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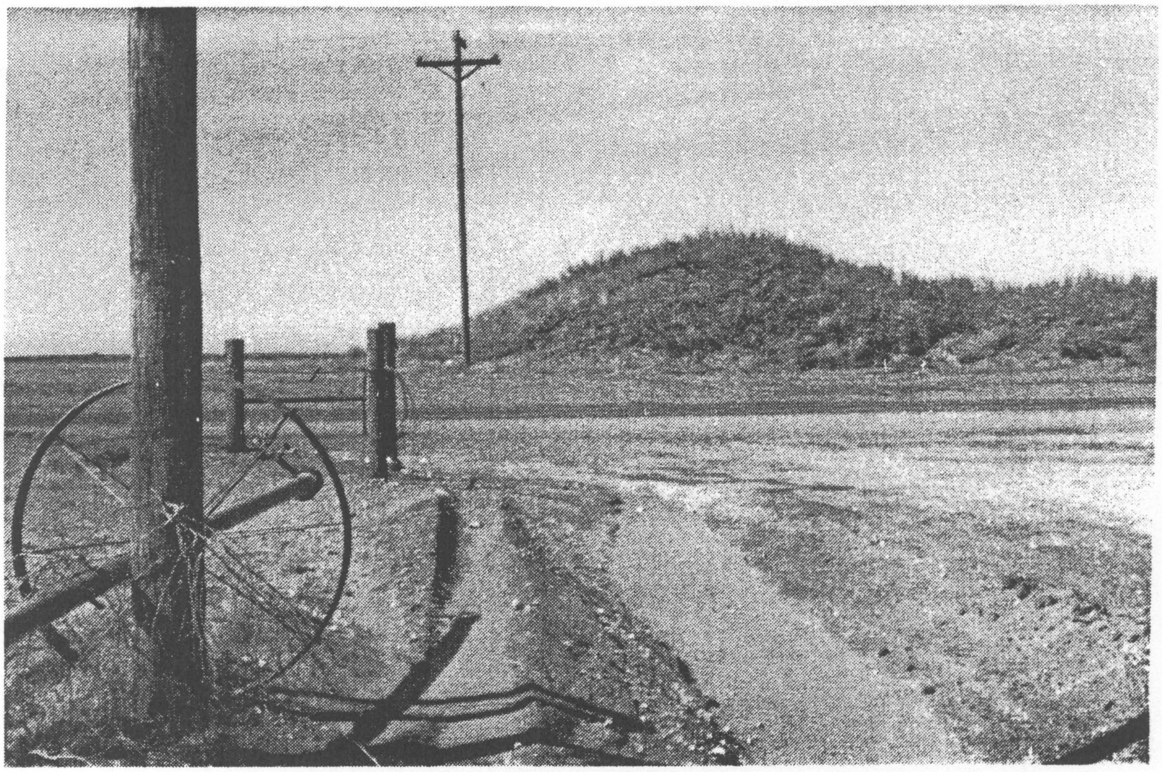

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PREDICTION OF SORGHUM CANOPY STRUCTURE FOR WIND EROSION MODELING

by

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ABSTRACT

The crop growth submodel of the new Wind Erosion Research Model will need to predict accurately not only total dry weight, but information on the canopy structure. Equations have been developed that estimate the leaf area, stem area, plant height, stem length, and canopy cover for field-grown grain sorghum plants using total dry weight. The equations are all of the natural growth function type. Leaf and stem area distributions with height relationships also were developed.

INTRODUCTION

Computer programs that simulate plant growth range from the relatively simple, such as SUCROS (van Keulen et al., 1982), to the extremely complex process - orientated SIMCOTT II (McKinion et al., 1975) and from the universal models that simulate all plants, as used in EPIC (Williams et al., 1984), to models that simulate only one particular species (Arkin et al., 1976) or only a specific plant part (Hoogenboon and Huck, 1986). The one characteristic that all these models have in common is that the main output is dry weight of the biomass produced. While dry weight is required for some submodels in the new Wind Erosion Research Model (WERM), information is also required on the structure of the plant canopy.

Canopy structure determines the aerodynamic roughness of the canopy, which determines the friction velocity at the top of the canopy. The distribution of leaf and stem area with height is needed to determine the depletion of the friction velocity through the canopy and, thus, the velocity near the soil surface. Distinguishing between stem and leaf area is necessary because leaves tend to streamline with the wind and have a drag coefficient (C_d) of about 0.1, while stems remain rigid and have a C_d of about 1.0. On a unit area basis, stems are about ten times more effective than leaves in depleting the friction velocity.

This paper describes the prediction of the canopy structure of grain sorghum [Sorghum bicolor (L.) Moench].

MATERIALS AND METHODS

ORO G grain sorghum was grown in Big Spring, Texas, during 1986 and Golden Acres TE-Dinero in Big Spring and Manhattan, Kansas, in 1987. Thirty plants were sampled every seven days from planting to maturity. Normal tillage and fertility practices were used. Measurements taken were:

1. Plant height at top leaf curl, top leaf collar, plant highest point
2. Length and width of head
3. Fresh and dry weight of head
4. Length and diameter of peduncle, above the top leaf collar and bottom of head
5. Stem diameter at base and at top leaf collar, including sheath
6. Canopy cover by the meter stick method (Adams and Arkin, 1977)
7. Stems and leaves were divided into one-fifth of height to the top leaf curl and leaf area, fresh and dry weight of leaves and stems in each fifth of the plant.

Stem silhouette area was calculated with the following equation:

$$(BD+TD)/2*TLCH$$

where BD = diameter at the stem base, TD = diameter at the top leaf collar, and TLCH = height at the top leaf collar. Estimation equations were developed using Manhattan data and then applied to data collected at Big Spring. Equations were developed using only the first eight harvests because canopy cover reached maximum at the sixth harvest and it was assumed that no wind erosion could occur after the soil surface was protected.

RESULTS AND DISCUSSION

Because the plant growth model selected to be the core of the CROP submodel of WERM will simulate daily biomass production, total biomass production was used in developing prediction equations to simulate grain sorghum canopy structure, i.e. canopy cover, plant height, leaf and stem area, and their distribution with height. All equations best fit the natural growth function equation

$$Y = a(1 - e^{bX})$$

where Y = parameter to be estimated, X = total dry weight, a = maximum value of Y, and b = rate at which Y approaches "a." Estimation equations developed from the Manhattan data for the eight harvests are given in Table 1. Linear regression coefficients (R^2) of the estimated values vs. measured values for Manhattan and Big Spring for the 30 - plant averages of eight harvests and for each individual plant are given in Table 2. Values for canopy cover at Big Spring were not available for analysis.

Table 1. Estimation equations developed from Manhattan grain sorghum data using averages of 30 plants.

Parameter	Equation	a	b
Leaf Area (cm^2)	$a(1 - e^{bX*})$	4250	-.0359
Stem Area (cm^2)	$a(1 - e^{bX})$	85	-.0631
Stem Length (cm)	$a(1 - e^{bX})$	50	-.0470
Plant Height (cm)	$a(1 - e^{bX})$	110	-.1178
Canopy Cover (%)	$a(1 - e^{bX})$	91	-.1649

*X = Total Dry Weight (g)

Table 2. Linear regression coefficients of observed vs. estimated values for Manhattan and Big Spring grain sorghum plants.

Parameter	Manhattan 1987		Big Spring 1986		Big Spring 1987	
	Average	Each Plant*	Average	Each Plant	Average	Each Plant
Leaf Area (cm^2)	.9923	.9374	.9932	.9257	.9115	.8782
Stem Area (cm^2)	.9731	.8704	.9716	.8916	.9652	.9028
Stem Length (cm)	.8887	.8177	.9606	.8897	.9544	.8935
Plant Height (cm)	.9772	.9378	.9120	.9091	.9629	.9136

* 240 Individual Plants

Judging by the coefficients of determination, the equations developed at Manhattan fit the Big Spring data very well, even though these data include two years and two different grain sorghum hybrids grown under a different environment.

Leaf and stem area distributions, expressed as a percentage of the total area, are shown in Figures 1 and 2, respectively. Leaf area distribution is triangular, with the maximum leaf area between 40 to 60 percent of the total height of the plant (Figure 1). This distribution was constant regardless of the age of the plant. Stem area is in the bottom 80 percent of the plant height (Figure 2).

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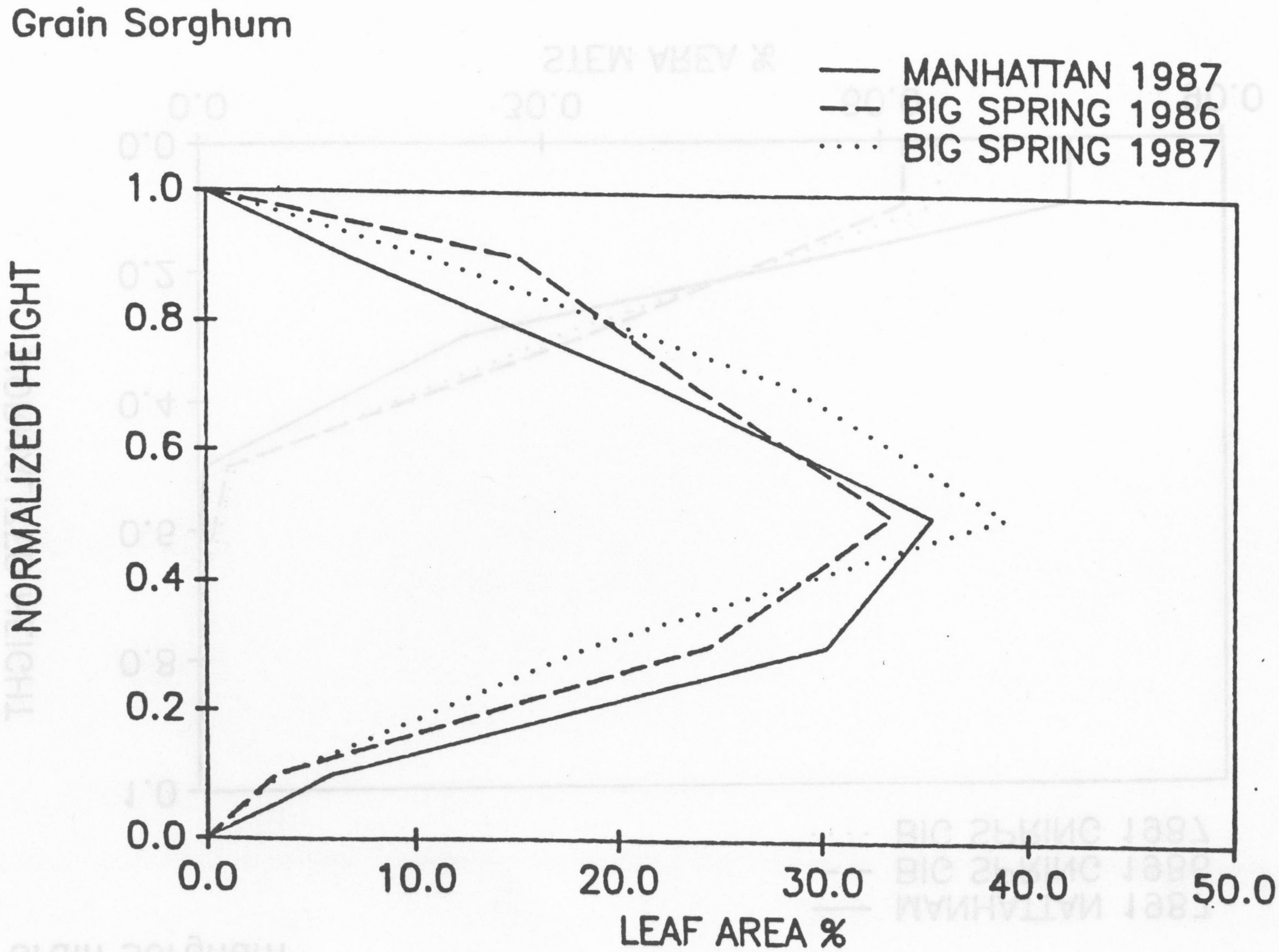

Figure 1. Average leaf area distribution with height.

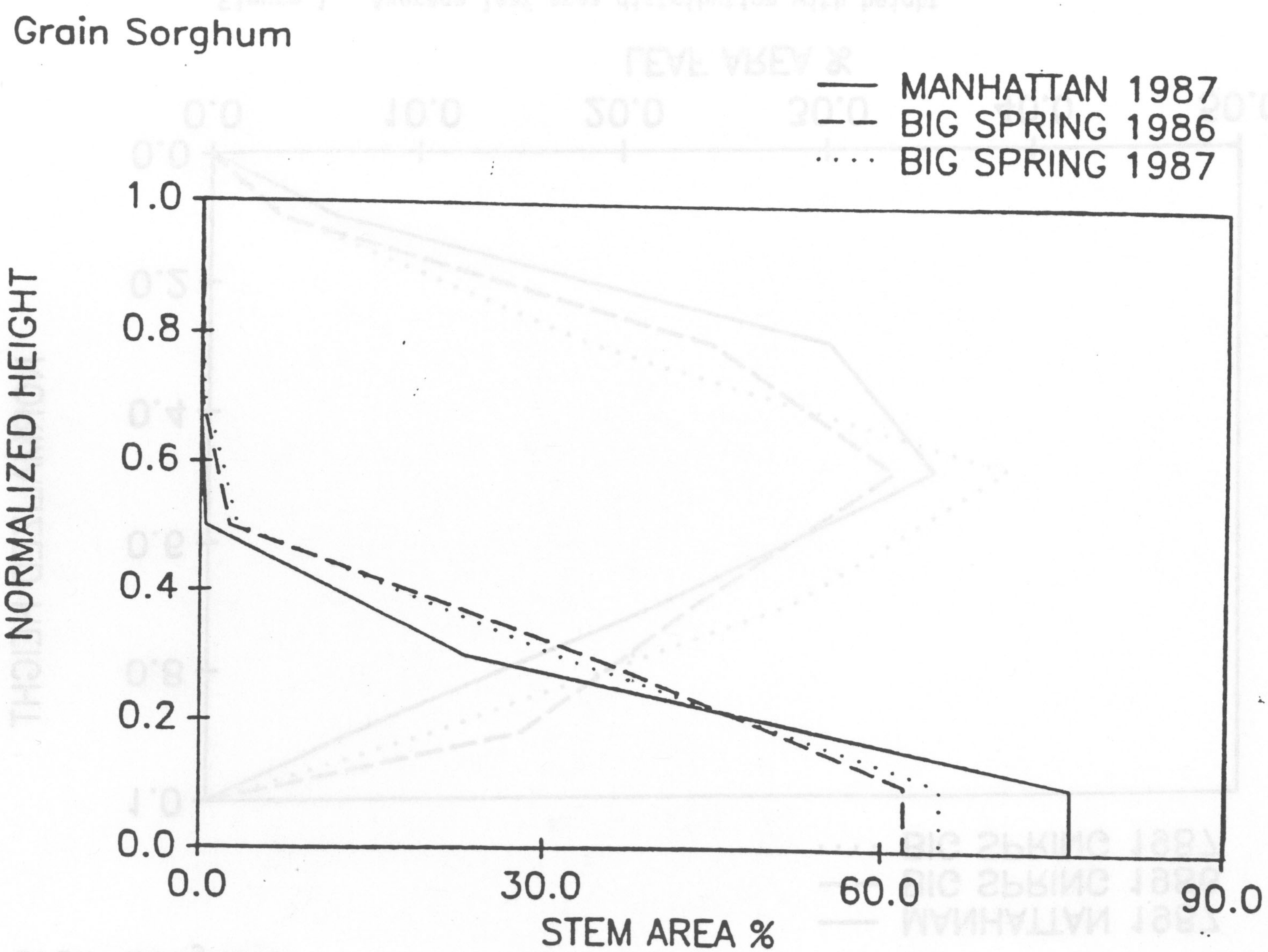

Figure 2. Average stem area distribution with height.