Soil temperature

Soil temperatures, particularly the extremes, adversely influence germination of seed, functional activity of roots, the rate and duration of plant growth, and the occurrence and severity of plant diseases (Chang 1968). The soil temperatures observed at any given location depend (Monteith 1979) on:

a. The rate at which radiant energy is absorbed;
b. the fraction of energy that is available for heating the soil and atmosphere (sensible heat), i.e., the fraction not used for evaporation (latent heat); and
c. the partitioning of sensible heat between soil and the atmosphere.

We measured the soil temperature, at 10 cm depth, of a medium-deep Alfisol planted to a postrainy-season sorghum crop at ICRISAT Center. Three mositure regimes were imposed on the crop.

1. No drought stress (by irrigating the crop every 10 days).
2. Drought stress imposed 35 to 65 days after emergence (DAE) (by withholding irrigations during this period and irrigating thereafter every 10 days).
3. Drought stress imposed from 65 DAE (by withholding irrigation) to maturity.

Soil temperatures were also measured on a nonirrigated, bare soil. Maximum soil temperatures under different treatments are shown in Figure 6. Treatment 1 showed the lowest soil temperatures to range between 21° and 24°C, up to 95 DAE. Because all irrigations were withheld thereafter, the soil temperatures showed a sudden increase. Treatment 2, which was under stress up to 65 DAE, showed soil temperatures that were, on an average, about 4°C higher than in treatment 1. In treatment 3, the temperatures were high, occasionally approaching those for the bare fallow in treatment 4.

Van Wambeke (1982) computed the mean annual, mean summer, and mean winter soil temperatures for selected stations in Africa from the mean air temperatures (see Table 7). According to the USDA Soil Conservation service (1975), Alfisol regions can be classified as Hyperthermic or Isohyperthermic.

In crops, the shoot meristem has been indentified as the site of temperature perception (Kleinendorst and Brouwer 1970; Peacock 1975). At the start of the growing season, the meristem may be at or just below the surface, so that the rate of leaf expansion is determined by surface soil temperature (Monteith 1979). As the shoot extends, the meristem moves away from the soil surface but, if transpiration is fast enough, its temperature may still be modified by the temperature of the root system and, therefore, of the water the roots absorb.

In relating the response of a crop plant to soil (or air) temperature, Monteith (1979) advocates that it is essential to record the duration of each developmental stage. Several management practices (e.g., mulching) aimed at favorably altering the soil-temperature regimes of Alfisols will be discussed during the course of this workshop, and the forementioned suggestion of monitoring the duration of growth in addition to the rates is worth considering.

Soil Water

Soil water storage capacity

The above discussion on rainfall, PE, and the length of the growing season provides rough solutions to broad, region-specific problems in agricultural planning. But the soil characteristics of the region are by themselves very important since the soil serves as a storage reservoir when rainfall exceeds PE. Availability of stored water is crucial for the successful harvest of a crop in SAT Alfisols, where water deficits during the growing season are frequent.

Traditionally, the water-storage capacity of a soil profile is determined by using the limits of water extraction at field capacity and -15 bars (permanent wilting point). The lower limit used in this procedure has come under criticism of late, because the proportion of the soil profile tapped by the crop is difficult to ascertain (Hsiao et al. 1980). By growing sorghum, pigeonpea, and chickpea under good management during the postrainy season on water stored in the soil, generalized estimates of crop-extractable water in deep and medium-deep Alfisols at the ICRISAT Center were determined. (See Fig. 5, El-Swaify et al. 1987, in this volume).

Table 7. Computed soil temperatures and soil taxonomy definition of the temperature regime for different stations in Alfisol areas of Africa.

Rainfall zone (mm a^{-1})	Station	Mean soil temperature (°C)			Temperature regime
		Annual	Summer	Winter	
<500	Mahalapye	23.0	25.7	18.5	Hyperthermic
500-600	Birni N'Konni	31.0	30.6	28.3	Isohyperthermic
600-800	Kayes	32.0	31.4	29.4	Isohyperthermic
800-1000	Lilongwe	22.4	23.6	19.3	Isohyperthermic
>1000	Bougouni	29.5	28.5	28.3	Isohyperthermic
>1000	Gaoua	30.0	28.3	30.2	Isohyperthermic

Source: van Wambeke 1982.

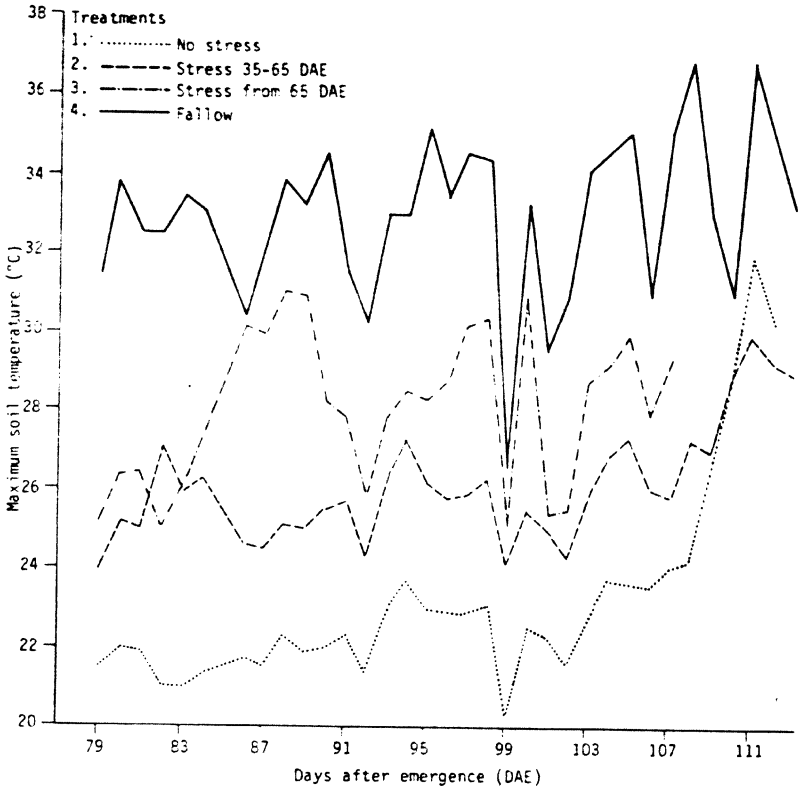

Figure 6. Seasonal variation in maximum soil temperature under different treatments in sorghum grown during the postrainy season at ICRISAT Center.