	37.02	55.96	55.91	54.53
221	4	SOYBEAN	1032	3.53	2.73	35.96	54.66	55.91	54.53
221	1	SOYBEAN	1036	3.52	2.75	35.21	53.33	54.65	55.16
221	1	SOYBEAN	1037	3.70	2.91	36.38	54.63	54.33	55.32
221	1	SOYBEAN	1037	3.85	3.00	37.26	55.82	54.33	55.32
230	4	SOYBEAN	850	3.97	3.18	36.20	53.77	76.77	34.81
230	4	SOYBEAN	852	4.00	3.17	37.70	56.67	76.39	35.18
230	4	SOYBEAN	854	4.03	3.29	37.75	57.81	76.01	35.56
230	1	SOYBEAN	902	4.21	3.50	37.72	56.86	74.45	37.06
230	1	SOYBEAN	903	4.11	3.29	36.96	55.56	74.25	37.24
230	1	SOYBEAN	905	3.99	3.15	36.43	54.23	73.85	37.62
231	4	SOYBEAN	828	4.33	3.45	37.49	54.95	80.44	30.47
231	4	SOYBEAN	830	4.47	3.60	39.67	59.06	80.08	30.85
231	4	SOYBEAN	831	4.35	3.63	39.19	59.20	79.91	31.04

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
231	1	SOYBEAN	838	4.37	3.63	37.16	55.47	78.64	32.37
231	1	SOYBEAN	840	4.23	3.42	36.98	55.10	78.28	32.75
231	1	SOYBEAN	841	4.30	3.36	36.80	54.07	78.09	32.94
231	4	SOYBEAN	1220	3.44	2.82	32.07	47.97	5.05	62.76
231	4	SOYBEAN	1222	3.62	3.02	34.58	52.43	3.98	62.79
231	4	SOYBEAN	1223	3.67	3.07	33.58	51.10	3.44	62.80
231	1	SOYBEAN	1229	3.86	3.24	33.74	50.92	0.23	62.84
231	1	SOYBEAN	1231	3.48	2.83	31.34	46.98	-0.84	62.84
231	1	SOYBEAN	1232	3.52	2.81	32.42	48.41	-1.38	62.83
237	4	SOYBEAN	839	4.21	3.38	35.94	53.81	76.30	31.56
237	4	SOYBEAN	840	4.26	3.36	35.95	54.83	76.11	31.75
237	4	SOYBEAN	842	4.36	3.54	38.03	58.27	75.73	32.12
237	1	SOYBEAN	849	4.23	3.42	35.59	53.95	74.40	33.43
237	1	SOYBEAN	858	4.20	3.33	35.24	53.37	72.64	35.10
237	1	SOYBEAN	905	4.09	3.26	34.41	52.04	71.23	36.39
242	4	SOYBEAN	859	4.35	3.54	34.85	51.69	70.52	34.37
242	4	SOYBEAN	901	4.45	3.61	37.37	56.14	70.11	34.74
242	4	SOYBEAN	902	4.36	3.63	36.05	54.60	69.91	34.92
242	1	SOYBEAN	910	4.60	3.72	37.91	56.40	68.24	36.37
242	1	SOYBEAN	910	4.74	3.89	38.27	57.45	68.24	36.37
242	1	SOYBEAN	912	4.49	3.62	35.74	52.92	67.82	36.73
245	4	SOYBEAN	900	4.87	3.98	34.72	51.21	69.14	33.99
245	4	SOYBEAN	901	5.15	4.25	36.65	54.23	68.94	34.17
245	4	SOYBEAN	901	5.53	4.80	33.66	50.49	68.94	34.17
245	1	SOYBEAN	905	5.05	4.10	36.95	55.03	68.11	34.89
245	1	SOYBEAN	906	4.88	3.97	35.20	53.38	67.90	35.07
245	1	SOYBEAN	906	5.10	4.04	34.07	49.74	67.90	35.07
245	4	SOYBEAN	1008	4.55	3.66	33.48	49.85	53.02	45.51
245	4	SOYBEAN	1009	4.70	3.86	35.78	53.34	52.74	45.67
245	4	SOYBEAN	1010	4.57	3.79	31.67	47.46	52.46	45.82
245	1	SOYBEAN	1013	4.52	3.67	34.43	51.76	51.61	46.28
245	1	SOYBEAN	1014	4.56	3.75	34.42	52.14	51.33	46.43
245	1	SOYBEAN	1014	4.67	3.77	32.80	48.95	51.33	46.43
245	4	SOYBEAN	1140	4.43	3.55	32.51	48.50	20.60	56.33
245	4	SOYBEAN	1140	4.57	3.75	34.47	52.14	20.60	56.33
245	4	SOYBEAN	1141	5.52	4.75	29.96	44.05	20.17	56.40
245	1	SOYBEAN	1144	4.65	3.78	33.30	49.88	18.86	56.59
245	1	SOYBEAN	1145	4.60	3.76	33.42	50.27	18.43	56.65
245	4	SOYBEAN	1237	3.95	3.20	28.61	42.65	-5.44	57.79
245	4	SOYBEAN	1238	3.86	3.18	29.01	44.06	-5.90	57.77
245	4	SOYBEAN	1239	4.63	4.00	25.32	37.96	-6.37	57.75
245	1	SOYBEAN	1242	4.05	3.32	28.99	43.65	-7.75	57.68
245	1	SOYBEAN	1243	4.06	3.33	28.99	43.46	-8.21	57.65
245	1	SOYBEAN	1243	4.33	3.59	27.29	40.18	-8.21	57.65
245	4	SOYBEAN	1345	4.43	3.65	31.08	46.20	-34.38	53.22
245	4	SOYBEAN	1347	4.30	3.62	30.76	46.31	-35.12	53.00
245	4	SOYBEAN	1348	5.08	4.35	29.13	42.65	-35.49	52.88
245	1	SOYBEAN	1353	4.54	3.79	31.42	46.93	-37.30	52.31
245	1	SOYBEAN	1355	4.60	3.82	30.56	45.47	-38.01	52.07
245	1	SOYBEAN	1357	4.61	3.85	28.38	42.14	-38.71	51.83
245	4	SOYBEAN	1604	4.66	3.88	33.70	50.24	-71.71	31.48
245	4	SOYBEAN	1606	4.47	3.69	32.24	48.64	-72.10	31.11
245	4	SOYBEAN	1607	5.36	4.62	29.97	43.44	-72.29	30.92
245	1	SOYBEAN	1612	4.95	4.11	34.12	50.29	-73.25	30.00
245	1	SOYBEAN	1612	4.68	3.94	31.53	46.87	-73.25	30.00
245	1	SOYBEAN	1613	5.34	4.40	33.16	48.79	-73.44	29.81

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
253	4	SOYBEAN	838	6.45	5.45	35.44	50.52	70.40	28.44
253	4	SOYBEAN	840	6.15	5.59	26.01	36.83	70.02	28.80
253	4	SOYBEAN	842	6.42	7.54	18.55	26.18	69.63	29.16
253	1	SOYBEAN	849	6.85	6.32	29.60	40.53	68.24	30.43
253	1	SOYBEAN	850	6.97	6.65	28.69	39.41	68.04	30.61
253	1	SOYBEAN	851	7.36	7.05	27.80	37.50	67.84	30.79
263	4	SOYBEAN	822	5.03	7.03	14.81	22.18	69.64	23.53
263	4	SOYBEAN	823	5.42	7.34	14.94	22.33	69.46	23.71
263	4	SOYBEAN	824	4.96	6.94	11.09	16.86	69.27	23.89
263	1	SOYBEAN	829	5.59	7.68	13.78	19.99	68.32	24.79
263	1	SOYBEAN	830	5.95	8.02	15.35	22.19	68.13	24.97
263	1	SOYBEAN	831	5.71	7.92	14.96	21.50	67.93	25.15
265	4	SOYBEAN	932	5.92	8.60	15.27	22.68	54.16	35.03
265	4	SOYBEAN	932	5.92	8.46	13.66	20.11	54.16	35.03
265	4	SOYBEAN	933	6.72	9.40	13.82	19.63	53.92	35.18
265	1	SOYBEAN	936	6.44	8.97	15.13	21.82	53.20	35.65
265	1	SOYBEAN	936	6.58	9.55	15.53	22.72	53.20	35.65
265	1	SOYBEAN	937	5.64	8.07	13.47	19.57	52.96	35.81
265	4	SOYBEAN	1007	5.60	7.99	14.42	21.07	45.23	40.20
265	4	SOYBEAN	1008	5.65	8.12	12.96	18.98	44.96	40.33
265	4	SOYBEAN	1008	6.57	9.29	13.45	19.03	44.96	40.33
265	1	SOYBEAN	1011	6.65	9.22	14.98	21.49	44.13	40.74
265	1	SOYBEAN	1011	6.40	9.05	14.98	21.54	44.13	40.74
265	1	SOYBEAN	1012	5.54	7.84	13.31	18.97	43.85	40.87
265	4	SOYBEAN	1138	5.72	8.31	13.94	20.27	15.55	49.20
265	4	SOYBEAN	1138	5.67	8.09	13.03	18.89	15.55	49.20
265	4	SOYBEAN	1139	6.02	8.50	12.11	17.26	15.17	49.25
265	1	SOYBEAN	1142	6.33	8.87	13.57	19.36	14.04	49.40
265	1	SOYBEAN	1142	6.33	9.09	14.15	20.37	14.04	49.40
265	1	SOYBEAN	1143	5.88	8.32	13.46	19.35	13.67	49.44
265	4	SOYBEAN	1231	5.34	7.81	12.84	18.78	-4.94	50.14
265	4	SOYBEAN	1231	5.15	7.38	11.93	17.31	-4.94	50.14
265	4	SOYBEAN	1232	5.94	8.28	11.93	16.81	-5.33	50.12
265	1	SOYBEAN	1235	5.85	8.22	13.00	18.37	-6.50	50.06
265	1	SOYBEAN	1235	5.75	8.12	13.03	18.46	-6.50	50.06
265	1	SOYBEAN	1236	5.41	7.59	12.02	17.00	-6.89	50.04
265	4	SOYBEAN	1331	5.72	8.33	13.88	20.21	-27.14	46.89
265	4	SOYBEAN	1332	5.58	7.96	13.02	18.84	-27.49	46.80
265	4	SOYBEAN	1332	6.16	8.73	12.64	18.01	-27.49	46.80
265	1	SOYBEAN	1335	6.30	8.94	14.23	20.35	-28.50	46.52
265	1	SOYBEAN	1336	6.37	9.17	14.15	20.40	-28.84	46.43
265	1	SOYBEAN	1336	5.36	7.80	12.17	17.74	-28.84	46.43
265	4	SOYBEAN	1426	5.78	8.54	13.97	20.54	-44.17	40.64
265	4	SOYBEAN	1427	5.74	8.25	13.27	19.22	-44.45	40.50
265	4	SOYBEAN	1427	6.60	9.24	13.32	18.54	-44.45	40.50
265	1	SOYBEAN	1430	6.26	8.86	13.91	19.90	-45.27	40.09
265	1	SOYBEAN	1431	6.22	8.84	13.97	19.99	-45.54	39.95
265	1	SOYBEAN	1431	5.91	8.56	13.75	19.42	-45.54	39.95
270	4	SOYBEAN	1048	6.30	8.86	13.39	19.27	31.37	43.61
270	4	SOYBEAN	1048	6.36	8.86	12.78	18.12	31.37	43.61
270	4	SOYBEAN	1049	7.07	9.62	13.51	18.61	31.06	43.71
270	1	SOYBEAN	1051	6.99	9.49	13.82	19.19	30.42	43.91
270	1	SOYBEAN	1051	7.17	9.89	14.17	20.00	30.42	43.91
270	1	SOYBEAN	1052	6.27	8.70	12.75	17.84	30.10	44.01
180	3	SUNFLOWER	1206	7.59	5.50	43.32	56.44	19.41	73.10
180	3	SUNFLOWER	1207	7.23	5.26	40.50	53.64	18.65	73.16

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
180	3	SUNFLOWER	1207	7.38	5.36	40.75	53.15	18.65	73.16
184	3	SUNFLOWER	1017	7.02	5.32	44.00	59.75	69.88	57.22
184	3	SUNFLOWER	1018	7.18	5.33	45.26	60.48	69.62	57.40
184	3	SUNFLOWER	1019	6.80	5.03	42.55	56.89	69.36	57.59
188	3	SUNFLOWER	927	7.38	5.79	47.98	68.18	80.59	47.49
188	3	SUNFLOWER	928	7.38	5.82	47.20	67.87	80.39	47.68
188	3	SUNFLOWER	930	7.55	5.92	49.95	70.07	80.00	48.06
188	3	SUNFLOWER	1223	7.09	5.55	40.08	54.48	6.74	73.04
188	3	SUNFLOWER	1224	7.17	5.46	41.22	55.82	5.96	73.06
188	3	SUNFLOWER	1225	7.12	5.47	41.43	56.07	5.16	73.08
197	3	SUNFLOWER	828	6.31	4.73	42.80	58.68	89.51	35.17
197	3	SUNFLOWER	829	6.62	4.83	44.00	59.90	89.35	35.36
197	3	SUNFLOWER	830	6.64	5.17	44.12	60.97	89.19	35.56
197	3	SUNFLOWER	916	6.67	5.10	48.53	68.49	81.28	44.43
197	3	SUNFLOWER	916	7.06	5.35	47.99	66.57	81.28	44.43
197	3	SUNFLOWER	917	5.79	4.43	36.98	51.39	81.09	44.62
197	3	SUNFLOWER	957	6.18	4.72	40.45	56.89	72.78	52.16
197	3	SUNFLOWER	958	6.45	4.80	43.10	59.33	72.55	52.35
197	3	SUNFLOWER	958	5.96	4.37	40.82	56.15	72.55	52.35
197	3	SUNFLOWER	1050	5.49	4.27	35.37	49.62	57.79	61.50
197	3	SUNFLOWER	1050	5.79	4.38	38.78	53.85	57.79	61.50
197	3	SUNFLOWER	1051	6.02	4.64	39.02	54.19	57.44	61.66
197	3	SUNFLOWER	1149	5.93	4.63	37.32	51.88	30.27	69.54
197	3	SUNFLOWER	1150	5.98	4.56	39.32	54.57	29.66	69.64
197	3	SUNFLOWER	1150	5.86	4.54	36.78	51.50	29.66	69.64
197	3	SUNFLOWER	1247	7.06	5.71	42.56	61.14	-10.73	71.52
197	3	SUNFLOWER	1248	8.29	6.96	47.76	69.67	-11.46	71.48
197	3	SUNFLOWER	1248	6.31	5.27	38.12	55.47	-11.46	71.48
197	3	SUNFLOWER	1352	5.81	4.53	36.87	51.61	-48.83	65.06
197	3	SUNFLOWER	1353	5.87	4.42	37.36	51.67	-49.26	64.91
197	3	SUNFLOWER	1354	5.84	4.41	37.47	52.50	-49.68	64.77
197	3	SUNFLOWER	1448	5.69	4.48	36.86	51.18	-67.77	55.79
197	3	SUNFLOWER	1448	6.07	4.76	35.51	48.83	-67.77	55.79
197	3	SUNFLOWER	1449	5.46	4.30	34.83	48.86	-68.04	55.61
201	3	SUNFLOWER	946	7.03	5.83	41.31	56.76	74.37	49.62
201	3	SUNFLOWER	947	7.07	5.89	41.01	56.55	74.15	49.81
201	3	SUNFLOWER	947	6.66	5.47	39.11	53.50	74.15	49.81
204	3	SUNFLOWER	832	8.02	6.93	41.49	56.03	87.52	35.11
204	3	SUNFLOWER	832	7.88	6.96	39.57	53.57	87.52	35.11
204	3	SUNFLOWER	832	7.53	6.45	39.98	53.51	87.52	35.11
204	3	SUNFLOWER	907	6.95	5.98	39.04	54.07	81.46	41.86
204	3	SUNFLOWER	907	7.61	6.38	41.76	56.03	81.46	41.86
204	3	SUNFLOWER	908	7.52	6.19	42.63	58.06	81.28	42.05
204	3	SUNFLOWER	948	6.93	5.79	39.75	54.08	73.18	49.60
204	3	SUNFLOWER	949	7.46	6.29	40.48	55.02	72.95	49.78
204	3	SUNFLOWER	951	6.96	5.76	40.24	54.64	72.50	50.15
204	3	SUNFLOWER	1035	6.67	5.58	37.25	50.93	60.86	57.98
204	3	SUNFLOWER	1035	7.46	6.18	39.93	54.36	60.86	57.98
204	3	SUNFLOWER	1036	6.78	5.56	39.32	53.82	60.55	58.15
204	3	SUNFLOWER	1204	6.98	5.68	36.48	48.69	19.65	69.45
204	3	SUNFLOWER	1205	7.57	6.28	40.39	54.35	19.01	69.51
204	3	SUNFLOWER	1206	7.10	5.79	39.35	53.16	18.36	69.58
204	3	SUNFLOWER	1319	7.40	6.19	39.64	53.14	-30.25	68.01
204	3	SUNFLOWER	1319	7.19	6.01	37.83	51.13	-30.25	68.01
204	3	SUNFLOWER	1320	6.83	5.80	38.30	52.16	-30.82	67.91
204	3	SUNFLOWER	1417	7.53	6.43	39.32	53.04	-56.38	60.21

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
204	3	SUNFLOWER	1417	7.45	6.20	38.90	51.97	-56.38	60.21
204	3	SUNFLOWER	1418	7.25	5.94	39.21	51.94	-56.72	60.05
204	3	SUNFLOWER	1517	7.70	6.54	38.25	50.17	-72.98	49.68
204	3	SUNFLOWER	1517	7.75	6.74	38.78	51.86	-72.98	49.68
204	3	SUNFLOWER	1518	7.31	6.14	38.13	51.78	-73.21	49.49
209	3	SUNFLOWER	912	9.42	8.12	39.61	51.61	79.27	42.15
209	3	SUNFLOWER	914	9.22	7.77	38.97	51.18	78.88	42.53
209	3	SUNFLOWER	917	8.47	7.27	37.66	50.12	78.30	43.10
209	3	SUNFLOWER	1146	8.97	7.93	35.77	47.75	29.34	66.93
209	3	SUNFLOWER	1147	8.56	7.44	35.20	46.82	28.78	67.02
209	3	SUNFLOWER	1148	7.54	6.58	32.17	42.86	28.22	67.11
209	3	SUNFLOWER	1412	8.41	7.57	34.16	45.31	-53.10	60.13
209	3	SUNFLOWER	1413	3.27	2.70	12.04	15.13	-53.45	59.97
209	3	SUNFLOWER	1414	4.13	3.52	16.16	21.00	-53.81	59.82
210	3	SUNFLOWER	917	9.48	8.48	42.18	56.50	78.03	42.96
210	3	SUNFLOWER	918	8.86	7.63	40.50	53.84	77.83	43.15
210	3	SUNFLOWER	919	8.82	7.79	40.55	54.41	77.63	43.34
214	3	SUNFLOWER	851	9.54	8.50	40.62	54.51	81.76	37.45
214	3	SUNFLOWER	852	9.22	8.04	39.73	52.86	81.58	37.64
214	3	SUNFLOWER	853	9.24	8.03	40.41	54.26	81.40	37.83
214	3	SUNFLOWER	1003	8.75	7.92	36.60	49.63	66.61	50.85
214	3	SUNFLOWER	1004	8.47	7.70	36.26	48.83	66.35	51.03
214	3	SUNFLOWER	1005	7.74	7.02	33.89	46.10	66.10	51.20
214	3	SUNFLOWER	1137	8.21	7.64	31.93	42.80	32.62	64.91
214	3	SUNFLOWER	1138	8.03	7.42	32.06	43.49	32.11	65.01
214	3	SUNFLOWER	1139	8.37	37.64	34.35	46.27	31.60	65.11
215	3	SUNFLOWER	1250	7.62	7.81	25.28	34.42	-11.08	67.38
215	3	SUNFLOWER	1250	7.66	7.74	25.13	33.99	-11.08	67.38
215	3	SUNFLOWER	1253	7.45	7.38	26.89	36.56	-12.91	67.25
215	3	SUNFLOWER	1407	6.88	6.97	25.21	34.83	-49.47	59.62
215	3	SUNFLOWER	1408	7.50	7.08	27.60	36.82	-49.84	59.48
215	3	SUNFLOWER	1409	6.96	6.73	26.44	35.99	-50.21	59.33
215	3	SUNFLOWER	1534	6.38	6.34	24.82	34.30	-73.69	44.74
215	3	SUNFLOWER	1535	6.17	6.10	24.18	34.00	-73.91	44.55
215	3	SUNFLOWER	1536	6.19	5.93	25.77	35.96	-74.12	44.37
215	3	SUNFLOWER	1648	6.26	6.09	26.99	36.84	-87.27	30.61
215	3	SUNFLOWER	1648	6.82	6.70	28.39	39.09	-87.27	30.61
215	3	SUNFLOWER	1649	6.49	6.09	27.52	37.56	-87.43	30.42
221	3	SUNFLOWER	1034	5.90	5.55	21.29	29.14	55.29	54.85
221	3	SUNFLOWER	1034	7.76	8.28	20.23	27.33	55.29	54.85
221	3	SUNFLOWER	1034	7.19	6.85	23.12	30.66	55.29	54.85
230	3	SUNFLOWER	855	5.93	5.77	20.48	28.47	75.81	35.75
230	3	SUNFLOWER	857	6.56	6.65	21.18	28.71	75.43	36.12
230	3	SUNFLOWER	859	7.89	8.03	23.62	31.28	75.04	36.50
231	3	SUNFLOWER	832	6.73	6.63	22.41	30.54	79.73	31.23
231	3	SUNFLOWER	833	6.79	6.77	22.23	30.21	79.55	31.42
231	3	SUNFLOWER	835	8.04	8.28	23.92	31.89	79.19	31.80
231	3	SUNFLOWER	1224	6.26	6.47	18.52	24.57	2.91	62.82
231	3	SUNFLOWER	1225	7.20	7.63	19.23	25.93	2.37	62.82
231	3	SUNFLOWER	1226	7.43	8.15	19.43	25.88	1.84	62.83
237	3	SUNFLOWER	843	5.72	6.06	16.55	23.09	75.55	32.31
237	3	SUNFLOWER	845	6.02	6.64	16.89	23.98	75.17	32.68
237	3	SUNFLOWER	848	7.40	8.36	18.61	25.39	74.59	33.25
242	3	SUNFLOWER	904	5.03	5.99	12.27	18.52	69.50	35.28
242	3	SUNFLOWER	905	5.36	6.31	15.03	22.16	69.29	35.46
242	3	SUNFLOWER	907	6.51	7.86	16.57	23.22	68.87	35.83

Table 6A.

REFLECTANCE FOR 1982

DAY OF YEAR	PLOT	CROP	TIME	MSS4	MSS5	MSS6	MSS7	SOLAR AZIMUTH	SOLAR ELEVATION
245	3	SUNFLOWER	902	6.41	7.00	17.46	25.88	68.73	34.35
245	3	SUNFLOWER	903	5.70	6.24	15.95	23.13	68.53	34.53
245	3	SUNFLOWER	903	8.03	10.01	18.09	25.96	68.53	34.53
245	3	SUNFLOWER	1011	5.64	6.42	15.64	23.00	52.18	45.98
245	3	SUNFLOWER	1011	4.88	5.39	15.36	22.53	52.18	45.98
245	3	SUNFLOWER	1012	7.83	9.98	16.70	23.64	51.90	46.13
245	3	SUNFLOWER	1142	6.20	7.46	15.71	23.02	19.73	56.46
245	3	SUNFLOWER	1143	6.98	8.53	15.87	22.70	19.30	56.53
245	3	SUNFLOWER	1143	8.07	10.02	16.58	22.78	19.30	56.53
245	3	SUNFLOWER	1239	5.26	6.19	13.96	20.46	-6.37	57.75
245	3	SUNFLOWER	1241	6.89	8.20	15.35	21.83	-7.29	57.70
245	3	SUNFLOWER	1242	6.62	8.30	13.93	19.66	-7.75	57.68
245	3	SUNFLOWER	1349	6.52	7.23	16.94	23.73	-35.85	52.77
245	3	SUNFLOWER	1350	6.39	7.45	17.25	24.84	-36.22	52.66
245	3	SUNFLOWER	1352	7.27	8.97	15.61	21.52	-36.94	52.43
245	3	SUNFLOWER	1608	6.17	7.08	17.03	25.07	-72.49	30.74
245	3	SUNFLOWER	1609	5.61	6.26	17.28	25.26	-72.68	30.55
245	3	SUNFLOWER	1610	7.22	8.93	16.34	23.61	-72.87	30.37

Table 7A. SAS program for determining a 4-space soil brightness index.

```
         DATA SOILFOUR;
         INPUT JDATE 1-3 PLOT 4-6 TIME 7-10 CH1 11-14 4 CH2 15-18 4 CH3 19-22 4 CH4 23-26
           4 SAZM 27-31 2 SELV 32-35 2;
         CH1=100*CH1;
         CH2=100*CH2;
         CH3=100*CH3;
         CH4=100*CH4;
         CARDS;

NOTE: DATA SET WORK.SOILFOUR HAS 97 OBSERVATIONS AND 9 VARIABLES. 250 OBS/TRK.
NOTE: THE DATA STATEMENT USED 0.36 SECONDS AND 202K.

         PROC SORT;
         BY JDATE;

NOTE: DATA SET WORK.SOILFOUR HAS 97 OBSERVATIONS AND 9 VARIABLES. 250 OBS/TRK.
NOTE: THE PROCEDURE SORT USED 0.89 SECONDS AND 210K.

         PROC MEANS NOPRINT MAXDEC=5;
         BY JDATE;
         VAR CH1 CH2 CH3 CH4;
         OUTPUT OUT=SOIL MEAN=MSS1 MSS2 MSS3 MSS4 STDERR=SEM1 SEM2 SEM3 SEM4;

NOTE: DATA SET WORK.SOIL HAS 17 OBSERVATIONS AND 9 VARIABLES. 250 OBS/TRK.
NOTE: THE PROCEDURE MEANS USED 0.28 SECONDS AND 206K.

         PROC MATRIX;
         FETCH X DATA=SOIL (KEEP=JDATE MSS1 MSS2 MSS3 MSS4);
         NOBS=NROW(X);
         NVAR=NCOL(X);
         DO K=1 TO NOBS;
         S=X(K,2 3 4 5);
         DO L=1 TO NOBS;
         IF L¬=K THEN DO;
           R=X(K,1);
           Q=X(L,1);
           F=X(L,2 3 4 5);
           B=S-F;
           D=SQRT(SSQ(B));
           A=B#/D;
           N=R||Q;
           M=N||A;
         OUTPUT M OUT=C(RENAME=(COL1=JDATE1 COL2=JDATE2 COL3=B1 COL4=B2 COL5=B3 COL6=B4))
         ;
           END;
         END;
         END;

NOTE: DATA SET WORK.C HAS 272 OBSERVATIONS AND 7 VARIABLES. 317 OBS/TRK.
NOTE: THE PROCEDURE MATRIX USED 1.96 SECONDS AND 214K AND PRINTED PAGE 1.

         PROC PRINT;

NOTE: THE PROCEDURE PRINT USED 1.25 SECONDS AND 202K AND PRINTED PAGES 2 TO 6.

         DATA SOILLINE;
         SET C;
         B1=ABS(B1);
         B2=ABS(B2);
         B3=ABS(B3);
         B4=ABS(B4);

NOTE: DATA SET WORK.SOILLINE HAS 272 OBSERVATIONS AND 7 VARIABLES. 317 OBS/TRK.
NOTE: THE DATA STATEMENT USED 0.24 SECONDS AND 202K.

         PROC MEANS;
         VAR B1 B2 B3 B4 ;
         TITLE COEFFICIENTS FOR THE 1982 FOUR BAND SOILLINE;

NOTE: THE PROCEDURE MEANS USED 0.36 SECONDS AND 206K AND PRINTED PAGE 7.
NOTE: SAS USED 214K MEMORY.

NOTE: SAS INSTITUTE INC.
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      PO BOX 8000
      CARY, N.C. 27511-8000
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Table 8A. SAS program for determining 4-space greenness indices.

```
DATA SOILFOUR;
INPUT JDATE 1-3 PLOT 4-6 TIME 7-10 CH1 11-14 4 CH2 15-18 4 CH3 19-22 4 CH4 23-26
  4 SAZM 27-31 2 SELV 32-35 2;
CH1=100*CH1;
CH2=100*CH2;
CH3=100*CH3;
CH4=100*CH4;
CARDS;

NOTE: DATA SET WORK.SOILFOUR HAS 97 OBSERVATIONS AND 9 VARIABLES. 250 OBS/TRK.
NOTE: THE DATA STATEMENT USED 0.35 SECONDS AND 202K.

PROC SORT;
BY JDATE;

NOTE: DATA SET WORK.SOILFOUR HAS 97 OBSERVATIONS AND 9 VARIABLES. 250 OBS/TRK.
NOTE: THE PROCEDURE SORT USED 0.97 SECONDS AND 210K.

PROC MEANS NOPRINT MAXDEC=5;
BY JDATE;
VAR CH1 CH2 CH3 CH4;
OUTPUT OUT=SOIL MEAN=SCH1 SCH2 SCH3 SCH4 ;

NOTE: DATA SET WORK.SOIL HAS 17 OBSERVATIONS AND 5 VARIABLES. 433 OBS/TRK.
NOTE: THE PROCEDURE MEANS USED 0.23 SECONDS AND 206K.

PROC PRINT;
TITLE FOUR BAND SOIL REFLECTANCES, MEANS BY DATE;

NOTE: THE PROCEDURE PRINT USED 0.27 SECONDS AND 202K AND PRINTED PAGE 1.

DATA FOURBAND;
INPUT JDATE 1-3 PLOT 4-6 TIME 7-10 CH1 11-14 4 CH2 15-18 4 CH3 19-22 4 CH4 23-26
  4 SAZM 27-31 2 SELV 32-35 2;
CH1=100*CH1;
CH2=100*CH2;
CH3=100*CH3;
CH4=100*CH4;
IF PLOT =508 THEN CROP='FCORN';
IF PLOT=509 THEN CROP='SCORN';
IF PLOT =507 THEN CROP='SORG';
IF PLOT=502 THEN CROP='SOY';
IF PLOT =503 THEN CROP='SUN';
IF PLOT =504 THEN CROP='PIN';
IF PLOT =505 THEN CROP='SOY';
IF PLOT=505 THEN CROP='MIL';
IF PLOT =510 THEN DELETE;
CARDS;

NOTE: DATA SET WORK.FOURBAND HAS 1138 OBSERVATIONS AND 10 VARIABLES. 235 OBS/TRK.
NOTE: THE DATA STATEMENT USED 2.48 SECONDS AND 202K.

PROC SORT;

BY CROP JDATE;

NOTE: DATA SET WORK.FOURBAND HAS 1138 OBSERVATIONS AND 10 VARIABLES. 235 OBS/TRK.
NOTE: THE PROCEDURE SORT USED 1.57 SECONDS AND 250K.

PROC MEANS NOPRINT MAXDEC=5;
BY CROP JDATE;
VAR CH1 CH2 CH3 CH4;
OUTPUT OUT=FOURBAND MEAN=CH1 CH2 CH3 CH4 STDERR= SEM1 SEM2 SEM3 SEM4;

NOTE: DATA SET WORK.FOURBAND HAS 122 OBSERVATIONS AND 10 VARIABLES. 235 OBS/TRK.
NOTE: THE PROCEDURE MEANS USED 1.12 SECONDS AND 206K.

PROC SORT;
BY JDATE;

NOTE: DATA SET WORK.FOURBAND HAS 122 OBSERVATIONS AND 10 VARIABLES. 235 OBS/TRK.
NOTE: THE PROCEDURE SORT USED 0.87 SECONDS AND 210K.
```

Table 8A. con't.

```
DATA GREEN;
MERGE FOURBAND(IN=INP) SOIL(IN=INS);
IF INP & INS;
BY JDATE;
B1=0.32961274;
B2=0.41107212;
B3=0.50824872;
B4=0.64140937;
CH1=100*CH1;
CH2=100*CH2;
CH3=100*CH3;
CH4=100*CH4;
X1=CH1-SCH1;
X2=CH2-SCH2;
X3=CH3-SCH3;
X4=CH4-SCH4;
D=X1*B1+X2*B2+X3*B3+X4*B4;
G1=X1-(D*B1);
G2=X2-(D*B2);
G3=X3-(D*B3);
G4=X4-(D*B4);
G5=(G1*G1+G2*G2+G3*G3+G4*G4)**0.5;
G1=G1/G5;
G2=G2/G5;
G3=G3/G5;
G4=G4/G5;
ORTH=G1*B1+G2*B2+G3*B3+G4*B4;
DROP X1 X2 X3 X4 G5;

NOTE: DATA SET WORK.GREEN HAS 95 OBSERVATIONS AND 24 VARIABLES. 98 OBS/TRK.
NOTE: THE DATA STATEMENT USED 0.51 SECONDS AND 210K.

PROC SORT;
BY CROP;

NOTE: DATA SET WORK.GREEN HAS 95 OBSERVATIONS AND 24 VARIABLES. 98 OBS/TRK.
NOTE: THE PROCEDURE SORT USED 0.99 SECONDS AND 210K.

PROC PRINT;

BY CROP;
TITLE SOIL AND VEGETATION REFLECTANCES, GREENNESS COEFFICIENTS, AND ORTHOGONALIT
Y;

NOTE: THE PROCEDURE PRINT USED 1.59 SECONDS AND 202K AND PRINTED PAGES 2 TO 6.

PROC MEANS;
BY CROP;
VAR G1 G2 G3 G4 ORTH;
TITLE MEAN GREENESS COEFFICIENTS FOR 1981;

NOTE: THE PROCEDURE MEANS USED 0.49 SECONDS AND 206K AND PRINTED PAGES 7 TO 8.

PROC MEANS;
VAR G1 G2 G3 G4 ORTH;
TITLE ALL CROP GREENESS COEFFICIENTS FOR 1981;

NOTE: THE PROCEDURE MEANS USED 0.31 SECONDS AND 206K AND PRINTED PAGE 9.

DATA OTHER;
SET GREEN;
IF ABS(ORTH)>0.05 THEN DELETE;

NOTE: DATA SET WORK.OTHER HAS 0 OBSERVATIONS AND 24 VARIABLES. 98 OBS/TRK.
NOTE: THE DATA STATEMENT USED 0.21 SECONDS AND 202K.
```

Table 8A. con't.

```
        PROC MEANS;
        BY CROP;
        VAR G1 G2 G3 G4 ORTH;
        TITLE MEAN GREENESS COEFFICIENTS FOR 1981;

NOTE: NO OBSERVATIONS IN DATA SET.
NOTE: THE PROCEDURE MEANS USED 0.27 SECONDS AND 206K.

        PROC MEANS;
        VAR G1 G2 G3 G4 ORTH;
        TITLE ALL CROP GREENESS COEFFICIENTS FOR 1981;

NOTE: NO OBSERVATIONS IN DATA SET.
NOTE: THE PROCEDURE MEANS USED 0.25 SECONDS AND 206K.

NOTE: SAS INSTITUTE INC.
      SAS CIRCLE
      PO BOX 8000
      CARY, N.C. 27511-8000
```

Table 9A. Procedure outline for determining 4-space greenness.*

1. Determine soil brightness coefficients from soil reflectance data by using the SAS program listed in Table 7A. The results are four soil coefficients; b_1, b_2, b_3, and b_4.

   Reflectance soil brightness = $b_1(RF_1) + b_2(RF_2) + b_3(RF_3) + b_4(RF_4)$

2. Use b_1, b_2, b_3, and b_4 with reflectance data taken over bare soil, reflectance data from a crop canopy, and the SAS program listed in Table 8A to determine greenness coefficients; g_1, g_2, g_3, and g_4.

3. Determine greenness for any reflectance observation by transforming the reflectance data through the greenness index as follows.

   Greenness = $g_1(RF_1) + g_2(RF_2) + g_3(RF_3) + g_4(RF_4)$

*Modified from Jackson (1983).

The Determination of Greenness Indices and the Relationships Between Greenness and Leaf Area Index and Total Dry Weight of Seven Crops

by

Maryann Samson Redelfs

B. S., Agronomy, Kansas State University, 1981

AN ABSTRACT OF

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

Kansas State University

Manhattan, Kansas

1983

ABSTRACT

Using spectral reflectance data collected with an Exotech 4-band radiometer, reflectance greenness indices were determined for seven crops and one overall greenness index was determined for all crops combined. The spectral data was collected in 1982 at the Ashland Evapotranspiration Research Site, Manhattan, Kansas. The crops evaluated were field corn, sweet corn, grain sorghum, pearl millet, pinto bean, soybean, and sunflower.

Field estimated values of green leaf area index (LAI) and total dry weight (DWT) were regressed against calculated greenness values. Significant relationships ($p < 0.01$) were determined between LAI and greenness. These relationships are linear and the intercepts are not significantly different from zero ($p > 0.05$). The resulting numerical crop factors, when multiplied by the greenness values, estimated LAI with $R^2 \geq 0.94$. The ability to estimate LAI from greenness does not depend on crop-specific greenness indices, as the overall greenness index was just as effective at estimating LAI as the individual crop indices. Also, general crop factors were determined for the grass crops and the broadleaf crops that, when multiplied by the overall greenness values, estimated LAI with $R^2 \geq 0.94$.

Significant relationships ($p < 0.05$) for all crops between greenness and DWT could only be determined for the beginning of the season until maximum LAI. Those relationships were determined for the grass crops and broadleaf crops and were linear, with nonsignificant intercepts ($p > 0.05$). The resulting dry weight crop factors, multiplied by greenness values, estimated beginning-season DWT with $R^2 \geq 0.91$.

The crop factor x greenness concept could be applied to large areas for estimations of LAI and DWT until maximum LAI that are not so labor and time consuming or prone to sampling biases as conventional field measurement techniques. This would allow a wide variety of crop growth models that require LAI or DWT as an input to be applied to larger areas.