where Y = yield (kg/ha)
K_m = crop factor (kg/ha),
CT = cumulative transpiration from beginning of growth season (mm), and
E_o = average free water surface evaporation rate (mm/day).

This equation allowed yield to be expressed as a function of water use by the crop. It also implied that there were no critical periods of crop growth during which water use was more important than at any other stage.

For a given crop and yield, Hanks (1974) calculated relative yield as a function of relative transpiration:

$$\frac{Y}{Y_p} = \frac{CT}{CT_p} \tag{22}$$

where Y_p = potential crop yield when water is not limiting (kg/ha),
and CT_p = cumulative transpiration that occurs when soil water does not limit transpiration (mm).

This equation was found to produce good results when the transpiration component was separated from evapotranspiration. It also allowed the prediction of relative yield at any time during the growing season as a function of transpiration to that time.

One of the best examples of the linear relationship between dry matter yield and evapotranspiration in the humid southeast can be found from South Carolina lysimeter studies reported by Allison et al. (1958). These data were obtained for several different crops (corn, millet, cowpeas, crotalaria, cotton, and soybeans) and crop rotations over a 12-year period from 1933 to 1945. These data are plotted in Figure 12, and give a linear relationship with a correlation coefficient of 0.959. Under these experimental conditions, they estimated bare soil evaporation rate to be about 406 mm per year.

Several other researchers including Arkley (1963), Hanks et al. (1969), Leggett (1959), Powers et al. (1961) and Whittlesly and Colzar (1968) verified the results given in Equations 21 and 22. The experimental results summarized by these equations demonstrate the important fact that a reduction in transpirational water use below potential rate results in a concomitant decrease in crop biomass yield. Bierhuizen and Slayter (1965), Tanner (1981), and Tanner and Sinclair (1983) showed that diffusion of CO_2 into the stomata and loss of water vapor from the stomata was the coupling mechanism between biomass yield and ET.

4.1.2 Grain Yield

Grain yields are more sensitive to water shortages during certain stages of growth than in others. Several approaches predict grain yields from